TMAC Resources Inc.

DORIS NORTH PROJECT
2013 Aquatic Effects Monitoring Program Report

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Prepared for:

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Executive Summary

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Executive Summary

The Doris North Project (the Project) is located within the Hope Bay Belt, an 80 by 20 km kilometre property located along the south shore of Melville Sound in Nunavut. The property consists of a greenstone belt (the Hope Bay Belt) that contains three main gold deposits. The Doris and Madrid deposits are located in the northern portion of the belt, and the Boston deposit is at the southern end. The Project is located approximately 125 km southwest of Cambridge Bay on the southern shore of Melville Sound. The nearest communities are Umingmaktok (75 km to the southwest of the property), Cambridge Bay, and Kingaok (Bathurst Inlet; 160 km to the southwest of the property).

TMAC Resources Inc. (TMAC) acquired the Hope Bay Belt Project from Newmont Corporation in March 2013. The acquisition included exploration and mineral rights over the Hope Bay Belt, including the Doris North Gold Mine and its permits, licences and authorizations for development received by previous owners. In late 2012, prior to the sale, the Hope Bay Belt Project was placed into care and maintenance, and the Project was seasonally closed during the winter of 2012/2013. TMAC re-opened the Doris North Camp in March of 2013 for the purposes of conducting site water management, environmental compliance programs and to support exploration activities. The Doris North Project remains in care and maintenance although it will not be seasonally closed for the winter of 2013/2014.

The compliance requirements for an Aquatic Effects Monitoring Program (AEMP) applicable to the Doris North Project Certificate (Nunavut Impact Review Board (NIRB) No. 003, issued September 15, 2006; NIRB 2006) and Type A Water Licence (Nunavut Water Board (NWB) Licence No. 2AM-DOH0713 Type A, issued September 19, 2007; NWB 2007) are as follows:

- 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, Hope Bay Mining Ltd. (HBML) submitted an AEMP Plan on February 24, 2010, after consultation with Environment Canada. The final AEMP Plan, *Doris North Gold Mine Project: Aquatics Effects Monitoring Plan* (the Plan; Rescan 2010c), was approved by the Nunavut Water Board (NWB) 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.

On September 12, 2013, a renewed and amended Type A Water Licence was issued to TMAC. The following text outlines the requirements of this Type A Water Licence (NWB Licence #2AM-DOH1323):

- Part K, Item 7. *The Licensee shall submit to the Board for review, six (6) months prior to Operations, a revised Doris North Gold Mine Project: Aquatic Effects Monitoring Plan (AEMP) that has been developed in consultation with Environment Canada. The revised AEMP shall consider modifications and advances in schedule which are consistent with the objectives and requirements of the MMER.*

Currently, the AEMP is being conducted in accordance with the final Plan approved on March 25, 2010. To comply with the requirements of the AEMP Plan, TMAC contracted ERM Consultants Canada Ltd. (ERM Rescan) to undertake the monitoring activities under the AEMP and to report on its findings.

This report presents the results from the fourth year of the AEMP. Data collected to date may serve as baseline information once the Project enters the operations phase. The AEMP approach would be validated as part of any update to the AEMP Plan. 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. Aquatic components evaluated in 2013 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 resurveyed in 2013.

Streams

There were no apparent adverse effects of 2013 Project activities on water quality, sediment quality, periphyton biomass, or benthic invertebrate communities in the study streams Doris Outflow, Roberts Outflow, and Little Roberts Outflow.

Out of the 18 water quality variables that were evaluated, total arsenic at Roberts Outflow and total aluminum at Little Roberts Outflow were the only variables that changed significantly from baseline years to 2013; however, parallel changes occurred at the reference streams, indicating that these changes were not due to Project activities. In both cases, concentrations decreased from baseline years to 2013, which is of no concern environmentally. Therefore, there were no effects of 2013 Project activities on the water quality of the study streams.

At Doris and Little Roberts outflows, there were some differences in the particle size composition of sediment samples collected in 2013 compared to the particle size composition of baseline samples. Variation in sediment particle size composition was unlikely related to 2013 Project activities, and probably reflected natural spatial heterogeneity in stream sediments. At Little Roberts Outflow, sediments in 2013 contained lower concentrations of total organic carbon, chromium, copper, lead, and zinc than did baseline sediments. These decreases were likely attributable to the significant decrease in the proportion of fine sediments in 2013 samples compared to baseline samples, since fine sediments tend to be associated with higher concentrations of total organic carbon and metals than coarse sediments. Decreases in the 2013 concentrations of total chromium and zinc compared to baseline samples were also observed at Reference B Outflow. Decreases in sediment metal concentrations are not of concern. Therefore, there were no apparent adverse effects of 2013 Project activities on the sediment quality of exposure streams.

There was evidence of non-parallelism in the 2010 to 2013 benthos family evenness trend between Doris Outflow and the reference streams and in the 2010 to 2013 Bray-Curtis Index between Roberts Outflow and the reference streams. However, this non-parallelism did not indicate that the Project was adversely affecting the benthos community at these sites. Doris Outflow benthos evenness remained higher than all other streams in 2013, and the Roberts Outflow Bray-Curtis Index was relatively low in 2013 compared to previous years, indicating that there was increased similarity between the benthos at Roberts Outflow and the median reference community in 2013. These differences in trends likely reflect natural annual variability or patchiness in the composition of the benthos community within streams. 2010 to 2013 trends in total density, family richness, and Simpson's Diversity Index at exposure streams paralleled the trends observed for the reference streams, indicating that there were no effects of 2013 Project activities on these benthos community descriptors.

Lakes

There were no apparent Project-related effects on under-ice dissolved oxygen concentrations, Secchi depths, water or sediment quality variables, phytoplankton biomass levels, or benthic invertebrate communities in the AEMP lake sites Doris Lake South, Doris Lake North, and Little Roberts Lake.

There was evidence of a change between baseline years and 2013 in water hardness (increase) at Doris Lake South, and in the concentrations of total arsenic (decrease), total molybdenum (increase), and total zinc (increase) at Doris Lake North. However, in all these instances, the before-after-control-impact analysis showed that parallel changes from baseline years to 2013 also occurred at the reference lake (Reference Lake B). Thus, there was no evidence that these changes to water quality were due to 2013 Project activities.

At Doris Lake South, there were some differences in the particle size composition in the sediment samples collected in 2013 compared to the particle size composition of baseline samples. Variation in sediment particle size composition was unlikely related to 2013 Project activities, and probably reflected natural spatial heterogeneity in lake sediments. There was evidence of a decrease between baseline years and 2013 in copper concentrations in sediments from Doris Lake South and Doris Lake North, as well as a decrease in the lead concentration in Little Roberts Lake sediments. Decreases in sediment metal concentrations are not of environmental concern. Therefore, there were no apparent adverse effects of 2013 Project activities on the sediment quality of exposure lakes.

There was evidence of non-parallelism in the 2010 to 2013 benthos Bray-Curtis Index trends in Doris Lake North and Doris Lake South relative to Reference Lake B. However, given the high inter-annual variability in the Bray-Curtis Index at these sites, the temporal trends are not clear. The 2013 Bray-Curtis Index calculated for Doris Lake North and Doris Lake South were within range of previous years, so it is unlikely that 2013 Project activities adversely affected the Bray-Curtis Index at these sites. 2010 to 2013 trends in total density, family richness, and Simpson's evenness and diversity indices at exposure lakes paralleled the trends observed for the reference lakes, indicating that there were no effects of 2013 Project activities on these benthos community descriptors.

Marine

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

The only water quality variable concentration that changed significantly from baseline years to 2013 was total suspended solids at Roberts Bay West. However, total suspended solids concentrations at this site decreased from baseline years to 2013, and the before-after-control-impact analysis showed that a parallel decrease occurred at the reference site. Therefore, there were no Project-related effects on water quality at the marine exposure sites in Roberts Bay.

In sediments from site Roberts Bay West in Roberts Bay, the concentrations of total organic carbon and several metals were higher in 2013 than in 2002. These increases were likely related to the higher silt and lower sand content of the 2013 sediment samples compared to 2002, since finer sediments have a higher affinity for metals and organic carbon. At the reference site, 2013 samples also contained a higher proportion of silt and a lower proportion of sand compared to baseline samples, and consequently, increases in total organic carbon and metal concentrations were also observed in the sediments from the reference site in 2013. There was some damage to the Roberts Bay jetty in 2013 that could have contributed to changes in particle size composition and sediment quality in a localized area, but the similarity between Roberts Bay West and the marine reference site with respect to increases in silt content, and increases in sediment metal and organic carbon concentrations from baseline years to 2013 suggests that the observed changes at Roberts Bay West were naturally occurring and unrelated to the jetty damage or other Project activities. The changes in sediment particle size composition and quality may have been due to regional re-distribution of sediments following a strong storm event that occurred in July 2013 (which was responsible for damaging the jetty), or these changes could also be the product of spatial sediment heterogeneity.

In the whole benthos community (adults and juveniles) and the adult subset, non-parallelism was detected for all evaluated benthos community descriptors at Roberts Bay West and Roberts Bay East relative to the marine reference site, except for the whole community benthos density at Roberts Bay East. Most 2013 benthos community descriptors were within range of previous years, and there was no indication that benthos communities in 2013 were adversely effected by Project activities (i.e., there was no evidence of an increase in the Bray-Curtis Index or of a decrease in density, richness, or evenness in 2013 compared to previous years). The non-parallelism in trends was likely attributable to the high inter-annual variability in most evaluated parameters.

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 management, tailings management, quarry and waste rock management, and waste management. 2013 results indicate that these mitigation measures were effective in preventing adverse effects to dissolved oxygen levels, water clarity (Secchi depth), water and sediment quality variables, periphyton and phytoplankton biomass levels, and benthic invertebrate communities in Project area waterbodies.

Atanguyat Nainaktok Onipkangat

Una Kapihiliktomi Havagiyaoyok (Una Havagiyaoyok Project) iloaniitok haffuma Kapihiliktomi Uyagaktakvighatni hamna anginikaktok imatot 80-nik tatva 20 km kilometre naninigiyaoyok tahamani hivugani haffuma Melville Sound iloani Nunavut. Hamna nanminigiyaoyok pikaktok hapkuninga huangayunik uyakanik (the Hope Bay Belt) tatva hamna ilolikaktok pingahonik atayonik kangoyaoyonik ukkua Kapihiliktomi uvalu Madrid-milo nalvaktaohimayot tatvani tunnuani haffuma nalvakviohimayup, tatvanilo Angmaloktoakjukmi nalvangoyaohimayok hamna hivuganiitok. Una Havagiyayok tahamaniitok 125 km huvugata oatani Ikaluktutiap hivugani hinnata haffuma Melville Sound. Hapkua kanignikhaoyot nunaliit Umingmaktok (75 km ungahiktigiyok hivugata oatani haffuma nanminikiyaoyup), Ikaluktutiak, unalo Kingaok, 160 km ungahiktigiyok hivugata oatani haffuma nanminigiyaoyup).

TMAC Resources Inc. (TMAC) niovighimayaat hamna Kapihiliktomi Nalvakviohimayok Uyagaghiokvighak tatvanga Newmont Corporation-kunin Masi 2013-mi. Hamna niovgotigihimayat ilaliotihimayot hapkua nalvakviohimayot tatvani Kapihiliktomi, ilaliotivlugo una Kapihiliktomi Uyagaghiokvighat uvalu hapkua laisikhait ihoaghaotighaitlo tatvani havagiyaoniaktomi. Tatvani ukkiomi 2012-mi, nioviktaoniahaktitlugo, una Kapihiliktomi Nalvakviohimayok taimaktaovluni monagiyaoliktok ikkitonin havaktonit, tatvanga una Havagiyaoyok omiktaohimayok tatvani ukkiomi 2012 /2013-milo. Ukkua TMAC-kut nangmavaaktat hamna Kapihiliktomi havagiyaoyok Masi 2013-mi havagiyomavlugit hapkua nalvakviohimayop immakaninga kanogitmangat, hamna avatilikinikut malikayaoyagha tatvalo nalvaghiokhimagomavlutik. Una Kapihiliktomi Havagiyaoyok huli omikhimayok monagiyaovloni kihiani ominghimainalaitok tatvani ukkiomi 2013/2014-mi.

Hapkua malikayaoyughat hapkununga Immap Kanoginingata Monaghitjutaitnik Havagiyaoyok (AEMP) atoktaoyok haffuma Kapihiliktomi Havagiyaoyup Naonaipkutanik (Nunavumi Avatilikiyiita Katimayiit (NIRB) No. 003, titigaktaohimayok Saptaipa 15, 2006; NIRB 2006) uvalu Titigak A Immap Laisikha (Nunavumi Immalikiyiita Katimayiit (NWB) Laisikhak No. 2AM-DOH0713 Titigak A, titigaktaohimayok Saptaipa 19, 2007; NWB 2007) ima titigaghimayot:

- Ilanga K, Titigak 7. *Una Laisikhaktaktok tonihiyagiakaktok tatvunga Katimayiitnun angektaoyoghamik…, una toghiotaoyok ihoaghaotighat hapkuninga* Immap Kanoginingata Monaghitjutaitnik Havagiyaoyok *(AEMP) ihoaghaikatigilugit ukkua Avatilikiyiitkut Kanatami. Una toghiotaoyok hapkuninga AEMP-gitnik pihimayagiakaktok alangoktigotighaitnik uvalu ihoaghaotighaitnik havagiyakhaita ihoakutighaitnik ukkua Haviknik Nalvakhioktot Hiamakpaliangitangita Malikat (MMER);*
- Ilanga K, Titigak 8. *Una Laisikhaktaaktok uvalu ukkua Avatilikiyiit Kanatami havakatigiyagiakaktat ukkua NWB-kut taima hapkua tughiotaoyot tatvani AEMP-gitni malikatiagiaghaita hapkuninga MMER-gitnik.*

Malikavlugo una Ilanga K, Titigak 7, ukkua Kapihiliktomi Uyagaghioktit (HBML) tonihihimayot parnaiyaotimik hapkuninga AEMP-gitnik tatvani Fipyoali 24, 2010-mi katimakatigilgakhugit ukkua Avatilikiyiit Kanatami. Una enekpiaghimayok AEMP-gita Parnaiyaotat, *Kapihiliktomi Uyagaghioktit Havagiyat: Immap Kanoginingata Kimilgokutighaitnik Parnaiyaotait* (una Parnaiyaotat; Rescan 2010c), angiktaohimayok ukkunanga Nunavumi Immalikiyiita Katimayiitnin (NWB) tatvani Masi 25, 2010-mi, Pigiaktitjutikaghutik 2009-23-L04. Una titigak pitjutikaktok hapkuninga atugaokataktonik tatvani MMER-gani (2002), taima malikaniakmatjuk una Ilanga K, Titigak 8 tatvani Titikami A Immap Laisikhami.

Tatvani Saptaipa 12, 2013-mi , una notangoktiktaohmayok Titigak A Immap Laisikhak toniyaohimayok tatvunga TMAC-kunot. Hapkua titigaghimayot malikayagiakaktot pitjutigivlugo una Titigak A Immap Laisikha (NWB Laisikha #2AM-DOH1323):

- Ilanga K, Titigak 7. *Una Laisikhakhimayok tunihiyagiakaktok tatvunga Katimayiitnun ihivgioktaghaitnik, 6-sinik (6) tatkighiotinik una havakvioliktinago, notamik tatvani Kapihiliktomi Uyagaghiokvioniaktomi: Immap Kanogilinganinganik Kimilgokutighaita Parnaiyaotighanik (AEMP) hamna ihoaghaktaoyagiaktok katimakatigilugit ukkua Avatilikiyiit Kanatami. Hamna ihoaghaktaoniaktok AEMP pitjutikagiakaktok alangoktikutaitnik uvalu havagiyaghaitnik malikayagiakaktot hapkuninga piyaoyomayonik uvalu maligoakutaitnik haffuma MMER-gata.*

Tatjaoyok, una AEMP-parnaiyaotat ihivgioktaoyok hamna malikavlugo enekhimayok Parnaiyaotat angektaohimayok tatvani Masi 25, 2010-mi. hamna malikayagiakakmatjuk maligak tatvani AEMP-parnaiyaotat, ukkua TMAC-kut havaktikaktot ERM Consultants Canada Ltd. (ERM Rescan) tatva havagiyagiakaktait hapkua kimilgokataklogit havagihaoyot atoklugo una AEMP-parnaiyaotat tatvalo onipkagilogit hapkua nalvagiyatik.

Una onipkagiyaoyok pitjutaoyok hapkuninga havagiyaitnik tatvani hitamani ukkioni havagiyaonmat una AEMP-parnaiyaotat. Hapkua naonaiyaotait katighoktaohimayot ublumimut atoktaoniakungnaghiyot tohaktitjutighait hamna Havagiyaoyoghak aolakutivalialikat. Una pitjutaoyok atoktaoniaktok ilaliotilgo tohakakhanik haffuminga AEMP- parnaiyaotatnun. Tatvani titigakhimayot Parnaiyaotini hapkua, pingayot kuukaoyat havangit, pingahot tattit havagiyat, uvalu malgok tagiokmi havagiyat kimilgoktaohimayot ilaliotivlugit ukkua malgaok naonaiyaotait kukaoyak havagiyat, malgok naonaiyaotait tattik havagiyat, uvalu ataohik tagiokmi naonaiyaotait havagiyat. Immakmiotat naonaiyaktaohimayot tatvani 2013-mi ilaliotihimayot: tattini uvalu tagiokmi hikup atani puplakakningit; tattit kanok ittinikakmangata; kukaoyat, tattit, uvalu tagiomi immak halomailgokagiakha; kuukaoyat iliitkohiit; tattini uvalu tagiomi naotiat kanoginingit; uvalu hapkua kuukaoyani, tattini, uvalu tagiop natkani alatkinik omayokagiaghait (kititlugit amigaitningit omayut uvalu naotiakakniit, ajikuhiokhugit, alatkinik uvalu ihomagilugo una Bray-Curtis Index naonaiyaot). Tattini uvalu tagiokmi ekalukakningit naonaiyaktaohimayot tatvani 2010-mi (Rescan 2011) tatva naonaiyaktaoffangitot tatvani 2013-mi.

<u>Kuukaoyat</u>

Pihimayakangitot hapkuninga ihoilotaoyonik tatvani 2013-mi Havagiyaoyomi hapkuninga immap kanogininganik, halomailgokakninganik,naotiat kanoginingit, uvalunin natkani omayot allatkit kanoginingit hapkunani naonaiyakvioyoni kuukaoyani Kapihiliktomin Anniayok, Roberts-mit Anniayok, uvalu Little Roberts-mit Anniayok.

Hapkunanga 18-guyonit immap kanoginingata ajikuhiokhugit naonaiyaihimangmata, tatva kititlugit hamna kayangnaktok halomailgok takunaktok tatvani Roberts-mi Anniaviani uvalu kititlugit hamna havivaluk tatvani Little Roberts-mi Anniaviani tapkuatoak naonaiyaotaitni alangokhimayok hapkunanga ukkioni naonaiyaihimatitlugit tatvunga 2013-mut; kihiani, ajikutaitnik alanguktikutikaktot hapkunani okaotaoyoni kuukaoyani, taimaitmat tatva alangutait pitjutaongitot Havakvioyomi hapkua havangit. Ukkua tamakmik naonaiyaktaongmanik, hapkua halomailgot mighivalikhimaliktot tatvanga naonaiyaktaolgakmata tatvunga 2013-mut, tatva taimatot avatilikiyioyonit ihomalotaongitok. Taimaitmat, hapkua ihomalutaongitmata ihoilotaongitot tatvani 2013-mi Havakvioyomi hapkua havangit immap kanogininganik hapkunani naonaiyakvioyoni kuukaoyani.

tatvani Kapihiliktomi uvalu Little Roberts-mi anniayok, mikiyomik alangavyaktot hapkua angitilangit hunavalokakningit naonaiyaktaoyot katighoktaongmata tatvani 2013-mi ajikutagingitait hapkua hivolikmi naonaiyakakalikmatjuk. Hamna alanguta angitilangita hapkua hunavalokakningit ilaliotihimayot pitjutaolgungitot hapkununga 2013-mi Havakvioyomi hapkua havangit, tatva imakaak hilaap kanogininganit taimaitpagungnakhiyok hunavaloit nunamit ilangotigangata kuukaoyak kukloaligangat. Tatvani Little Roberts-mi anniayok, tatvani 2013-mi hamna hunavaloit mikitkiyamik iliitogiyaohimayok katitlugit hapkua havivaloit carbon chromium, copper, lead, uvalu haviktalik takuktaolgakmata naonaiyakhugit. Hapkua mikhivalianingit immakak hikoptikpaliahimangata hunavaloit ilaliotihimayot tatvani 2013-mi naonaiyaihimangmata, tatva taimaikatakmata hapkua hikoptikhimayot havivaliot hiamatjakpaliangangamik. Mikhivalianingit tatvani 2013-mi hunavaloit hapkua havivaloit chromium uvalu haviktalik naonaiyaktaohimangmiyot tatvani Naonaiyakvioyomi B kuukloakviani. Hapkua havivaloit ihomalotaongitot. Taimaitmata, takunangitok ihoilotaoyonik tatvani 2013-mi Havakvioyomi havangitnik halomailgok hunavaloitlo kanogininganik kuukaoyani naonaiyaktaongmata.

Tatva takunaktok hamna alatkininga akunani 2010-mi tatvunga 2013-mut tagiop natkani kanogininga tatvani Kapihiliktop anniavinganin hapkununga naonaiyaktaoyonut kuukaoyat anniaviitnun tatvalo akungani 2010-mi tatvunga 2013-mi Bray-Curtis Index naonaiyaotatni akungani uma Roberts-mi Anniavianin tatvunga naonaiyakvioyonot kuukaoyat anniaviatnun. Kihiani, kihiani hamna alanganinga naonaiyaotaongitok hamna Havakvioyok ihoiyaotaoyaghanik tagiop natkanik hapkunani naonaiyakvioyoni. Tatva Kapihiliktomi kuukata annianingata tagiop natkanut ittitkiyaoyot tamaitnin kuukaoyanin tatvani 2013-mi, tatvalu uvani Roberts-mi annianingani Bray-Curtis Index ikkatkiyaoyot tatvani 2013-mi ahianin kingoani ukkionit, tatva taimatot naonaipkutaovok immaokangingitnik hapkua tagiop natkangit tatvani Roberts-mi Anniaviani uvalu akungani hapkua noanaiyakvioyot kuukaoyat tatvani 2013-mi. Hapkua alanganiit immakak naonaipkutaovut hilap kanogininga uvalu immaokangningit hapkua tagiop natkangitni annianingitni hapkua kuukaoyat. Tatva 2010-min akungani 2013-mut iliitkohiit hapkua atayot kuukaoyat, uvalu una Simpson's Diversity Index naonaiputait hapkua kuukaoyat kimilgoktaohimangmata, taima naonaiyaotaovuk hapkua 2013-mi tatvani Havakvioyomi havangit ihoiyaotaongitot hapkunani tagiop natkani kuukaoyat annivitni.

<u>Tattit</u>

Kanighimayakangitot tatvani Havagiyaoyomi ihoilotaoyonik hikkup atani puplaop illiitkohiitnik, Immap ittiningit, immap uvalunin hunavaluit natkani kanogingingitnik,naotiakakningitnik, uvalunin immap natkani omayot kanogingingit haffuma AEMP-ganik naonaiyakvitni hapkunani Kapihiliktomi, Doris-mi Tahik Hivugani, Doris-mi Tahik Tunuani-mi, uvalu Little Roberts Lake-milo.

Tatva naonaitok alangotait naonaiyalihaktitlugit akungani tatvunga 2013-mut immaokakpalianinganik tatvani Doris-mi Tahik Hivugani, uvalu pitakakningitnik haffuma kayangnaktonik tokunaktoniktokakninga (mikhivaliktok), kititlugo hamna amigaikpalinga, uvalu kititlugo hamna haviktalik (angiklivaliktok) tatvani Doris-mi Tahik Tunuani. kihiani, tamaitni hapkua iliitkohiitni, hamna kingungani- kangiktatitlugulo hamna kanogiliyokakhimanikat naonaiyaotait takunaktot alangoktait naonaiyaotaolihaktitlugit tatvunga 2013-mun taima pitjutikakmiyot tatvani naonaiyakvioyomi tattimi (Naonaiyakvioyoni Tahikmi B). Tatva, pitakangitok naonaiyaotinik immap kanogininganik alangokhimanikat haffuma 2013-mi una Havakvioyok havagiyaotitlugo.

Tatvani Doris-mi Tahik Hivugani, tatva alangayut hapkua angitiningit halumailgot naonaiyaotit katikhoktaohimayot tatvani 2013-mi tatvanganit kingoani naonaiyaotaitnit. Hapkua alangotait halumailgot katikhoktaohimayot tatvanga pitjutaonginahugiyait 2013-mi Havagiyaoyop havangitnit, tatva imakak tattit kanogininganit pitjutaonahugiyaoyot hapkua tattimi halumailgot. Tatva naonaitok mikhivalianinga akungani kingoani ukkioni naonaiyaktaohimangmat tatvunga 2013-mut hapkuninga kannoyaoyat hikuptighimayot tatvanga Doris-mi Tahik Hivugani uvalu Doris-mi Tahik Tunuani, tatvalu mikhivalikhimayok hamna haviktak tatvani Little Roberts-mi Tahikmi. Hamna haviktakaknia avatilikinikut ihomalotaongitok. Taimaitmat, pihimayakangitot ihoilotaoyonik tatvanga 2013-mi Havakvioyop havagiyaitnit halumaigonik hapkunani naonaiyaktaoyoni tattini.

Tatva naonaitok hamna ajikutagingitat akungani 2010-min tatvunga 2013-mut immap natkani Bray-Curtis Index iliitkohit tatvani Doris-mi tahik Tunnuani uvalu Doris-mi Tahik Hivugani ajikutagiya haffuma Naonaiyaktaoyup Tahik Lake B. Kihiani, naonaitmat hamna alangavalakninga tatvani naonaiyaotaitni Bray-Curtis Index-nik hapkunani naonaiyakvioyoni, hapua kanga alangokhimaningit naonaktot. Una 2013-mi Bray-Curtis Index naonaiyaot katitiktaohimayok tatvani Doris-mi Tahik Tunnuani uvalu Doris-mi Tahik Hivugani kanitigekhimayok kingungani ukkioni, tatva taima pitjutaonginahugiyaoyok hamna 2013-mi Havagiyaoyok ihoilotaoloni hapkuninga Bray-Curtis Index naonaipkutat hapkunani naonaiyaktaoyoni. Tatva 2010-mi tatvunga 2013-mut iliitkohit hapkua kititlugit hapkua alatkiit naonaiyaotaoyot hapkunani tattini kanok alangakhaita hapkua naonaiyakvioyot tattit, naonaitok tatva ihoilotaongitot uvani 2013-mi Havagiyaoyot hapkua tattit natkani.

<u>Tagiok</u>

Naonaitok tatva hamna Havagiyaoyok ihoilotaongitok ukkiomi kikihimayonik auktokhimaliktonik ublakakninut, immaknik uvalu hunavaluknik, naotiakakningit kanoginingit, uvalunin hapkuninga immap natkani omayonut hapkunani AEMP-gita tagiomik naonaiyakvioyoni Roberts Bay-mi Oatani uvanilo Roberts Bay Kivatani.

Una avaliitok immap kanoginingata alangokpalaghimayok hapkunanga kingoani ukkiongitnin naonaiyaktaohimangmat tatvunga 2013-mut hapkua notkaktitaohimayot ikakokviohimayot tatvani Roberts Bay-mi Oatani. Kihiani, hapkua notkaktitaohimayot ikakokviohimayot tatvani havakvioyomi mikhivalighimayot kingoanin ukkionin naonaiyaktaohimatitlugit tatvunga 2013-mut, hamnalo taimanimit ublumimut kanogilivalianinganik naonaiyaotait iliitugiyat hamna halumailgok mighivalighimaliktok tatvani naonaiyakvioyomi. Taimaitmat, pitakangitok tatvani Havagiyaoyomi ihoilotaoyonik haffuma immap kanogininganik tatvani tagiokmik naonaiyakvioyomik Roberts Bay-mi.

Hapkua hunavaloit halumailgot naonaiyakvioyomit haffuma Roberts Bay-mi Oatani tatvani kanighokmi, hapkua naonaiyaotait hunavaluknik omayoniklo tatvalo alatkinik havivaloknik amigaitkiyaoyot 2013-mi taimanionganin 2002-min. hapkua amigaikpaliknahugiyaoyot kingikhivalikhimangmata makluvalok tatvalo hiogavalok mikhivalikhimangmat 2002-min tatvani 2013-mi naonaiyaktaohimangmat, taimaitmat hamna hunavaluk hikuptikhimagangat katikhukvioloakpaktot havivaluknik uvalu hunavaloknik omayonik. Tatvani naonaiyakvioyomi, hapkua 2013-mi naonaiyaotait pitjutikaktot kingikiyanik makluvaloknik uvalu mikhivalikhimavloni hamna hiogavalok taimanionganit naonaiyaktaohimangmata, taimatovalak, amigaikpalikhimavut hapkua hunavaluit omayut uvalu havivaloit tatvani naonaiyakviohimayomi 2013-gutitlugo. Tatvataok una omiat tulaktakviat ahigukhimangmat tatvani Roberts Bay-mi 2013-mi pitjutaonahugiyaoyok hapkuninga hunavaluknik hikumikyaohimayonik tahamani tagiokmi, kihiani hamna ajikuhiokhimayaat tatvani Roberts Bay-mi Oatani tatvanilo tagiokmi naonaiyakvioyomi pitjutaotilugit hapkua katikhughimayot makluvalok, uvalu amigaikpalikningit hapkua havivaluit uvalu alatkit hunavaluit omayut kingoanin naonaiyaktaolgaktitlugit ublumimut 2013-mun tatva ihomagiyaoyok hapkua alangutait tatvani Roberts Bay-mi Oatani hilap kanogininganin pitjutaohimayot tatvalo una omiat tulaktakvia ahikutaohimangmat pitjutaongitok uvalunin hapkua tatvani Havagiyaoyot. Hapkua alangutaohimayot hunavaluit hikuptikhimayot kanoginingitlo pitjutaonahugitaoyot tavuna anugikyoaktokaktitlugo July 2013-mi (tatvuna hamna omiat tulaktakviat anukip ahikutikhimaya), uvalunin hamna alangutaohimayok pitjutaoyahugitaongmiyok hilap kanogininganin.

Hapkua tamatiomavlugit immap natkani omayot (innikhimayot uvalu mikatait) uvalu hapkua innikhimayot omayot ahiningakhimayot illiitugiyaohimayot immap natkani Roberts Bay-mi Oatani uvalu Roberts Bay-mi Kivatani ajikutagiyaoyot hapkunanga tagiomi naonaiyakvioyunit, kinhingokhugo hamna alakinik omayokakningit tatvani Roberts Bay-mi Kivatani. Hapkua tamatkiomavyaktot 2013-mi hunavaloit omayot naonaiyaotait ajikutagivyaktait kingoani ukkionin naonaiyaktaohimangmata, tatvalo pihimayakangitot naonaiyaotinik tatva hapkua immakmiotanik omayot tatvani 2013-mi nayogait ihoiyaktaohimayagiakhaitnik hamna Havagiyaotitlugo (oktutigilugit, pikangitot naonaipkutinik haffuma amigaikninganik hapkua Bray-Curtis Index-mi naonaiyaktaohimayot uvalunin mikhilakninganik uvalunin ajikutagiyaitnik tatvani 2013-mi naonaiyakhimaningit kinguano ukkioni). Hapkua ajikingitot aipagugangat kingekningit hilap hannahimayait.

- Hapkua ihoaghaotighaitnik oktutaoyut ikkilivaliatjutighait hapkua ihoilotaoniaktot kuuktaiyanot,tattitnot, uvalu tagiokmi angutighakangingit tatvani Kapihiliktop kangingani ilaliotivlugit hapkua tagiokmut annianinga immap kuukloakninga, puyok hiogakmit ilangakpaligomavlugo, naonaiyakvioyomi immap monagitjutat, koviviokataktot monagitjutat, uyagaktakvioyot uvalu uyakat atoktaongitot kinhingoktaoyot monagitjutighait. 2013-mi hapkua naonaiyaotait ihivgioktaohimangmata hapkua ihoaghaotighait oktutaoyut kanok ihoakutaohimayot ihoiyaotaovalangitot hapkununga auktokhimayot hikup atanin puplat kanoginingitnik, immap imagingningitnut (ittiningitnun), immap uvalu hunavaloit halomailgotlo kanoginingitnun, hapkua alatkit naotiat uvalu naotiakakningit, uvalu hapkua omayot nayugaitlo tahamani Havagiyaoyup kaningani immakmut attayut.

ᑐᓴᒐᒃᓴᖅ ᓇᐃᓈᖅᓯᒪᔪᖅ

ᐅᕙᓂ Doris North–ᒥ ᐱᓕᕆᕝᕕᒃ Hope Bay–ᒨᖓᔪᖅ, ᐃᒪᐃᓪᓗᐊᖅᑐᖅ ᐊᖏᓂᖓ 80 ᑐᑭᒧᑦ ᐊᒻᒪᓗ 20 ᓴᓂᒧᑦ ᑲᓛᒥᑕ ᐱᖁᑎᖃᕝᕕᒃ ᒫᓃᑦᑐᖅ ᓯᓈᓂ ᒪᑐᒪ ᐅᐊᖕᓇᖓᓂ Melville Sound–ᒥ, ᓄᓇᕘᒥ. ᐱᖁᑎᒋᔭᖅ ᐱᑕᓕᒃ ᐆᔭᐅᔭᖅᒦᑦᑐᖅ ᓄᓇᖑᐊᑎᒍᑦ ᓇᖓᓗᓇᐃᖅᑕᐅᓯᒪᔪᖅ (ᐅᕗᖓᖓᔪᖅ Hope Bay Belt–ᒧᑦ) ᐱᑕᓖᑦ ᐱᖓᓱᑦ ᒨᓗᓂᒃ. ᐅᑯᓇᓂ Doris–ᒥ, Madrid–ᒥ ᐱᑕᓖᑦ ᑲᓇᖕᓇᖓᓃᑦᑐᑦ ᐃᓚᖓᓅᖓᔪᑦ ᐱᑕᓕᒃ, ᐅᕙᓂᓗ Boston–ᒥ ᐱᑕᓕᒃ ᑲᓇᖕᓇᖓᑕ ᐃᓯᐊᓂ. ᐃᑲᓃᑦᑐᖅ ᐱᓕᕆᕝᕕᒃᓴᖅ ᒥᒃᓴᐅᓴᒃᑐᒥ ᐃᒫᒃ 125 ᑲᓛᒥᑕᐃᑦ ᓯᕙᑐᓂᖓ ᐅᐊᖕᓇᖓᑕ ᑕᓕᖅᐱᐊᓂ ᐃᖃᓗᒃᑑᓯᐊᑉ ᐅᐊᖕᓇᖓᓂ ᓯᓇᓃᑦᑐᖅ Melville Sound. ᖃᓂᒃᓵᑦ ᓄᓈᑦ ᐅᑯᐊ ᐅᒥᖕᒪᒃᑑᖅ (75 ᑲᓛᒥᑕ ᐅᐊᖕᓇᖓᓂ ᐱᖁᑎᖃᕝᕕᐅᑉ), ᐃᖃᓗᒃᑑᑦᑎᐊᖅ, ᕿᖓᐅᓪᓗ (Bathurst Inlet; 160 ᑲᓛᒥᑕᐃᑦ ᓯᕙᑐᓂᖓ ᐅᐊᖕᓇᖓᑕ ᐅᐊᓕᓂᐊᓂ ᐱᖁᑎᖃᕝᕕᐅᑉ).

ᐅᑯᐊ TMAC Resources Inc.–ᑯᑦ ᐅᕗᖓᖓᔪᖅ Hope Bay Belt–ᒧᑦ ᐱᓕᕆᕝᕕᒋᔭᖓᖓᑦ ᐅᑯᐊ Newmont Corporation–ᑯᑦ ᒫᑦᓯ 2013–ᒥ. ᐊᑑᑕᐅᔪᑦ ᒪᑯᓂᖓ ᐃᓚᖃᖅᓯᑎᒃ ᕿᓂᒃᓴᖅᓯᑎᒃ ᐊᒻᒪᓗ ᐊᑑᑎᒋᐊᓕᖕᒥᓐᓂᒃ ᓄᓇᒥ ᓴᓇᔾᔪᑎᒥᓂᒃ ᐱᔪᓐᓇᐅᒻᒥᒃ ᑲᔪᓯᑎᖃᖅᓯᑎᒃ ᐅᕗᖓᖓᔪᒧᑦ Hope Bay Belt–ᒧ, ᐃᓕᑦᔭᐅᓪᓗᑎᒃ Doris North Gold Mine–ᒥ ᐅᔭᕋᒃᓴᖅᓯᐅᕈᑎᑦ ᒨᓗᒥᒃ ᐊᒻᒪᓗ ᐱᔪᓐᓇᕈᑎᖃᖅᓯᑎᒃ, ᓚᐃᓴᖃᖅᓯᑎᒃ ᐊᒻᒪᓗ ᑲᔪᓯᒍᑎᓂᒃ ᐱᓪᓗᑎᒃ ᐱᕙᓪᓕᐊᑎᑦᓯᒍᑎᓂᒃ ᓯᕗᓪᓕᖅᒥ ᓇᖏᓂᖃᖄᔪᓂᒃ ᐱᓪᓗᑎᒃ. ᓄᖑᐊᓂ 2012–ᒥ, ᓯᕗᕐᖓᒍᑦ ᓂᐅᕝᕕᐊᖑᓚᐅᖅᑎᓐᓇᒍ, ᐅᕗᖓᖓᔪᖅ ᐃᓅᓐᓇᖓᓅᖓᔪᒥᒃ Hope Bay Belt–ᒨᖓᔪᖅ ᐱᓕᕆᕝᕕᒃ ᐸᕿᔭᐅᓕᔫᒪᑦ ᒪᑭᒪᔭᐅᓪᓗᓂ, ᐊᒻᒪᓗ ᐱᓕᕆᕝᕕᒃ ᒪᑐᒪᔪᒻᒪᑦ ᐅᑭᐅᖏᓐᓂ ᐅᑯᐊ 2012/2013. ᐅᑯᐊ TMAC–ᑯᑦ ᒪᑐᐃᖅᓯᑲᓐᓂᓕᔪᑦ ᐆᒥᖓ Doris North ᓄᓇᓕᒋᔭᐅᓲᒥᒃ ᓯᓚᑖᓂ ᒫᑦᓯ 2013–ᒥ ᐊᐅᓚᑕᐅᓪᓗᑎᒃ ᐃᒥᓕᕆᔾᔪᑎᓂᒃ ᑖᕗᖓᖓᔪᒥᒃ, ᐊᕙᑕᓅᖓᔪᓂᓗ ᒪᓕᒃᑕᐅᖃᕇᓇᐊᓕᖕᓂᒃ ᐱᖁᔭᖅᑎᒍᑦ ᐊᑑᑎᓪᓗᑎᒃ ᐊᒻᒪᓗ ᕿᓂᕈᑎᓂᒃ ᐊᐅᓚᐦᓯᒍᑎᓂᒃ. ᐅᕙᓂ Doris North–ᒥ ᐱᓕᕆᕝᕕᒃ ᐸᕿᔭᐅᖃᑦᑕᕐᓗᓂ ᐊᒻᒪᓗ ᓴᓇᓯᒪᐃᓐᓇᓂᐊᕐᒪᑦ ᒪᑐᔭᐅᖃᑦᑕᕐᓂᐊᕈᓐᓃᖅᑐᖅ ᐅᑭᐅᖓᓂ 2013/2014.

ᐱᖁᔭᖅᑎᒍᑦ ᐊᑑᑕᐅᖃᕇᓇᐊᖢᑦ ᐃᒪᕐᒥᐊᑕ ᓱᕐᕋᒍᓐᓇᖅᑐᑦ ᖃᐅᔨᓴᖅᑕᐅᒍᑎᓂᒃ ᐊᑑᑎᒋᐊᓕᖕᒋᑦ ᐅᑯᐊ Doris North–ᑯᑦ ᐱᓕᕆᐊᕐᔪᑎᒥᒍᑦ ᓇᓗᓇᐃᒃᑯᑕᖅ (ᓄᓇᕘᑦ ᐅᕙᑎᓕᕆᔩᑦ ᑲᑎᒪᔩᖏᓐᓂᒃ ᐱᔪᖅ) ᓈᓴᐅᑎᓕᒃ No. 003–ᒥ, ᑐᓂᔭᐅᓚᐅᖅᓯᒪᔪᖅ September 15, 2006–ᒥ; NIRB 2006) ᐃᒪᐃᑦᑐᖅ ᐱᓕᕆᐊᕐᔪᑎᒃᓴᖅ Type A ᐃᒥᕐᒥᒃ ᓚᐃᓴᕐᑲᕈᑦ (ᐅᑯᓇᖓ ᓄᓇᕘᑦ ᐃᒪᓕᕆᔩᑦ ᑲᒪᔩᖏᓐᓂᒃ ᓚᐃᓴ No. 2AM-DOH0713 Type A, ᑐᓂᔭᐅᓚᐅᖅᓯᒪᔪᖅ September 19, 2007; NWB 2007–ᒥ) ᒪᑯᐊ ᒪᓕᒃᑐᐅᒋᐊᓖᑦ:

- ᐃᓚᖓ K, ᐱᔾᔪᑦ 7. *ᓚᐃᓴᓖᑦ ᑐᓂᓯᒋᐊᓖᑦ ᑲᑎᒪᔩᓄᑦ ᐊᖏᖅᑕᐅᒋᐊᓕᖕᓂᒃ... ᑐᒃᓯᕋᐅᑎᒋᓗᒍ ᐱᓕᕆᐊᕐᔪᑎᒃᓴᖅ ᐃᒪᕐᒥᐅᑕᑦ ᓱᕐᕋᒃᑕᐅᒻᒪᖔᑕ ᖃᐅᔨᓴᕈᑎᒃᓴᓂᒃ ᐅᖃᖅᑎᖃᖅᑲᓇᐊᓖᑦ ᐊᕙᑎᓕᕆᓂᕐᒃᑯᓐᓂᒃ ᑲᓇᑕᒥ. ᑐᒃᓯᕌᖅ ᖃᐅᔨᓴᕈᑎᒃᓴᖅ ᐃᒪᕐᒥᐅᑕᑦ ᓱᕐᕋᒃᑕᐅᒻᒪᖔᑕ ᐋᖏᕆᐊᖅᑕᐅᒍᓐᓇᖅᑐᓂᒃ ᐊᒻᒪᓗ ᓴᓇᔭᐅᕆᐊᕈᓐᓇᖅᑐᓂᒃ ᒪᓕᒃᑐᓂᒃ ᐊᑑᑕᐅᕆᐊᓕᖕᓂᒃ ᓴᕙᕋᔭᒃᓴᖅᑕᓕᖕᓂ ᐅᔭᕋᓂᐊᕝᕕᖕᒥ ᐊᒃᑕᑯᑦ ᐱᖁᔭᖅᑎᒍᑦ;*

- ᐃᓚᖓ K, ᐱᔾᔪᑦ 8. *ᓚᐃᓴᓖᑦ ᐊᒻᒪᓗ ᑲᓇᑕᒥ ᐊᕙᑎᓕᕆᔨᒃᑯᑦ ᐱᓕᕆᖃᑎᖃᕆᐊᓖᑦ ᓄᓇᕗᑦᒥ ᐃᒪᓕᕆᔩᑦ ᑲᒪᑎᔨᖏᓐᓂᒃ ᐋᖅᑭᒃᓯᒪᔪᐊᕋᓗᐊᖅᒪᖔᑕ ᐅᔾᔨᖅᑑᖅᑲᑎᖃᓪᓗᑎᒃ ᑐᓂᔭᐅᓯᒪᔪᑦ ᐃᒪᕐᒥᐅᑕᓂᒃ ᓱᖁᒃᑕᐅᒍᓇᖅᑐᓂᒃ ᖃᐅᔨᓴᕈᑎᓂᒃ ᒪᓕᔪᐊᕋᓗᐊᖅᒪᖔᑕ ᐊᑑᑕᐅᖅᑯᓯᒪᔭᖏᓐᓂᒃ ᐊᑑᑕᐅᔪᐊᕋᓗᐊᖅᒪᖔᑕ ᓴᕕᖃᔭᒃᓴᖅᑕᓖᑦ ᐅᔭᖃᓐᓂᐊᖅᕕᐅᕙᒃᑐᑦ ᕿᒻᒪᑯᓕᕆᔾᔪᑎᑦ ᐊᒃᑕᑯᓂᒃ ᐱᖁᔭᖅᑎᒍᑦ ᒪᓕᒐᖅᓂᒃ.*

ᒪᓕᒃᑕᐅᔪᐊᖑᖃᐊᓖᑦ ᐱᔪᓐᓇᐅᑏᑦ ᐅᑯᓇᓃᑦᑐᑦ ᐃᓚᖓ K, ᐱᔾᔪᑦ 7, Hope Bay Mining Ltd.–ᑯᑦ ᑐᓂᓯᓯᒪᔪᑦ ᐃᒪᕐᒥᐅᑕᑦ ᓱᖁᒃᑕᐅᖅᑯᓇᕆᑦ ᖃᐅᔨᓴᕈᑎᑦ ᐅᕙᓂ February 24, 2010–ᒥ, ᐅᖃᖃᑕᐅᓚᐅᖅᑎᓪᓗᕆᑦ ᐊᕙᑎᓕᕆᔨᒃᑯᑦ ᑲᓇᑕᒥ. ᑭᖑᓪᓕᖅᐸᖅᓯᐅᑎᑦ ᐃᒪᕐᒥᐅᑕᑦ ᖃᐅᔨᓴᖅᑕᐅᓂᖕᒋᑦ ᓱᖁᒃᑕᐅᓯᒪᖕᒋᒃᑲᓗᐊᖅᒪᖔ ᐅᕙᓂ *Doris North–ᒥ ᒍᓗᓂᒃ ᐅᔭᖃᓐᓂᐊᖅᕕᖕᒥ: ᐊᑑᑕᐅᕆᐊᓖᑦ ᐃᒪᕐᒥᐅᑕᑦ ᓱᖁᒃᑕᐅᓯᒪᖕᒋᒃᑲᓗᐊᖅᒪᖔᑕ ᖃᐅᔨᓴᕈᑏᑦ (ᐋᖅᑭᓯᒪᔭᖕᒋᑦ ᐅᑯᐊ* Rescan 2010c), ᐊᖏᓚᐅᖅᓯᒪᔭᖕᒋᑦ ᓄᓇᕗᑦᒥ ᐃᒪᓕᕆᔩᑦ ᑲᑎᒪᔨᖕᒋᑦᑕ ᐅᕙᓂ March 25, 2010, ᒪᓕᒃᑐᑦ ᐱᕆᐊᕈᑕᐅᓯᒪᔪᑦ 2009-23-L04. ᐅᑯᐊ ᑎᑎᖃᑦ ᒪᓕᒃᑐᑦ ᐊᑑᑕᐅᔫᓂᒃ ᐊᒻᒪᓗ ᒪᓕᒃᑕᐅᔪᐊᕆᐊᓕᖕᓂᒃ ᐋᖅᑭᒃᓯᒪᔭᖕᒋᑦ ᓴᕕᖃᔭᒃᓴᔭᓂᒃ ᐅᔭᖃᓐᓂᐊᖅᕕᖕᓂᒃ ᓱᕈᐃᔪᓇᖅᑐᖅᑕᓖᑦ ᐱᖁᔭᓕᕆᔾᔪᑎᑦ (2002–ᒥ), ᒪᓕᒃᑕᐅᕆᐊᓖᑦ ᐅᕙᓃᑦᑐᑦ ᐃᓚᖓ K, ᐱᔾᔪᑦ 8 ᐃᒪᓕᕆᔾᔪᑦ ᓚᐃᓴ.

ᐅᕙᓂ September 12, 2013–ᒥ, ᓄᑖᕈᕆᐊᖅᑕᐅᔪᒻᒪᑦ ᐋᖅᑭᕆᐊᖅᑕᐅᓪᓗᓂ ᐃᒪᐃᑦᑐᖅ A–ᒦᑦᑐᖅ ᐃᒥᓕᕆᔾᔪᑦ ᓚᐃᓴᑦ ᑐᓂᔭᐅᔪᔪᖅ ᐅᑯᓄᖓ TMAC–ᑯᓐᓄᑦ. ᑎᑎᕋᖅᓯᒪᔪᑦ ᐱᔾᔪᑎᓖᑦ ᐅᑯᓂᖓ ᐱᔾᔪᒻᒥᒃ A–ᒥ ᐃᒥᓕᕆᔾᔪᑎᑦ ᓚᐃᓴᐃᑦ (#2AM-DOH1323):

- ᐃᓚᖓ K, ᐱᔾᔪᑦ 7. *ᓚᐃᓴᓕᒃ ᑐᓂᓯᕆᐊᓕᒃ ᑲᑎᒪᔩᑦ ᕿᒥᕐᕈᕆᐊᖃᒻᒪᕆᑦ, ᐱᖓᓲᔪᖅᑐᑦ (6) ᑕᕿᑦ ᓯᕗᕐᖓᒍᑦ ᐊᐅᓚᓯᓚᐅᖕᒋᓇᓂᖕᒋᓇᓂ, ᐋᖅᑭᐊᖅᑕᐅᕆᐊᓖᑦ Doris North Gold Mine–ᒨᖓᔪᑦ ᐱᓕᕆᔾᔪᑎᑦ: ᐱᔾᔪᑎᓖᑦ ᐃᒪᕐᒦᑦᑐᓂᒃ ᓱᖁᒃᓯᒪᖕᒪᖔᑕ ᖃᐅᔨᓴᕈᑎᑦ ᐋᖅᑭᓱᖅᓯᒪᔭᓂᒃ ᐅᖃᖃᑎᕆᔫᒻᒪᑕ ᑲᓇᑕᒥ ᐊᕙᑎᓕᕆᔨᒃᑯᓐᓂᒃ. ᐋᖅᑭᖕᒋᐊᖅᑕᐅᕆᐊᓖᑦ ᐃᒪᕐᒥᐅᑕᑦ ᓱᖁᒻᒪᖔᑕ ᖃᐅᔨᓴᕈᑎᑦ ᖃᓄᖅᑑᕈᑕᐅᕆᐊᖃᒻᒪᑕ ᐋᖅᑭᕆᐊᖃᐊᓖᑦ ᐊᒻᒪᓗ ᒫᓇᕐᓂᑕᕈᖃᐊᓖᑦ ᑕᒪᒃᑯᐊ ᒪᓕᖕᒪᑕ ᐊᑑᑕᐅᕆᐊᓕᖕᓂᒃ ᐅᔭᖃᓐᓂᐊᖅᕕᒃᑕᓕᖕᓂ ᓴᕕᖃᔭᒃᓴᔭᓂᒃ ᓴᓇᓂᑯᑦ ᐊᒃᑕᑯᑦ ᐱᖁᔭᓕᕆᔾᔪᑎᑎᒍᑦ.*

ᒫᓇ, *ᐃᒪᕐᒥᐅᑕᑦ ᓱᖅᑯᒻᒪᖔᑕ ᖃᐅᔨᓴᕈᑎᑦ* ᐊᐅᓚᑕᑦ ᒪᓕᒃᓱᑎᒃ ᑭᖑᓪᓕᖅᐹᓂᒃ ᐋᖅᑭᒃᓱᐃᒍᑎᓂᒃ ᐊᖏᖅᑕᐅᔪᔪᓂᒃ ᐅᕙᓂ March 25, 2010–ᒥ. *ᐃᒪᕐᒥᐅᑕᑦ ᓱᖅᑯᒻᒪᖔᑕ ᖃᐅᔨᓴᕈᑎᑦ* TMAC–ᑯᑦ ᐱᓕᕆᑎᕐᔪᔪᑦ ᑲᓐᑐᖅᑳᖅᑎᕐᓯᓪᓗᑎᒃ ᐅᑯᓂᖓ ERM Consultants Canada Ltd.–ᑯᓐᓂᒃ ᕿᒥᕐᕈᖅᑯᓪᓗᕆᑦ ᖃᐅᔨᓴᖅᑯᓪᓗᕆᓪᓗ ᒪᓕᒃᑐᓂᒃ ᐅᑯᑎᒎᓇ (ERM Rescan) *ᐃᒪᕐᒥᐅᑕᑦ ᓱᖅᑯᒻᒪᖔᑕ ᖃᐅᔨᓴᕈᑎᑦ* ᐊᒻᒪᓗ ᑐᓴᖅᑎᕐᔪᓗᑎᒃ ᖃᐅᔨᔭᒥᓇᓂᒃ.

ᐅᑯᐊ ᑐᓴᒐᒃᓴᑦ ᖃᐅᔨᔭᒥᓂᕐᓂᒃ ᐱᔾᔪᑎᓖᑦ ᑭᖑᕐᖓᒍᑦ ᐊᓂᒎᑎᓯᒪᓕᖅᑎᓪᓗᕆᑦ ᐊᕐᕋᒍᐃᑦ ᓯᑕᒪᑦ ᐱᔾᔪᑎᓖᑦ ᒪᑯᓂᖓ *ᐃᒪᕐᒥᐅᑕᑦ ᓱᖅᑯᒻᒪᖔᑕ ᖃᐅᔨᓴᕈᑎᑦ.* ᓄᐊᑕᒥᓃᑦ ᖃᐅᔨᒪᔾᔪᑎᒃᓴᑦ ᐱᔭᐅᓯᒪᓕᖅᑐᑦ ᐊᑑᑎᓂᖅᑲᕈᓇᕐᓂᐊᕐᒪᑕ ᐅᔾᔨᖅᑑᑕᐅᓗᑎᒃ ᐱᓕᕆᕙᒃᓴᒨᖓᔪᓂᒃ ᐊᐅᓚᑦᓯᒍᑎᑦ ᐊᑑᑕᐅᓂᐅᓴᓕᖅᐸᑕ ᐊᐅᓚᑦᓯᒍᑎᒃᓴᑦ. ᐅᑯᐊ ᐊᑑᑕᐅᔪᓇᕐᓂᐊᕐᒪᑕ ᓇᓗᓇᐃᖅᓯᒍᑏᑦ ᐃᓚᒋᔭᐅᓪᓗᑎᒃ ᖃᓄᐃᓐᓇᖅ ᐱᔾᔪᑎᓖᑦ ᒫᓇᕐᓂᑕᓂᒃ ᒪᑯᓄᖕᖓᖕᖓᔪᓂᒃ *ᐃᒪᕐᒥᐅᑕᑦ ᓱᖅᑯᒻᒪᖔᑕ ᖃᐅᔨᓴᕈᑎᑦ.* ᓇᓗᓇᐃᔭᖅᓯᒪᔭᑦ, ᐱᖓᓱᑦ ᑰᑦ ᑕᐃᑲᓂ ᓄᓇᒥ, ᐱᖓᓱᓂᒃ ᑕᓯᖅᑕᓖᑦ, ᐊᒻᒪᓗ ᐃᒪᕐᒥᐅᑕᑦ ᖃᐅᔨᓴᖅᑕᐅᖃᑦᑕᔪᒻᒥᔪᑦ ᑰᒃᑕᓖᑦ, ᒪᕿᓂᓪᓗ ᑕᓯᖅᑕᓕᒃ, ᐃᒪᕕᖕᒨᖓᔪᒥᒃ. ᐃᒪᕐᒥᐅᑕᖅᑕᓖᑦ ᕿᒥᕐᕈᔭᐅᔪᔪᑦ ᐅᕙᓂ 2013–ᒥ ᐃᓚᖃᖅᓱᑎᒃ

ᒪᑯᓂᖓ: ᑕᓯᖅ, ᐃᒪᕙᒡᓗ ᓯᑰᑉ ᐊᑖ, ᐃᖅᑲᖓ ᐃᒪᐅᑉ ᐃᖅᑮᑎᓯᒪᔪᑦ ᖃᓄᑎᒋ ᐊᐅᓚᔪᒨᖓᒐᒪᖔᑕ; ᑕᓯᖅ ᖃᓄᑎᒋ ᐃᑎᑎᕆᒪᖔᖅ; ᑰᑦᑕᓕᒃ, ᑕᓯᖅᑕᓕᒃ, ᑕᕆᐅᒨᖓᔪᖅ ᐃᒪᖅ ᐊᒻᒪᓗ ᐃᖅᑳ ᖃᓄᐃᑦᑑᖕᒪᖔᖅ; ᑰᖏᑦᑐᑦ ᐆᒪᔪᐊᖅᔪᐃᑦ ᖃᓄᐃᓪᓗᐊᖅᑎᕆᔪᒥᒪᖔᑕ; ᑕᓯᖅᒥ ᐊᒻᒪᓗ ᑕᕆᐅᖅᒥ ᐆᒪᔪᐊᖅᔪᐃᑦ ᖃᓄᑎᒋ ᐅᖓᓯᒃᑐᒨᖓᓂᖏᑦ; ᑰᖏᑦᑐᑦ, ᑕᕆᐅᖅᒥᓗ ᐃᖅᑲᒥᐅᑕᑦ ᐆᒪᔪᐊᖅᔪᐃᑦ ᐃᓂᖏᑦ (ᖃᓄᑎᒋ ᐱᑕᖅᑲᓪᓚᕆᒪᖔᖅ, ᖃᓄᑎᒋ ᓱᖁᓚᖓᖏᒪᖔᑕ, ᖃᓄᑎᒋ ᐊᔾᔨᒪᖔᑕ, ᓇᒨᖓᖓᒐᒪᖔᑕ, ᐃᑯᖓᓗ ᑎᑭᐅᑎᓯᒪᔪᑦ Bray-Curtis–ᒧᑦ). ᑕᓯᖅᒥᐅᑕᑦ, ᑕᕆᐅᒥᐅᑕᑦ ᐃᖅᑲᓗᐃᑦ ᖃᓄᐃᓪᓗᐊᖅᑎᕆᓂᖏᑦ ᐃᓂᒥᓃᑦᑐᑦ ᖃᐅᔨᓴᖅᑕᐅᔪᔪᑦ 2010–ᒥ (ᐅᑯᓄᖓ Rescan 2011) ᖃᐅᔨᓴᖅᑕᐅᔪᖏᑦᑐᑦ ᐅᑯᓂ 2013–ᒥ.

<u>ᑰᑦ</u>

ᓱᖁᑦᓯᒪᔪᓂᒃ ᖃᐅᔨᓴᐅᔪᖃᔪᖏᑦᑐᖅ ᐅᑯᓂ 2013–ᒥ. ᐊᐅᓚᑕᐅᔪᔪᑦ ᐱᓕᕆᐊᖑᓪᓗᑎᒃ ᐃᒥᓕᕆᔪᑦ ᖃᓄᐃᑦᑑᒪᖔᖅ, ᐃᖅᑲᖓ, ᐆᒪᔪᕈᓗᐃᑦ ᖃᓄᐃᓪᓗᐊᖅᑎᕆᒪᖔᑕ ᐅᑯᓗᑭᐊᖅ ᐃᖅᑲᒥᐅᑕᑦ ᐃᓂᒥᓃᑦᑐᑦ ᖃᐅᔨᓴᖅᑕᐅᔪᔪᑦ ᑰᖓᓃᑦᑐᑦ Doris–ᐅᑉ ᑰᖓᓂ, ᐊᒻᒪᓗ Roberts ᑰᖓᓂ, ᐊᒻᒪᓗ ᐅᑯᖖᖅᑐᑦ Roberts ᑰᖓᓂ ᐊᒻᒪᓗ ᑲᕙHᓕᒃᑑᒥᒃ.

ᐅᑯᐊ ᐱᔪᑦ 18–ᓂᒃ ᐃᒥᓕᕆᔾᔪᑎᓂᒃ ᖃᓄᑐᐃᓐᓇᖅ ᖃᐅᔨᓴᖅᑕᐅᔪᔪᑦ, ᖃᓄᐃᓪᓗᐊᖅᑎᕆᔪᑦ ᑐᖁᓐᓇᑐᖅᑕᓖᑦ ᐋᖅᓴᓂᒃᑕᓖᑦ ᐃᑲᓂ Roberts-ᒥᒃ ᑰᒃᑐᒥᒃ ᐊᒻᒪᓗ ᓴᕙᖁᔾᔮᔾᔪᑦ ᐅᖅᑭᑦᑐᒃᓴᔾᔪᑦ ᐃᑲᖓᑦ Little Roberts–ᒥᒃ ᑰᒃᑐᑦ ᑭᓯᐊᓂ ᖃᓄᐃᑦᑐᑐᐃᓐᓇᖅᑕᓖᑦ ᓱᖁᓱᑦ ᑕᐃᒪᖓᓂᑦ ᑎᑭᑦᓱᒍ ᐅᕗᖓ 2013–ᒧᑦ; ᓱᖁᓱᖅ ᖃᖓᐅᓕᖃᐃᒻᒪᑦ ᑰᓐᖓ, ᐱᔾᔪᑎᖏᔾᔭᐅᖓᑎᒃ ᐱᔪᑦ ᐱᓕᕆᐊᓂᒃ ᐊᐅᓚᑕᓂᒃ. ᑕᒪᖅᒥᒃ, ᐃᓚᒋᓕᐅᑎᒑᐃᒻᒪᑕ ᐃᖑᓪᓚᐅᑎᒑᐃᒐᒥᒃ ᐱᑕᖃᑦ ᑭᓱᓂ ᖃᑦᔫᓇᕈᓲᑦ ᑖᒃᑯᐊ ᖃᐅᔨᒪᔾᔪᑦ ᖃᐅᔨᓴᖅᑕᐅᓯᒪᔪᓂᒃ ᐅᑯᓇᓂ ᑎᑭᑦᓱᒍ ᐊᖅᕇᒍᖓᓄᑦ 2013, ᐃᓱᒫᓗᖓᖏᑦᑐᑦ ᑕᒪᒃᑯᐊ ᓱᖁᐃᓂᐊᖅᒪᖔᑕ ᐊᕙᑖᓂ. ᐱᑕᖅᑲᔪᖏᑦᑐᖅ ᓱᖁᑦᓯᒪᔪᓂᒃ ᐅᑯᓂ 2013–ᒥ ᐱᓕᕆᔪᑦ ᐊᐅᓚᔾᔨᑎᓪᓗᒋᑦ ᐃᒫᓂ ᖃᐅᔨᓴᖅᓱᑎᒃ ᑰᖏᓐᓂ.

ᐅᑯᓂ Doris–ᒥ ᐅᑯᓂᓗ Little Roberts–ᒥ ᑖᒃᑯᓇᖓᑦ ᑰᒃᑐᖅ, ᐊᔾᔨᒌᖏᑦᑑᑎᓂᒃ ᐱᑕᖅᑲᔪᖅ ᐃᒪᖓᓂ ᐃᖅᑳᓂᒃ ᐆᒃᑐᖃᖅᑎᓪᓗᒋᑦ ᓄᐊᑦᓯᓪᓗᑎᒃ ᐅᑯᓂ 2013–ᒥ ᐆᒃᑐᖃᖅᓱᑎᒃ ᒥᑭᔩᑎᕈᓗᖓᓂᒃ ᐃᖅᑲᖓᓃᑦᑐᓂᒃ ᖃᐅᔨᓴᖅᓱᒋᑦ ᐆᒃᑐᖃᖅᑕᐅᔫᒪᑕ. ᖃᓄᐃᑦᑐᑐᐃᓐᓇᐃᑦ ᐃᖅᑳᓃᑦᑐᑦ ᑕᑯᒃᓴᑦ ᐱᖁᔪᖏᑦᑐᑦ ᐱᓕᕆᐊᓂᒃ ᐅᑯᓂ 2013–ᒥ ᐊᐅᓚᑦᓯᑎᓪᓗᒋᑦ, ᐃᒻᒪᖃᖃᐃ ᑰᖑᑦ ᑕᐃᒪᐃᑎᑦᑕᑦ ᐱᐅᓯᖅᓱᖅᑐᒧᑦ ᐃᖅᑳ ᐊᐅᓚᓕᖅᒪᑦ ᐊᓯᕈᖅᐸᓪᓕᐊᓪᓗᓂ. ᐅᑯᖓᑦ Little Roberts–ᒥᒃ ᑰᒃᑐᖅ, ᐃᖅᑲᓕᕆᒍᑎᒥᓃᑦ ᐅᑯᓂ 2013–ᒥ ᐊᒃᐸᓯᖕᓂᖅᓴᐅᔪᔪᑦ ᐱᑕᓖᑦ ᐱᐅᓯᖅᓱᖅᑐᓂᒃ, ᓴᕙᖁᔾᔮᔾᔪᓂᒃ, ᑲᓐᓄᐊᒐᖅ, ᐃᒃᑕᕆᒃᑐᖅ ᐅᖁᒪᐃᑦᑐᖅ, ᓴᕙᖁᔾᔮᔾᔪᓗ ᖃᐅᔨᓴᖅᑎᓪᓗᒋᑦ ᐱᔾᔪᔪᑦ ᐃᖅᑳᓂᒃ. ᒥᑭᓪᓕᔪᑦ ᑕᒪᒃᑯᐊ ᐱᖁᖅᑐᑦ ᓱᖁᑦᑐᓂᒃ ᐃᖅᑲᖓᓂᒃ ᐱᔾᔪᖅ ᒥᑭᔫᑕᐅᒪᑕ ᓯᐅᖁᐃᑦ ᐱᔾᕙᓃᑦ ᐅᑯᓂ 2013–ᒥ ᐆᒃᑐᖃᖅᑕᐅᔪᔪᑦ ᐅᔾᔨᖅᑑᑎᖅᑲᖅᓱᑎᒃ ᖃᓄᑎᒋ ᓱᖅᑮᔪᖅᑲᒪᖔᖅ, ᑕᐃᒪᖓᓂᒃ ᒥᑭᔩᑎᑦ ᓯᐅᖁᑦ ᐃᖅᑳᓃᑦᑐᑦ ᐱᔾᔪᐅᖓᔪᖓᒪᑕ ᐱᐅᓯᖅᓱᖅᑐᑦ ᐋᓚᑕᖅᑲᖏᑦᑐᑦ ᓴᕙᖁᔾᔮᔾᔪᐃᑦ ᐊᖏᔩᑎᓗ ᐃᖅᑲᖓᓃᑦᑐᑦ. ᒥᑭᓪᓛᓪᓕᖅᑐᑦ ᐅᑯᓂ 2013–ᒥ ᐃᖅᑲᓂᒃ ᐱᔾᔪᑦ ᑭᕙᓯᒪᔪᑦ ᓴᕙᖁᔾᔮᔾᔪᑦ ᐊᒻᒪᓗ ᖃᓄᐃᑦᑐᑐᐃᓐᓇᐃᑦ ᐃᒃᑕᕆᒃᑐᒃᓴᔾᔪᐃᑦ ᐆᒃᑐᖃᖅᑕᐅᔪᒪᑕ ᖃᐅᔨᒪᔾᔪᑦ ᐊᑐᖅᑕᐅᓪᓗᑎᒃ ᖃᐅᔨᒪᔾᔪᔨᑎᑦ ᑭᓲᒪᖔᑕ ᖃᐅᔨᓴᕈᑎᒃᑯᑦ ᐃᒪᐃᑦᑐᒃᑯᑦ B–ᑯᑦ ᑰᖑ. ᒥᑭᓂᖅᓴᐅᓕᔪᔪᑦ ᐃᖅᑳᓂᒃ ᐱᔾᔪᑦ ᓴᕙᒃᓴᔾᔪᑦ ᐃᓱᒫᓗᖓᖅᑐᖅᑲᔪᖏᑦᑐᖅ ᐋᓚᑕᖅᑲᔪᖏᑦᑐᖅ ᓴᕿᖅᑐᓂᒃ. ᐅᔾᔨᓇᓪᓚᕆᒃᑐᓂᒃ ᓱᖁᐅᑕᐅᖁᔾᔪᖅᑐᓂᒃ ᐅᑯᓂ 2013–ᒥ ᐊᐅᓚᔾᔨᑎᓪᓗᒋᑦ ᐱᓕᕆᔪᑦ ᐃᖅᑳᓂᒃ ᑰᖔᖓᔪᓂᒃ.

ᖃᐅᔨᒪᔾᔪᑎᒃᓴᓂᒃ ᓴᕿᖅᑐᖅᑲᔪᔪᑦ ᓱᖁᐅᑎᖁᔾᔪᖏᑦᑐᓂᒃ ᐅᑯᓂ 2010–ᒥ ᑎᑭᑦᓱᒍᑦ 2013–ᒧᑦ ᐃᖅᑲᒥᐅᑕᑦ ᐊᔾᔨᒋᓐᓂᖅᑲᔪᔪᑦ ᐊᑯᖖᖓᓐᓂ Doris ᑰᖓᑕ ᐊᒻᒪᓗ ᓇᒧᑦ ᑰᖏᖓᓄᑦ ᖃᐅᔨᒪᔾᔪᑎᑦ ᒪᓕᒃᑕᐅᓪᓗᑎᒃ ᐅᑯᓂ

2010–ᒥ ᑎᑭᑦᓱᒍ 2013–ᒧᑦ ᐅᕗᖓᖓᔪᒧᑦ Bray-Curtis–ᒧᑦ ᐊᑯᕐᖓᓐᓂ Roberts ᑰᒃᑐᒥᒃ ᐊᒻᒪᓗ ᐊᓱᐊᓄᑦ ᑰᒃᑐᑦ. ᓇᒧᙵᔪᑦ ᒪᓕᒃᑕᐅᓪᓗᑎᒃ ᐅᖅᓵᓈᖅᑐᓂᒃ ᖃᐅᔨᒪᔾᔪᑎᒃᓴᓂᒃ ᐱᑕᖃᔪᖏᑦᑐᖅ ᐱᓕᕆᕝᕕᒥ ᓱᕋᐅᑎᒐᔾᖅᑐᓂᒃ ᐃᖄᒥᐅᑕᓄᑦ ᑖᒃᑯᓇᖓᑦ ᐱᔪᓂᒃ ᓄᓇᓂᒃ. ᐅᕙᙱᖅᑐᖅ Doris–ᒥᒃ ᐃᖄᒥᐅᑕᖏᑦ ᐊᔾᔨᒌᔪᑦ ᑕᐃᒫᓴᐃᓐᓇᖅ ᖁᑦᓯᖕᓂᖅᓴᐃᑦ ᐊᓯᖏᓐᓂᒃ ᑰᖕᓂᒃ ᐅᕙᓂ 2013–ᒥ, ᐅᕙᓂᓗ Roberts–ᒥᒃ ᑰᒃᑐᖅ ᐃᑯᖓᖓᔪᖅ Bray-Curtis–ᒧᑦ ᐋᒃᐸᓱᖕᓂᖅᓴᖅ ᐅᕙᓂᐅᔫᒪᓂᑦ 2013–ᒥ ᓇᓗᓇᐃᔭᖅᑕᐅᔫᒪᑕ ᐊᕿᓂᑕᐃᑦ, ᐅᖅᓵᖅᑑᑕᐅᓪᓗᑎᒃ ᐊᑑᑕᐅᖅᑲᖅᓯᒪᔪᑦ ᓯᕗᓪᓕᕐᓂ ᐊᕐᕈᒍᐃᑦ, ᖃᐅᔨᒪᔾᔪᑎᑦ ᐊᖏᓂᖅᓴᐅᓕᖅᑐᑦ ᑕᐃᒫᓴᐃᓐᓇᐸᓗᒃ ᐊᑯᕐᖓᓐᓂ ᐃᖄᒥᐅᑕᑦ ᐅᕗᓂᑎᑐᑦ Roberts ᑰᖓᓂ ᐊᒻᒪᓗ ᖃᓄᐃᑦᑐᑦ ᑕᒡᕙᓂᒥᐅᖠᔪᑦ ᐅᕙᓂ 2013–ᒥ. ᑖᒃᑯᐊ ᐊᔾᔨᒌᖏᓐᓂᖏᑦ ᒪᓕᒃᑐᑦ ᐱᐅᓯᖅᓱᖅᑐᓂᒃ ᓱᕋᒃᓯᒪᖏᑦᑐᓂᒃ ᐊᕙᑖᓂ ᐅᕝᕙᓗᑭᐊᖅ ᐃᖏᑯᐊᖅᑐᑦ ᐃᖄᒥᐅᑕᑦ ᑲᑎᖓᐅᖅᑐᑦ ᑰᖏᓐᓂ. ᐱᒋᐊᕐᓗᒍ 2010–ᒥᒃ ᑎᑭᓪᓗᒍ 2013–ᒧᑦ ᐊᒥᖂᓕᖅᑲᖓᔪᑦ, ᐆᒪᐃᑦ, ᐊᒻᒪᓗ ᐋᑐᑕᐅᓪᓗᓂ ᐱᖁᓱᖓ Simpson ᖃᓄᖅ ᓱᕋᖂᑦ ᖃᐅᔨᒪᔾᔪᑎᑦ ᓴᖅᑭᐅᒪᔪᑦ ᖃᐅᔨᓴᖅᑕᐅᔫᒪᑕ ᒪᓕᒃᑕᐅᓪᓗᑎᒃ ᖃᐅᔨᓴᕆᑏ ᑰᖑᑦᑐᓂᒃ, ᖃᐅᔨᒪᔾᔪᑎᑦ ᓱᕋᒃᑐᖃᓐᓂᖏᑦᑐᖅ ᐅᕙᓂ 2013–ᒥ ᐱᓕᕆᐊᑦ ᐊᐅᓚᑕᐅᑎᓪᓗᒋᑦ ᐃᖄᒥᐅᑕᓕᕆᑎᓪᓗᒋᑦ ᐊᑐᖅᓯᑎᒃ ᓇᓗᓇᐃᔭᐃᒍᑎᒥᓐᓂᒃ.

<u>ᑕᓲᑦ</u>

ᐅᖅᓵᖅᑐᓂᒃ ᐱᑕᖃᓚᐅᖏᑦᑐᖅ ᓱᕋᐅᑕᐅᔪᓂᒃ ᐱᔪᓂᒃ ᐱᓕᕆᕝᕕᒥᒃ ᓯᖂᑉ ᐊᑖᓂ ᐋᓪᓚᓂᒃ ᐱᒥᑎᖅᓯᒪᔪᓂᒃ. ᐊᑐᖅᑕᐅᑎᓪᓗᒋᑦ ᐃᒥᐅᑉ ᐃᑎᓐᖓᓂᒃ ᖃᐅᔨᓴᕆᑎᑦ, ᐃᒥᖅᓗ ᖃᐅᔨᓴᖅᑕᐅᑎᓪᓗᒍ, ᐃᖃᖓᓗ ᓱᕋᒃᓯᒪᖕᒪᙱᖅ ᖃᓄᑐᐃᓐᓇᖅ, ᐆᒪᔪᕈᓗᐃᓪᓗ ᓇᒥᑐᐃᓐᓈᖅᑐᑦ ᓯᐊᒻᒪᖓᔪᑦ, ᐅᕝᕙᓗᑭᐊᖅ ᐃᖄᒥᐅᑕᑦ ᐆᒪᔪᕈᓗᐃᑦ ᖃᐅᔨᓴᖅᑕᐅᑎᓪᓗᒋᑦ ᐃᒪᕿᒥᐅᑕᑦ ᖃᐅᔨᓴᕈᑎᓄᑦ ᓱᕋᒃᓯᒪᖕᒪᙱᑕ ᑕᓱᖏᓐᓂ ᐅᑯᐊ Doris Lake ᐅᐊᖓᓐᖓᓂ, Doris Lake ᑕᓱᖓᑕ ᑲᓐᖓᓐᖓᓂ ᐊᒻᒪᓗ Little Roberts Lake–ᒥ.

ᐱᑕᖃᓚᐅᖅᑐᑦ ᖃᐅᔨᒪᔾᔪᑎᑦ ᖃᐅᔨᒍᑕᐅᒪᑕ ᑕᐃᒪᖓᓂᑦ ᖃᖓᓂᑦ ᐊᓱᕈᖅᑐᑦ ᖃᐅᔨᓴᖅᑕᐅᖃᑦᑕᖅᓯᒪᔪᑦ ᐊᑯᕐᖓᓐᓂ ᐊᕿᒍᐃᑦ 2013–ᖑᔫᒪᓂᑦ ᐃᒥᖅ ᑲᑭᐊᒍᓐᓃᖅᑐᖅ ᐲᑦᑐᓕᕐᒪᑦ (ᐱᕙᓪᓕᐊᒻᒪᑦ) ᐅᕙᓃᑦᑐᖅ Doris Lake ᑕᓱᖓᑕ ᐅᐊᖓᓐᖓᓂ, ᐊᒻᒪᓗ ᐃᖃᖓᓃᑦ arsenic–ᒥᒃ ᐋᖅᓴᓂᒃ ᑕᐃᔭᖅ ᑐᖁᓐᓇᖅᑐᖅᑕᓕᒃ (ᒥᑭᓂᖅᓴᐅᓕᖅᑐᖅ), ᐃᖃᖓᓃᑦᑐᑦ ᓴᕝᕋᔭᒃᓴᔭᐃᑦ ᐱᕙᓪᓕᖅᑐᑦ), ᐊᒻᒪᓗ ᐃᖄᓃᑦᑐᑦ ᓴᕝᕋᔭᒃᓴᔭ (ᐱᕙᓪᓕᖅᑐᖅ), ᐃᑲᓂ Doris Lake ᑕᓱᖓᑕ ᑲᓐᖓᓐᖓᓂ. ᑕᒪᒃᑯᐊ ᑕᐃᒪᐃᒻᒪᑕ, ᐅᖅᓵᖅᑑᑎᑦ, ᓯᕗᕐᖓᒍᑦ ᑭᖑᕐᖓᒍᓪᓗ ᖃᓄᖅ ᓴᖀᐊᓂᖅᑲᖅᑲᖅᑐᑦ ᓱᕋᔪᑦ ᖃᐅᔨᓴᖅᑕᑦ ᓴᖀᐅᒪᓂᖏᑦ ᐊᓱᕈᐊᕚᑐᑦ ᑭᒡᓕᖅᑲᑎᓪᓗᒋᑦ ᖃᖓᓂᑦ ᐊᕿᒍᐃᑦ ᑎᑭᓱᒍ 2013–ᒧᑦ ᐊᒻᒪᓗ ᖃᐅᔨᒪᔾᔪᑎᑦ ᑕᓱᖅᓂᒃ (ᐅᑯᓇᓃᑦᑐᑦ ᑕᓱᓕᕆᔾᔪᑎᑦ B–ᒥ). ᓴᖀᐅᒪᔪᖅᑲᓚᐅᖏᑦᑐᖅ ᑕᒪᒃᑯᓄᖓᖓᔪᓂᒃ ᓱᕋᒃᑐᓂᒃ ᐃᒥᓕᕆᔾᔪᑎᑦ ᑎᑭᑦᓱᒍ 2013–ᒧᑦ ᐱᓕᕆᐊᑦ ᐊᐅᓚᑕᐅᑎᓪᓗᒋᑦ.

ᐅᕙᓂ Doris Lake–ᒥ ᐅᐊᖓᓐᖓᓂ, ᐱᑕᖃᔪᖅ ᐊᔾᔨᐅᒍᓐᓃᖅᑐᓂᒃ ᐃᖄᒥᐅᑕᓂᒃ ᐊᖏᓂᖏᑦ ᐃᖄᓃᑦᑐᑦ ᐆᒃᑐᖅᑕᐅᑎᓪᓗᒋᑦ ᓄᐊᑕᐅᔪᑦ 2013–ᒥ ᐅᖅᓵᖅᑑᑕᐅᔫᒪᑕ ᖃᓄᐃᓪᓗᐊᖅᓂᖏᑦ ᒪᓕᒃᑕᐅᓗᑎᒃ ᑭᒡᓕᖓᓂᓂᑦ ᓱᖁᐃᔭᐃᒍᑎᑎᒍᑦ. ᖃᓄᐃᑦᑐᑐᐃᓐᓇᐃᑦ ᐃᖄᓃᑦᑐᑦ ᐊᖏᓂᖏᑦ ᐋᒃᑐᐊᓂᖅᖄᖅᑰᖏᑦᑐᑦ ᐅᕗᖓ 2013–ᒧᑦ ᐱᓕᕆᐊᑦ ᐊᐅᓚᑕᐅᑎᓪᓗᒋᑦ, ᐊᒻᒪᓗ ᐱᖅᑰᖅᑐᑦ ᐱᐅᓯᖅᓱᖅᑐᓂᒃ ᐊᕙᑖᓂᒃ ᑕᓱᐅᑉ ᐃᖃᖓᓃᑦᑐᑦ. ᐱᔭᑦ ᖃᐅᔨᒪᔾᔪᑎᓂᒃ ᐱᓗᐊᕈᓐᓃᖅᑐᑦ ᑕᐃᒪᖓᓂᑦ ᑭᒡᓕᖓᓂᓂᑦ ᖃᐅᔨᓴᖅᑕᐅᓕᔫᒪᑕ ᐊᕿᒍᐃᑦ ᐊᒻᒪᓗ 2013–ᒧᑦ ᑲᓐᓄᐊᕗᖅᑕᓖᑦ ᐃᖄᓂ ᑕᓱᖓᑕ Doris Lake ᐅᐊᖓᓐᖓᓂ ᐊᒻᒪᓗ Doris Lake ᑲᓐᖓᓐᖓᓂ, ᐊᒻᒪᓗ ᐃᓚᖓᖅᓯᒪᓕᖅᓱᑎᒃ ᐅᖁᒪᐃᑦᑐᒃᓴᔭᐃᑦ ᑯᓱᖅᓯᐊᒃᓴᔭᐃᑦ ᐃᑲᓂ Little Roberts Lake ᑕᓱᖓᑕ ᐃᖄᓂ. ᐃᓄᐃᓴᓐᓂᖅᓴᐅᓕᖅᑐᑦ ᐃᖄᓃᑦᑐᑦ

ᓴᕕᖃᔾᑲᔭᐃᑦ ᐊᏅᑖᓄᑦ ᐃᓱᒫᓗᓐᓇᖏᑦᑐᑦ. ᓱᕐᖃᒃᑐᖅᑲᓚᐅᖏᑦᑐᖅ ᐅᔾᔨᓇᓪᓚᕆᒃᑐᓂᒃ ᓱᕐᖃᐅᑎᔪᓂᒃ 2013−ᒥ ᑖᒃᑯᓂ ᐱᓕᕆᐊᑦ ᐊᐅᓚᓯᕕᐅᑎᓗᒍ ᐃᖅᑲᓕᕆᑎᓪᓗᒋᑦ ᖃᓂᒋᔭᖓᓂ ᖃᐅᔨᓴᖅᓱᑎᒃ ᑕᓱᕐᓂᒃ.

ᐱᑕᖅᑲᓚᐅᕐᒥᔪᖅ ᖃᐅᔨᒪᔾᔪᑎᒃᓴᓂᒃ ᐅᕙᖔᖓᖏᑦᑐᓂᒃ ᒫᓐᓇᖃᑖᖅ ᐊᑑᑕᐅᑎᓪᓗᒋᑦ 2010−ᒥᒃ ᑎᑭᑦᓱᒍ 2013−ᒧᑦ ᐃᖅᑲᒥᐅᑕᓕᕆᔾᔪᑎᑦ ᐅᕗᖓᖓᔪᒧᑦ Bray-Curtis−ᒧᑦ ᐊᑖᑕᐅᓲᑦ Doris Lake ᐅᐊᓐᓇᖓᓂ ᐊᒻᒪᓗ Doris Lake ᑲᓐᓇᖓᓂ ᖃᐅᔨᓴᕈᑎᑦ ᐅᑯᓄᖓ ᑕᓯᓕᕆᔾᔪᑎᑦ Lake B−ᒥ. ᐊᑖᑕᐅᖅᑦᑕᕐᒪᑕ ᕐᑯᑦᓯᓐᓂᓖᑦ ᐊᕐᖁᑎᒫᑦ ᖃᓄᑐᐃᓐᓇᖅ ᐅᑯᑎᒎᓇ Bray-Curtis−ᑯᑦ ᑖᒃᑯᓇᓂ ᓄᓇᓂ, ᐊᑖᑕᐅᑲᐃᓐᓇᖅᑐᖅ ᐅᔾᔨᓇᕟᐊᖏᑦᑐᑦ. ᐅᏅᓂ 2013 Bray-Curtis ᖃᐅᔨᓴᕈᑕᐅᖅᑦᑕᖅᓯᒪᔪᑦ ᐅᕗᖓᖓᔪᑦ Doris Lake−ᒧᑦ ᑲᓐᓇᖓᓄᑦ ᐊᒻᒪᓗ Doris Lake ᐅᐊᓐᓇᖓᓅᖓᔪᑦ ᐊᑖᑕᐅᖅᑦᑕᖅᓯᒪᔪᑦ ᐊᕐᕿᒍᐃᑦ ᐊᓂᒌᑎᓯᒪᓕᖅᑐ, ᐊᑖᑕᐅᕐᑰᕐᓂᖏᑦᑐᑦ ᐅᏅᓂ 2013−ᒥ ᐱᓕᕆᔪᑦ ᐊᐅᓚᓯᑎᓪᓗᒋᑦ ᓱᖃᐃᓯᒪᓪᓚᕆᒃᑐᑦ ᐅᑯᑎᒎᓇ ᐱᓕᕆᐊᑦ ᐊᐅᓚᑕᐅᑎᓪᓗᒋᑦ Bray-Curtis−ᑯᑦ ᐊᑖᑕᐅᓪᓗᑎᒃ ᑖᒃᑯᓇᓂ ᓄᓇᓂ. 2010−ᒥᒃ ᑎᑭᑦᓱᒍ 2013−ᒧᑦ ᐊᑖᑎᔪᒥᓃᑦ ᐱᑕᖅᑲᓪᓚᕆᒃᑐᑦ, ᐃᓚᕌᒃᓴᔾᑦ, ᐊᒻᒪᓗ Simpson−ᑯᑦ ᐊᔾᔨᕌᓐᓂᒃ ᐊᒻᒪᓗ ᓱᕐᕿᓲᓂᒃ ᖃᓂᒃᓴᖅᑐᓂᒃ ᑕᓱᕐᓂᒃ ᐅᔾᔨᕆᔭᒥᓃᑦ ᖃᐅᔨᒪᔭᐅᓂᐊᕐᒪᑕ ᑕᓲᑦ, ᖃᐅᔨᒪᔾᔪᑎᑦ ᐱᑕᖅᑲᓪᓚᕆᓐᓂᖏᑦᑐᑦ ᓱᕐᖃᒃᓯᒪᔪᓂᒃ ᐅᏅᓂ 2013−ᒥ ᐱᓕᕆᔪᑦ ᐊᐅᓚᓯᑎᓪᓗᒋᑦ ᐃᖅᑲᒥᐅᑕᓕᕆᑎᓪᓗᒋᑦ.

<u>ᑕᕆᐅᖅ ᐃᒪᖅ</u>

ᐱᑕᖅᑲᓚᐅᖏᑦᑐᖅ ᓴᕿᐅᒪᔪᓂᒃ ᐱᓕᕆᕙᖏᓐᒨᖓᔪᓂᒃ ᓱᖃᐃᔪᓐᓇᖅᑐᓂᒃ ᐅᑭᐅᒥ ᓴᕿᖅᑐᒥᓂᕐᓂᒃ ᓱᖃᐃᓗᑎᒃ ᐱᐅᓯᖅᓱᖅᑐᓂᒃ ᒫᓂ ᐃᒫᓄᑦ, ᐃᖅᑳᓂᓗ ᖃᓄᐃᑦᑐᑐᐃᓐᓇᐃᑦ, ᐆᒪᔪᕈᓗᐃᑦ ᖃᓄᐃᓪᓗᐊᖅᑎᒋᔪᑦ ᐅᕝᕙᓗᑭᐊᖅ ᐃᖅᑲᒥᐅᑕᑦ ᐆᒪᐅᔪᑎᒥᓐᓃᑦᑐᑦ ᐃᓂᖏᓐᓂ ᐊᑖᑕᐅᑎᓪᓗᒋᑦ ᒪᑯᐊ *ᐃᒪᕐᒥᐅᑕᑦ ᓱᕐᕌᒪᖔᑕ ᖃᐅᔨᓴᕈᑎᑦ* ᑕᕆᐅᕐᒥ ᒫᓂ Roberts Bay−ᒥ ᐅᐊᓕᓂᐊᓂ ᐊᒻᒪᓗ Roberts Bay ᐅᕐᑯᐊᓂ.

ᑭᓯᐊᓂ ᐃᒪᐅᑉ ᐱᐅᓯᖅᓱᕐᓂᖓ ᐊᓯᕈᓪᓚᕆᒃᑐᖅ ᑕᐃᖓᓂᑦ ᑎᑭᐅᑎᓯᒪᔪᓕᒫᑦ ᑭᒡᓕᖓᓅᖓᔪᑦ ᖃᐅᔨᓴᖅᑕᐅᓕᔪᒪᑕ 2013−ᖑᑎᓪᓗᒍ ᑕᒪᒃᑯᐊ ᐃᖄᓂ ᑭᕙᓯᒪᔪᑦ ᐃᒪᖓᓂ Roberts Bay ᐅᐊᓕᓂᐊᓂ. ᖃᓄᐃᓪᓗᐊᕐᓂᕆᔭᖏᑦ ᐃᖄᓃᑦᑐᑦ ᒥᑭᓂᖅᓴᐅᓕᖅᑐᑦ ᖃᐅᔨᓴᖅᑕᐅᖅᑦᑕᓕᔪᒪᑕᓂᑦ ᑎᑭᑦᓱᒧᑦ ᐊᕐᕿᒍᖅ 2013, ᓯᕗᕐᖓᒍᑦ ᐊᒻᒪᓗ ᑭᖑᕐᖓᒍᑦ ᐊᐅᓚᑕᒥᓃᑦ ᖃᐅᔨᓴᖅᑕᐅᓕᔪᒪᑕᓂᑦ ᓴᕿᐅᒪᓂᓖᑦ ᒥᑭᓂᖅᓴᐅᓕᖅᑐᑦ ᒪᓕᒃᑕᐅᓪᓗᑎᒃ ᖃᐅᔨᓴᕈᑎᑦ ᓴᕿᐅᒪᔪᖅᑲᓚᐅᖏᑦᑐᖅ ᐱᔪᓂᒃ ᑕᒫᓂ ᐱᓕᕆᕝᕕᒃ ᓱᖃᐃᔪᓂᒃ ᐃᒪᖓᓂᒃ ᑕᕆᐅᕐᒥ ᐊᒃᑐᐊᔪᓂᒃ ᐱᔪᓂᒃ Roberts Bay−ᒥ.

ᐃᖄᓂᒃ ᐱᔪᑦ ᐅᕙᖓᑦ Roberts Bay ᐅᐊᓕᓂᐊᓂᒃ ᒪᑐᒪ Roberts Bay ᑲᖏᕐᓗᖓᓂᒃ, ᐃᖄᓐᓂᑦᑐᑦ ᐱᐅᓯᖅᓱᖅᑐᑦ ᐱᑕᓖᑦ ᐊᒻᒪᓗ ᐊᒥᓱᑦ ᓴᕕᖃᔾᑲᔭᖅᑕᓖᑦ ᕐᑯᑦᓯᓂᖅᓴᐅᔪᔪᑦ, 2013−ᒥ ᑕᐃᒪᖓᓂᑦ 2002−ᖑᔪᒪᑦ. ᑖᒪᑯᐊ ᑖᒃᑯᐅᓂᖅᓴᐅᓕᕐᒪᑦ ᕐᑯᑦᓯᓂᖅᓴᒥᒃ ᓇᓗᓇᐃᔭᐃᒍᑎᒃᑯᑦ ᐱᔪᑦ ᒪᕐᖃᐃᑦ ᐊᒻᒪᓗ ᐊᒃᐸᓯᓐᓂᖅᓴᖅ ᓯᐅᖃᖅ ᐅᏅᓂ 2013−ᒥ ᐃᖄᓂᒃ ᐆᒃᑐᖃᐅᑎᑦ ᑕᐃᒪᖓᓂᑦ ᒪᓕᒃᓱᑎᒃ ᖃᐅᔨᓴᐅᑎᓂᒃ ᐊᑐᖅᑕᓕᔪᒪᑕ 2002−ᒥ, ᑕᐃᖓᓂᑦ ᒥᑭᐧᑎᕈᓗᐃᑦ ᐃᖄᓐᓂᑦᑐᖅ ᕐᑯᑦᓯᓂᖅᓴᐅᓱᖑᒥᒪᑦ ᐱᑕᓕᓚᕇᑦ ᓴᕕᖃᔾᑲᔭᖅᑕᓖᑦ ᐊᒻᒪᓗ ᐱᐅᓯᖅᓱᖅᑐᓂᒃ ᐱᑕᓖᑦ. ᖃᐅᔨᓴᖅᕕᖕᒥ ᓄᓇᒥ, 2013−ᖑᑎᓪᓗᒍ ᐆᒃᑐᖃᐅᑎᑦ ᐱᑕᖅᔪᒥᔪᑦ ᕐᑯᑦᓯᓂᖅᓴᓂᒃ ᐃᓚᖓᓅᖓᔪᓂᒃ ᒪᖃᐃᑦ ᐊᒻᒪᓗ ᐊᒃᐸᓯᓐᓂᖅᓴᐃᑦ ᐃᓚᖓᓅᖓᔪᖅ ᓯᐅᖃᒧᑦ ᖃᐅᔨᓴᖅᑕᐅᓯᒪᔪᑦ ᑭᒡᓕᖓᓅᖓᔪᖅ ᐆᒃᑐᖃᐅᑕᐅᑎᓪᓗᒋᑦ, ᐊᒻᒪᓗ ᖃᓄᐃᓪᓗᐊᕐᒪᖔᑕ ᐱᐅᓯᖅᓱᖅᑐᑦ ᐱᐅᓯᖅᓱᖅᑐᑦ ᐊᒻᒪᓗ ᓴᕕᖃᔾᑲᔭᐃᑦ ᖃᐅᔨᔭᐅᔪᒥᔪᑦ ᐃᖄᓐᓂᑦᑐᑦ ᖃᐅᔨᓴᖅᕕᖕᒥ 2013−ᒥ. ᐱᑕᖅᑲᔪᒥᔪᖅ ᓱᕈᖅᑎᖅᓯᒪᔪᒥᒃ ᐃᑲᓂ Roberts Bay ᑲᖏᕐᓗᖓᓐᓂᑦᑐᖅ ᑐᓚᒃᑕᖅᕕᒃ ᓴᓇᔭᐅᓯᒪᔪᖅ ᐅᏅᓂ 2013−ᒥ ᐊᑖᑎᓂᖅᑲᖃᔭᖅᑐᑦ ᐊᓯᕈᖅᐸᑕ ᐱᑕᓖᑦ ᖃᓄᐃᓪᓗᐊᖅᑐᓂᒃ ᐃᖄᓂ ᐃᓂᒥᓐᓂᑦᑐᑦ, ᑭᓯᐊᓂ ᐊᔾᔨᐸᓗᖏᑦ

ᐅᕙᓃᑦᑐᑦ Roberts Bay ᐅᐊᓕᓂᐊᓂ ᐊᒻᒪᓗ ᑕᕆᐅᒻᒥ ᖃᐅᔨᓴᖅᑲᒃᑕᓖᑦ ᖃᓄᑎᒋ ᓱᕋᓂᐊᕐᒪᖓᑖ ᐱᕚᓕᕐᓗᑎᒃ ᑲᑭᐊᒃᑎᑦᓯᕐᕆᑦᑐᑦ ᐃᒫᓂ ᒪᕋᐃᑦ ᖃᓄᐃᑦᑐᑦ, ᐱᑕᕐᑲᓐᓂᖅᓴᐅᓕᕐᒪᑦ ᐃᖅᑳᓂ ᓴᕙᕌᔾᓭᔾᓂᒃ ᐊᒻᒪᓗ ᐱᐅᓯᖅᓱᖅᑐᒥᒃ ᐃᖅᑳᓃᑦᑐᓂᒃ ᖃᔫᓴᕿᑏᑦ ᐊᑐᖅᑕᐅᑎᓪᓗᒋᑦ 2013–ᒥ ᐃᒪᐃᑦᑐᕆᐅᔾᔪᒻᒪᑕ ᖃᐅᔮᐅᓴᖅᑕᑦ ᖃᓄᑎᒋ ᓱᕋᕐᑲᑦᑕᖅᑐᑦ ᐃᑲᓂ Roberts Bay ᐅᐊᓕᓂᐊᓂ ᐃᖏᓂᒃ ᐱᐅᓯᖅᓱᖅᑐᑦ ᐊᒻᒪᓗ ᑕᐃᒪᐃᑎᑕᐅᕐᕆᑦᑐᑦ ᓴᓇᔾᔪᓯᒪᔪᒧᑦ ᑐᓚᒃᑕᕙᖑᒧᑦ ᓱᕈᕋᓗᐊᕐᐸᑦ ᐅᕝᕙᓗᑭᐊᖅ ᐊᓯᐊᓅᖓᔪᑦ ᐊᐅᓚᔪᕙᐅᑎᓪᓗᒍ ᐱᓕᕆᑎᓪᓗᒋᑦ. ᐊᓯᕈᐊᔪᑦ ᐃᖃᓃᑦᑐᑦ ᒥᑭᓷᑎᕈᓗᐃᑦ ᐊᒻᒪᓗ ᖃᓄᐃᑦᑐᑦ ᐱᔪᑦ ᑖᒫᓂ ᓱᕋᕐᑲᑦᑕᕐᒪᑕ ᐃᖃᓃᑦᑐᑦ ᐊᓄᕆᓗᐊᓕᕋᐃᒻᒪᑦ ᓯᓚᕐᓂᓗᒃᓯᓂ ᐅᕙᓂ July 2013–ᒥ (ᓱᕐᑯᒥᔾᔪᒻᒪᑦ ᑐᓚᒃᑕᖅᕙᓕᐊᖑᓯᒪᔪᖅ), ᐅᕝᕙᓗᑭᐊᖅ ᑕᒪᒃᑯᐊ ᐊᓯᕈᕈᑕᐅᓲᑦ ᐱᒻᒪᑕ ᐊᓯᐊᓂᒃ ᐃᖅᑳᓂᒃ ᐱᐅᓯᖅᓱᖅᑐᒥᒃ ᓯᓚᒨᑦ ᑕᐃᒪᑎᑦ.

ᐊᑕᕐᕆᖅᓱᑎᒃ ᐃᖃᒻᒥᐅᑕᑦ ᐃᓂᒥᓃᑦᑐᑦ (ᐃᓐᓇᐃᑦ ᐊᒻᒪᓗ ᕿᑐᕐᖓᕐᕆᑦ) ᐊᒻᒪᓗ ᐃᓐᓇᐃᑦ ᐱᕈᕆᖅᓯᒪᔪᑦ, ᐃᓅᓐᓇᑎᒃ ᓱᕋᒃᓯᒪᕐᕆᑦᑐᑦ ᖃᐅᔨᓴᖅᑕᐅᑎᓪᓗᒋᑦ ᐃᖃᒻᒥᐅᑕᑦ ᐃᑲᓂ Roberts Bay ᐅᐊᓕᓂᐊᓂ ᐊᒻᒪᓗ Roberts Bay ᐅᕐᑯᐊᓂ ᑕᕆᐅᒻᒥᐅᑕᑦ, ᐋᖓᑐᐊᖅ ᐱᑕᓖᑦ ᐃᓂᒥᓃᑦᑐᑦ ᐃᖅᑲᓂ ᐊᒥᓱᑦ ᐃᑲᓂ Roberts Bay ᐅᐊᓕᓂᐊᓂ. ᐃᓅᓐᓇᐸᓗᑎᒃ 2013–ᒥ ᐃᖃᓃᑦᑐᑦ ᖃᐅᔨᒪᔾᔪᑎᑦ ᐊᐆᑕᐅᕙᔪᔪᑦ ᓯᕗᓪᓕᕐᒥ ᐊᕐᕌᒍᕐᓂ ᐊᓂᒎᑎᓯᒪᓕᖅᑐᑦ, ᖃᐅᔨᒪᔾᔪᑎᒃᓴᓂᒃ ᐱᑕᕐᑲᔪᕐᕆᑦᑐᖅ ᐃᖃᒻᒥᐅᑕᑦ ᐃᓂᕐᕆᓐᓂ ᐅᕙᓂ 2013–ᒥ ᓱᕋᒃᓯᒪᔪᕐᑲᔪᕐᕆᑦᑐᖅ ᐱᔪᓂᒃ ᐱᓕᓇᔪᑦ ᐊᐅᓚᔪᑎᓪᓗᒋᑦ (ᒪᑯᓂᖓ ᖃᐅᔨᒪᒍᑎᒃᓴᓂᒃ ᐱᕖᓪᓕᖅᑐᓂᒃ ᐃᑲᓂ Bray-Curtis ᖃᐅᔨᓴᖅᕙᕐᒥ ᐸᓚᕐᓂᖅᓴᑦ ᑕᒡᕙᐅᔪᑦ, ᐆᒻᒪᐅᔾᔪᑎᕐᕆᑦ ᐅᕝᕙᓗᑭᐊᖅ ᐊᔾᔨᕆᑦᑐᒥᒃ ᓴᕿᐅᒪᔪᓂᒃ ᐅᕝᕙᓗᑭᐊᖅ 2013–ᒥ ᖃᐅᔨᓴᕈᑕᐅᕐᑲᑦᑕᖅᓯᒪᔪᑦ ᐊᕐᕚᒍᐃᑦ ᐊᓂᒎᑎᓯᒪᓕᖅᑐᑦ). ᐱᓚᕿᔪᒃᓴᐅᓂᕐᒪᑕ ᐱᔪᓂᒃ ᕐᑯᑦᓯᕐᓂᓖᑦ ᖃᐅᔨᓴᖅᑕᐅᕙᒃᑐᑦ ᐊᕐᕚᒍᑕᒫᑦ ᐊᐆᑕᐅᑎᓪᓗᒋᑦ ᓱᕐᑯᐃᔾᔭᐃᔪᑦ ᖃᓄᐃᓪᓗᐊᖅᑐᓂᒃ ᐆᒃᑐᕋᖅᓱᑎᒃ.

ᐸᓚᕈᑎᒃᓴᑦ ᐊᐆᑕᐅᕙᒃᑐᑦ ᐸᓚᕐᑯᓪᓗᕆᑦ ᓱᕋᐃᔪᓐᓇᖅᑐᑦ ᑰᖕᒥᐅᑕᓂᒃ, ᑕᓯᕐᒥᐅᑕᓂᒡᓗ ᐊᒻᒪᓗ ᑕᕆᐅᕐᒥᐅᑕᑦ ᐃᑲᓂ Doris North–ᒥ ᐃᓚᕆᔾᔭᐅᓪᓗᑎᒃ ᓱᕋᐃᓲᑦ ᒪᑯᐊ ᐊᐳᑦ ᐊᐅᒐᐃᒻᒪᑦ ᓯᐊᒻᒪᓲᖑᒻᒪᑦ ᓇᒧᑦ ᑰᓕᖅᓱᓂ ᑕᒪᒃᑯᓄᖕᖓᖕᖓᔪᓂᒃ ᐊᐅᓚᔪᒍᑎᑕᕐᑲᒻᒪᑕ, ᐸᓚᕐᑯᓪᓗᕆᑦ ᐳᔪᕐᓘᑎᓯᕙᒃᑐᑦ, ᐃᒥᓕᕆᔾᔪᑎᑦ, ᐊᒃᑕᑯᓕᕆᔾᔪᑎᑦ, ᐅᔾᕿᕆᕙᖕᓂ ᖄᖅᑎᓯᕙᐅᕙᒃᑐᑦ ᐊᒻᒪᓗ ᓇᒧᑦ ᐃᓕᐅᖃᐃᕙᐅᕙᒃᑐᑦ ᐊᑐᕐᓂᐊᕐᕆᑦᑐᓂᒃ ᐅᔾᕐᑲᓂᒃ, ᐊᒃᑕᑯᓕᕆᔾᔪᑏᓪᓗ. 2013–ᒥ ᓴᕿᔪᔪᑦ ᓴᕿᐅᒪᓂᓖᑦ ᑕᒪᒃᑯᓄᖕᖓᖕᖓᔪᓂᒃ ᐸᓚᕈᑎᒃᓵᓂᒃ ᐊᑑᑎᓂᕐᑲᑦᓯᐊᖅᑐᑦ ᑕᒪᒃᑯᐊ ᓱᕋᐃᑦᑕᐃᓕᒍᑏᑦ ᐃᒫᓄᑦ ᐃᖄᓅᕐᓂᖅᐸᑕ ᐃᖑᓪᓚᐅᑎᑲᔾᔭᖅᑐᑦ ᓯᐊᒻᒪᕐᓗᑎᒃ ᖃᓄᑎᒋ, ᐃᒥᐅᓪᓗ ᑲᑭᐊᖕᓂᖕᖓᓂᒃ (ᐃᖅᑲᓕᕆᔾᔪᑎᑦ), ᐃᒥᓕᕆᔾᔪᑎᑦ, ᐃᖅᑳᓂᒃ ᖃᓄᐃᑦᑐᐃᓐᓇᐃᑦ ᓱᕋᒃᑕᐅᓱᖑᒻᒪᑕ, ᐆᒪᔪᕈᓗᐃᑦ ᐊᒻᒪᓗ ᐃᖃᒻᒥᐅᑕᑦ ᖃᓄᐃᓪᓗᐊᖅᑐᑦ, ᐊᒻᒪᓗ ᐃᖃᒻᒥᐅᑕᑦ ᐆᒪᔪᕈᓗᐃᑦ ᐃᓂᕐᕆᑦ ᐱᓕᕆᕙᐅᑉ ᐃᒪᕐᕆᓐᓂ.

Résumé opérationnel

Le projet Doris North (le projet) est situé dans la ceinture de la baie de L'Espoir (Hope Bay Belt), la propriété couvre 80 km par 20 km, le long de la rive sud du détroit de Melville au Nunavut. La propriété est constituée d'une ceinture de roches vertes (greenstone belt) possédant trois importants gisements d'or. Les gisements de Doris et de Madrid sont situés au nord de la ceinture et le gisement de Boston est situé à l'extrémité sud. Le projet est localisé à environ 125 km au sud- ouest de la baie de Cambridge, sur la rive sud du détroit de Melville. Les communautés voisines sont Umingmaktok (à 75 km au sud-ouest de la propriété), Cambridge Bay et Kingaok (Bathurst Inlet situé 160 km au sud-ouest de la propriété).

TMAC Resources Inc. (« TMAC ») a acquis le projet Hope Bay Belt (le projet) de la compagnie Newmont en mars 2013. L'achat de la propriété comprend le transfert des droits d'exploration et des droits miniers de Hope Bay Belt, y compris la mine d'or Doris North et ses licences, permis et autorisations d'exploitation. À la fin de l'année 2012, avant l'achat de la propriété, le projet Hope Bay Belt a été placé en surveillance et entretien lors de la fermeture en hiver 2012/2013. TMAC a rouvert le camp Doris North en mars de 2013 dans le but d'entreprendre la gestion des eaux du site, les programmes de conformité de l'évaluation environnementale et d'appuyer les activités d'exploration minière. Durant l'hiver 2013/2014, le projet Doris North demeurera en entretien sans fermeture saisonnière.

Les exigences à la conformité du programme de surveillance des répercussions sur le milieu aquatique (PSRMA) « Aquatic Effects Monitoring Program » applicable au certificat du projet Doris North (« Nunavut Impact Review Board (NIRB) » no 003, émis le 15 septembre 2006; NIRB 2006) et le permis d'utilisation des eaux de Type A (Office des eaux du Nunavut (OEN) Permis Type A no 2AM-DOH0713, émis le 19 septembre 2007 ; OEN 2007) sont les suivantes:

- Partie K, point 7. « Le titulaire du permis doit présenter à l'OEN pour l'approbation…d'un plan de surveillance des répercussions aquatiques (PSRA) « Aquatic Effects Monitoring Plan » en collaboration avec Environnement Canada. La proposition d'un PSRA devra tenir compte de toutes les modifications de l'échéancier en respectant les exigences du règlement sur les effluents des mines de métaux (REMM) « Metal Mining Effluent Regulations» »;
- Partie K, point 8. « Le titulaire du permis et Environnement Canada devront consulter avec l'OEN afin de s'assurer que la présentation avancée du PSRA réponde aux exigences du REMM. »

En conformité avec les mesures prescrites dans la partie K, point 7, Hope Bay Mining Ltd. (HBML) a présenté un PSRA le 24 février 2010, à la suite d'une consultation avec Environnement Canada. Le PSRA final, Doris North Gold Mine Project: Aquatics Effects Monitoring Plan (the Plan; Rescan 2010c), a été approuvé par l'OEN le 25 mars 2010, en vertu de la motion 2009-23-L04. Ce document est conforme aux méthodes et pratiques énoncées dans le REMM (2002) et conforme aux mesures prescrites dans la partie K, point 8, du permis d'utilisation des eaux de Type A.

Le 12 septembre 2013, le permis d'utilisation des eaux de Type A émis à TMAC, a été renouvelé et modifié. Le texte suivant décrit les exigences de ce nouveau permis d'utilisation des eaux de Type A (Licence d'OEN # 02-DOH1323):

- Partie K, point 7. « Le titulaire du permis doit soumettre à l'OEN, six 6 mois avant le début des opérations, un PSRA révisé (Doris North Gold Mine Project: Aquatics Effects Monitoring Plan) élaboré en consultation avec Environnement Canada. Le PSRA révisé devra tenir compte des modifications de l'échéancier en respectant les exigences du REMM »;

Actuellement, le PSRA est mené en conformité au PSRA final (Doris North Gold Mine Project: Aquatics Effects Monitoring Plan) qui a été approuvé le 25 mars 2010. Afin de se conformer aux exigences du PSRA, TMAC a demandé à ERM Consultants Canada Ltd. (« ERM Rescan ») de mener, à contrat, les activités du programme de surveillance du PSRA et de présenter ses résultats.

Le présent rapport, a pour but de démontrer les résultats obtenus lors de la quatrième année du PSRA. Les données recueillies à ce jour peuvent aussi servir d'information de base pour les études de suivi entreprises pendant la phase d'exploitation. Cette option serait approuvée sous forme de mise à jour du PSRA. Tel que décrit dans le plan final, la zone d'échantillonnage du programme comprenait une zone exposée, composée de trois sites de cours d'eau, trois sites de lacs et deux sites marins ainsi qu'une zone de référence, composée de trois cours d'eau, de trois lacs et de deux sites marins. En 2013, les analyses du milieu aquatique comprenaient: la concentration d'oxygène dissoute (sous la glace) des lacs et des sites marins, la profondeur de la disparition du disque de Secchi, l'évaluation de la qualité des eaux et des sédiments aquatiques (cours d'eau, lacs et sites marins), l'estimation de la biomasse de périphyton (cours d'eau) et de la biomasse des phytoplanctons (lacs et des sites marins), les mesures de la communauté d'invertébrés benthiques y compris la densité totale, la richesse des taxons (au niveau de la famille), l'indice de régularité, la diversité, ainsi que l'index dissimilitude de Bray-Curtis. La composition des communautés de poissons des lacs et des sites marins a été évaluée au cours de l'année 2010 (Rescan 2011), par contre, elle n'a pas été réévaluée en 2013.

Cours d'eau

Les études de suivi menées dans les trois cours d'eau (Doris Outflow, Roberts Outflow, et Little Roberts Outflow) n'ont trouvé aucun effet nocif sur la qualité de l'eau et des sédiments, de la biomasse du périphyton ou des communautés d'invertébrés benthiques provenant des activités du projet au cours de l'année 2013.

Parmi les 18 variables utilisées pour l'analyse de la qualité des eaux, les taux d'arsenic à Roberts Outflow et les taux d'aluminium à Little Roberts Outflow étaient les seules variables qui ont changé de manière significative entre 2013 et les années de référence. Cependant, des changements similaires des taux d'arsenic et d'aluminium ont été observés dans les cours d'eau de la zone de référence, démontrant que ces changements n'étaient pas causés par les activités du projet. En effet, les concentrations d'arsenic et d'aluminium dans les zones d'échantillonnages ont diminué entre les années de référence jusqu'à 2013 et la diminution de ces taux n'ont aucun effet nocif sur l'environnement. Par conséquent, les activités du projet en 2013 n'ont pas eu d'effet nocif sur la qualité de l'eau des cours d'eau dans la zone d'échantillonnage.

À Doris Outflow et à Roberts Outflow, il y avait quelques différences dans la distribution granulométriques des échantillons prélevés en 2013 et ceux prélevés à l'étude de base. Les cours d'eau sont naturellement caractérisés par une forte hétérogénéité spatiale en distribution granulométrique, par conséquent, il est improbable que les différences observées soient associées aux activités du projet en 2013. À Roberts Outflow, les teneurs en carbone organique total et la concentration de chrome, de cuivre, de plomb et de zinc des échantillons prélevés en 2013 étaient plus faibles que ceux prélevés à l'étude de base. Ceci reflète la diminution en proportion des sédiments fins, observés dans les échantillons de 2013, qui favorise l'augmentation des teneurs en carbone organique et la concentration des métaux plus que les sédiments grossiers. Les échantillons prélevés en 2013 étaient plus faibles en concentration de chrome total et de zinc que ceux prélevés à l'étude de base, ce qui a également été observés pour les échantillons de référence prélevés dans la zone de référence Reference B Outflow. Ainsi, les activités du projet n'ont pas eu d'effet sur la qualité des sédiments dans les cours d'eau dans la zone d'échantillonnage en 2013.

Dans l’évaluation des communautés d’invertébrés benthiques, la comparaison de l’indice de régularité des taxons était considérée non semblable entre le Doris Outflow et la zone de référence, de même que l’indice de Bray-Curtis entre le Roberts Outflow et la zone de référence de 2010 à 2013. Toutefois, ces résultats n’indiquent aucun effet nocif des activités du projet sur les communautés du benthos. L’indice de régularité est resté supérieur à Doris Outflow par rapport aux autres cours d’eau échantillonnés en 2013 et l'indice de Bray-Curtis à Roberts Outflow était relativement faible en 2013 par rapport aux années précédentes, ce qui indique une similitude accrue des communautés d’invertébrés benthiques entre Roberts Outflow et la médiane de la zone de référence en 2013. Les différences observées pendant cette étude reflètent la variabilité de la distribution temporelle (annuelle) et spatiale des communautés d’invertébrés benthiques. Les mesures des communautés entre la zone d’exposition et la zone de référence de 2010 à 2013, soient la densité totale, la richesse de taxon et l’indice de diversité Simpson ont obtenu des tendances similaires. Par conséquent, les activités du projet en 2013 n'ont pas eu d'effet sur les mesures de la communauté d’invertébrés benthiques dans la zone d’échantillonnage des cours d’eau.

Lacs

Aucun effet n’ont été associé aux activités du projet aux niveaux d’oxygène dissoute (sous la glace), la profondeur de la disparition du disque de Secchi, les mesures de qualité des eaux et des sédiments, la biomasse des phytoplanctons ou des communautés d'invertébrés benthiques sur les sites des lacs PSRA Doris Lake South, Doris Lake North et Little Roberts Lake.

Par rapport à l’année de référence, les changements des mesures de la dureté de l'eau (augmentation) au sud du lac Doris et dans les concentrations d'arsenic total (diminution), molybdène total (augmentation) et zinc total (augmentation) au Lac Doris North ont été observés en 2013. Cependant, l’analyse de ces résultats (plan avant-après et plan contrôle-impact), ont démontré que les changements dans la zone d’exposition étaient similaires à ceux dans la zone de référence (Reference Lac B) et similaire entre l’année de référence et en 2013. Donc, les changements des mesures de la qualité de l'eau ne peuvent être associés aux activités du projet en 2013.

À Doris Lake South, il y avait quelques différences dans la distribution granulométrique dans les échantillons prélevés en 2013 et ceux prélevés à l’année de référence. Les sédiments lacustres sont naturellement caractérisés par une forte hétérogénéité spatiale en distribution granulométrique, par conséquent, il est improbable que les différences observées soient associées aux activités du projet en 2013. À Doris Lake North et à Doris Lake South, la concentration de cuivre dans les sédiments était plus faible que celles prélevée à l’étude de base, en plus d'une diminution de la concentration de plomb dans les sédiments de Little Roberts Lake. La diminution des concentrations de métaux de sédiments n’a pas d’effet nocif sur l'environnement. Alors, les activités du projet en 2013 n'ont pas eu d'effet nocif sur la qualité des sédiments lacustres dans la zone d’échantillonnage.

Dans l’évaluation des communautés d’invertébrés benthiques, la comparaison de l’indice de régularité des taxons était considérée non semblable entre Doris Lake North et Doris Lake South par rapport à la zone de référence (Reference Lake B). Mais, étant donné la variabilité temporelle dans l'indice de Bray-Curtis à ces sites, les tendances temporelles ne sont pas claires. L'indice de Bray- Curtis du Doris Lake North et du South Lake Doris, calculé en 2013, correspondait aux indices des années précédentes, donc il est peu probable que les activités du projet en 2013 aient eu un effet à l'indice de Bray-Curtis à ces sites.

Des résultats similaires pour les tendances en densité totale, la richesse de taxon, l’indice de régularité et de diversité Simpson ont été observés entre la zone d’exposition et la zone de référence de 2010 à 2013. Conséquemment, les activités du projet en 2013 n'ont pas eu d'effet sur les mesures de la communauté d’invertébrés benthiques dans la zone d’échantillonnage des lacs.

Site marin

Aucun effet n'ont été associé aux activités du projet sur les niveaux d'oxygène dissout pendant l'hiver, les mesures de la qualité des eaux et des sédiments, la biomasse des phytoplanctons ou des communautés d'invertébrés benthiques dans les sites marins du PSRA à Roberts Bay West et Roberts Bay East.

Le total des solides en suspension prélevé à Roberts Bay West étaient la seule mesure de qualité des eaux qui a changé de manière significative entre 2013 et les années de référence. Cependant, l'analyse de ces résultats, (plan avant-après et plan contrôle-impact), a démontré que la diminution dans la zone d'exposition était similaire à celle observée dans la zone de référence. Ainsi, les changements des mesures de la qualité de l'eau au site marin à Roberts Bay ne peuvent être liés aux activités du projet en 2013.

Les sédiments aquatiques du site Roberts Bay West à Roberts Bay avaient des concentrations de carbone organique total et de métaux plus élevées en 2013 qu'en 2002. Ceci reflète l'augmentation en teneurs de limon (sédiments fins) et la diminution en teneur de sable (sédiments grossiers) des échantillons de 2013 par rapport à 2002, qui ont une affinité plus élevée pour les métaux et le carbone organique que le sédiment plus grossier. Dans la zone de référence, les échantillons prélevés en 2013 contenaient également des teneurs plus fortes en proportion de limon et plus faible en proportion de sable par rapport aux échantillons prélevés à l'étude de base. Par contre en 2013, l'augmentation de la teneur en carbone organique total et les concentrations de métaux ont également été observées dans la zone de référence. Il serait possible que les dommages causés à la jetée de Roberts Bay en 2013 peuvent avoir contribué au changement dans la distribution granulométrique et de la qualité des sédiments dans cette zone. Par contre, des tendances similaires dans la teneur en carbone organique totale des concentrations de métaux entre la zone de référence et la zone d'exposition Roberts Bay West entre 2013 et les années de référence suppose que les changements observés à Roberts Bay West ne sont pas liés aux dommages causé à la jetée, ni aux activités du projet. Il est probable que les changements de la distribution granulométrique et de la qualité des sédiments sont attribuables à la redistribution régionale des sédiments à la suite d'une tempête qui a eu lieu en juillet 2013 (la cause du dommage à la jetée) ou au haut niveau d'hétérogénéité spatiale de la distribution des sédiments en milieux marins.

À l'exception de la densité de la communauté des invertébrés benthique à Roberts Bay East qui était semblable au site de référence, les mesures pour l'analyse des communautés d'adultes et juvéniles et le sous-ensemble des adultes du benthos, était considéré non semblable à Roberts Bay West et Roberts Bay East par rapport au site de référence. Cependant, les mesures de communauté du benthos en 2013 correspondaient aux mesures des années précédentes, donc il est peu probable que les activités du projet en 2013 aient eu un effet sur les communautés du benthos sur ces sites (c.-à-d., il n'y avait aucune augmentation de manière significative de l'indice de Bray-Curtis ou de la diminution de la densité, de la richesse ou de l'indice de régularité en 2013 par rapport aux années précédentes). Les tendances non similaires des mesures du benthos étaient probablement attribuables à la forte variabilité interannuelle des paramètres évalués.

Les mesures d'atténuation entreprise par le projet pour réduire le risque d'effets négatifs ou nocifs sur les cours d'eau, lacs et habitats marins sont: la gestion des eaux de surface à Doris North, la réduction des émissions de poussière, la gestion de l'eau du site, la gestion des résidus et rejets miniers, la gestion des haldes de stériles et la gestion de l'évacuation des déchets. Les résultats obtenus en 2013 indiquent que ces mesures d'atténuation ont été efficaces dans la prévention des effets indésirables sur les niveaux d'oxygène dissous, la clarté de l'eau (la profondeur de disparition de Secchi), la qualité des eaux et des sédiments, la biomasse de périphyton et de phytoplancton et les communautés d'invertébrés benthiques dans les milieux aquatique de la zone du projet.

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ERM

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This report was prepared for TMAC by ERM Rescan and was written by Carol Adly (M.Sc.), Erin Forster (B.Sc.), and Mike Henry (Ph.D.), and reviewed by Mike Henry. The compliance program was coordinated by Cassie Chow (B. Eng., E.I.T.) and managed by Marc Wen (M.Sc., R.P.Bio.).

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DORIS NORTH PROJECT
2013 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.

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 variable concentration that is reported as being below a specified detection limit, although the actual concentration is not known.
Chl *a*	Chlorophyll *a*
Chlorophyll *a*	An essential light-harvesting pigment for photosynthetic organisms including phytoplankton. Because of the difficulty involved in the direct measurement of plant carbon, chlorophyll *a* is routinely used as a 'proxy' estimate for plant biomass in aquatic studies.
CTD	Conductivity, temperature, depth probe
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.
ERM Rescan	ERM Consultants Canada Ltd.
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
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
NIRB	Nunavut Impact Review Board
NTU	Nephelometric Turbidity Units
NWB	Nunavut Water Board
OF	Outflow
PEL	Probable effects level
the Project	the Doris North Project
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.
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
TMAC	TMAC Resources Inc.
TOC	Total organic carbon
TSS	Total suspended solids
$Z_{1\%}$	The 1% euphotic depth, i.e., the depth of the water column at which 1% of the surface irradiance reaches.

1. Introduction

1. Introduction

The Doris North Project (the Project) is located within the Hope Bay Belt, an 80 by 20 km kilometre property located along the south shore of Melville Sound in Nunavut (Figure 1-1). The property consists of a greenstone belt (the Hope Bay Belt) that contains three main gold deposits. The Doris and Madrid deposits are located in the northern portion of the belt, and the Boston deposit is at the southern end. The Project is located approximately 125 km southwest of Cambridge Bay on the southern shore of Melville Sound. The nearest communities are Umingmaktok (75 km to the southwest of the property), Cambridge Bay, and Kingaok (Bathurst Inlet; 160 km to the southwest of the property).

TMAC Resources Inc. (TMAC) acquired the Hope Bay Belt Project from Newmont Corporation in March 2013. The acquisition included exploration and mineral rights over the Hope Bay Belt, including the Doris North Gold Mine and its permits, licences and authorizations for development received by previous owners. In late 2012, prior to the sale, the Hope Bay Belt Project was placed into care and maintenance, and the Project was seasonally closed during the winter of 2012/2013. TMAC re-opened the Doris North Camp in March of 2013 for the purposes of conducting site water management, environmental compliance programs and to support exploration activities. The Doris North Project remains in care and maintenance although it will not be seasonally closed for the winter of 2013/2014.

The compliance requirements for an Aquatic Effects Monitoring Program (AEMP) applicable to the Doris North Project Certificate (Nunavut Impact Review Board (NIRB) No. 003, issued September 15, 2006; NIRB 2006) and Type A Water Licence (Nunavut Water Board (NWB) Licence No. 2AM-DOH0713 Type A, issued September 19, 2007; NWB 2007) are as follows:

- 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, Hope Bay Mining Ltd. (HBML) submitted an AEMP Plan on February 24, 2010, after consultation with Environment Canada. The final AEMP Plan, *Doris North Gold Mine Project: Aquatics Effects Monitoring Plan* (the Plan; Rescan 2010c), was approved by the Nunavut Water Board (NWB) 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.

On September 12, 2013, a renewed and amended Type A Water Licence was issued to TMAC. The following text outlines the requirements of this Type A Water Licence (NWB Licence #2AM-DOH1323):

- Part K, Item 7. *The Licensee shall submit to the Board for review, six (6) months prior to Operations, a revised Doris North Gold Mine Project: Aquatic Effects Monitoring Plan (AEMP) that has been developed in consultation with Environment Canada. The revised AEMP shall consider modifications and advances in schedule which are consistent with the objectives and requirements of the MMER.*

PROJECT # 0194098-0005 GIS # HB-01-111 February 06 2014

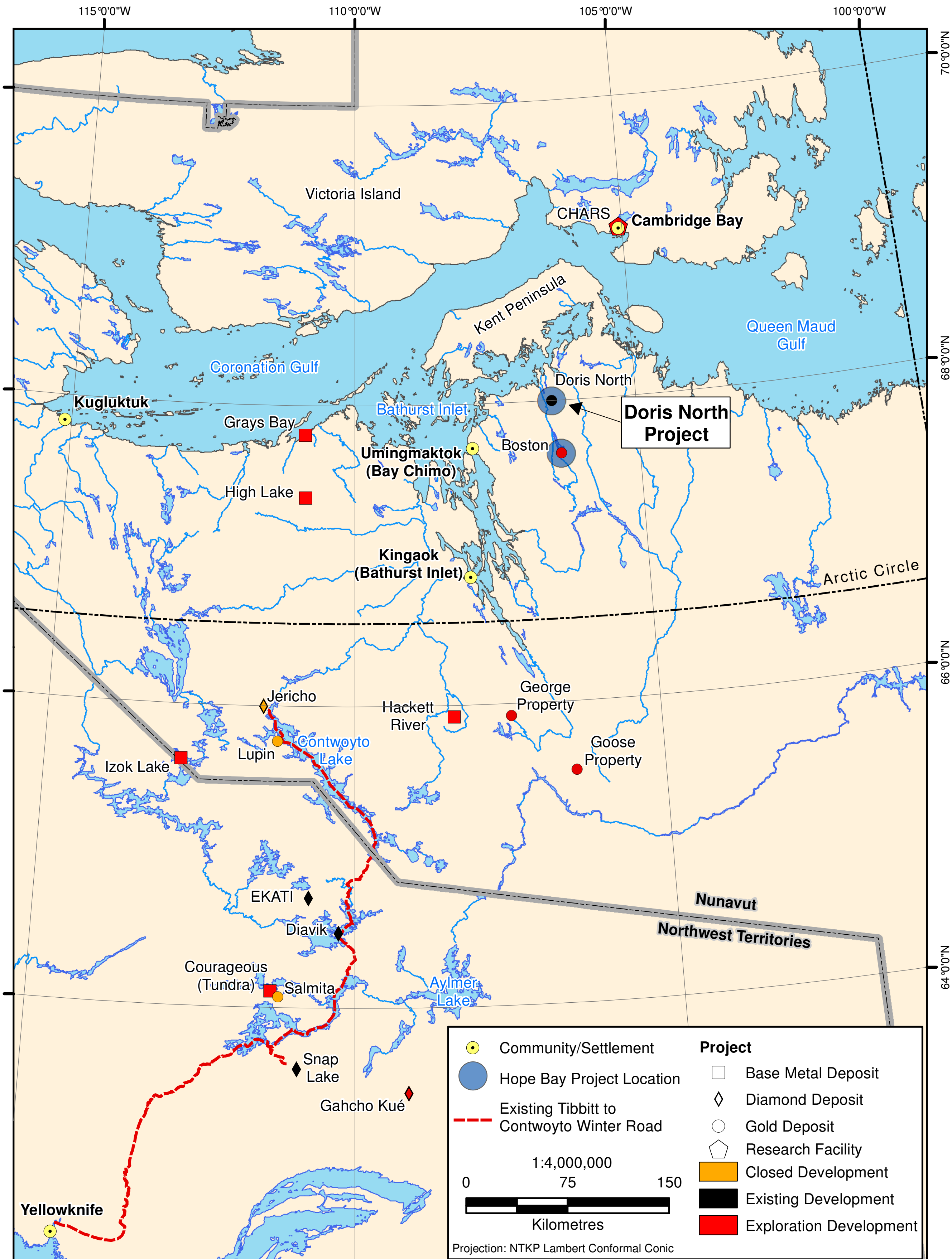

Figure 1-1

Doris North Project Location

TMAC RESOURCES

Rescan an ERM company

Currently, the AEMP is being conducted in accordance with the final Plan approved on March 25, 2010. Although some construction activities occurred in 2008 to support the camp development, the construction initiated in 2010 was more relevant in terms of aquatic effects and marks a reasonable delineation for baseline years. The first AEMP, initiated in 2010, was designed to assess the potential effects of these activities on the aquatic environment. An AEMP has been conducted annually since 2010, and this report presents the results from the fourth year of the AEMP. Data collected to date may serve as baseline information once the Project enters the operations phase. The AEMP approach would be validated as part of any update to the AEMP Plan.

1.1 2013 PROJECT ACTIVITIES

The Hope Bay Belt Project was placed into care and maintenance in 2012, and the Project was seasonally closed during the winter of 2012/2013. TMAC re-opened the Doris North Camp in March 2013 for the purposes of conducting site water management, environmental compliance programs and to support exploration activities. Construction activities in the area have been limited to work required for site upkeep and maintenance.

In 2013, Project activities that could have affected the Doris North aquatic environment included the repairs to the jetty in Roberts Bay, which was damaged during the summer of 2013. The erosion of the jetty could have affected the sediment composition in the surrounding marine environment. However, a silt curtain was installed during repair work to contain the suspended solids that were generated by the jetty repair.

Site water management involves the discharge of site water into Doris Creek to manage water levels in the lake. This discharge has been occurring seasonally since 2011, and is unlikely to affect the aquatic environment because discharged site water is closely monitored to ensure that established discharge criteria are met.

Figure 1.1-1 presents the existing infrastructure for the Doris North Project. Infrastructure that already existed in 2013 included the following: the Roberts Bay jetty, 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 TIA (formerly Tail Lake): treated effluent from this facility is expected to be released into Doris Outflow where it would flow successively through Little Roberts Lake and into Little Roberts Outflow before entering Roberts Bay. 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 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 management, tailings management, quarry and waste rock management, and waste management.

1.2 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 components 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). According to the original AEMP Plan, 2013 was anticipated to be the second year of mine operation (and effluent discharge), and the second year of fish monitoring. The purpose of fish studies under the MMER is to determine whether there are any effects of effluent discharge on fish populations and fish tissue. Because mine operation had not begun in 2013, the second year of fish monitoring was postponed in accordance with the modified mine development schedule. The AEMP Plan will be revised prior to the discharge of effluent from the TIA and a new fish monitoring schedule will be outlined.

1.3 REPORT STRUCTURE

This document presents the methods, evaluation of effects, and conclusions of the 2013 AEMP. Raw data and results from the 2013 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 2013 evaluation of effects is provided in Appendix B.

PROJECT # 0194098-0005 GIS # HB-15-093 October 28 2013

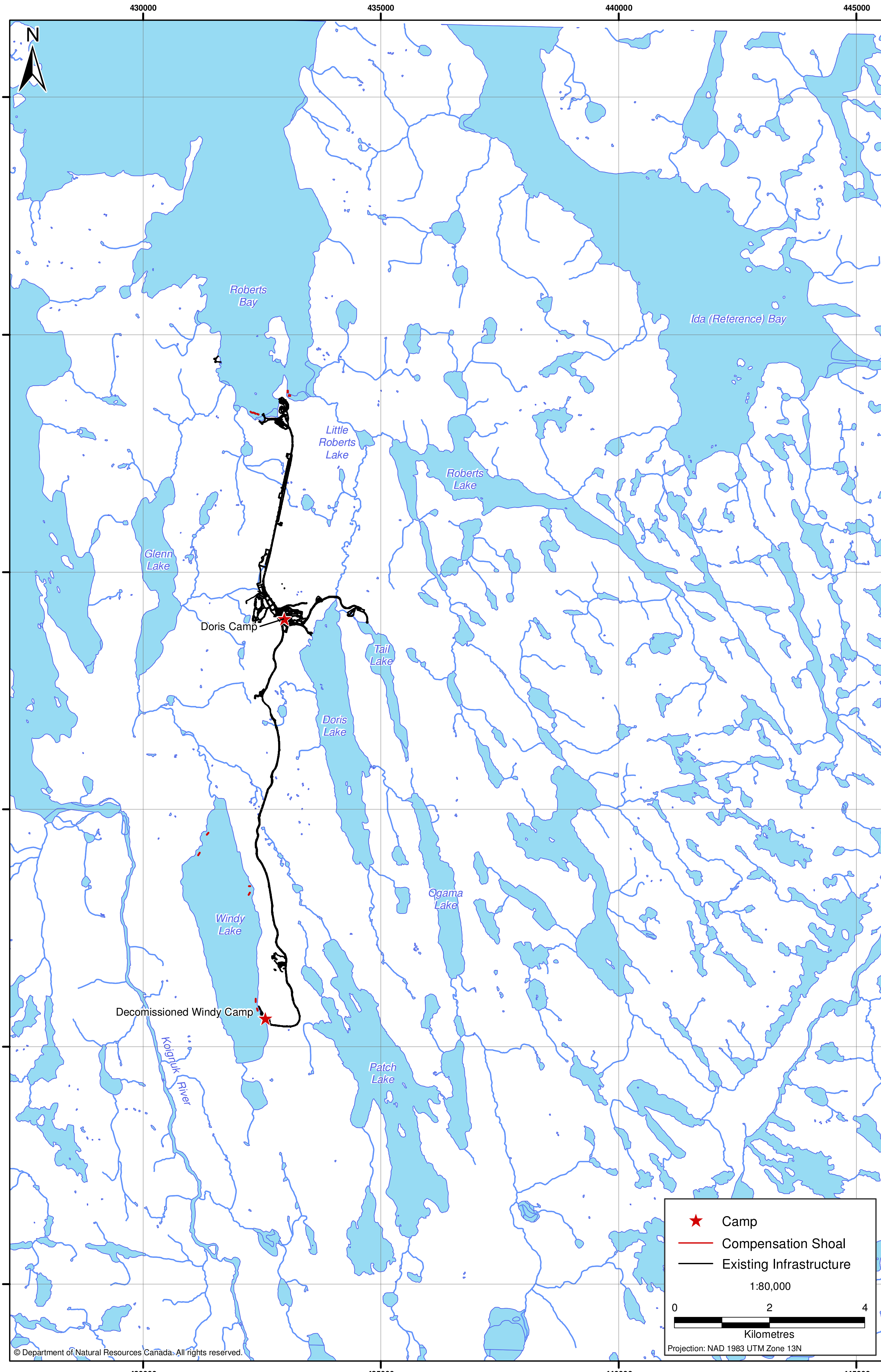

Figure 1.1-1

Existing Infrastructure, Doris North Project

Figure 1.1-1

2. Methods

2. Methods

2.1 SUMMARY OF AEMP STUDY DESIGN

The 2013 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 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. Two marine exposure sites and one marine reference site were also sampled. Figure 2.1-1 shows the sampling sites, the aquatic components sampled, 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 AEMP Plan (Rescan 2010c) includes a description of the site selections. A summary table (Table 2.1-1) and text are provided below.

2.1.1.1 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).

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 to 2013 sampling for improved comparability with the Doris North sampling location, which is also in a deep basin (> 10 m deep; Figure 2.1-1).

2.1.1.2 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.

Table 2.1-1. AEMP Sampling Locations, Descriptions, and Purpose, Doris North Project, 2013

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 an abandoned silver mine and past 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
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))

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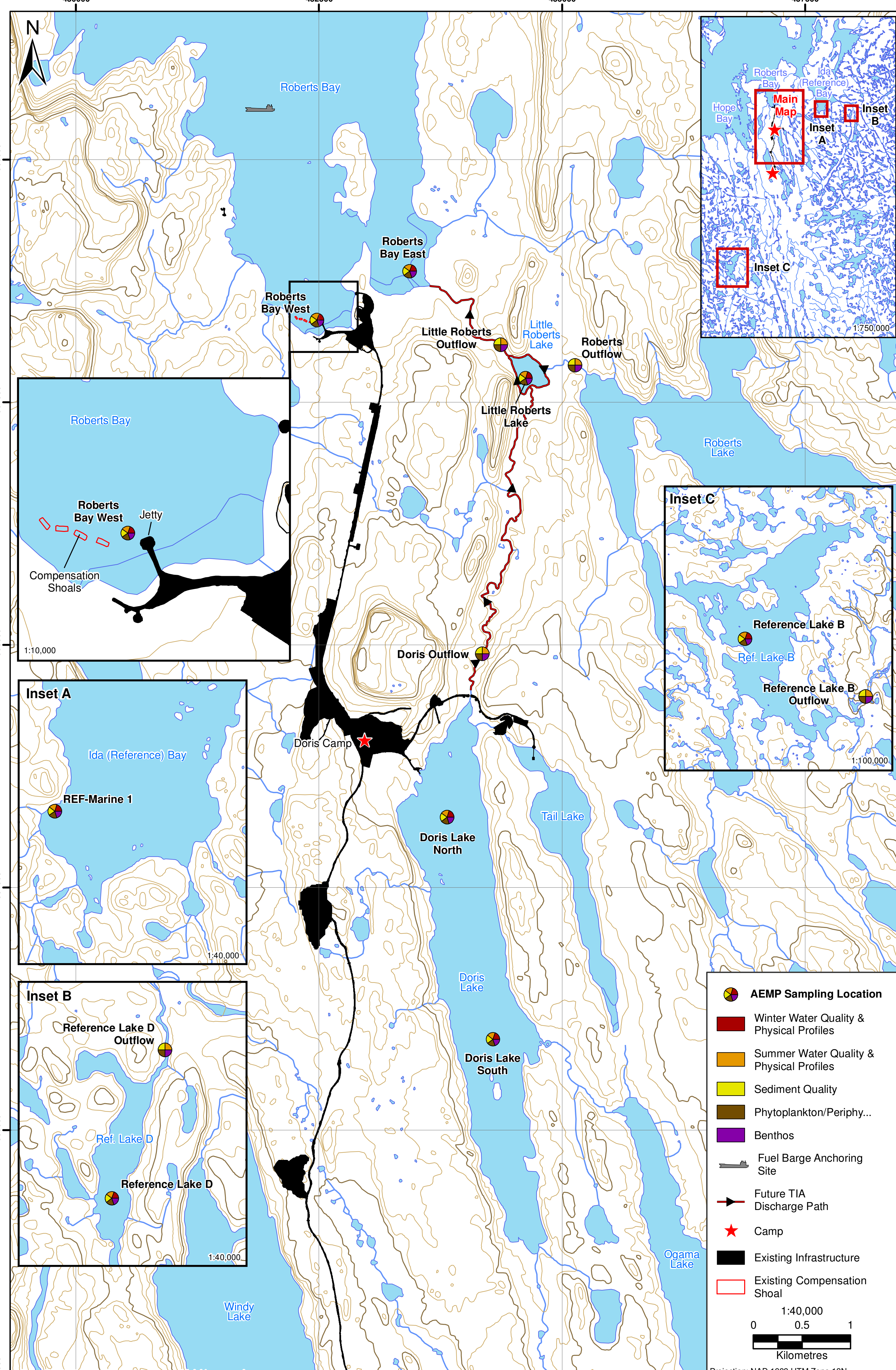

Figure 2.1-1

TMAC RESOURCES

2013 AEMP Sampling Locations, Doris North Project

Rescan an ERM company

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.

2.1.2 2013 Sampling Schedule

The AEMP schedule is outlined in the current Plan (Rescan 2010c). For 2013, 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 2013 sampling schedule is provided in Table 2.1-2.

Table 2.1-2. Summary of the 2013 AEMP Sampling Dates, Doris North Project

Waterbody	Variable	Sampling Dates
Streams	Water Quality	June 12-13
		July 17-19
		August 16-22
		September 18-23
	Sediment Quality	August 16-22
	Periphyton Biomass	July 17-19*
		August 16-22*
		September 17-23*
	Benthos	August 16-22
Lakes	Physical Limnology	April 25-28
		July 17-21
		August 18-21
		September 19-23
	Water Quality	April 25-28
		July 17-21
		August 18-21
		September 19-23
	Sediment Quality	August 18-21
	Phytoplankton Biomass	April 25-28
		July 17-21
		August 18-21
		September 19-23
	Benthos	August 18-21
Marine	Physical Oceanography	April 27-28
		July 20-21
		August 14-15
		September 20-28

(continued)

Table 2.1-2. Summary of the 2013 AEMP Sampling Dates, Doris North Project (completed)

Waterbody	Variable	Sampling Dates
Marine *(cont'd)*	Water Quality	April 27-28
		July 20-21
		August 14-15
		September 20-28
	Sediment Quality	August 14-15
	Phytoplankton Biomass	April 27-28
		July 20-21
		August 14-15
		September 20-28
	Benthos	August 14-15

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

2.2 DETAILED 2013 AEMP METHODS

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

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 2013. 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 using a motorized auger. The ice thickness was then recorded and the lake bottom depth measured using a Hummingbird 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 profiles extended from the surface to approximately 1 m above the sediment surface to reduce suspension of bottom sediments.

Table 2.2-1. Summary of the 2013 AEMP Environmental Sampling Program, Doris North Project

Monitoring Variable	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

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 or zodiac. 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 using a motorized auger. 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 2013. 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 variables are summarized in Table 2.2-3. Sampling locations are presented in Figure 2.1-1. The sampling procedures used for each aquatic habitat are described below.

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 12 and September 23, 2013. Locations of the 2013 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 re-suspended sediments. Samples were collected using appropriate verified-clean bottles provided by ALS Laboratory Group, Burnaby, BC (ALS). Samples were collected in duplicate and the appropriate preservatives provided by ALS were added in the field after sample collection.

Table 2.2-2. AEMP Stream, Lake, and Marine Water Quality Sampling Dates and Depths, Doris North Project, 2013

Habitat	Site	Sampling Date	Depth(s) (m)
Stream	Doris Outflow	12-Jun-13	Surface
		17-Jul-13	Surface
		19-Aug-13	Surface
		18-Sep-13	Surface
	Roberts Outflow	13-Jun-13	Surface
		18-Jul-13	Surface
		16-Aug-13	Surface
		18-Sep-13	Surface
	Little Roberts Outflow	12-Jun-13	Surface
		18-Jul-13	Surface
		17-Aug-13	Surface
		17-Sep-13	Surface
	Reference B Outflow	13-Jun-13	Surface
		19-Jul-13	Surface
		22-Aug-13	Surface
		23-Sep-13	Surface
	Reference D Outflow	13-Jun-13	Surface
		18-Jul-13	Surface
		17-Aug-13	Surface
		18-Sep-13	Surface
Lake	Doris Lake North	25-Apr-13	1.0, 10
		17-Jul-13	1.0, 12.0
		20-Aug-13	1.0, 12.5
		20-Sep-13	1.0, 11.0
	Doris Lake South	26-Apr-13	1.0, 9.7
		19-Jul-13	1.0, 9.0
		20-Aug-13	1.0, 9.5
		20-Sep-13	1.0, 8.0
	Little Roberts Lake	27-Apr-13	0*
		20-Jul-13	0.5
		21-Aug-13	0.5
		19-Sep-13	0.5
	Reference Lake B	28-Apr-13	1.0, 8.0
		19-Jul-13	1.0, 8.0
		18-Aug-13	1.0, 8.0
		23-Sep-13	1.0, 9.0
	Reference Lake D	28-Apr-13	1.0
		21-Jul-13	1.0
		18-Aug-13	1.0
		21-Sep-13	1.0
Marine	RBE (Roberts Bay)	27-Apr-13	1.0
		20-Jul-13	0.5
		14-Aug-13	0.1
		21-Sep-13	0.5
	RBW (Roberts Bay)	27-Apr-13	1.0
		20-Jul-13	0.5
		14-Aug-13	1.0
		20-Sep-13	1.0
	REF-Marine 1 (Ida Bay)	28-Apr-13	1.0
		21-Jul-13	0.5
		15-Aug-13	1.0
		28-Sep-13	1.0

** Sample collected from Little Roberts Lake in April was included in water quality appendix but not in report results because this sample was contaminated by sediment and is not considered representative of the water quality at this site. There was 20 cm of water below the ice, and it was not possible to collect an uncontaminated sample.*

Table 2.2-3. AEMP Water Quality Variables and Realized Detection Limits, Doris North Project, 2013

		Realized Detection Limits				Realized Detection Limits	
Variable	Units	Freshwater	Marine	Variable	Units	Freshwater	Marine
Physical Tests				**Total Metals (cont'd)**			
pH	pH	0.1	0.1	Chromium (Cr)	mg/L	0.0005	0.0005
Alkalinity, Total (as $CaCO_3$)	mg/L	1.0 or 2.0	2.0	Cobalt (Co)	mg/L	0.00005	0.00005
				Copper (Cu)	mg/L	0.0005	0.00005
Hardness (as $CaCO_3$)	mg/L	0.5	4.3	Gallium (Ga)	mg/L	0.00005	0.0005
Conductivity	µS/cm	2.0	-	Iron (Fe)	mg/L	0.03	0.01
Total Suspended Solids	mg/L	1.0	2.0 or 3.0	Lead (Pb)	mg/L	0.00005	0.00005
Total Dissolved Solids	mg/L	10	80	Lithium (Li)	mg/L	0.0002	0.02
Turbidity	NTU	0.1	0.1	Magnesium (Mg)	mg/L	0.1	1.0
Salinity		-	1.0	Manganese (Mn)	mg/L	0.0002	0.00005
				Mercury (Hg)	µg/L	0.0005	0.0005
Anions				Molybdenum (Mo)	mg/L	0.00005	0.002
Bromide (Br)	mg/L	0.05	5.0	Nickel (Ni)	mg/L	0.0002	0.00005
Chloride (Cl)	mg/L	0.5	50	Phosphorus (P)	mg/L	0.30	1.0
Fluoride (F)	mg/L	0.02	0.75	Potassium (K)	mg/L	2.0	20
Sulphate (SO_4)	mg/L	0.5	50	Rhenium (Re)	mg/L	0.000005 or 0.00001	0.0005
Nutrients				Rubidium (Rb)	mg/L	0.00002	0.005
Ammonia (as N)	mg/L	0.005	0.005	Selenium (Se)	mg/L	0.0002 or 0.0004	0.0005
Nitrate (as N)	mg/L	0.005	0.006	Silicon (Si)	mg/L	0.05	0.5
Nitrite (as N)	mg/L	0.001	0.002	Silver (Ag)	mg/L	0.000005 or 0.00003	0.0001
Total Phosphorus	mg/L	0.002	0.002	Sodium (Na)	mg/L	2.0	20
				Strontium (Sr)	mg/L	0.00005	0.05
Cyanides				Tellurium (Te)	mg/L	0.00001	0.0005
Cyanide Total	mg/L	0.001	0.001	Thallium (Tl)	Mg/L	0.000002	0.00005
Cyanide, Free	mg/L	0.001	0.001	Thorium (Th)	mg/L	0.000005	0.0005
				Tin (Sn)	mg/L	0.0002 or 0.0004	0.001
Organic Carbon				Titanium (Ti)	mg/L	0.0002	0.005
Total Organic Carbon	mg/L	0.5	0.5	Tungsten (W)	mg/L	0.00001	0.001
				Uranium (U)	mg/L	0.000002	0.00005
Total Metals				Vanadium (V)	mg/L	0.00005	0.0005
Aluminum (Al)	mg/L	0.003	0.005	Yttrium (Y)	mg/L	0.000005	0.0005
Antimony (Sb)	mg/L	0.00001 to 0.00004	0.0005	Zinc (Zn)	mg/L	0.003	0.0008
Arsenic (As)	mg/L	0.00005 to 0.0005	0.0004	Zirconium (Zr)	mg/L	0.00005	0.0005
Barium (Ba)	mg/L	0.0001	0.001				
Beryllium (Be)	mg/L	0.000005	0.0005	**Speciated Metals**			
Bismuth (Bi)	mg/L	0.00005 or 0.0001	0.0005	Methylmercury	µg/L	-	0.00005
Boron (B)	mg/L	0.005 to 0.015	0.1				
Cadmium (Cd)	mg/L	0.000005	0.00002	**Radiochemistry**			
Calcium (Ca)	mg/L	0.05	0.5	Radium-226	Bq/L	0.010	0.010
Cesium (Cs)	mg/L	0.000005	0.0005				

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 analysis. The analyzed variables and their realized detection limits are presented in Table 2.2-3.

2.2.2.2 Lakes and Marine

Water quality samples were collected in lakes and the marine environment during the 2013 AEMP program. Lake samples were collected from three sites in two lakes within the Doris and Roberts watersheds (Doris Lake South, Doris Lake North, Little Roberts Lake), and from two reference lakes (Reference Lake B and Reference Lake D). Marine water quality samples were collected from two sites in Roberts Bay (RBE, RBW) and at one reference site in the adjacent inlet, Ida (Reference) Bay (REF-Marine 1). Locations of the 2013 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 25 and September 28, 2013. Within each lake, samples were collected at approximately 1 m depth over the deepest part of the lake. At the deepest lake sites (Doris Lake North, Doris Lake South, and Reference Lake B), samples were collected both at approximately 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 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 trigger the bottle shut and to ensure the collection of discrete samples. At Little Roberts Lake, there was very little water (20 cm) under the ice layer during sampling in April 2013. The augering process disturbed the sediments at this site, and the water samples collected were noted as being very turbid and full of re-suspended sediments. As a result, the samples collected at Little Roberts Lake in April 2013 were not considered representative of the actual winter water quality at this site. Analytical results of water quality at Little Roberts Lake in April 2013 are included in Appendix A, but are not included in any report graphs, discussion, or statistical analyses.

During summer and fall sampling, water samples were collected using an acid-washed 5 L GO-FLO sampling bottle. The GO-FLO was securely attached to a metred cable line and was lowered to the appropriate sampling depth. It was then triggered closed using a brass messenger and brought aboard the boat for subsampling. Each GO-FLO cast represented one replicate sample.

Subsamples for the various water quality components (e.g., physical variables/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 analysis as described for stream water quality samples. The variables 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 variables. 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 samples. A set of travel, field, and equipment blanks (~20% of total samples) was also processed during each trip 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 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 2013. This sampling coincided with benthic invertebrate sampling. Sampling dates and depths for all sites are presented in Table 2.2-4 and the analyzed variables are summarized in Table 2.2-5. 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, 2013

Habitat	Site	Sampling Date	Depth (m)
Stream	Doris Outflow	19-Aug-13	NA
	Roberts Outflow	16-Aug-13	NA
	Little Roberts Outflow	17-Aug-13	NA
	Reference B Outflow	22-Aug-13	NA
	Reference D Outflow	17-Aug-13	NA
Lake	Doris Lake North	21-Aug-13	13.5
	Doris Lake South	20-Aug-13	10.0
	Little Roberts Lake	21-Aug-13	2.2
	Reference Lake B	18-Aug-13	10.2
	Reference Lake D	20-Aug-13	1.3
Marine	RBE (Roberts Bay)	14,16-Aug-13	0.5
	RBW (Roberts Bay)	14-Aug-13	4.5
	REF-Marine-1 (Ida Bay)	15-Aug-13	6.0

NA - not applicable

2.2.3.1 Streams

Three replicate sediment samples were collected at each stream site. At each site, a replicate sample was a 1 L composite of several spoonfuls (plastic) of sediments, with replicates collected three times the channel width apart from each other whenever possible. 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.

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 variables that were analyzed and their corresponding detection limits.

Table 2.2-5. AEMP Sediment Quality Variables and Realized Detection Limits, Doris North Project, August 2013

		Realized Detection Limit				Realized Detection Limit	
Variable	**Units**	**Freshwater**	**Marine**	**Variable**	**Units**	**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	5.0	5.0
Organic Carbon				Magnesium (Mg)	mg/kg	20	20
Total Organic Carbon	%	0.1	0.1	Manganese (Mn)	mg/kg	1.0	1.0
				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
				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	1.0 or 4.0	1.0 or 4.0	Silver (Ag)	mg/kg	0.1	0.1
Available Nitrite-N	mg/kg	0.4 or 0.8	0.4 or 0.8	Sodium (Na)	mg/kg	100	100
Available Phosphate-P	mg/kg	2.0 or 4.0	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	2.0	2.0
Antimony (Sb)	mg/kg	0.1	0.1	Titanium (Ti)	mg/kg	1.0	1.0
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 approximately 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. 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. 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 variables that were analyzed and their corresponding detection limits.

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 approximately 5 to 20 m apart. The sampling depths are provided in Table 2.2-4. Each sediment sample was carefully transferred onto a tray, and the top 2 to 3 cm of sediment was scraped into two Whirl-Pak bags: one for particle size, and one for sediment chemistry. 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 variables 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 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, 2013

Stream Site	Installation Date	Retrieval Date
Doris Outflow	12-Jun-13	17-Jul-13
	17-Jul-13	19-Aug-13
	19-Aug-13	18-Sep-13
Roberts Outflow	13-Jun-13	18-Jul-13
	18-Jul-13	16-Aug-13
	16-Aug-13	17-Sep-13
Little Roberts Outflow	12-Jun-13	18-Jul-13
	18-Jul-13	17-Aug-13
	17-Aug-13	17-Sep-13
Reference B Outflow	13-Jun-13	19-Jul-13
	19-Jul-13	22-Aug-13
	22-Aug-13	23-Sep-13
Reference D Outflow	13-Jun-13	18-Jul-13
	18-Jul-13	17-Aug-13
	17-Aug-13	18-Sep-13

The samplers were 10 cm × 10 cm Plexiglas® plates that were affixed to rocks with fishing line and placed in the stream such that they remained submerged until retrieval. Overall, six 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 whenever possible.

Upon collection, the sample plates were scraped using a razor blade, and rinsed into a 500 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 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 approximately 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 approximately 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 sampling information and the volume of water filtered. The filters were kept frozen until they were sent to ALS Burnaby for analysis.

At Little Roberts Lake, there was very little water (20 cm) under the ice layer during under-ice sampling in April 2013. The augering process disturbed the sediments at this site, and the water collected was noted as being very turbid and full of re-suspended sediments. As a result, the phytoplankton biomass samples collected at Little Roberts Lake in April 2013 were not considered representative of the actual winter biomass at this site. Phytoplankton biomass results for Little Roberts Lake in April 2013 are included in Appendix A, but are not included in any report graphs, discussion, or statistical analyses.

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 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 2013. This coincided with the sediment quality sampling. Sampling dates and depths for all sites are presented in Table 2.2-4 and 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 AEMP streams from August 16 to August 22, 2013. To comply with EEM requirements, three separate subsamples were collected and pooled for each replicate sample, and five replicates were collected at each site. 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 whenever possible.

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%. 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. Immature organisms that were not identifiable to the family level (oligochaete cocoons, and trichopteran pupa) and taxonomic groups that made up a minor proportion of the total assemblage and were not identifiable to the family level (microturbellarians) were excluded from the community analysis. Organisms belonging to the groups Hydracarina and Ostracoda were not identifiable to family, but made a significant contribution to the benthic assemblage, so these groups were included at the next highest taxonomic category. 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 × 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:

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

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

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

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:

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

where BC is the Bray-Curtis distance between sites 1 and 2, *n* 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, 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 and Doris Lake South, 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 2013 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 AEMP lakes from August 18 to August 21, 2013. Like streams, 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 approximately 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. 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%. 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 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 at the two sites in Roberts Bay (RBW and RBE) and at the reference site in Ida Bay (REF-Marine 1) between August 14 and 16, 2013. Samples were collected with a Petite Ponar grab sampler (surface sampling area of 0.023 m^2). Five replicates were collected approximately 5 to 20 m apart at each site, with each replicate consisting of three pooled grab samples. At RBE, the substrate was hard and sandy and Petite Ponar grabs yielded very little sediment, so the method was modified at this site. Several (more than three) grab samples were collected at RBE until the sediment volume collected was comparable to the sediment volume of replicates collected at the other marine sites (~3 L). 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%. Benthos samples were sent to Columbia Science (Courtney, BC) for enumeration and identification. Benthos counts were normalized to three times the surface area of the of the Petite Ponar sampler (i.e., $3 \times 0.023\ m^2$) 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. Nematodes and harpacticoid copepods were excluded from the calculations of community metrics as these groups 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. Immature organisms that were not identifiable to the family level (unidentified invertebrate egg cases) and taxonomic groups that were not identifiable to the family level (e.g., foramniferans, ostracods, amphipods, etc.) 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. 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 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 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 2013 data to determine whether there were adverse changes to the aquatic environment that could be directly attributed to 2013 Project activities. Data from 2010, 2011, and 2012 were not included in the baseline years of the evaluation of effects because Project construction began in 2010. The only exception to this was for the evaluation of under-ice dissolved oxygen concentrations in lake and marine sites; 2010 was considered a baseline year for this assessment for reasons described below.

2.3.1 Variables Subjected to Evaluation

Table 2.3-1 presents the physical, chemical, and biological variables that were evaluated for 2013. Water quality variables 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 variables. As per the MMER and EEM requirements, the benthic invertebrate community and associated sediment variables (sediment particle size and total organic carbon content) were evaluated. Additional sediment variables 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. Variables Subjected to Effects Analysis, Doris North Project, 2013

Category	Variable
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 Variables[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 Variables[b]	Dissolved Oxygen[d]
	Secchi Depth
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] Variables regulated as deleterious substances as per Schedule 4 of the MMER
[b] Variables required for effluent characterization and water quality monitoring as per Schedule 5 of the MMER
[c] Variables required as part of the benthic invertebrate surveys as per Schedule 5 of the MMER
[d] Variables 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 2013.

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 2013 data.

The approaches used to assemble the appropriate baseline datasets and to determine whether there were any effects on evaluated variables in 2013 are discussed below. Key determining factors for the inclusion of baseline data included the proximity of baseline sampling sites to 2013 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, 2012, 2013), RL&L Environmental Services Ltd. and Golder Associates Ltd. (2003a, 2003b), and Golder Associates Ltd. (2005, 2006, 2007, 2008, 2009). Full details of the rationale used in the selection of baseline data that could be used for comparison with the 2013 data are provided in Appendix B.

All statistical analyses were run using R version 2.15.2. 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. A complete description of the statistical analyses used to assess the evaluated variables, including lists of outliers and detailed methodology and results, is presented in Appendix B.

2.3.2.1 Under-ice Dissolved Oxygen

<u>Data Selection</u>

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 2013.

Ice cover usually forms in October or November in the Doris North region, and remains until June or July of the following year. Waterbodies in the Doris North area would not be exposed to any atmospheric inputs such as dust that could be generated by Project activities while they are covered in ice. Therefore, the under-ice water column that is profiled in April or May reflects activities from the previous year. For example, profiles collected in April 2010 reflect activities from 2009 rather than 2010. For this reason, profiles collected in the spring of 2010 are included in the baseline dataset despite 2010 being considered year 1 of construction.

Baseline (pre-2011) 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.

In the marine environment, baseline under-ice dissolved oxygen profiles were collected at RBE in 2006 and 2010, and at RBW in 2009 and 2010. No pre-2011 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 2013 had to be noticeably different from all available baseline years (pre-2011). For example, if 2013 dissolved oxygen levels were different from 2005, but similar to 2007, it was concluded that there were no 2013 Project effects at that exposure site. Dissolved oxygen concentrations and inter-annual trends at the reference sites were also considered in the evaluation of effects. Dissolved oxygen concentrations were compared against CCME guidelines for the protection of aquatic life (CCME 2013b) to determine if baseline or 2013 concentrations dropped below recommended levels.

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 2013 sampling locations. At least three years of baseline (pre-2010) Secchi depth data are available for Doris Lake South, Doris Lake North, 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. At site RBE, all Secchi depths measured in 2013 reached the bottom sediments, while at site RBW, all but one Secchi depth reached the bottom (Appendix A), indicating that water clarity was high and that the euphotic zone typically 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 2013, Secchi depth was not evaluated for the Roberts Bay sites RBW and RBE.

Effects Analysis

Annual mean Secchi depth graphs were used to compare before (pre-2010)-after (2013) 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 2013 was conducted. A mixed model ANOVA 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 (2013). 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. If the results of the before-after analysis indicated that the mean Secchi depth in 2013 was not significantly different from the baseline mean, it was concluded that there was no effect of 2013 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 2013 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 effect. The BACI analysis compares the before-after trend apparent at the exposure site with the before-after trend at a 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 2013 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. 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 2013 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.

2.3.2.3 Water Quality

<u>Data Selection</u>

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 2013 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 2013 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 (Rescan 2011) because the 1996-2000 sampling site was more than 1 km north of the 2010 Doris Lake South sampling site (Figure 2.3-1). In 2011, the Doris Lake South sampling site was moved into deeper water approximately 500 m away from the 1996-2000 sampling site, and has remained at this location for 2013 sampling. Therefore, these historical data were considered comparable to the 2013 water quality data and were included in the 2013 evaluation of effects for Doris Lake South.

<u>Effects Analysis</u>

All 18 evaluated water quality variables presented in Table 2.3-1 were screened against relevant CCME guidelines for the protection of freshwater and marine aquatic life (CCME 2013b). For each variable, a graph showing annual mean variable 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 2013 mean was conducted for each of the 18 evaluated variables (provided that baseline data were available). A mixed model ANOVA 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 (2013). 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 freshet or under-ice sampling) or *late* (i.e., July or later, which included open-water season sampling). If the results of the before-after analysis indicated that a 2013 variable mean was not significantly different from the baseline mean, it was concluded that there was no effect of 2013 Project activities on this variable, and no further statistical analysis results were discussed.

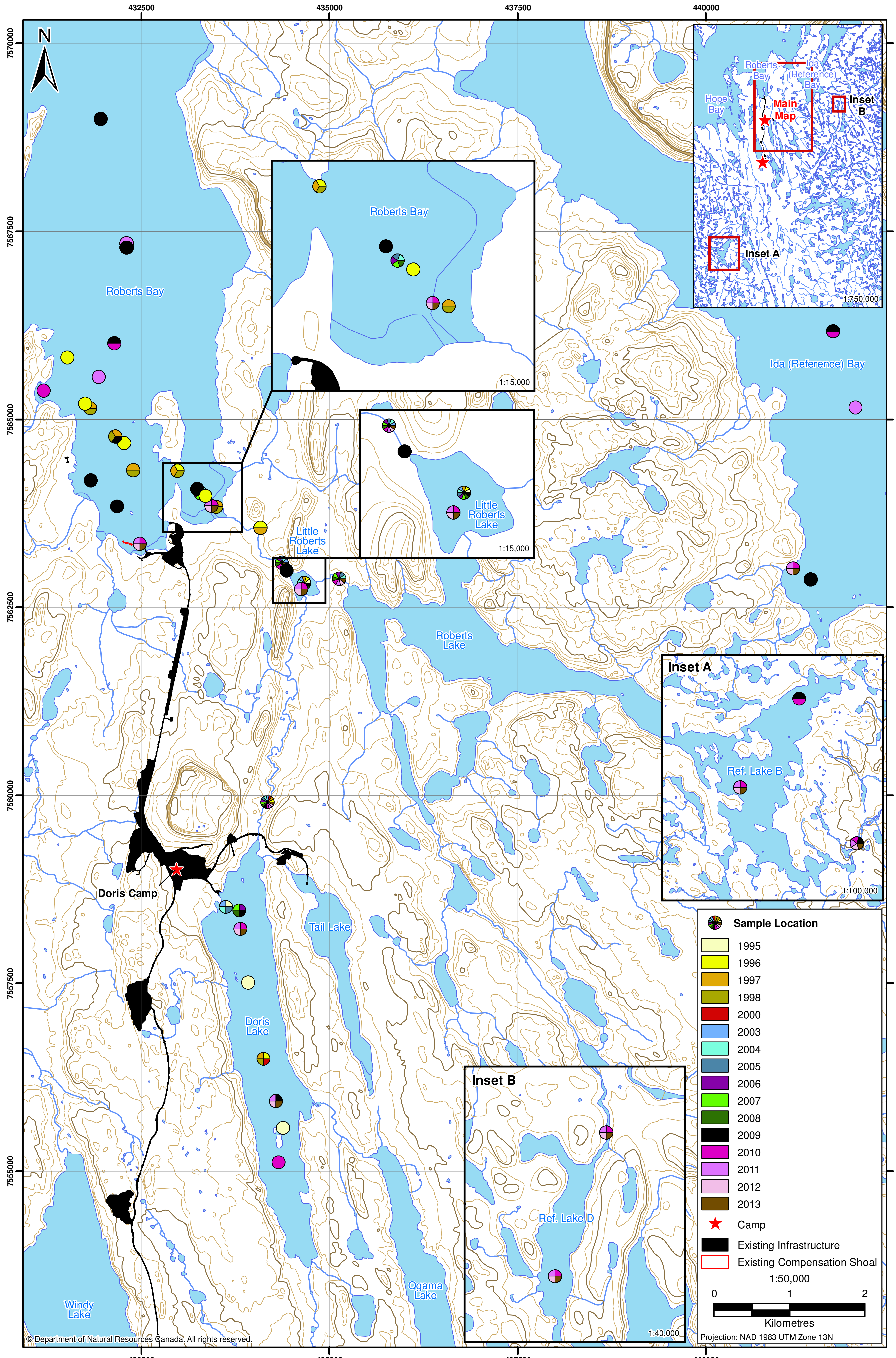

Figure 2.3-1

MAC RESOURCES

Historical Water Quality Sampling Stations in AEMP Waterbodies, Doris North Project, 1995-2013

Rescan an ERM company

If the before-after comparison revealed that a 2013 variable 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 variable 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 2013 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 variable that occurred at the exposure site also occurred at the reference site. 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 2013 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 variables, 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 variables, 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 2013 contributed some information on the year effect, which improved the precision of the BACI analysis.

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 variable mean regardless of sampling depth. For all effects analyses, statistical results were considered unreliable if > 70% of the values in the dataset for a variable 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. Similar results were obtained regardless of whether half the detection limit or the full detection limit was substituted for these censored values. The few instances where the substitution of half versus the full detection limit affected the conclusions of the effects assessment are discussed in the text. 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.

2.3.2.4 Sediment Quality

Data Selection

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 2013 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 2013 Doris Lake South data.

The selection of historical data was also based on the proximity of baseline sampling sites to the 2013 sites and the similarity of sampling techniques.

<u>Effects Analysis</u>

The nine sediment quality variables presented in Table 2.3-1 were evaluated using graphical analysis, before-after comparisons, and BACI analysis. All evaluated sediment quality variables were screened against relevant CCME guidelines for the protection of freshwater and marine aquatic life (CCME 2013a). Relevant CCME guidelines are included on effects analysis graphs, as well as in Appendix A.

Before-after comparisons were used to determine if mean 2013 concentrations of sediment quality variables differed from baseline means. A mixed model ANOVA 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 (2013). Each waterbody was treated independently and each variable was treated separately. If the results of the before-after analysis indicated that a 2013 variable mean was not significantly different from the baseline mean, it was concluded that there was no effect of 2013 Project activities on this variable 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, 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 variable 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 variables were not possible, and only before-after comparisons were performed.

The key effect of interest in this BACI design is the interaction effect. If exposure site variables 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).

For marine sediment quality variables, 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 variables, 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 analysis.

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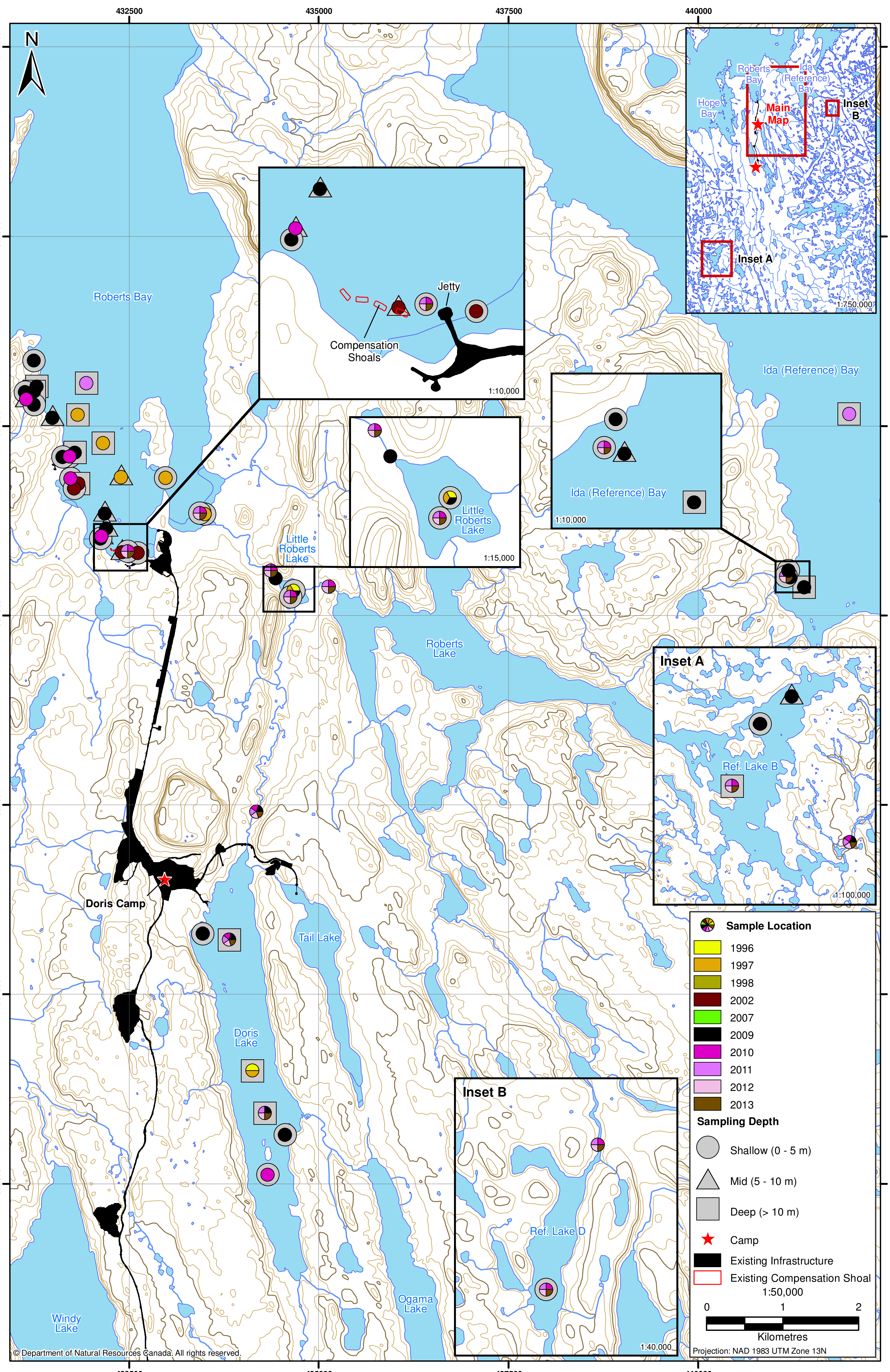

Figure 2.3-2

Historical Sediment Quality Sampling Stations in AEMP Waterbodies, Doris North Project, 1996-2013

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Like water quality, highly censored variables (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.

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 2013 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 2013). 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 2013 phytoplankton biomass and were included in the 2013 evaluation of effects for Doris Lake South.

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 2013 biomass mean was conducted (provided that baseline data were available). A mixed model ANOVA 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 (2013). 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. If the results of the before-after analysis indicated that the 2013 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 2013 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 2013 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. 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.

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 2013 contributed some information on the year-effect, which improved the precision of the BACI analysis.

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.

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. Starting in 2010, this approach was changed to accommodate the EEM methodologies as required under the Type A Water Licence for the Doris North Project. The 2010 to 2013 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), pre-2010 benthos data were not considered comparable to data collected from 2010 to 2013.

Effects Analysis

Because of methodological differences, no pre-construction benthos data are available for comparison against 2013 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 2013). Because of the limited data available, evidence of non-parallelism between 2010 and 2013 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.

For lake and marine benthos data, the 2010 to 2013 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 2013 trend for each exposure site was compared against the 2010 to 2013 trend obtained using data from both reference streams (Reference B Outflow and Reference D Outflow) for the impact level-by-time analysis.

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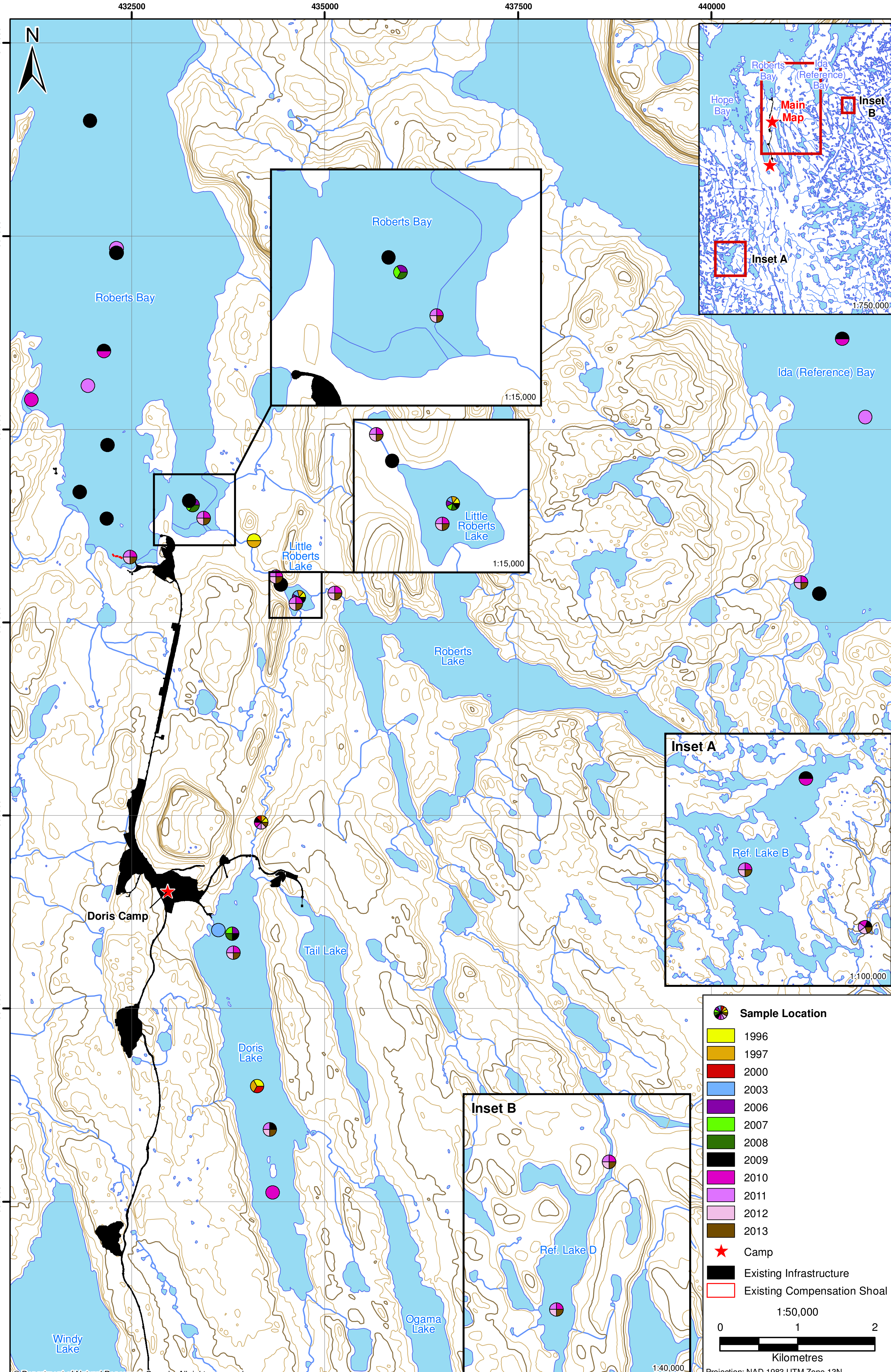

Figure 2.3-3

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Historical Phytoplankton and Periphyton Sampling Stations in AEMP Waterbodies, Doris North Project, 1996-2013

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Figure 2.3-3

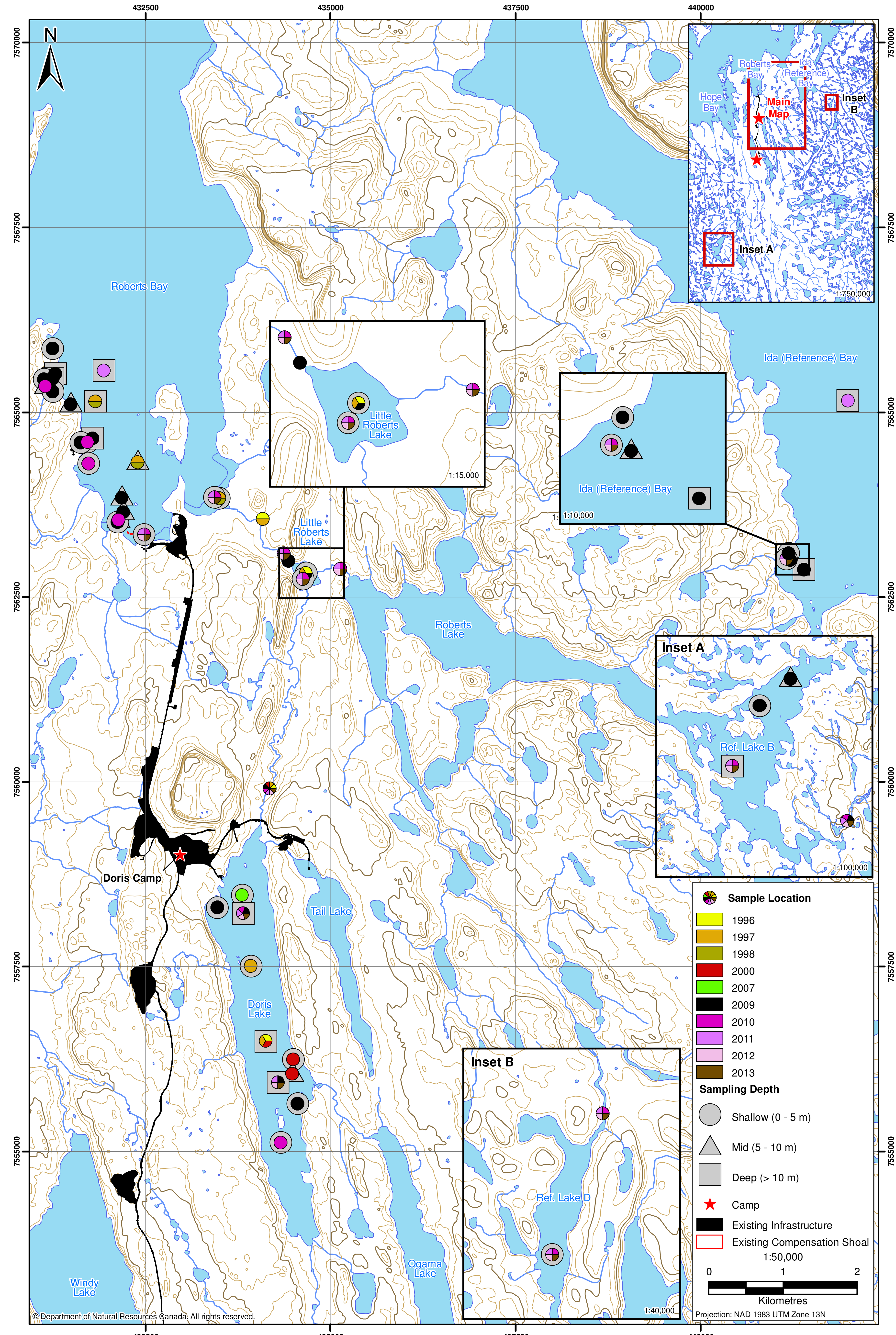

Figure 2.3-4

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Historical Benthic Invertebrate Sampling Stations in AEMP Waterbodies, Doris North Project, 1996-2013

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3. Evaluation of Effects

3. Evaluation of Effects

3.1 UNDER-ICE DISSOLVED OXYGEN

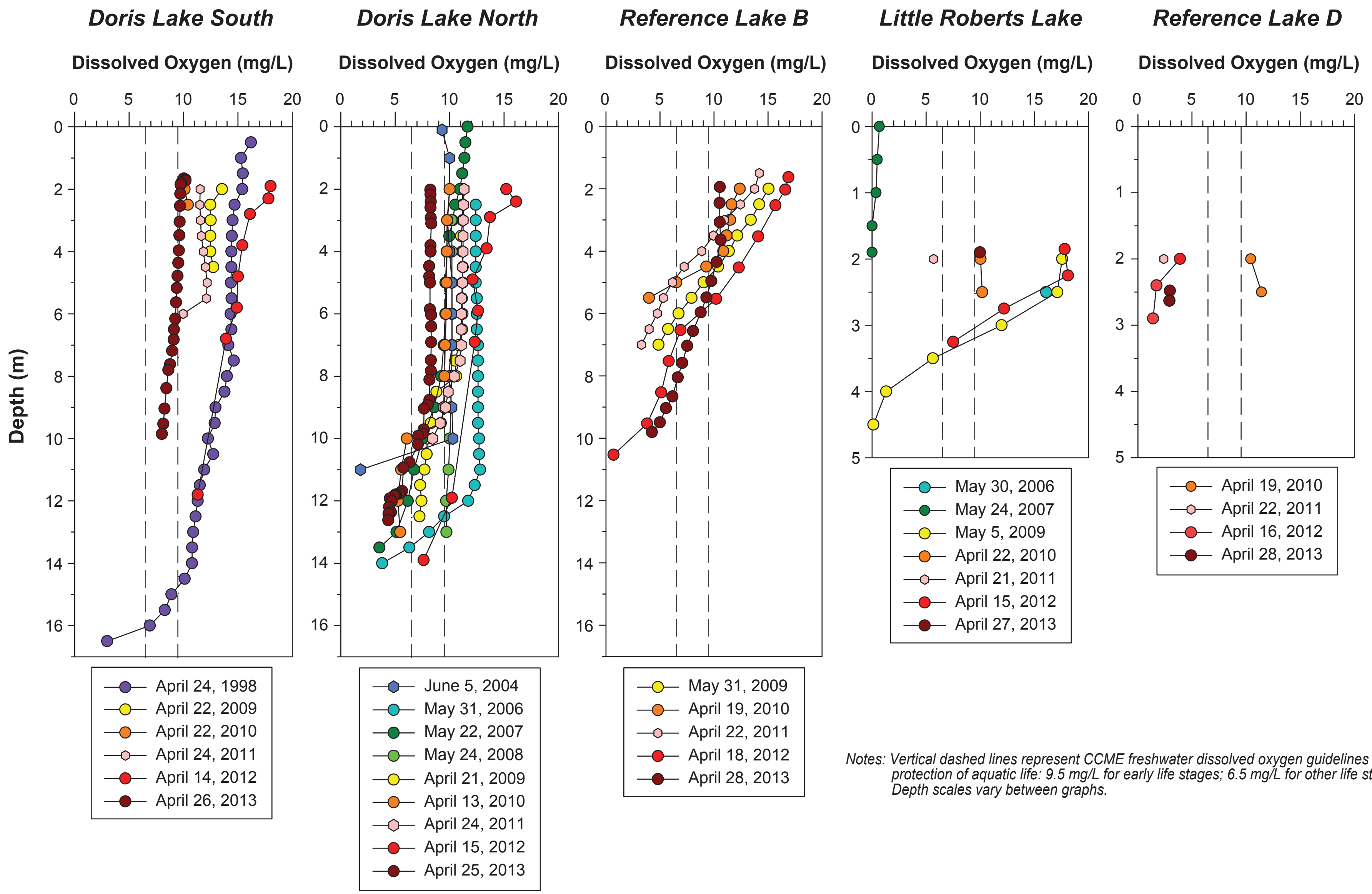
Potential effects on lake and marine dissolved oxygen concentrations were evaluated using under-ice dissolved oxygen concentrations, since concentrations are lowest during this period and pose the greatest concern for aquatic life. Minimum oxygen levels are required for critical life stages of fish and other freshwater and marine organisms (CCME 2013b). Ice cover usually forms in October or November in the Doris North region, and under-ice oxygen profiles were collected in April 2013. The formation of the ice cover in November 2012 isolated lakes, streams, and Roberts Bay from any atmospheric inputs such as dust that could have been generated by Project activities between November 2012 and June/July 2013. Therefore, the water column that was profiled in April 2013 reflects activities from 2012 rather than 2013.

Figures 3.1-1 and 3.1-2 present the 2013 and historical under-ice dissolved oxygen profiles for the lake and marine AEMP sites. 2013 under-ice profiles were collected in late April, and historical under-ice profiles were collected between late April and early June.

3.1.1 Lakes

The 2013 under-ice dissolved oxygen concentrations in Doris Lake North and South were slightly lower than in previous years (including baseline and mine construction years). At both Doris Lake sites, dissolved oxygen concentrations in the uppermost 10 m of the water column dropped below the CCME guideline for cold-water, early life stages (9.5 mg/L). In the bottom waters of Doris Lake North, dissolved oxygen concentrations dropped below the cold-water guideline for other life stages (6.5 mg/L), which also occurred during some baseline years (Figure 3.1-1). In Reference Lake B, dissolved oxygen concentrations just below the ice were also slightly lower than previous years. As observed in Doris Lake North, dissolved oxygen concentrations in Reference Lake B dropped below 6.5 mg/L in deeper waters, which was consistent with historical observations for this lake (Figure 3.1-1). This dissolved oxygen decrease at depth is a common phenomenon in seasonally stratified lakes. The trends in under-ice dissolved oxygen concentrations observed in Doris Lake North and South were generally similar to the trend seen in Reference Lake B; hence, no adverse changes were detected.

Baseline winter dissolved oxygen concentrations varied widely in the shallow exposure site, Little Roberts Lake, between 2006 and 2010 (range: < 1 mg/L in May 2007 to 17.6 mg/L in May 2009; Figure 3.1-1). The 2013 concentration (10.0 mg/L) was above the CCME guideline for early life stages (9.5 mg/L) and fell within the wide range of baseline measurements; therefore, no adverse changes to 2013 winter dissolved oxygen concentrations were apparent in Little Roberts Lake. In the shallow reference lake, Reference Lake D, under-ice dissolved oxygen concentrations also varied widely over time. Concentrations measured in April 2013 (2.9 and 3.0 mg/L) were below the CCME cold-water guideline for non-early life stages (6.5 mg/L). 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.



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.

Figure 3.1-1

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Winter Dissolved Oxygen Concentrations at AEMP Lake Sites, Doris North Project, 1998 to 2013

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Figure 3.1-1

3.1.2 Marine

The 2013 under-ice dissolved oxygen concentrations were similar at both of the marine exposure sites RBW and RBE, averaging 8.6 mg/L and 8.3 mg/L throughout the water column, respectively (Figure 3.1-2). These concentrations are 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). Baseline under-ice dissolved oxygen concentrations at the marine exposure sites were greater than 2013 concentrations; however, there are only two years of pre-2011 baseline data available for each site, so this could reflect natural inter-annual variability. The CTD malfunctioned at the reference site (REF-Marine 1) in April 2013; therefore, no reference site data are available for comparison to exposure site data. Dissolved oxygen concentrations at RBW and RBE in 2013 were similar to concentrations at both reference and exposure sites in 2012. There is no evidence of adverse effects on marine dissolved oxygen levels 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 2013 Project activities negatively affected lake water clarity. The results of statistical methods and analyses for the evaluation of effects for Secchi depth in lakes are provided in Appendix B.

The Secchi depth at the shallow marine sites RBE and RBW typically reached the bottom in 2013. At site RBE, all Secchi depths measured in 2013 reached the bottom sediments, while at site RBW, all but one Secchi depth reached the bottom (Appendix A), indicating that water clarity was high and that the euphotic zone typically extended throughout the entire water column. As water clarity at marine sites was high in 2013, Secchi depth was not evaluated for RBE and RBW.

3.2.1 Lakes

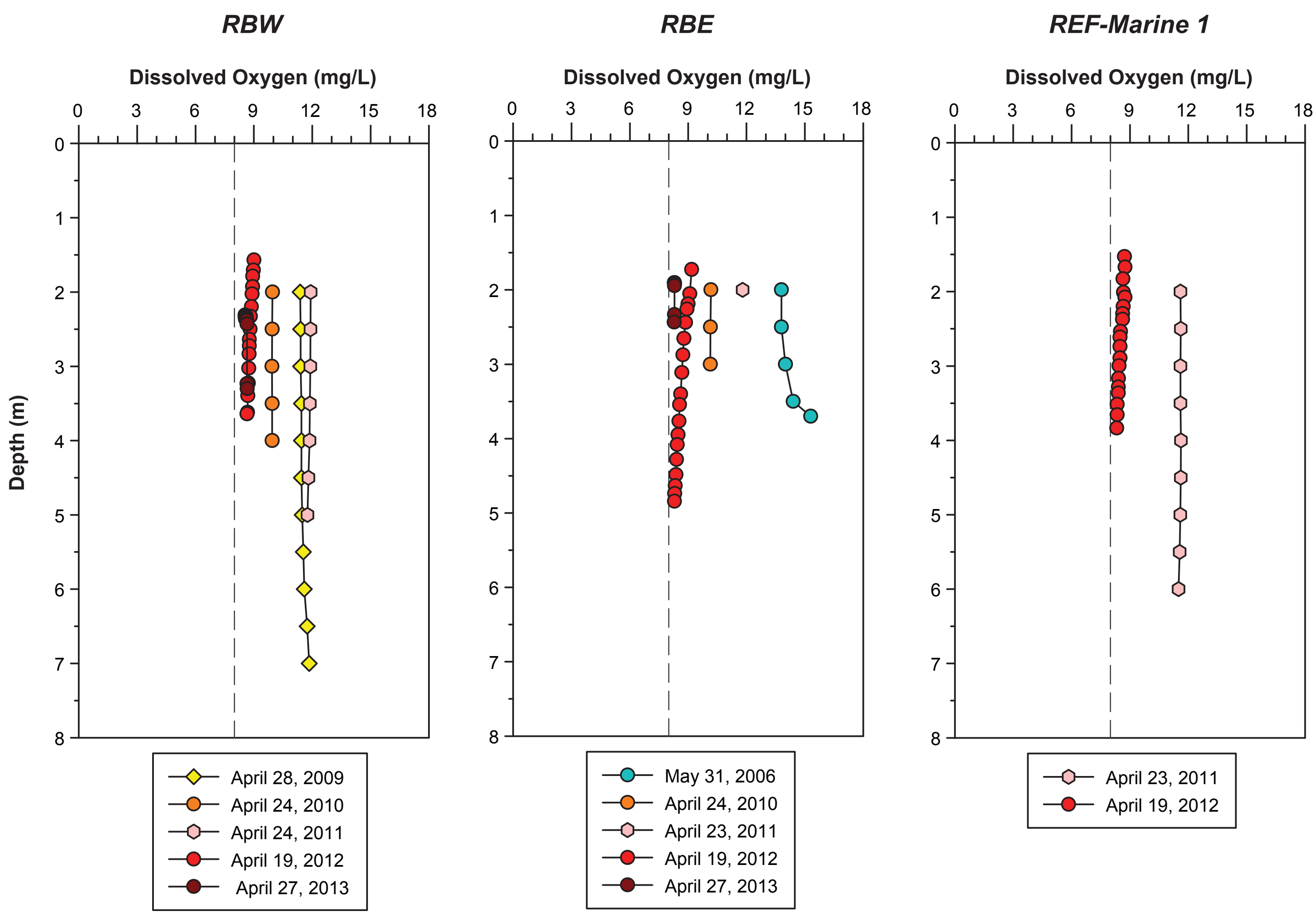
Figure 3.2-1 shows the mean annual Secchi depth at lakes sites between 1995 and 2013. Mean annual Secchi depth was similar among years and among exposure lakes, generally ranging between 1.0 and 2.1 m at Doris Lake South, Doris Lake North, and Little Roberts Lake. The Secchi depth recorded at Doris Lake South in August 2000 (4.2 m) was higher than in other years. Mean annual Secchi depths were generally higher at the reference lakes, ranging from 5.4 to 7.5 m in Reference Lake B and from 2.1 to 3.7 m in Reference Lake D.

Mean 2013 Secchi depths in the exposure lakes were within the range of baseline measurements. The before-after comparison confirmed that the baseline mean Secchi depth was not distinguishable from the 2013 mean Secchi depth for any exposure lake ($p = 0.68$ for Doris Lake South, $p = 0.27$ for Doris Lake North, and $p = 0.26$ for Little Roberts Lake). Therefore, there was no apparent effect of 2013 Project activities on lake Secchi depth.

3.3 WATER QUALITY

A specific set of water quality variables (see Table 2.3-1) was evaluated to determine whether 2013 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 variables 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 variables that were below analytical detection limits. The complete results of statistical methods and analyses are provided in Appendix B.

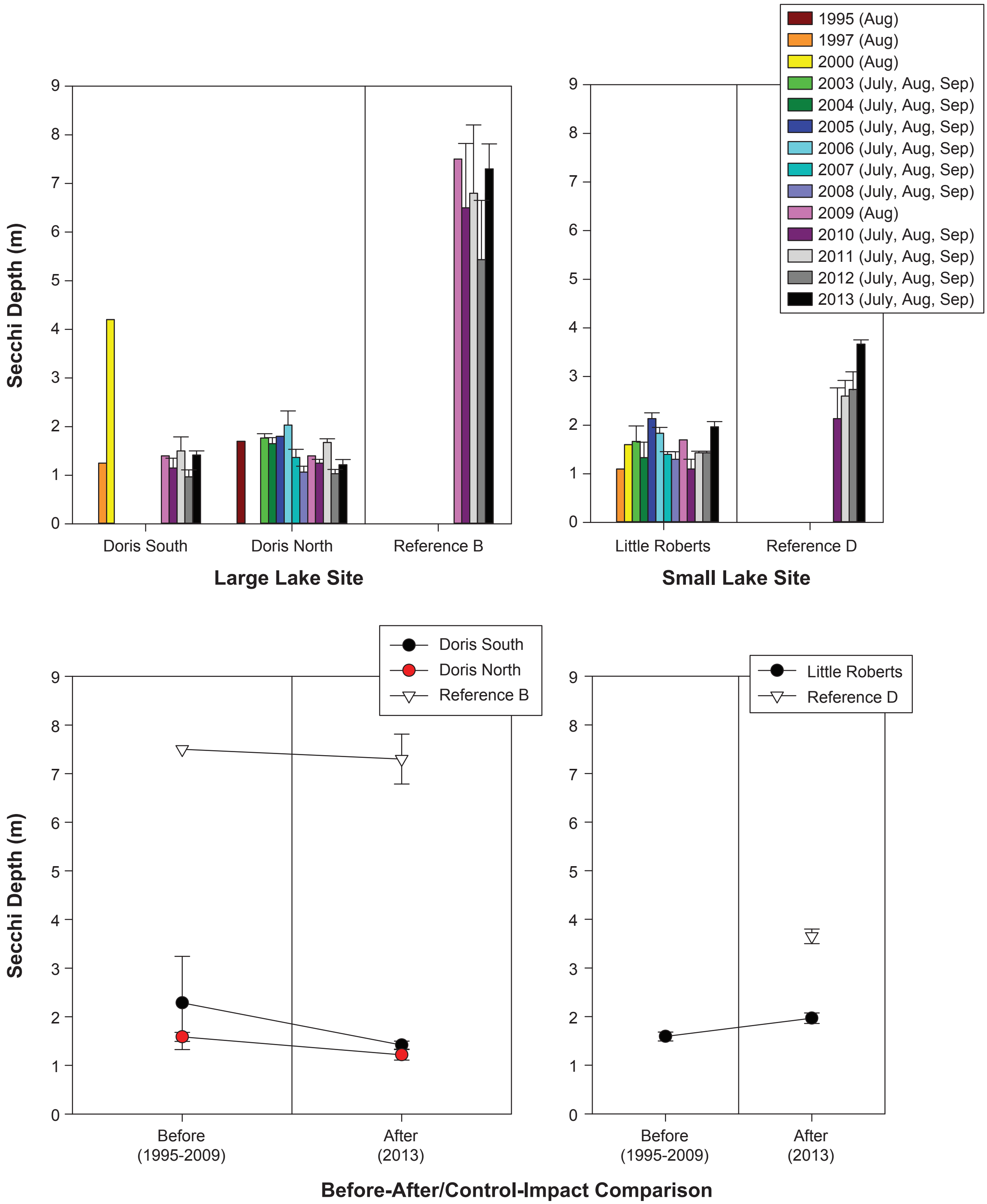


Notes: Vertical dashed lines represent the CCME interim guideline for the minimum concentration of dissolved oxygen in marine and estuarine waters (8.0 mg/L). Data not available for April 2013 at REF-Marine 1 due to CTD malfunction.

Figure 3.1-2

Winter Dissolved Oxygen Concentrations at AEMP Marine Sites, Doris North Project, 2006 to 2013

Figure 3.1-2



Notes: Error bars represent the standard error of the mean.
Bottom depth was used as an estimate of Secchi depth when Secchi depth reached the lake bottom.

Figure 3.2-1

Secchi Depth in AEMP Lake Sites, Doris North Project, 1995 to 2013

Water quality variables were compared to CCME water quality guidelines for the protection of aquatic life (CCME 2013b) 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 2013. 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. Statistical results are presented in Appendix B.

3.3.1.1 pH

pH is a required variable for water quality monitoring as per Schedule 5, s. 7(1)(c) of the MMER. Exposure stream pH levels measured in 2013 ranged from 7.2 to 7.7, while reference stream pH ranged from 7.1 to 7.5. Mean 2013 pH levels in the exposure streams 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 2013 mean pH in any exposure stream ($p = 0.38$ for Doris Outflow, $p = 0.33$ for Roberts Outflow, and $p = 0.36$ for Little Roberts Outflow). Therefore, there was no effect of 2013 Project activities on the pH of exposure streams. 2013 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

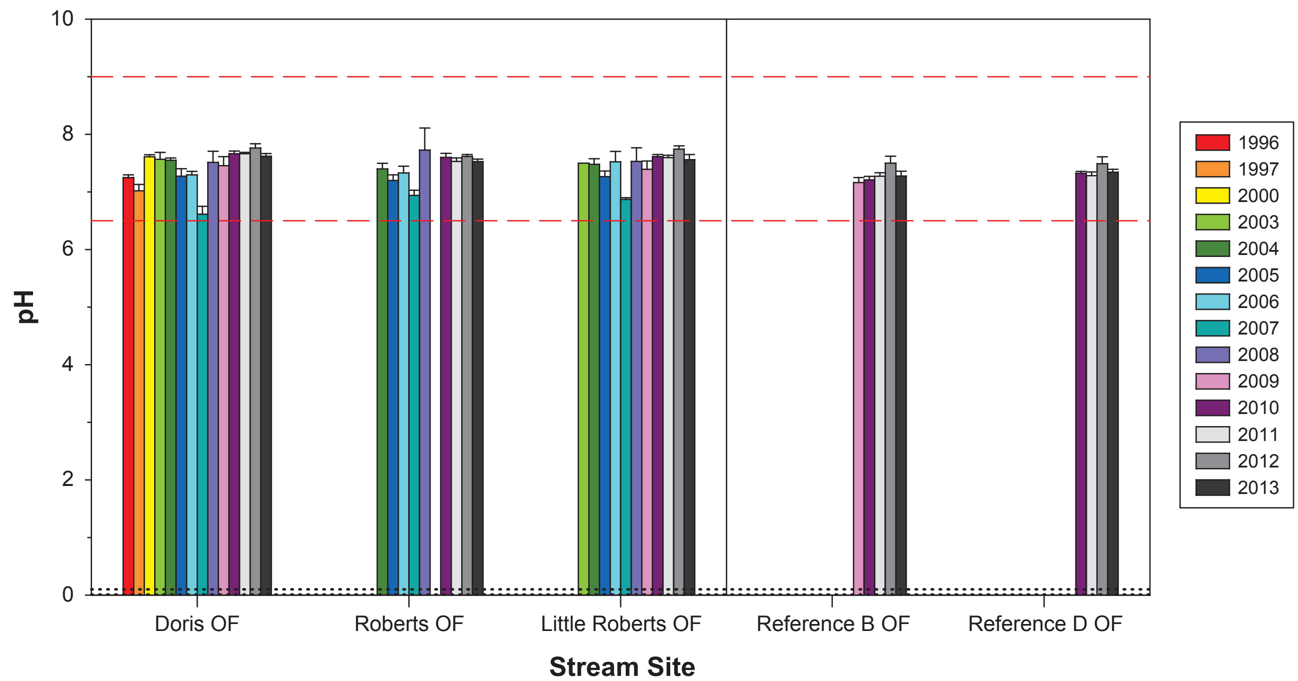
Total alkalinity is a required variable for effluent characterization and water quality monitoring as per Schedule 5, s. 4(1) and s. 7(1)(c) of the MMER. Total alkalinity (as CaCO3) varied among streams with consistently higher levels in the exposure streams than the reference streams (Figure 3.3-2). Mean 2013 alkalinity levels in exposure streams were slightly higher than mean alkalinity levels measured during baseline years; however, the before-after comparison determined that these slight increases were not statistically significant ($p = 0.20$ for Doris Outflow, $p = 0.028$ for Roberts Outflow, and $p = 0.62$ for Little Roberts Outflow). Mean alkalinity levels in Reference B Outflow in 2013 were also slightly higher than the baseline (2009) mean. There was no apparent effect of 2013 Project activities on exposure stream alkalinity.

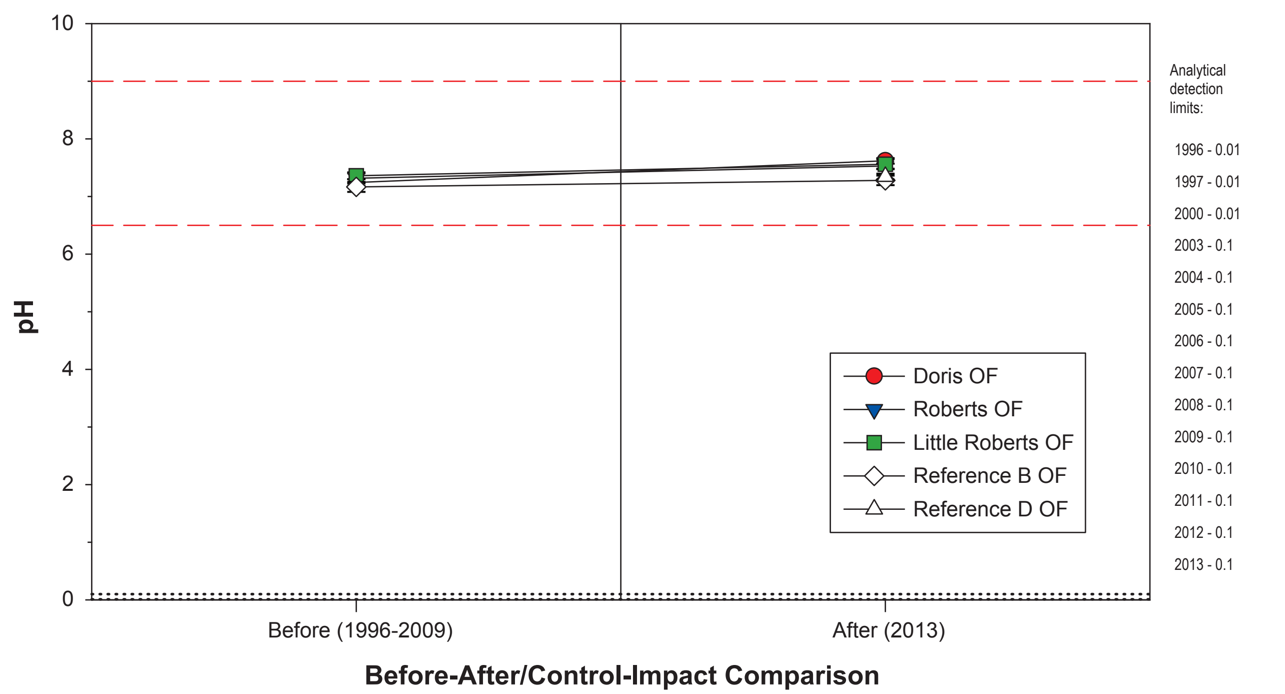
3.3.1.3 Hardness

Hardness is a required variable for effluent characterization and water quality monitoring as per Schedule 5, s. 4(1) and s. 7(1)(c) of the MMER. Mean annual hardness (as $CaCO_3$) varied among streams, but was relatively consistent within each stream over time (Figure 3.3-3). For each exposure stream, the before-after comparison indicated that the mean 2013 hardness was not distinguishable from the baseline mean ($p = 0.28$ for Doris Outflow, $p = 0.085$ for Roberts Outflow, and $p = 0.20$ for Little Roberts Outflow); therefore, there was no apparent effect of 2013 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.





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.

Figure 3.3-1

pH in AEMP Stream Sites, Doris North Project, 1996 to 2013

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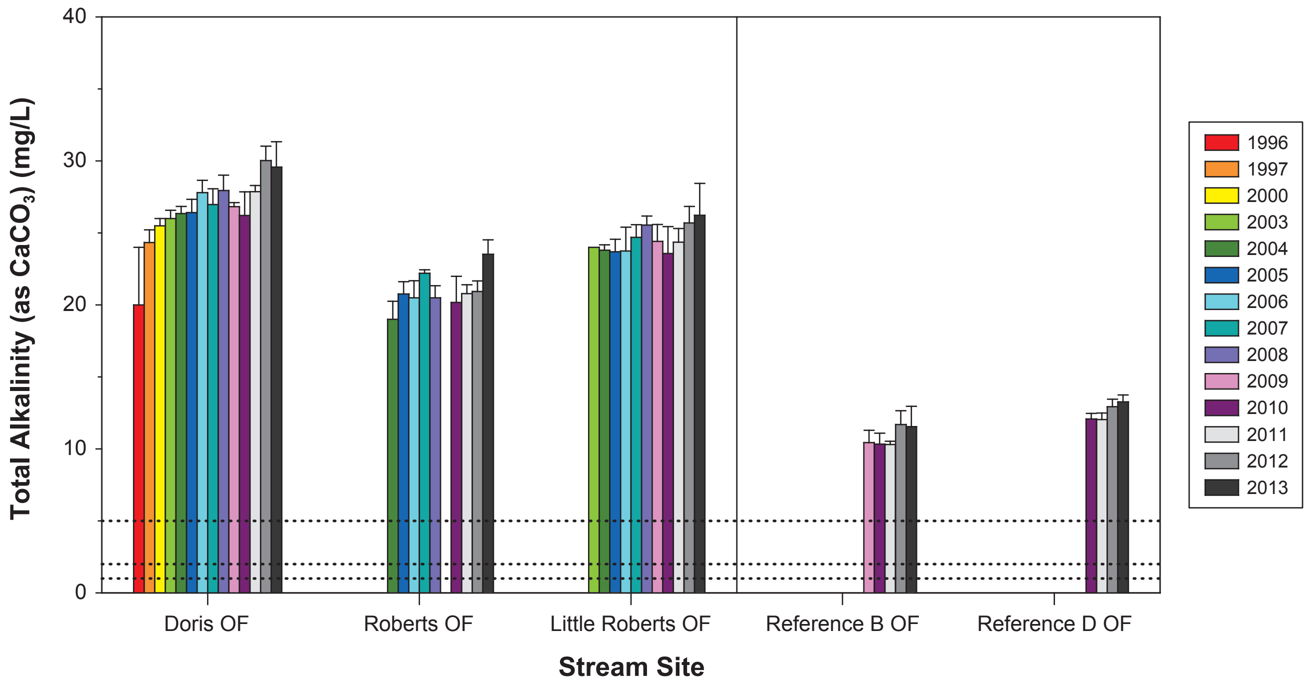

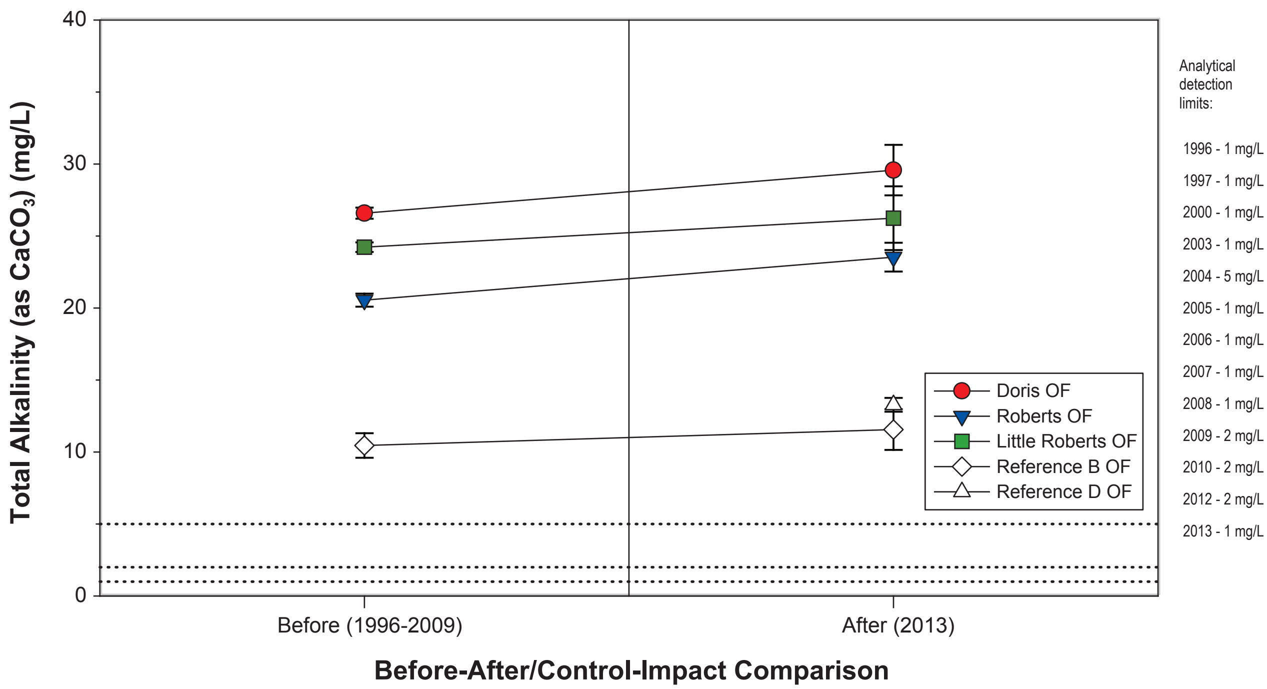

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
Total alkalinity is a required parameter for effluent characterization and water quality monitoring as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

Figure 3.3-2

Total Alkalinity in AEMP Stream Sites, Doris North Project, 1996 to 2013

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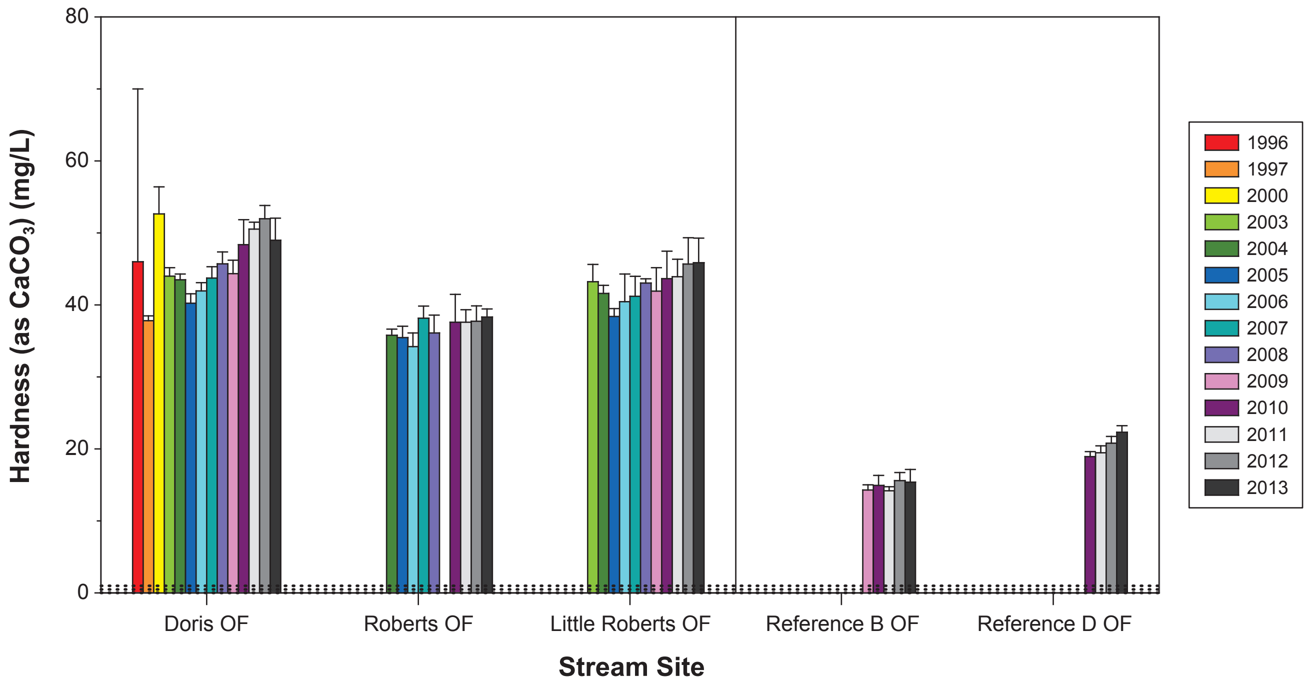

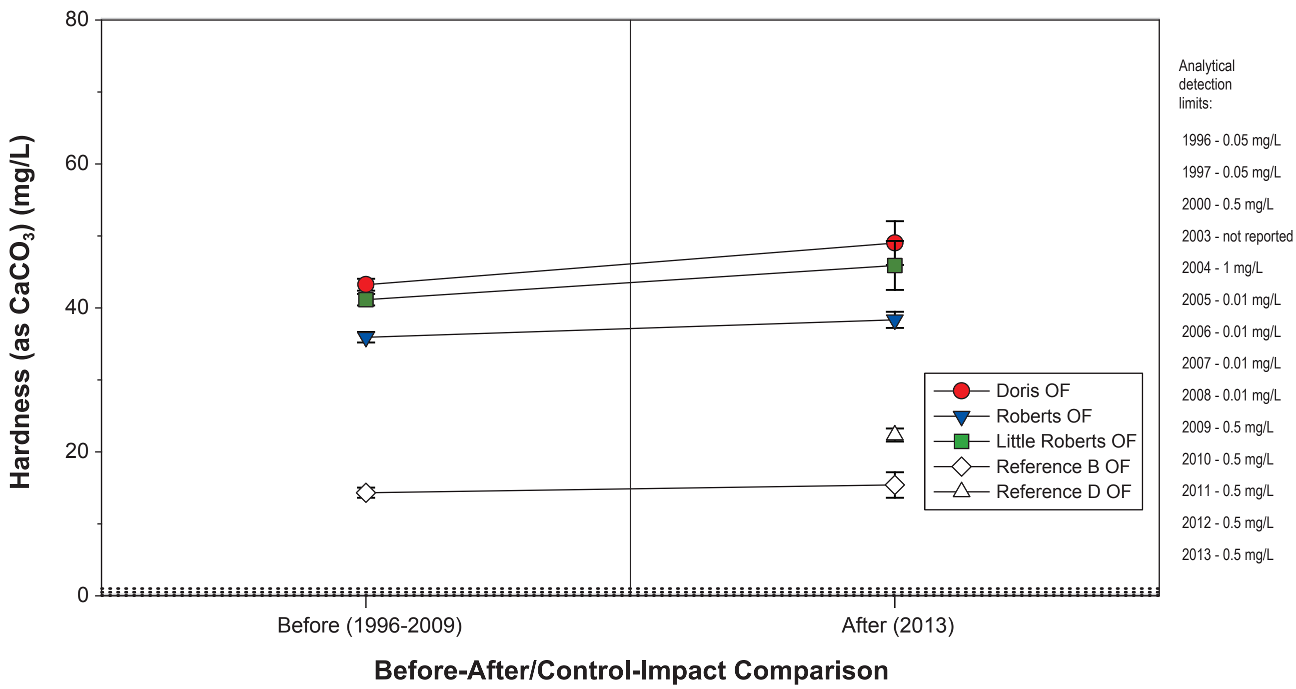

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits.
Hardness is a required parameter for effluent characterization and water quality monitoring as per Schedule 5, s. 4(1) and s. 7(1)(c) of the MMER.

Figure 3.3-3

Hardness in AEMP Stream Sites, Doris North Project, 1996 to 2013

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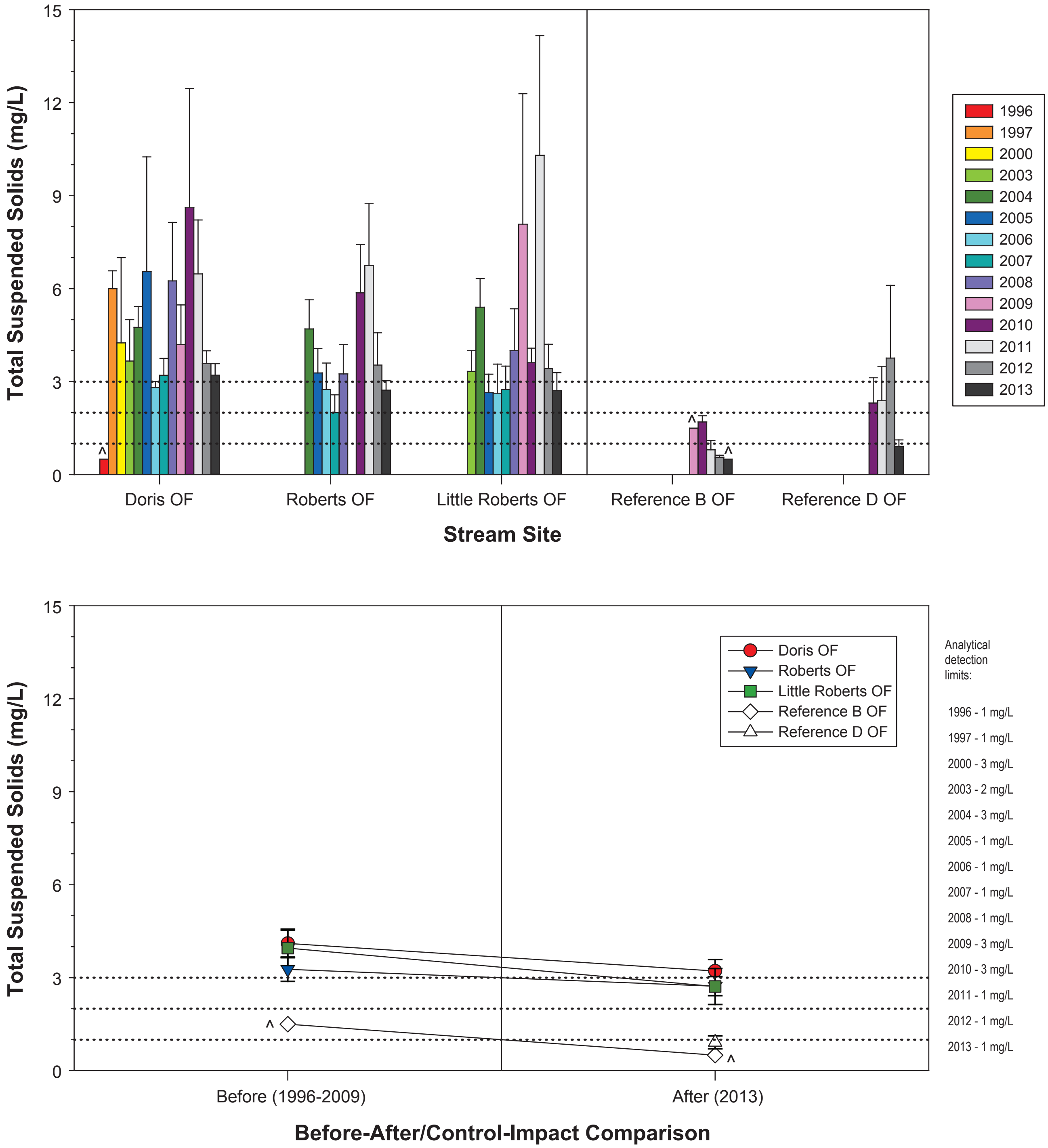

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
The CCME freshwater guideline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

Figure 3.3-4

Total Suspended Solids Concentration in AEMP Stream Sites, Doris North Project, 1996 to 2013

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The mean 2013 TSS concentrations in all three exposure streams were within the range of the baseline means (Figure 3.3-4), and there was no evidence of a difference between 2013 and baseline concentrations in any of the exposure streams ($p = 0.63$ for Doris Outflow, $p = 0.46$ for Roberts Outflow and $p = 0.21$ for Little Roberts Outflow). Therefore, there was no significant effect of 2013 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 2013b). Because there was no significant increase in TSS concentrations from baseline levels in Doris, Roberts or Little Roberts outflows, 2013 TSS concentrations in these streams were below the CCME guideline.

3.3.1.5 Total Ammonia

Total ammonia is a required variable for effluent characterization as per Schedule 5, s. 4(1) of the MMER. All 2013 concentrations of total ammonia in exposure and reference streams were well below the pH- and temperature-dependent CCME guideline (Figure 3.3-5). At Roberts and Little Roberts outflows, all 2013 total ammonia concentrations were below the detection limit of 0.005 mg ammonia-N/L; at Doris Outflow, the mean 2013 concentration of 0.008 mg ammonia-N/L was within the range of baseline means, suggesting that there was no effect of Project activities on ammonia concentrations (Figure 3.3-5). The before-after analysis confirmed that there was no difference between 2013 and baseline means in any exposure stream ($p = 0.77$ for Doris Outflow, $p = 0.14$ for Roberts Outflow, and $p = 0.23$ for Little Roberts Outflow).

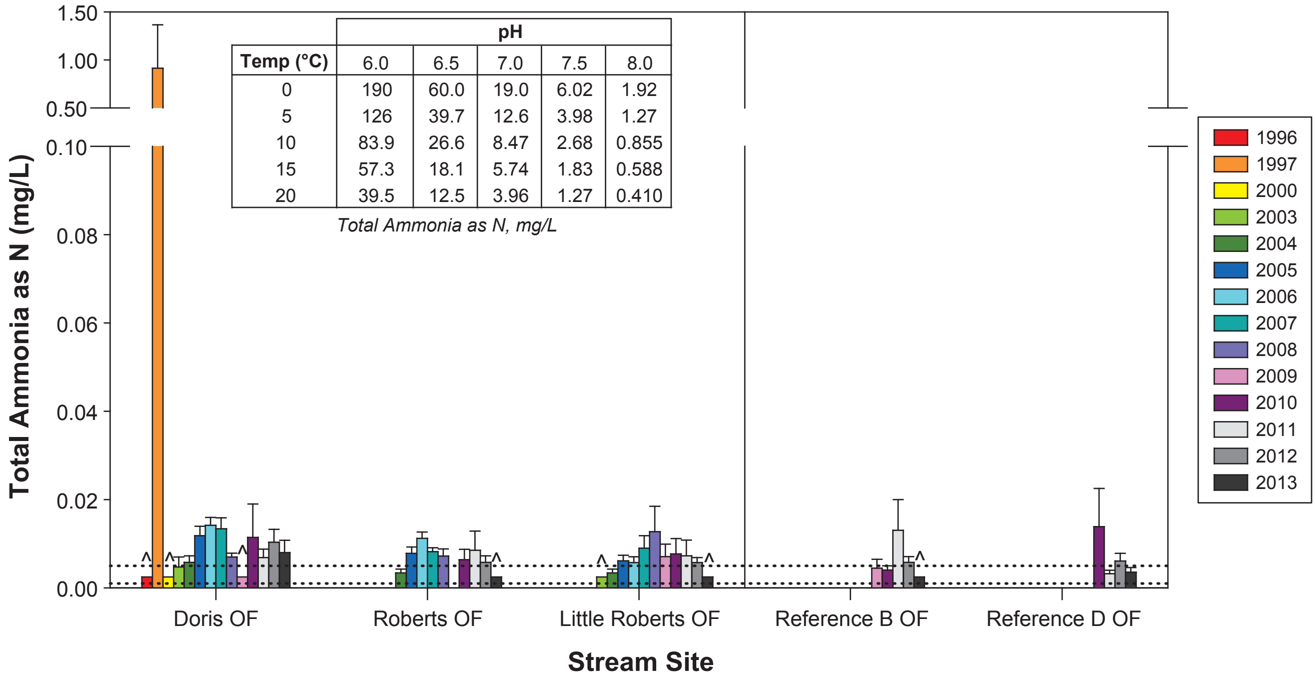
3.3.1.6 Nitrate

Nitrate is a required variable for effluent characterization as per Schedule 5, s. 4(1) of the MMER. All 2013 nitrate concentrations in exposure and reference streams were well below the CCME guideline of 3.0 mg nitrate-N/L (Figure 3.3-6). All 2013 nitrate concentrations measured at Roberts and Little Roberts outflows and the majority of 2013 concentrations measured at Doris Outflow were below the analytical detection limit of 0.005 mg nitrate-N/L. At Doris Outflow, the mean 2013 concentration of 0.0033 mg/L was within the range of baseline means, suggesting that there was no effect of Project activities on nitrate concentrations (Figure 3.3-6). Statistical results for the before-after analysis are not presented here because > 80% of nitrate concentrations in the datasets for each exposure stream were below analytical detection limits. The very low nitrate and ammonia concentrations in exposure streams in 2013 indicate that on-site management of surface waters and quarry rock was successful in keeping ammonium nitrate salt and residues out of surface waters.

3.3.1.7 Total Cyanide

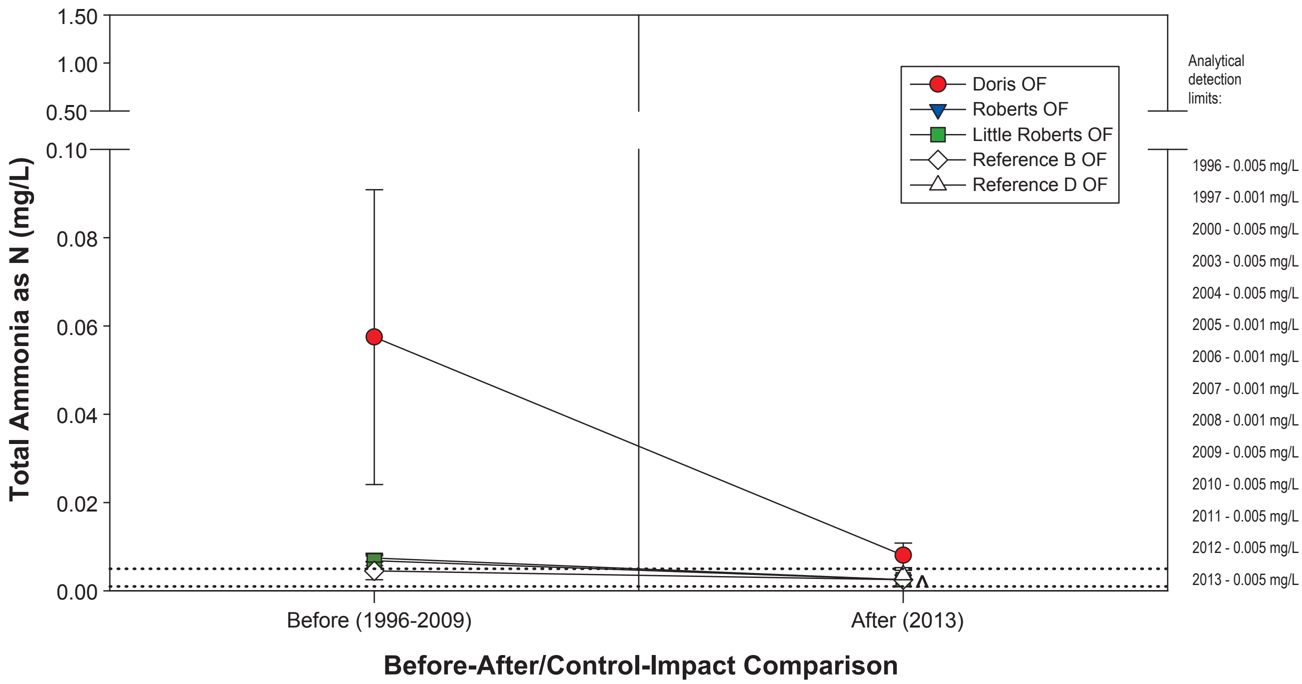
Total cyanide is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. All 2013 cyanide concentrations in exposure and reference streams were below the analytical detection limit of 0.001 mg/L (Figure 3.3-7). Therefore, there was no evidence of an effect of Project activities on total cyanide concentrations in the exposure streams.

Free cyanide concentrations (cyanide existing in the form of HCN and CN^-) in stream samples were also measured in 2013 to allow for direct comparisons with the CCME guideline (0.005 mg/L as free cyanide). The 2013 free cyanide concentrations in stream samples were always below the detection limit of 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 exposure streams.



	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.

Figure 3.3-5

Total Ammonia Concentration in AEMP Stream Sites, Doris North Project, 1996 to 2013

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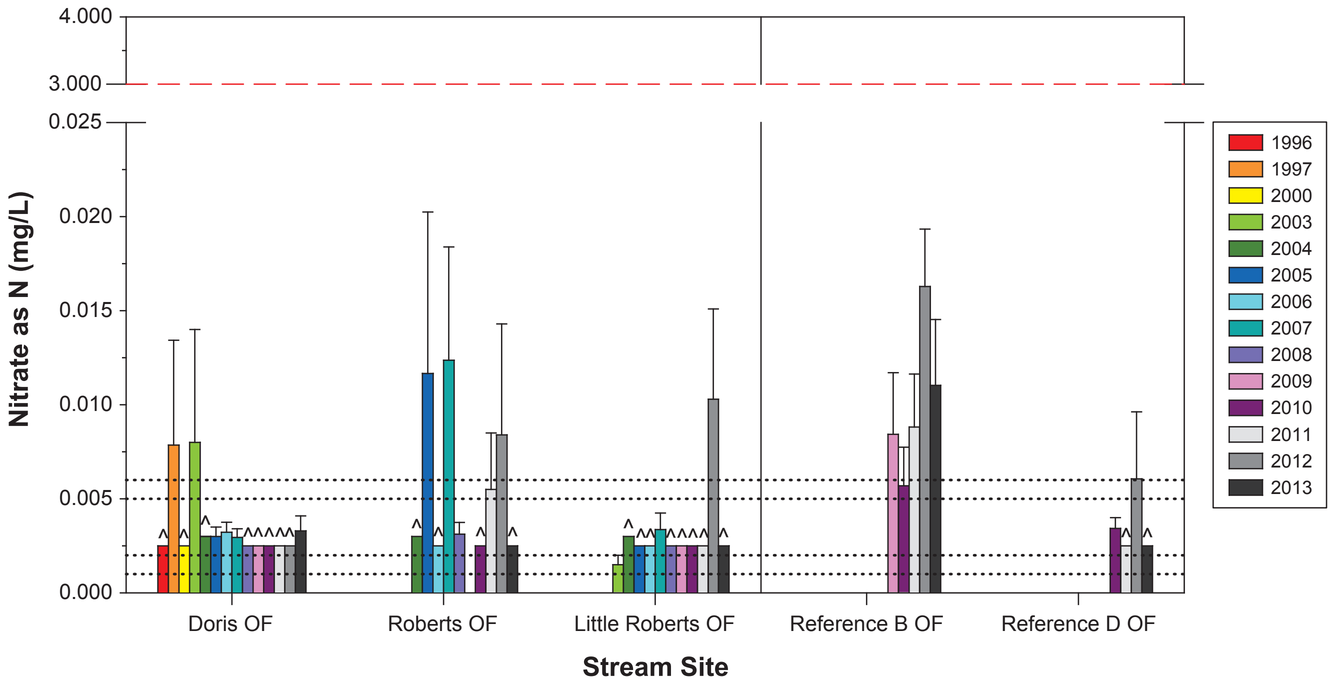
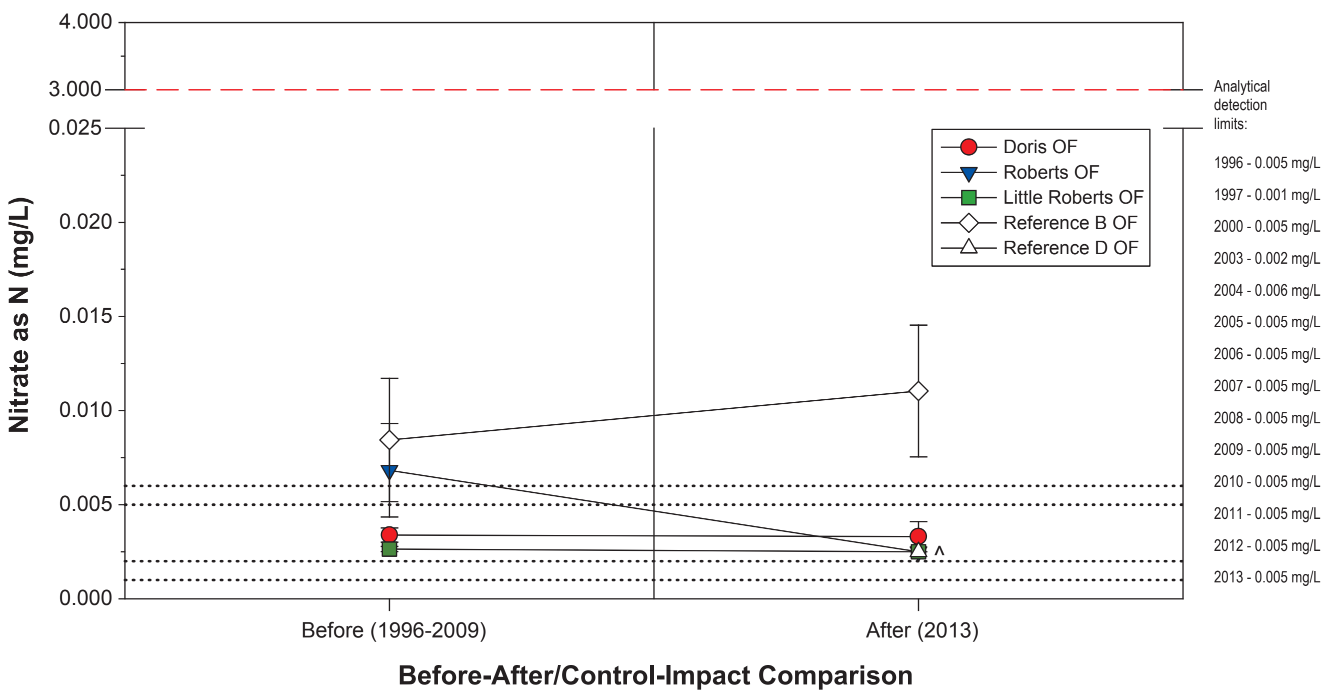
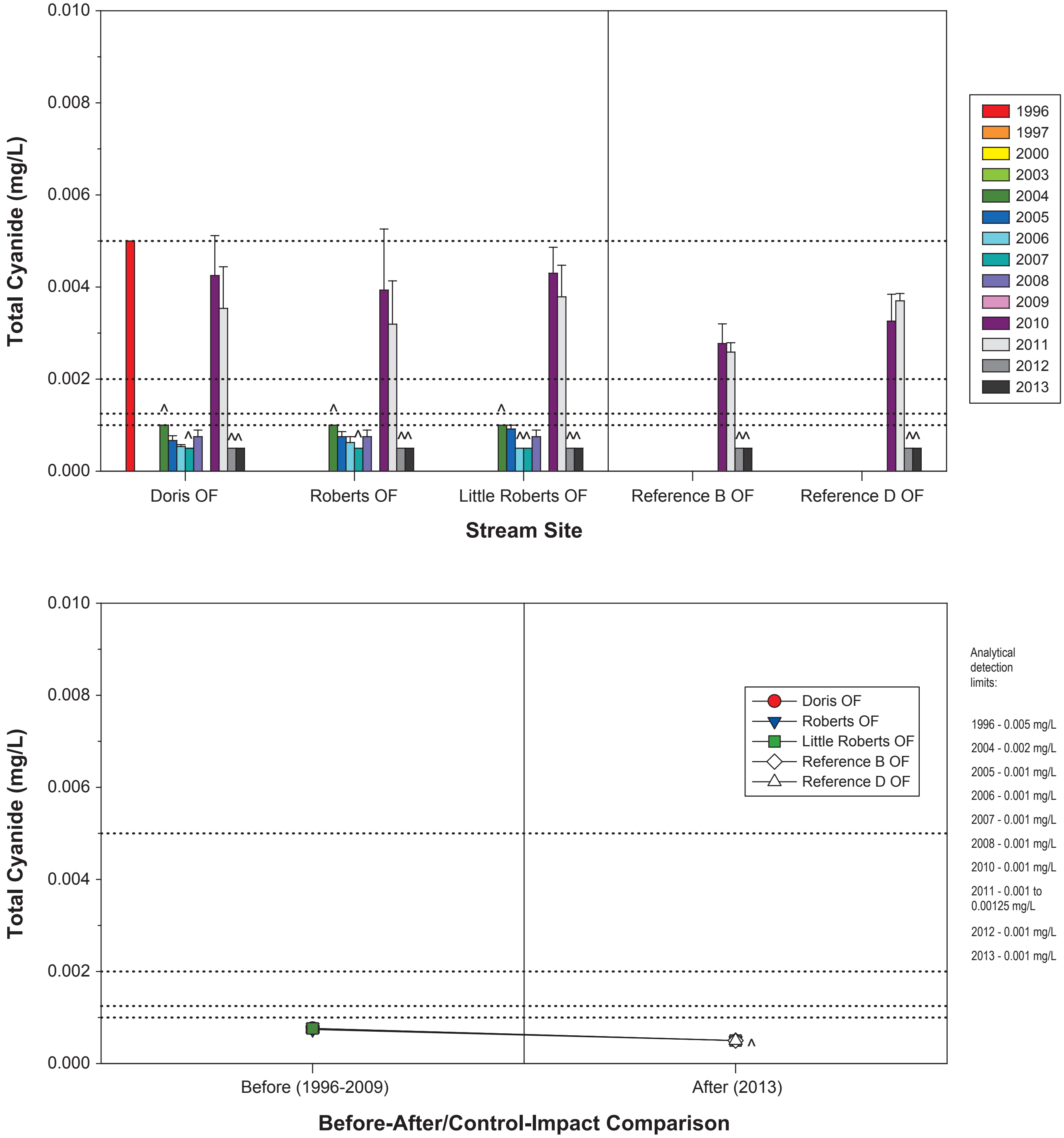




Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed line represents the CCME freshwater guideline for nitrate as N (3.0 mg/L; long-term concentration).
Nitrate is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

Figure 3.3-6

Nitrate Concentration in AEMP Stream Sites, Doris North Project, 1996 to 2013



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.

Figure 3.3-7

Total Cyanide Concentration in AEMP Stream Sites, Doris North Project, 1996 to 2013

3.3.1.8 Radium-226

Radium-226 is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. All 2013 radium-226 concentrations in exposure and reference streams were below the analytical detection limit of 0.01 Bq/L (Figure 3.3-8). Therefore, there was no evidence of an effect of Project activities on radium-226 concentrations in the exposure streams.

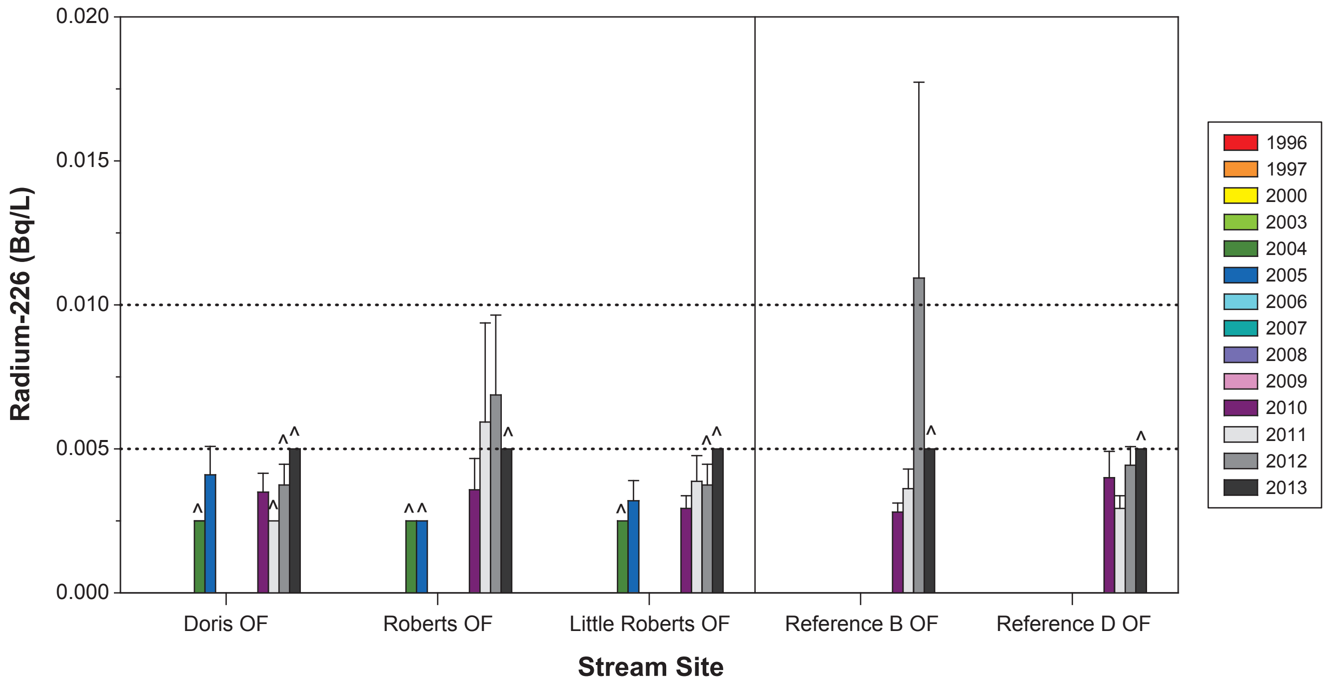
3.3.1.9 Total Aluminum

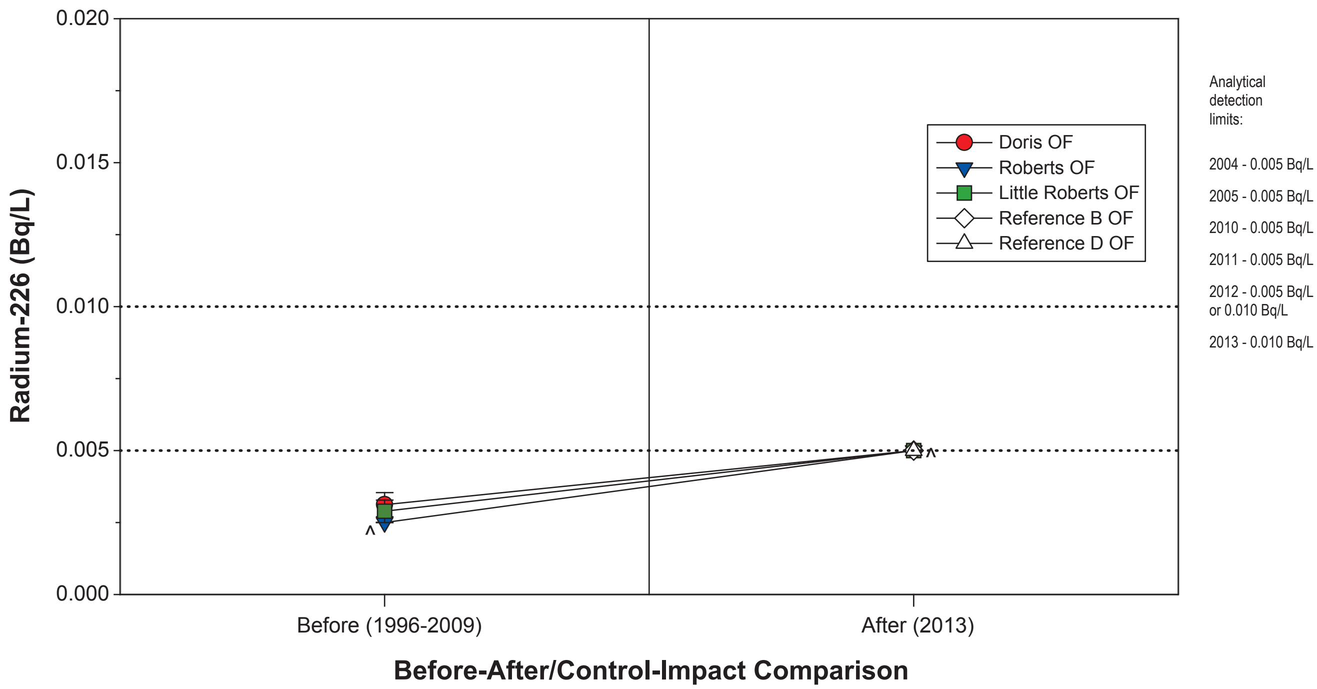
Total aluminum is a required variable for effluent characterization as per Schedule 5, s. 4(1) of the MMER. Total aluminum concentrations were variable among streams. Within each stream, there was also a large amount of inter-annual and seasonal variability. In all exposure and reference streams, mean 2013 concentrations were either the lowest or among the lowest in the historical dataset available for each stream. 2013 was a drier than average year (ERM Rescan 2014), so the magnitude of the freshet and associated flushing of terrestrial inputs would have been relatively low in 2013. Although mean 2013 concentrations in all streams were below the pH-dependent CCME guideline of 0.1 mg/L, total aluminum concentrations in a subset of samples collected in 2013 from Roberts, Little Roberts, and Reference D outflows were higher than the CCME guideline. However, this guideline was frequently exceeded in all exposure streams during baseline years, particularly in Roberts and Little Roberts outflows where nearly all mean baseline concentrations exceeded this guideline (Figure 3.3-9).

The before-after plot shows that mean 2013 total aluminum concentrations in all exposure streams were lower than baseline means (Figure 3.3-9). The before-after analysis revealed that the mean 2013 total aluminum concentration in Little Roberts Outflow was significantly different than the baseline mean ($p = 0.0051$); however, since the mean concentration decreased in 2013 compared to baseline years, the change is not of concern. Furthermore, the BACI analysis showed that a parallel change occurred in the reference streams ($p = 0.22$), so this change is likely a natural phenomenon. For the remaining exposure streams, the before-after analysis showed that mean 2013 total aluminum concentrations were not distinguishable from baseline means ($p = 0.36$ for Doris Outflow, and $p = 0.029$ for Roberts Outflow). Therefore, Project activities in 2013 did not negatively affect total aluminum concentrations in any exposure stream.

3.3.1.10 Total Arsenic

Total arsenic is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. Mean 2013 total arsenic concentrations in the exposure streams were more than an order of magnitude lower than the CCME guideline of 0.005 mg/L (Figure 3.3-10). Baseline arsenic concentrations in exposure streams were generally similar to or slightly higher than 2013 concentrations (Figure 3.3-10). The before-after comparison indicated that was a significant decrease in arsenic concentrations in Roberts Outflow in 2013 compared to baseline years ($p = 0.0074$); however, a decrease in arsenic concentrations is of no concern. The BACI analysis showed that a parallel change occurred in the reference streams ($p = 0.051$), so this change is likely a natural phenomenon. The before-after comparison showed that there was no significant change in mean arsenic concentrations between baseline years and 2013 for Doris Outflow ($p = 0.39$) and Little Roberts Outflow ($p = 0.27$). Therefore, there was no adverse effect of Project activities on arsenic concentrations in exposure streams in 2013.





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.

Figure 3.3-8

Radium-226 Concentration in AEMP Stream Sites, Doris North Project, 1996 to 2013

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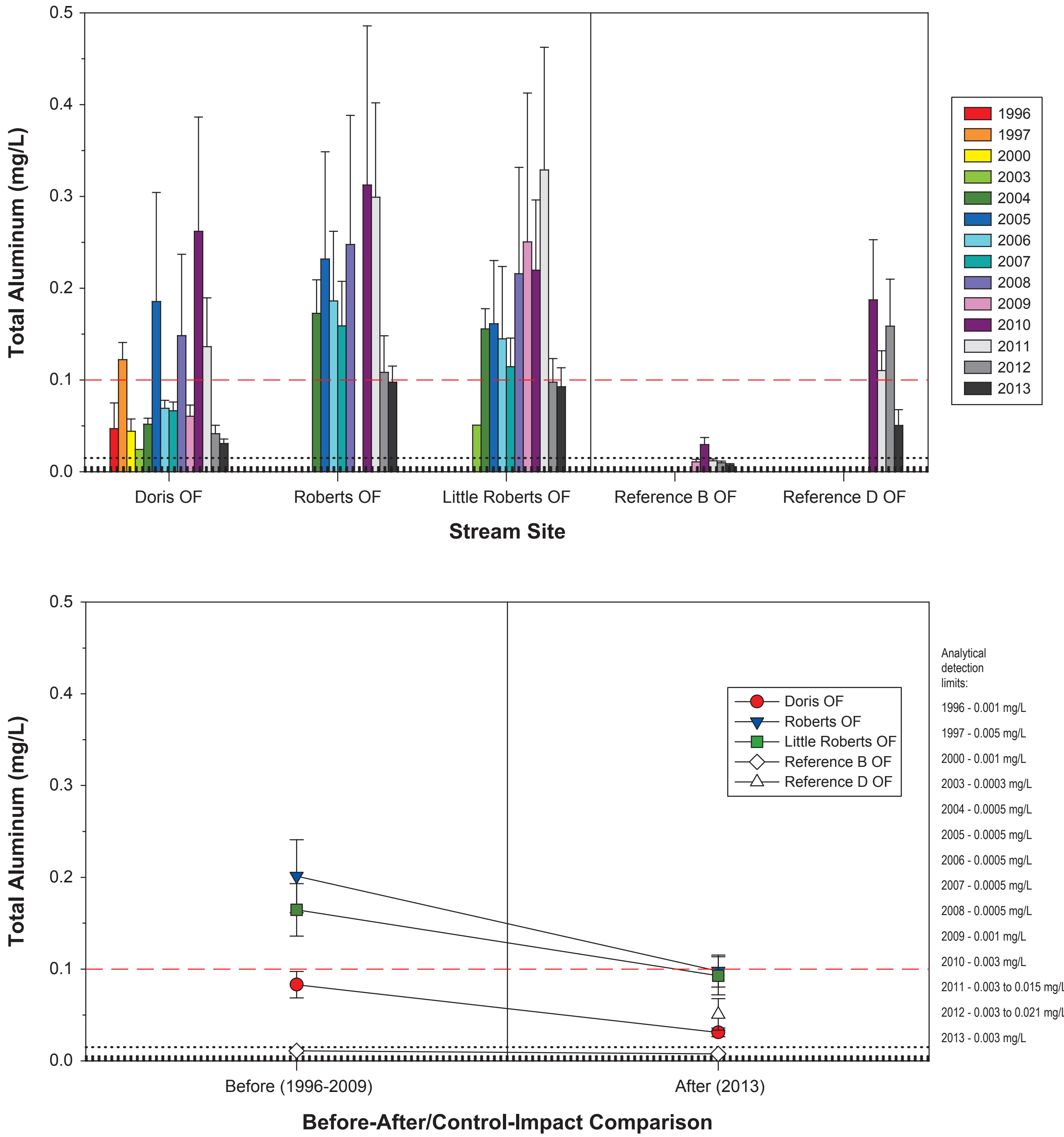

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
Red dashed lines represent the pH-dependent CCME freshwater guideline for aluminum (0.005 mg/L at pH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

Figure 3.3-9

Total Aluminum Concentration in AEMP Stream Sites, Doris North Project, 1996 to 2013

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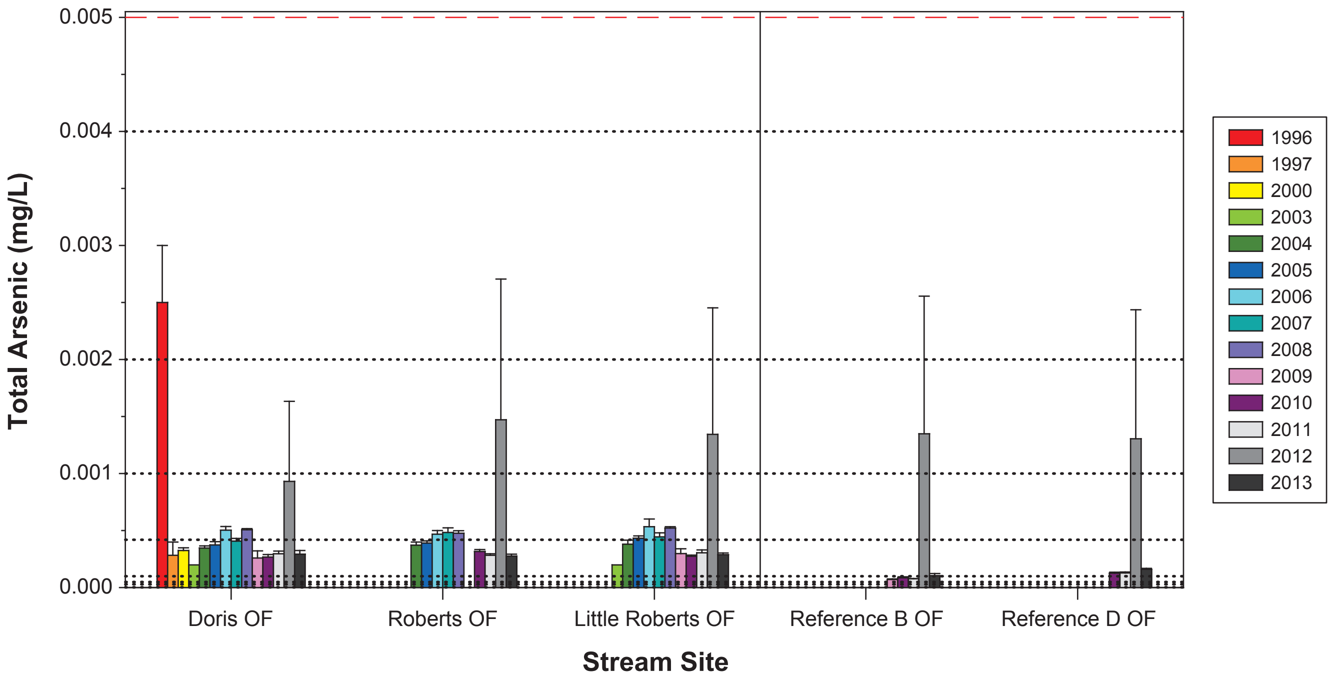

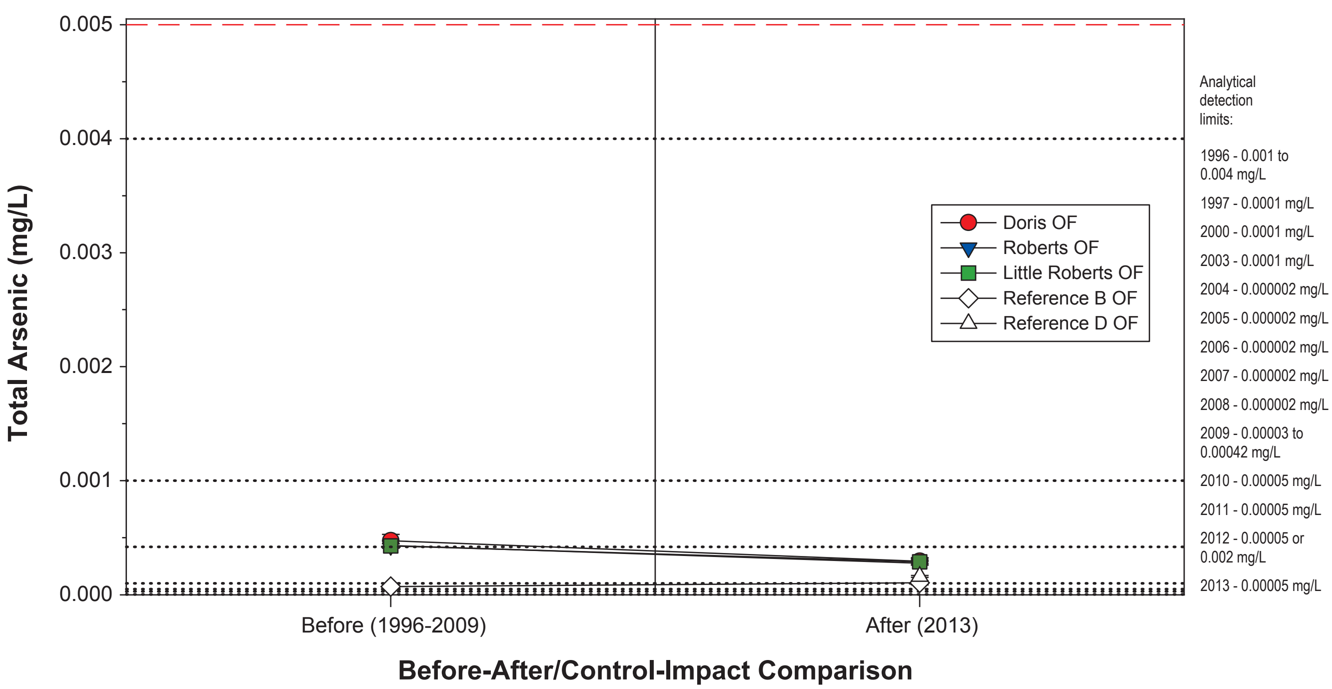

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
Red dashed lines represent the CCME freshwater guideline for arsenic (0.005 mg/L).
Total arsenic is regulated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

Figure 3.3-10

Total Arsenic Concentration in AEMP Stream Sites, Doris North Project, 1996 to 2013

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3.3.1.11 Total Cadmium

Total cadmium is a required variable for effluent characterization as per Schedule 5, s. 4(1) of the MMER. Total cadmium concentrations measured at Roberts and Little Roberts outflows in 2013 were all below the detection limit of 0.000005 mg/L (Figure 3.3-11; Appendix A), so there was no evidence of an effect of Project activities on cadmium levels in these exposure streams. At Doris Outflow, six out of eight concentrations measured in 2013 were below the detection limit; however, the highest concentration of 0.0000201 mg/L measured in September was slightly higher than the sample-specific hardness-dependent guideline of 0.0000197 mg/L (Appendix A). Nevertheless, 2013 cadmium concentrations at Doris Outflow were within range of baseline concentrations, so there was no evidence of a Project-related increase in cadmium levels in this stream. Statistical results are not presented here because of the high proportion of concentrations that were below detection limits in the datasets for exposure streams, which renders statistical results unreliable.

3.3.1.12 Total Copper

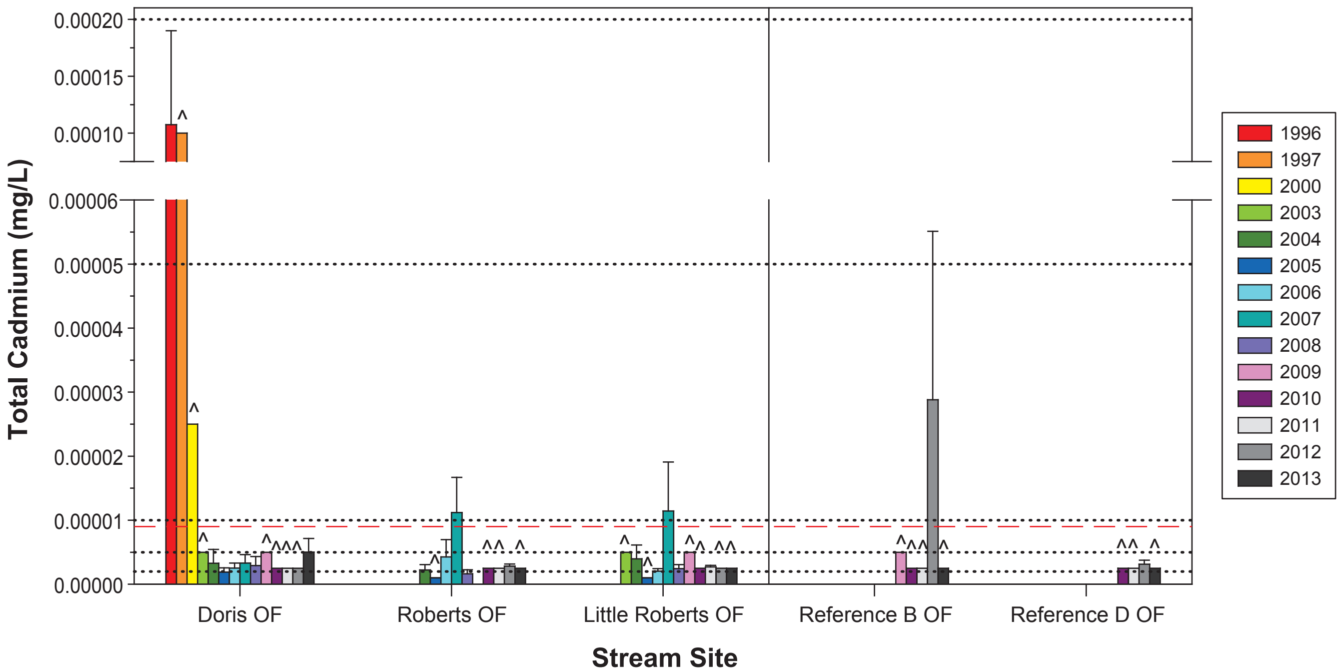
Total copper is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. In all exposure streams, mean 2013 copper concentrations were at the low end of the range of baseline means and below the hardness-dependent CCME guideline (Figure 3.3-12). The before-after analysis showed that there was no significant difference in the mean copper concentration between baseline years and 2013 for any exposure stream ($p = 0.20$ for Doris Outflow, $p = 0.43$ for Roberts Outflow, and $p = 0.21$ for Little Roberts Outflow). Therefore, there was no effect of 2013 Project activities on total copper concentrations.

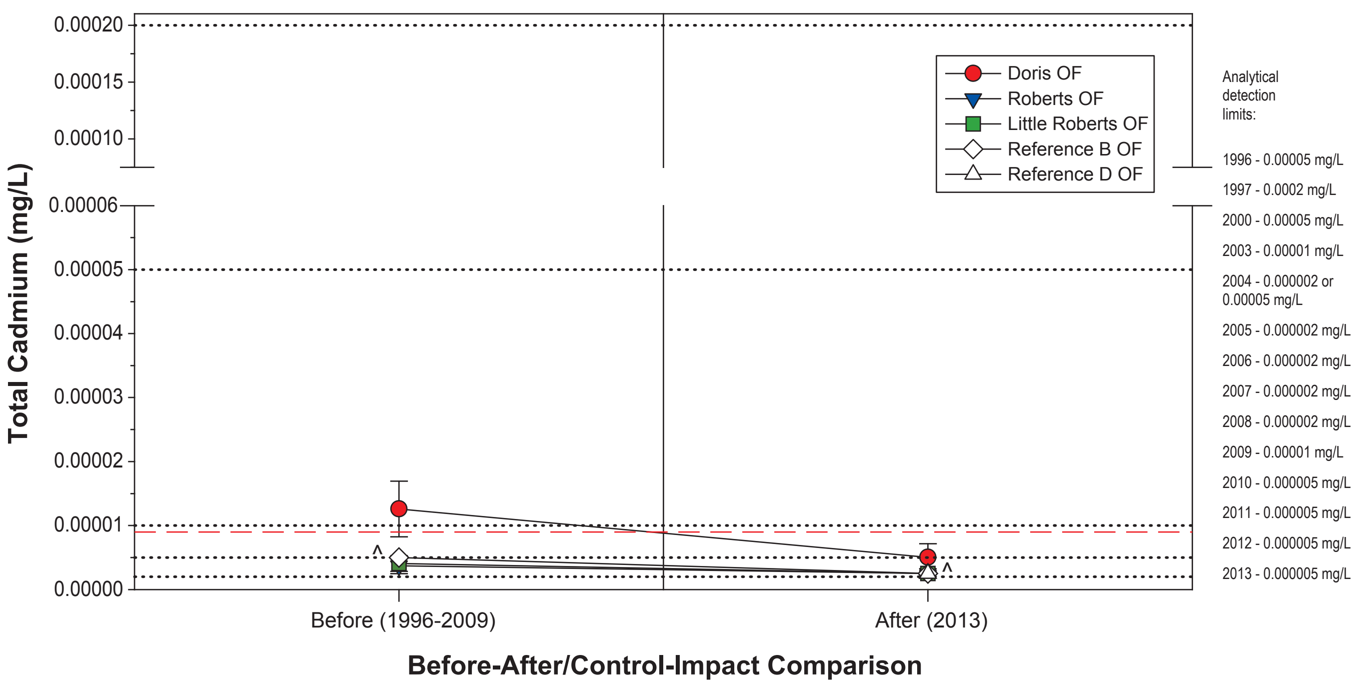
3.3.1.13 Total Iron

Total iron is a required variable 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). At Little Roberts Outflow, the total iron concentrations measured in June samples were slightly greater than the CCME guideline level of 0.3 mg/L (Appendix A); however, iron concentrations in baseline samples were also occasionally above this guideline (Figure 3.3-13). For all the exposure streams, mean 2013 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 2013 means for any exposure stream ($p = 0.63$ for Doris Outflow, $p = 0.19$ for Roberts Outflow, and $p = 0.42$ 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. 2013 lead concentrations in exposure streams were either below the analytical detection limit of 0.00005 mg/L, or slightly above this detection limit (maximum concentration of 0.000061 mg/L at Little Roberts Outflow). Total lead concentrations in all streams were well below the hardness-dependent CCME guideline (Figure 3.3-14). Mean 2013 lead concentrations in the exposure streams were lower than mean baseline levels, indicating that there was no negative Project-related effect on stream lead concentrations. The before-after comparison determined that 2013 mean concentrations were not significantly different from baseline means for the exposure streams ($p = 0.27$ for Doris Outflow, $p = 0.059$ for Roberts Outflow, and $p = 0.079$ for Little Roberts Outflow).

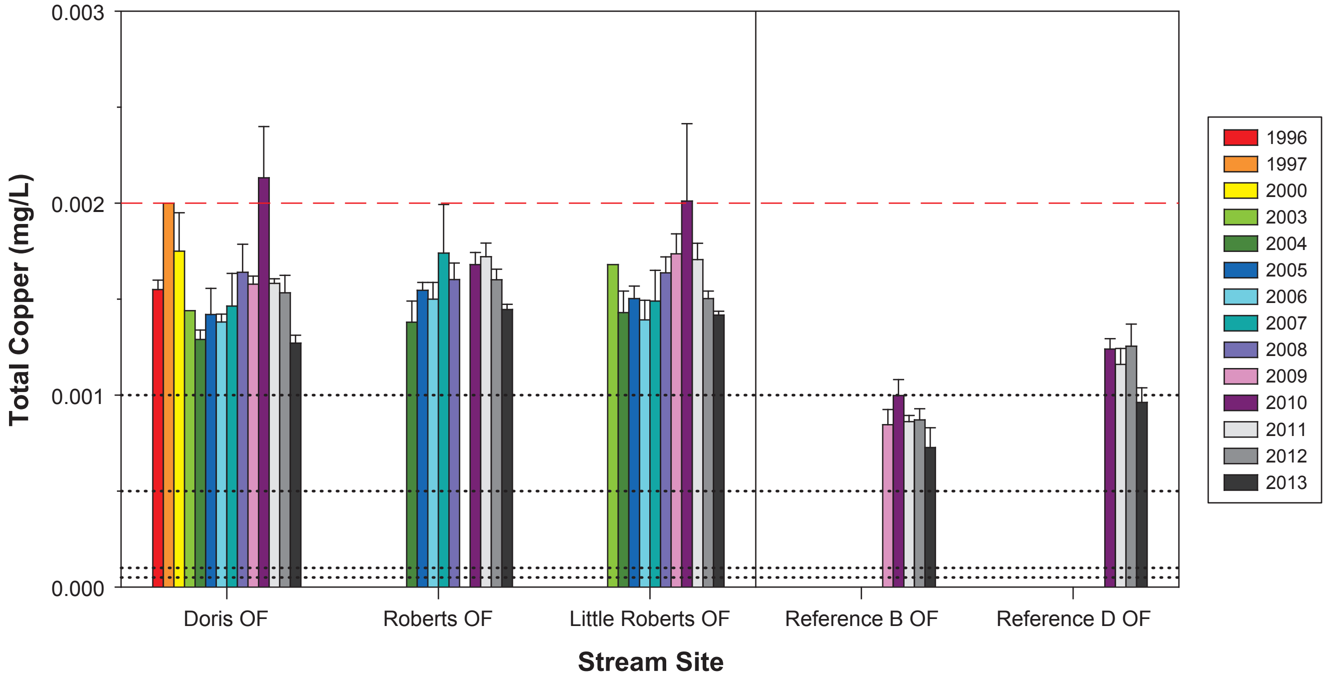


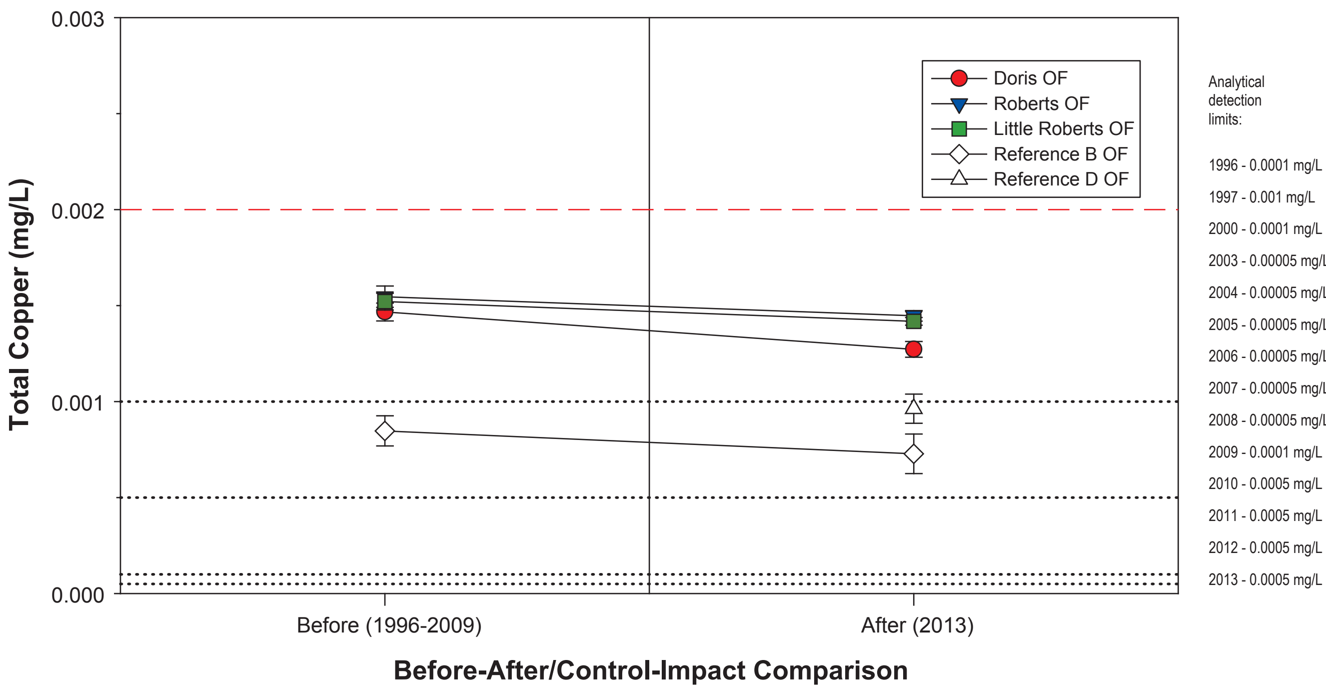


Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
The CCME freshwater guideline for cadmium is hardness dependent.
Red dashed lines represent the minimum CCME freshwater guideline for cadmium based on the minimum hardness measured in exposure streams between 1996 and 2013 (hardness: 22 mg/L; CCME guideline: 0.000009 mg/L).
Total cadmium is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

Figure 3.3-11

Total Cadmium Concentration in AEMP Stream Sites, Doris North Project, 1996 to 2013





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 3.3-12

Total Copper Concentration in AEMP Stream Sites, Doris North Project, 1996 to 2013

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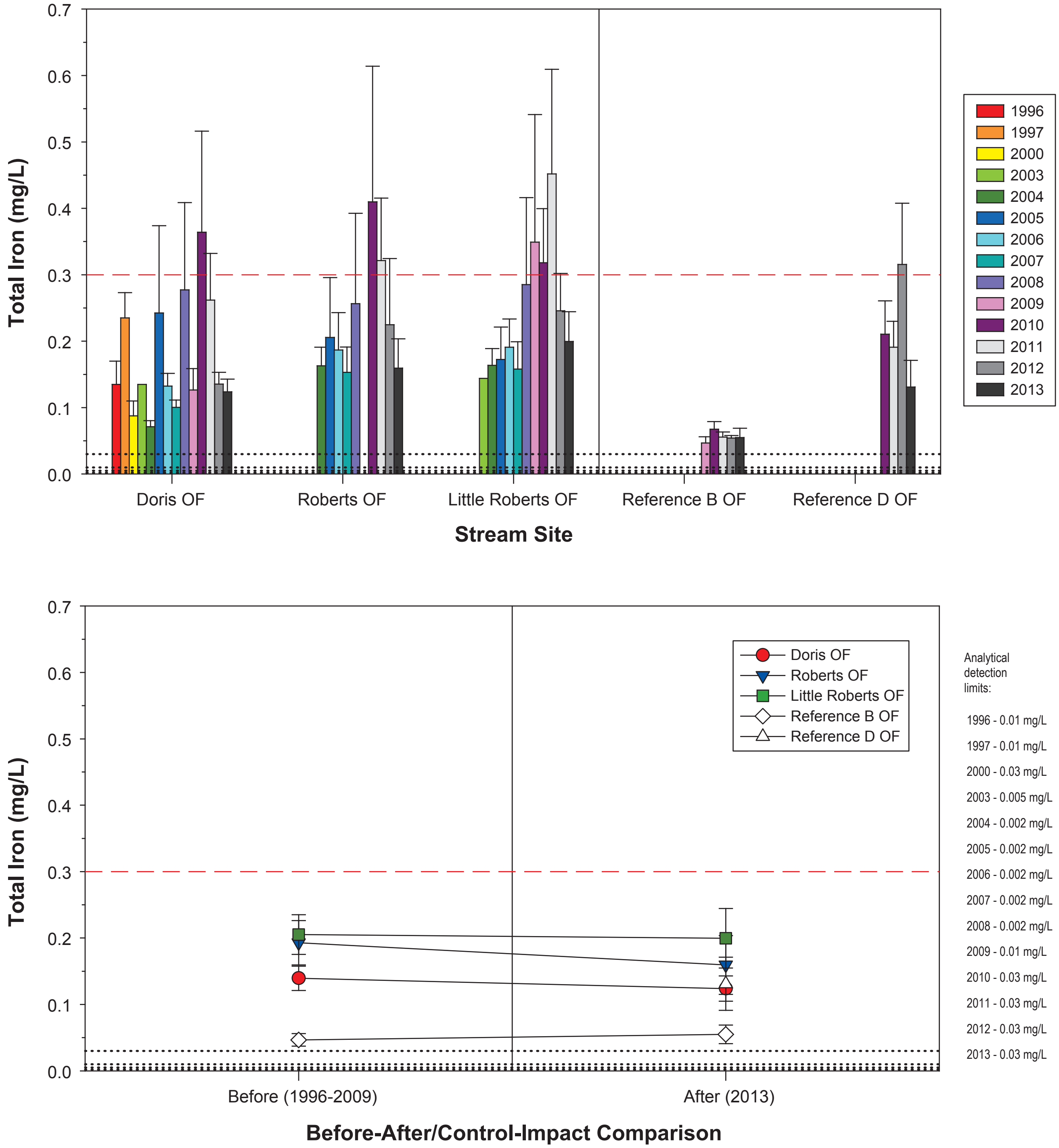

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
Red dashed lines represent the CCME freshwater guideline for iron (0.3 mg/L).
Total iron is a required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

Figure 3.3-13

Total Iron Concentration in AEMP Stream Sites, Doris North Project, 1996 to 2013

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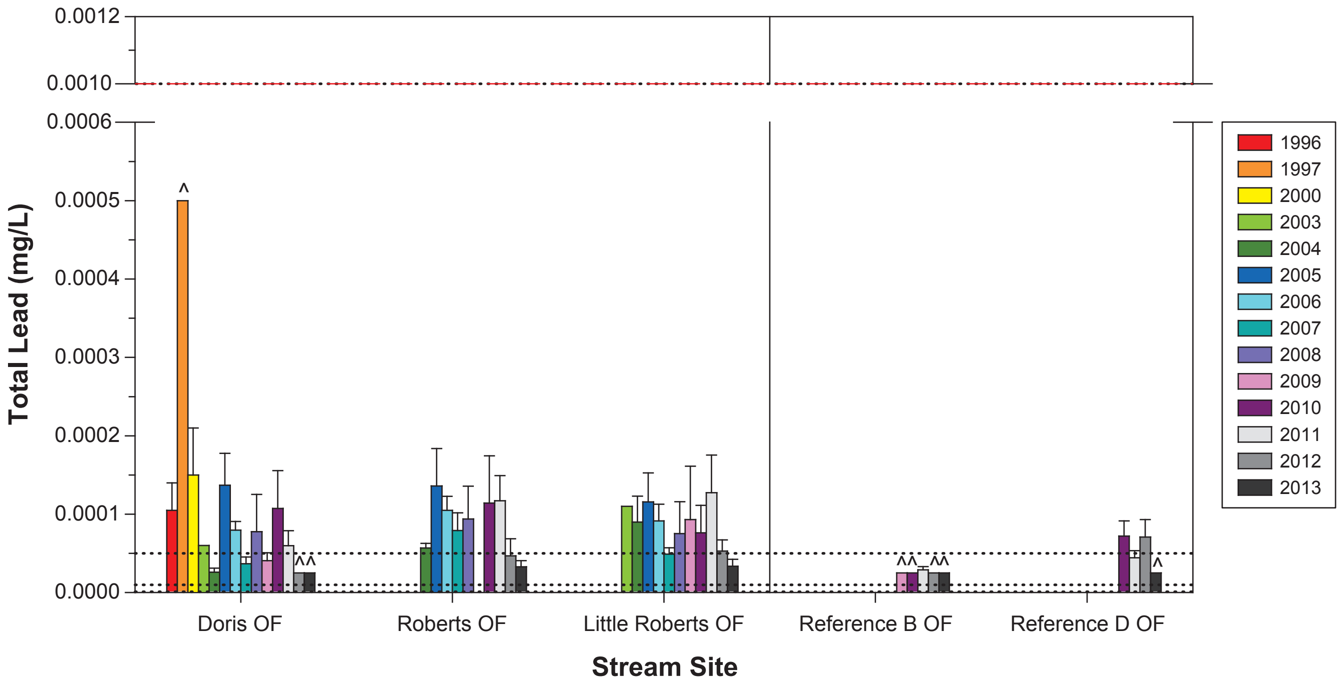

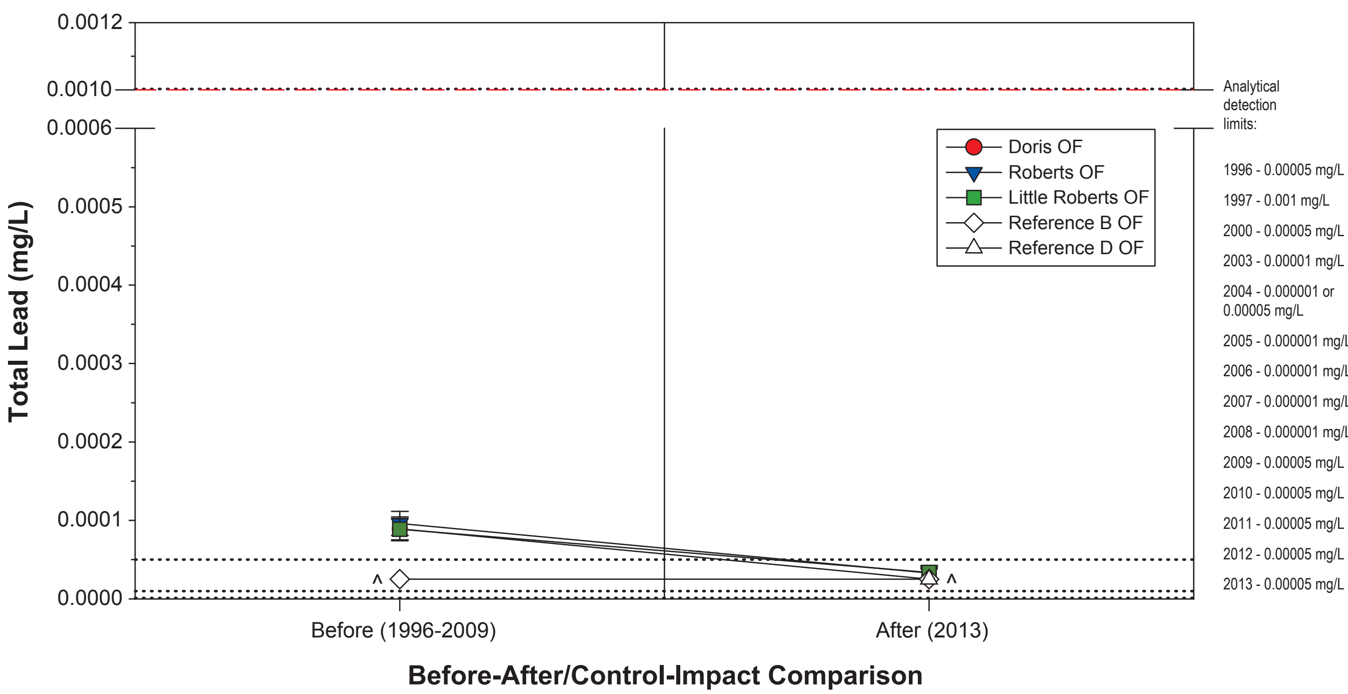

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
The CCME freshwater guideline for 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 2013

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3.3.1.15 Total Mercury

Total mercury is a required variable for effluent characterization as per Schedule 5, s. 4(1) of the MMER. A high proportion of total mercury concentrations in the combined baseline and 2013 datasets for exposure streams were below analytical detection limits (75% for Doris Outflow, 55% for Roberts Outflow, and 68% for Little Roberts Outflow). The majority of total mercury concentrations measured in exposure streams in 2013 were above the ultra-low detection limit of 0.0000005 mg/L, and ranged from below detection (< 0.0000005 mg/L) to 0.0000024 mg/L. There was one exception: an anomalously high concentration of 0.000106 mg/L measured at Roberts Outflow in July, which was the only sample that exceeded the CCME guideline for inorganic mercury of 0.000026 mg/L (Figure 3.3-15; Appendix A). However, the total mercury concentration measured in the duplicate sample collected at Roberts Outflow in July was slightly over the detection limit at 0.00000064 mg/L, suggesting that the anomalously high concentration may have resulted from sample contamination. Comparisons to pre-2010 baseline data are problematic because of the high proportion of baseline data that were below detection limits, and the widely variable historical detection limits. Mean 2013 total mercury concentrations at Doris and Little Roberts outflows were within the range of baseline means, suggesting that there was no effect of Project activities on mercury concentrations in these streams (Figure 3.3-15). At Roberts Outflow, the 2013 mean was higher that the baseline mean, but this was driven by the single anomalously high concentration, and the before-after analysis showed that there was no significant difference in means between baseline years and 2013 ($p = 0.099$). Therefore, there was no evidence of an increase in total mercury concentrations in streams due to 2013 Project activities.

3.3.1.16 Total Molybdenum

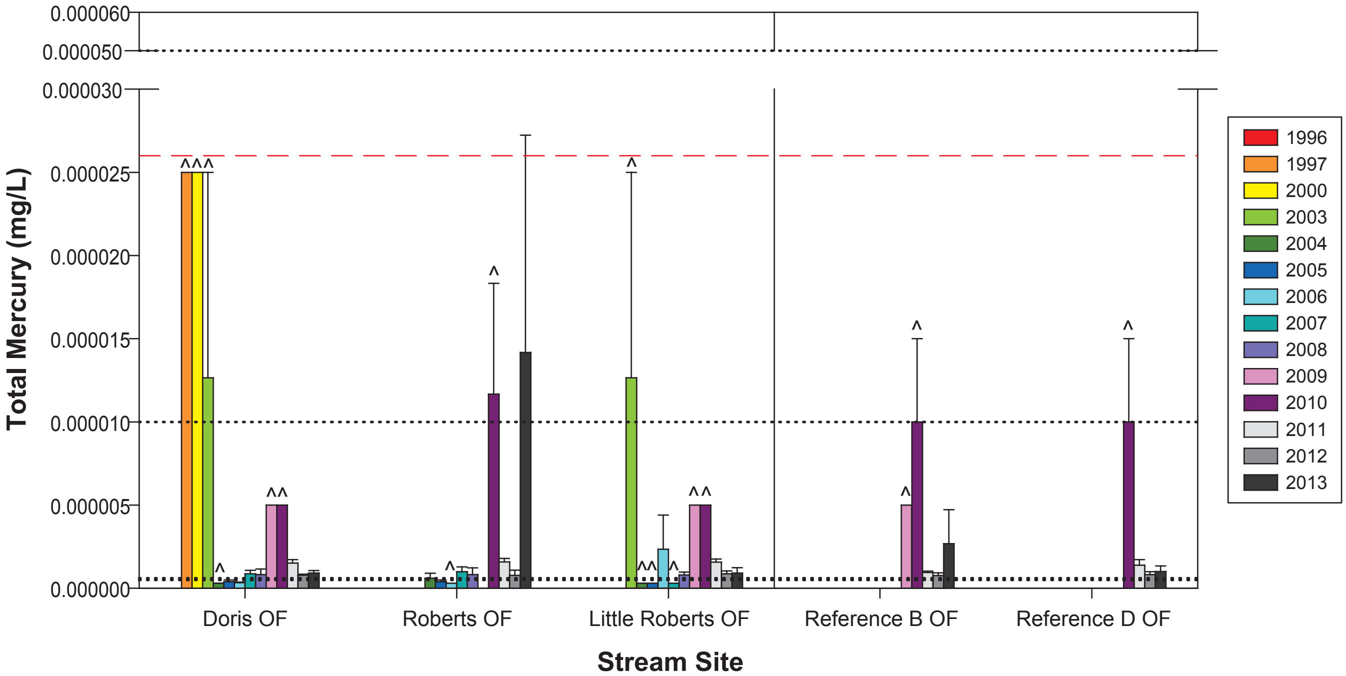
Total molybdenum is a required variable for effluent characterization as per Schedule 5, s. 4(1) of the MMER. Mean total molybdenum concentrations within each exposure stream have been remarkably consistent from year to year (Figure 3.3-16). In all exposure streams, 2013 concentrations were similar to baseline levels, and the before-after comparison confirmed that there was no effect of 2013 Project activities on total molybdenum concentrations ($p = 0.090$ for Doris Outflow, $p = 0.18$ for Roberts Outflow, and $p = 0.57$ for Little Roberts Outflow). Total molybdenum concentrations in all 2013 samples were more than two orders of magnitude lower than the interim CCME guideline of 0.073 mg/L (Figure 3.3-16).

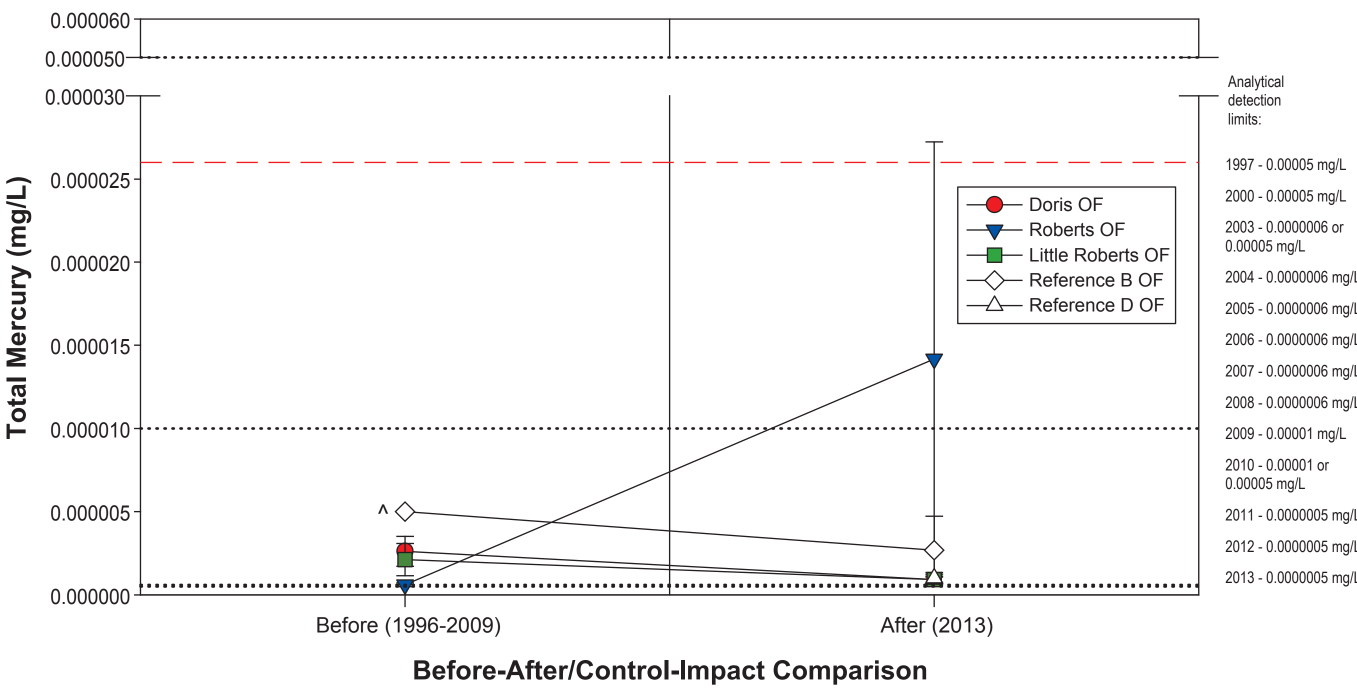
3.3.1.17 Total Nickel

Total nickel is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. Mean 2013 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 shows that concentrations in 2013 were similar to baseline concentrations (Figure 3.3-17), and the before-after analysis confirmed that there was no significant difference between mean baseline and mean 2013 nickel concentrations ($p = 0.53$ for Doris Outflow, $p = 0.078$ for Roberts Outflow, and $p = 0.25$ for Little Roberts Outflow). Therefore, there was no effect of 2013 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 Doris and Little Roberts outflows, all 2013 zinc concentrations were below the detection limit of 0.003 mg/L. In Roberts Outflow, concentrations ranged from below to slightly above the detection limit (maximum of 0.0039 mg/L), and were within range of baseline concentrations (Figure 3.3-18). The before-after analysis confirmed that there was no significant difference in zinc concentrations between 2013 and baseline years for Roberts Outflow ($p = 0.33$). All 2013 total zinc concentrations in exposure streams were well below the CCME guideline of 0.03 mg/L (Figure 3.3-18). There was no apparent effect of Project activities 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.

Figure 3.3-15

Total Mercury Concentration in AEMP Stream Sites, Doris North Project, 1996 to 2013

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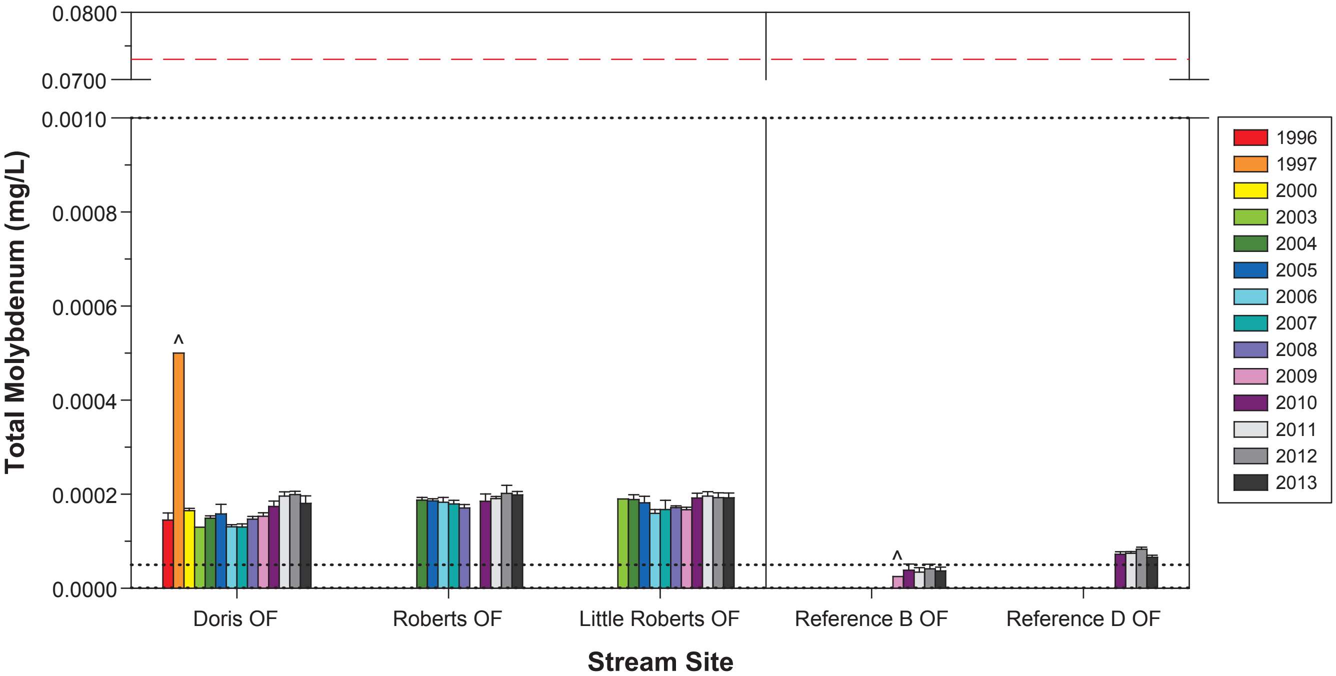
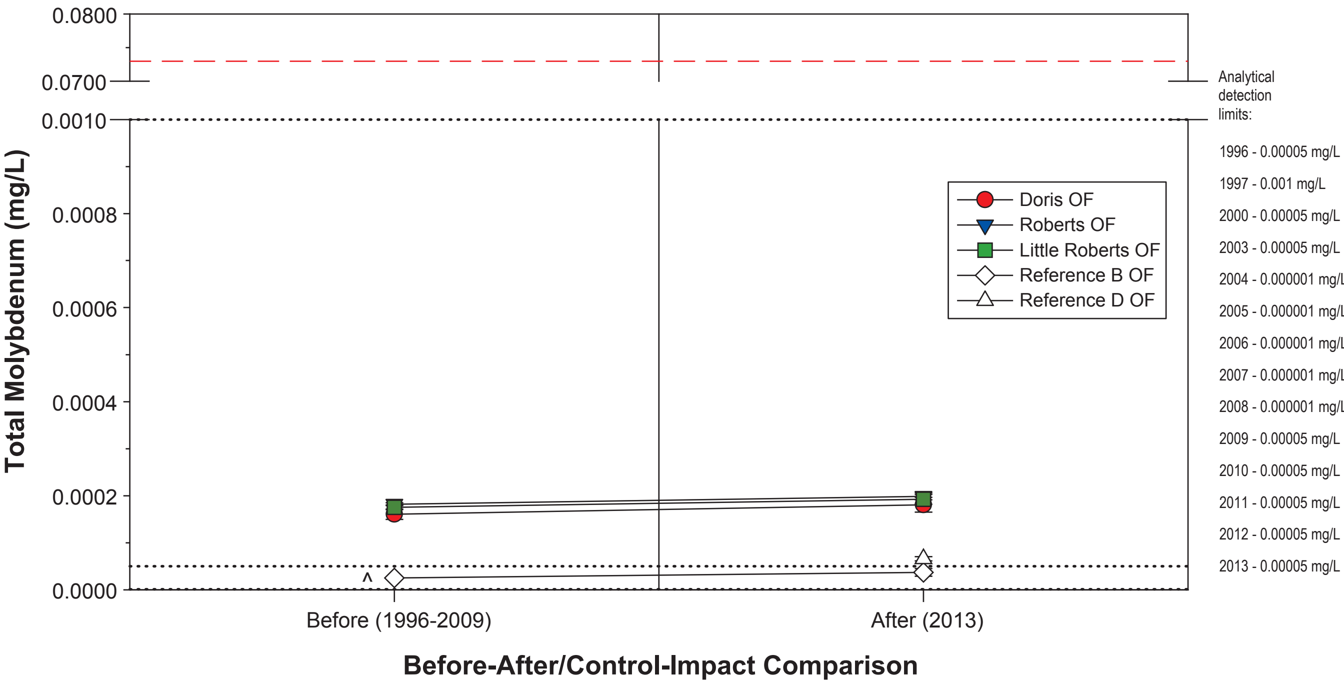
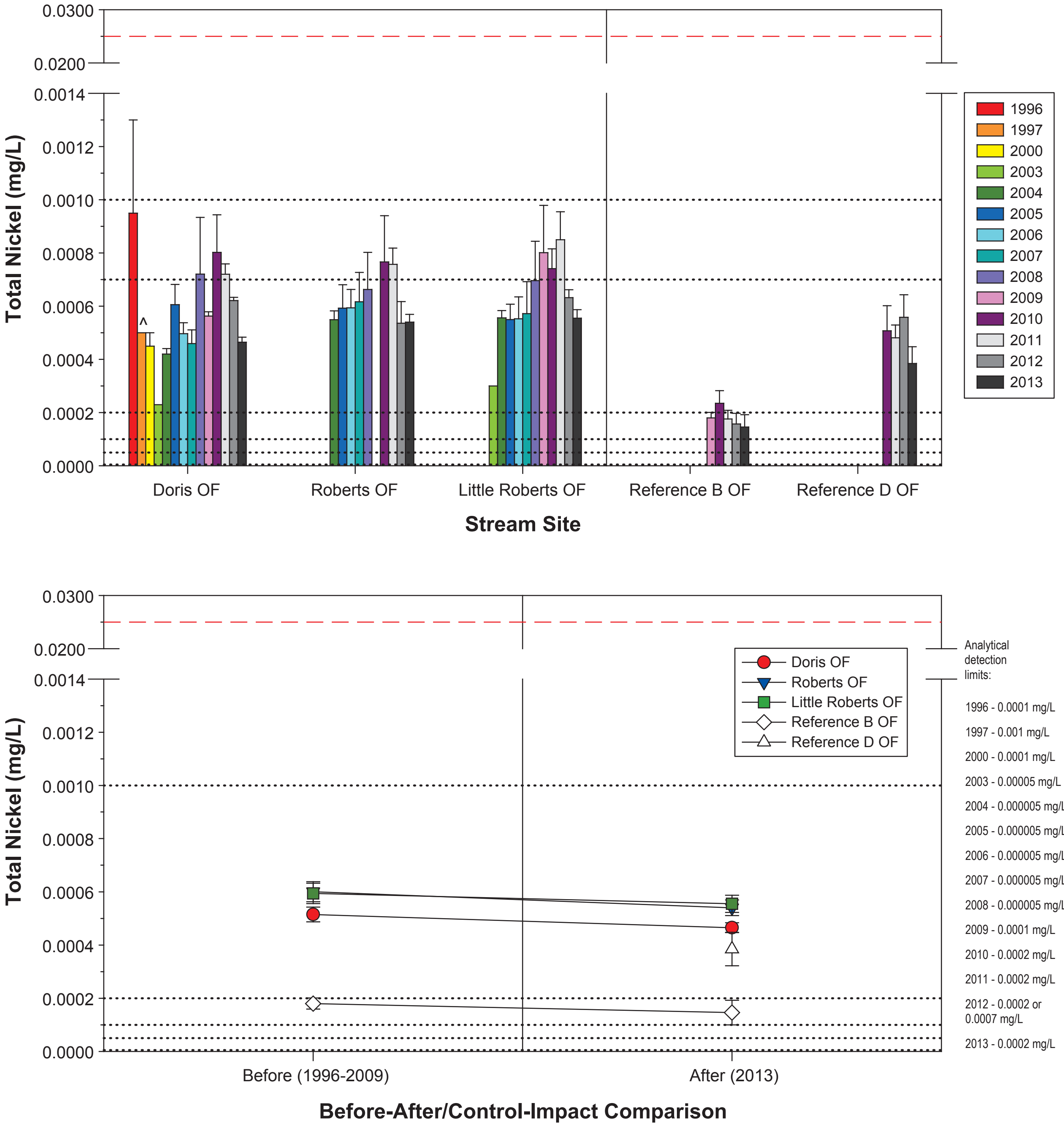




Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed lines represent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

Figure 3.3-16

Total Molybdenum Concentration in AEMP Stream Sites, Doris North Project, 1996 to 2013



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 3.3-17

Total Nickel Concentration in AEMP Stream Sites, Doris North Project, 1996 to 2013

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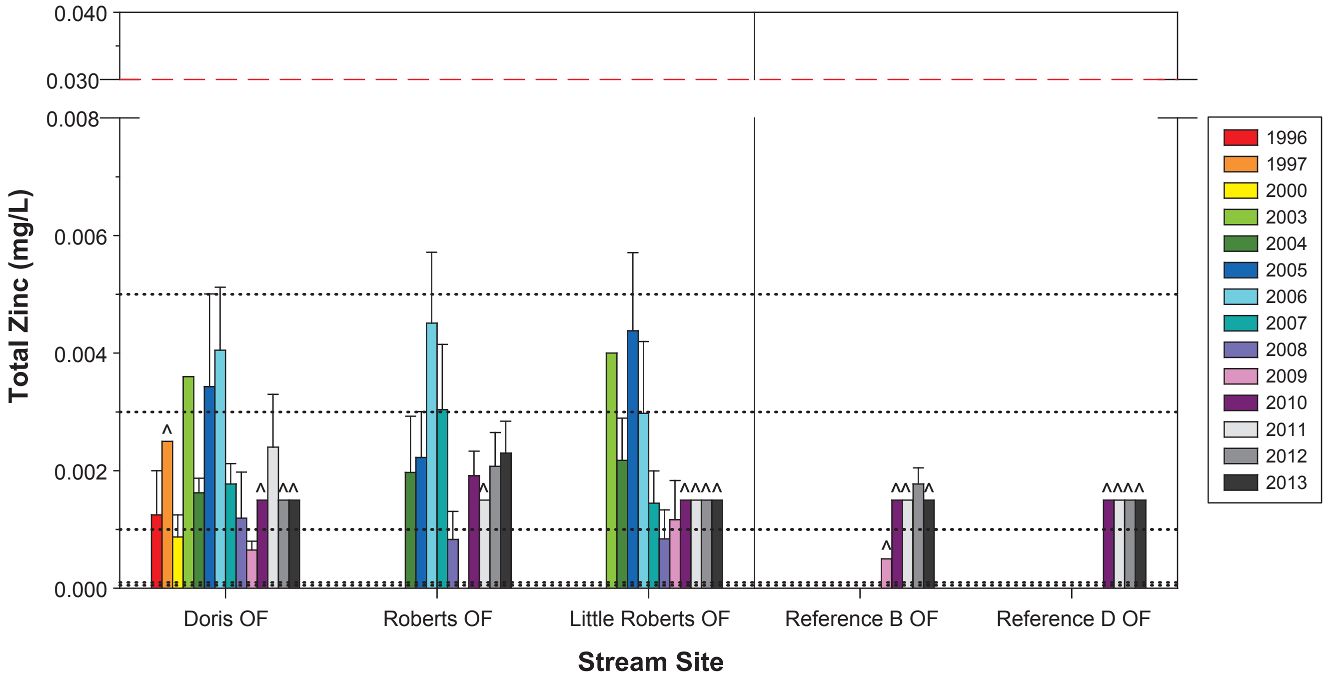

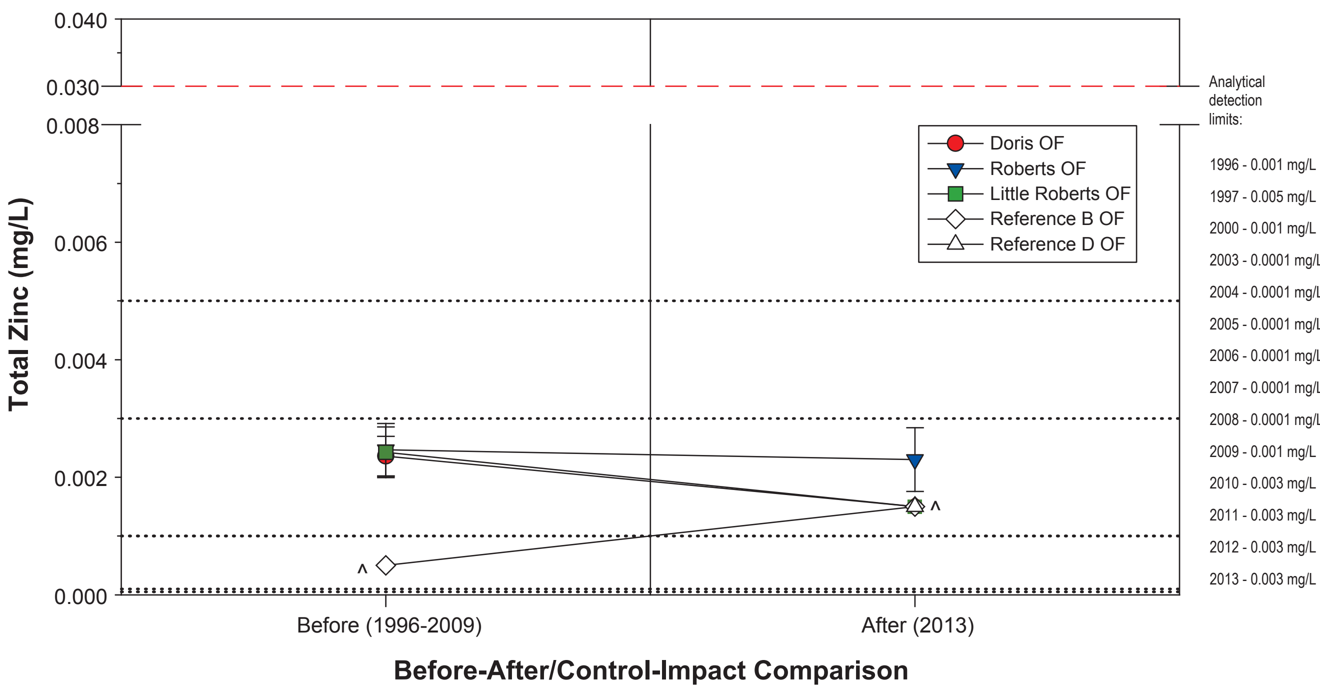

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed lines represent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

Figure 3.3-18

Total Zinc Concentration in AEMP Stream Sites, Doris North Project, 1996 to 2013

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3.3.2 Lakes

Water quality samples from lakes were collected from three exposure lake sites (Doris Lake South, Doris Lake North, and Little Roberts Lake) and two reference lakes (Reference Lake B and Reference Lake D) in 2013. For the exposure lakes, relevant baseline data are available from 1995 to 1998, 2000, and 2003 to 2009 (though all lake sites were not sampled each year). The only available baseline data for Reference Lake B are from 2009, and no pre-2010 baseline data are 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. Because no baseline data are available for Reference Lake D, no statistical analyses were possible for this lake, and no BACI analysis was possible for Little Roberts Lake. 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

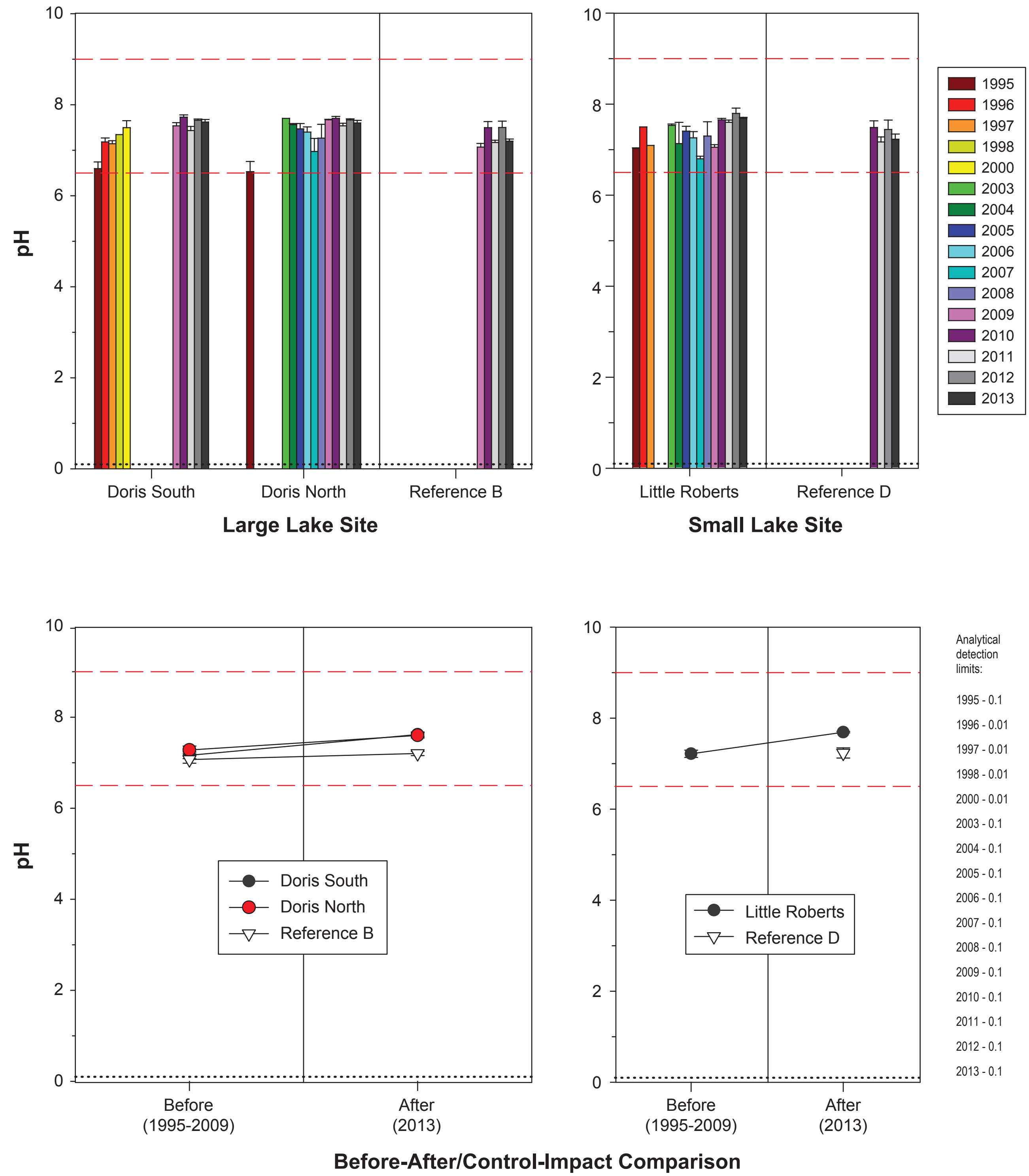
pH is a required variable for water quality monitoring as per Schedule 5, s. 7(1)(c) of the MMER. pH levels measured in 2013 in exposure lakes were always within the recommended CCME guideline range of 6.5 to 9.0, and were similar to baseline pH levels (Figure 3.3-19). The before-after analysis confirmed that the mean baseline pH was not distinguishable from the mean 2013 pH in any exposure lake site ($p = 0.39$ for Doris Lake South, $p = 0.41$ for Doris Lake North, and $p = 0.081$ for Little Roberts Lake). Therefore, there was no apparent effect of 2013 Project activities on pH in exposure lakes.

3.3.2.2 Total Alkalinity

Total alkalinity is a required variable 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 2013 were similar to 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 site in 2013 ($p = 0.13$ for Doris Lake South, $p = 0.13$ for Doris Lake North, and $p = 0.64$ for Little Roberts Lake).

3.3.2.3 Hardness

Hardness is a required variable 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, 2013 mean hardness levels were slightly higher than baseline means (Figure 3.3-21). The before-after analysis indicated that this difference was statistically significant for Doris Lake South ($p = 0.0093$) but not for Doris Lake North ($p = 0.045$). The BACI analysis showed that the change in hardness at Doris Lake South was paralleled at Reference Lake B ($p = 0.21$); therefore, the difference in hardness levels in Doris Lake South between baseline years and 2013 was likely attributable to a natural phenomenon. In Little Roberts Lake, 2013 hardness levels were within the range of baseline levels, and the 2013 mean was not distinguishable from the baseline mean ($p = 0.58$). Therefore, 2013 Project 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.

Figure 3.3-19

pH in AEMP Lake Sites, Doris North Project, 1995 to 2013

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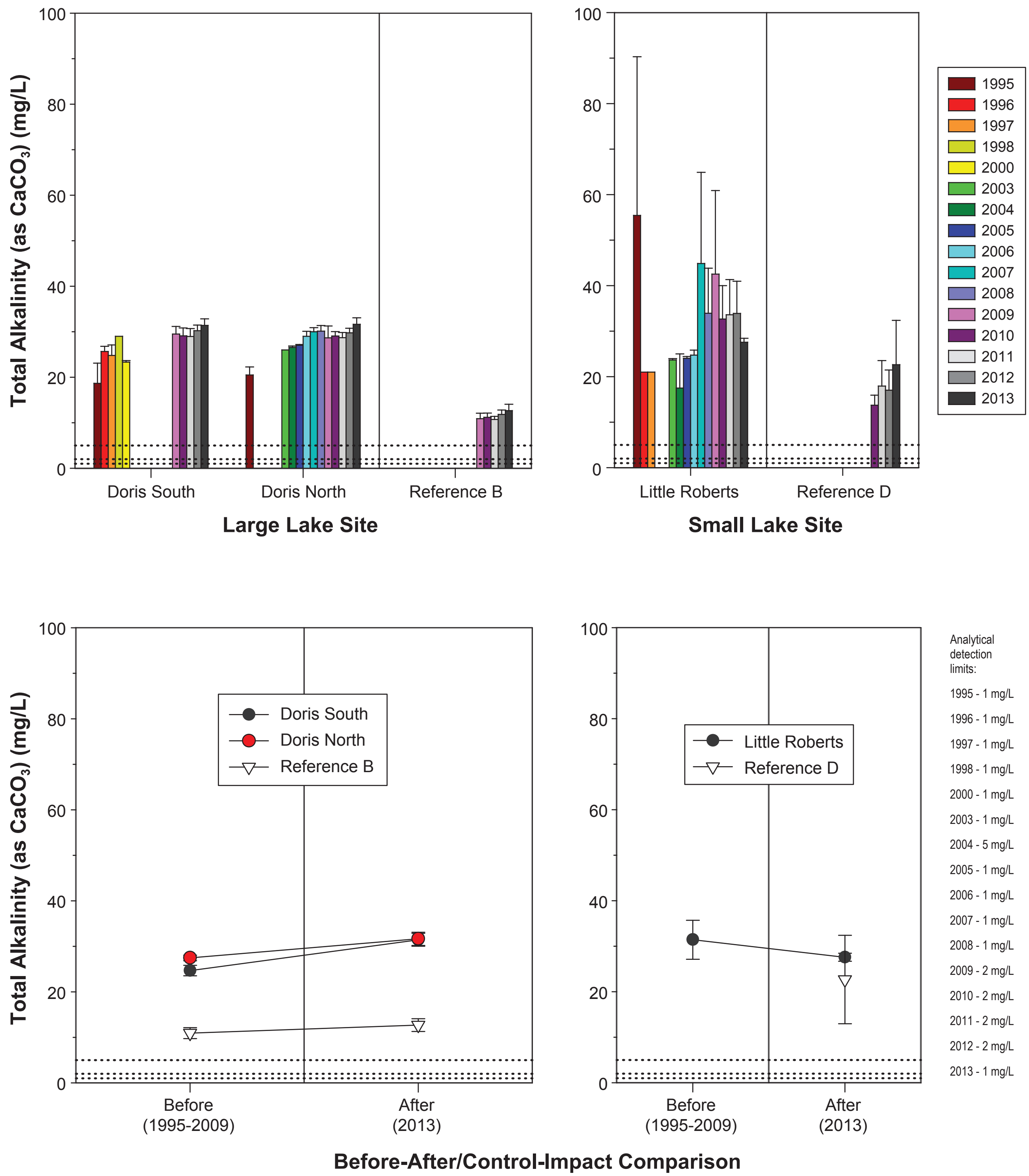

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
Total alkalinity is a required parameter for effluent characterization and water quality monitoring as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

Figure 3.3-20

Total Alkalinity in AEMP Lake Sites, Doris North Project, 1995 to 2013

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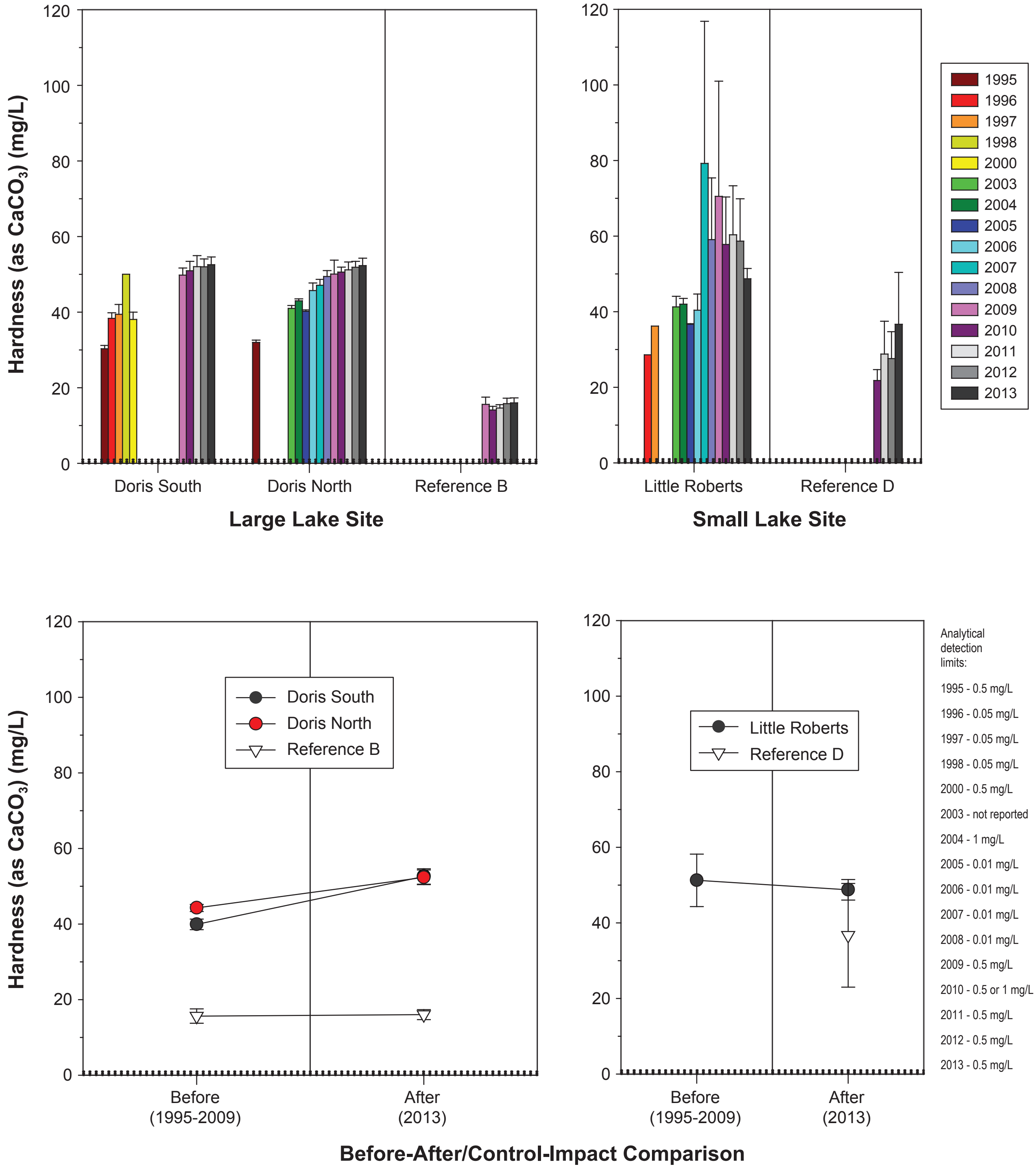


Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits.
Hardness is a required parameter for effluent characterization and water quality monitoring as per Schedule 5, s. 4(1) and s. 7(1)(c) of the MMER.

Figure 3.3-21

Hardness in AEMP Lake Sites, Doris North Project, 1995 to 2013

3.3.2.4 Total Suspended Solids

TSS are regulated as deleterious substances in effluents as per Schedule 4 of the MMER. Mean TSS concentrations were inter-annually variable, particularly in Little Roberts Lake (Figure 3.3-22). 2013 TSS concentrations measured in the exposure lakes were within the range of baseline concentrations, and the before-after analysis showed that 2013 means were not statistically different from baseline means in any of the exposure lake sites ($p = 0.89$ for Doris Lake South, $p = 0.54$ for Doris Lake North, and $p = 0.67$ for Little Roberts Lake). Therefore, there was no apparent effect of 2013 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 2013b). Because there was no increase in TSS concentrations from background levels, 2013 TSS concentrations in exposure lakes were below the CCME guideline.

3.3.2.5 Total Ammonia

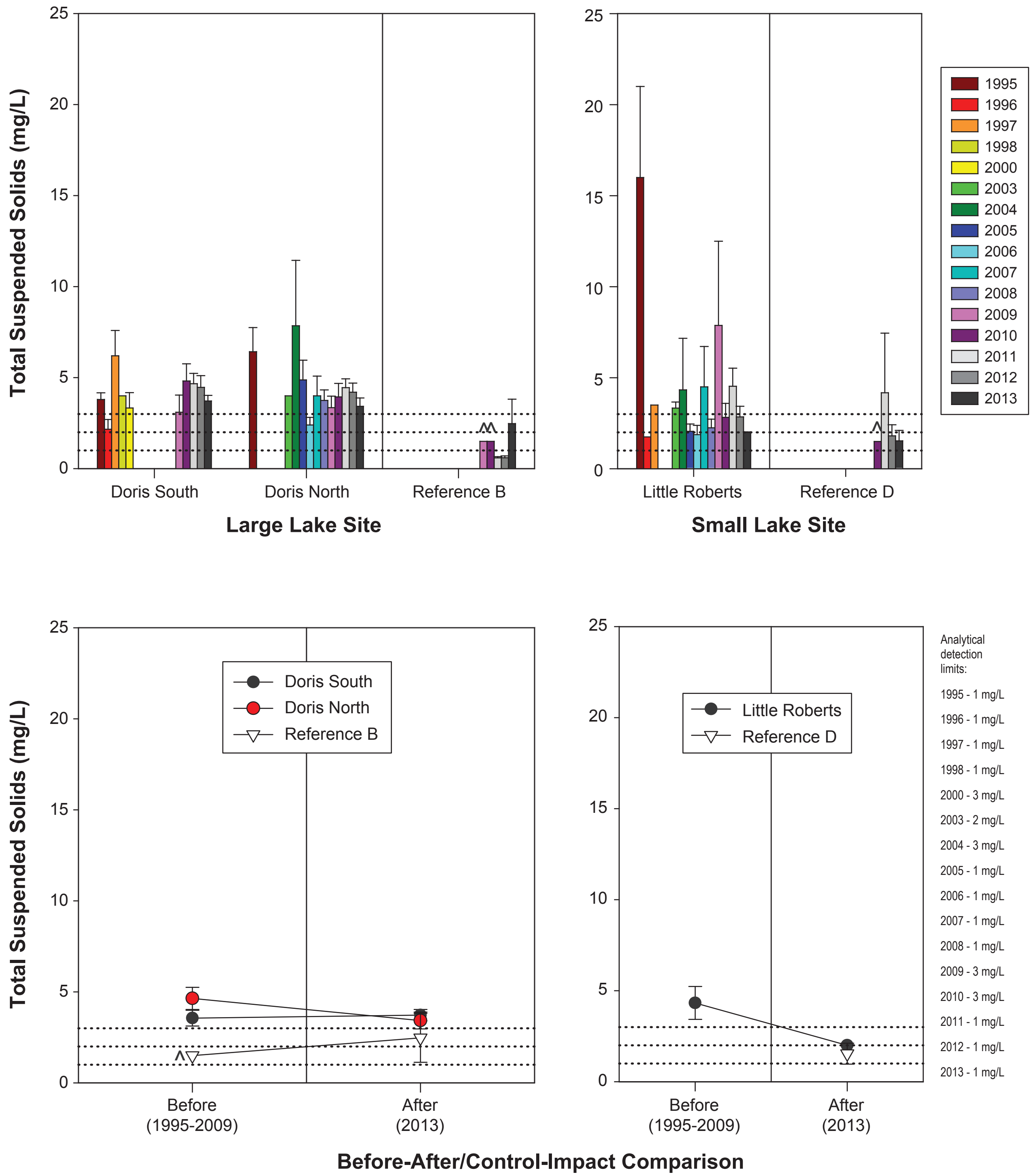
Total ammonia is a required variable for effluent characterization as per Schedule 5, s. 4(1) of the MMER. Baseline and 2013 concentrations of total ammonia in exposure and reference lakes were always well below the pH- and temperature-dependent CCME guideline (Figure 3.3-23). Mean 2013 total ammonia concentrations at the Doris Lake sites were near the lower end of the range of baseline means, suggesting that 2013 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 was no significant difference between baseline and 2013 means for any Doris Lake site ($p = 0.14$ for Doris Lake South and $p = 0.47$ for Doris Lake North). In Little Roberts Lake, all 2013 total ammonia concentrations were below the detection limit of 0.005 mg ammonia-N/L, so there was no evidence of an effect of Project activities on ammonia concentrations in this lake.

3.3.2.6 Nitrate

Nitrate is a required variable for effluent characterization as per Schedule 5, s. 4(1) of the MMER. Both within-year and inter-annual variability in nitrate concentrations were relatively high in the exposure and reference lakes (Figure 3.3-24). Nitrate concentrations measured in exposure lakes in 2013 were well below the long-term CCME guideline of 3.0 mg nitrate-N/L (Figure 3.3-24). The mean 2013 nitrate concentration at Doris Lake South was higher than the baseline mean; however, this was largely driven by one anomalously high measurement, as most concentrations measured at this site in 2013 were below the detection limit of 0.005 mg nitrate-N/L (Appendix A). The before-after analysis showed that the mean 2013 concentration was not distinguishable from the baseline mean nitrate concentration at Doris Lake South ($p = 0.38$). At Doris Lake North and Little Roberts Lake, mean 2013 concentrations were within the range of baseline measurements, and the before-after analysis confirmed that 2013 mean nitrate concentrations were not statistically different from baseline means ($p = 0.16$ for Doris Lake North and $p = 0.91$ for Little Roberts Lake). These results indicate that there were no effects of Project activities on nitrate concentrations in exposure lakes in 2013, 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. All total cyanide concentrations measured in exposure and reference lakes in 2013 were below the analytical detection limit of 0.001 mg/L (Figure 3.3-25). Therefore, there was no evidence of an increase in total cyanide concentrations due to 2013 Project activities.



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.

Figure 3.3-22

Total Suspended Solids Concentration in AEMP Lake Sites, Doris North Project, 1995 to 2013

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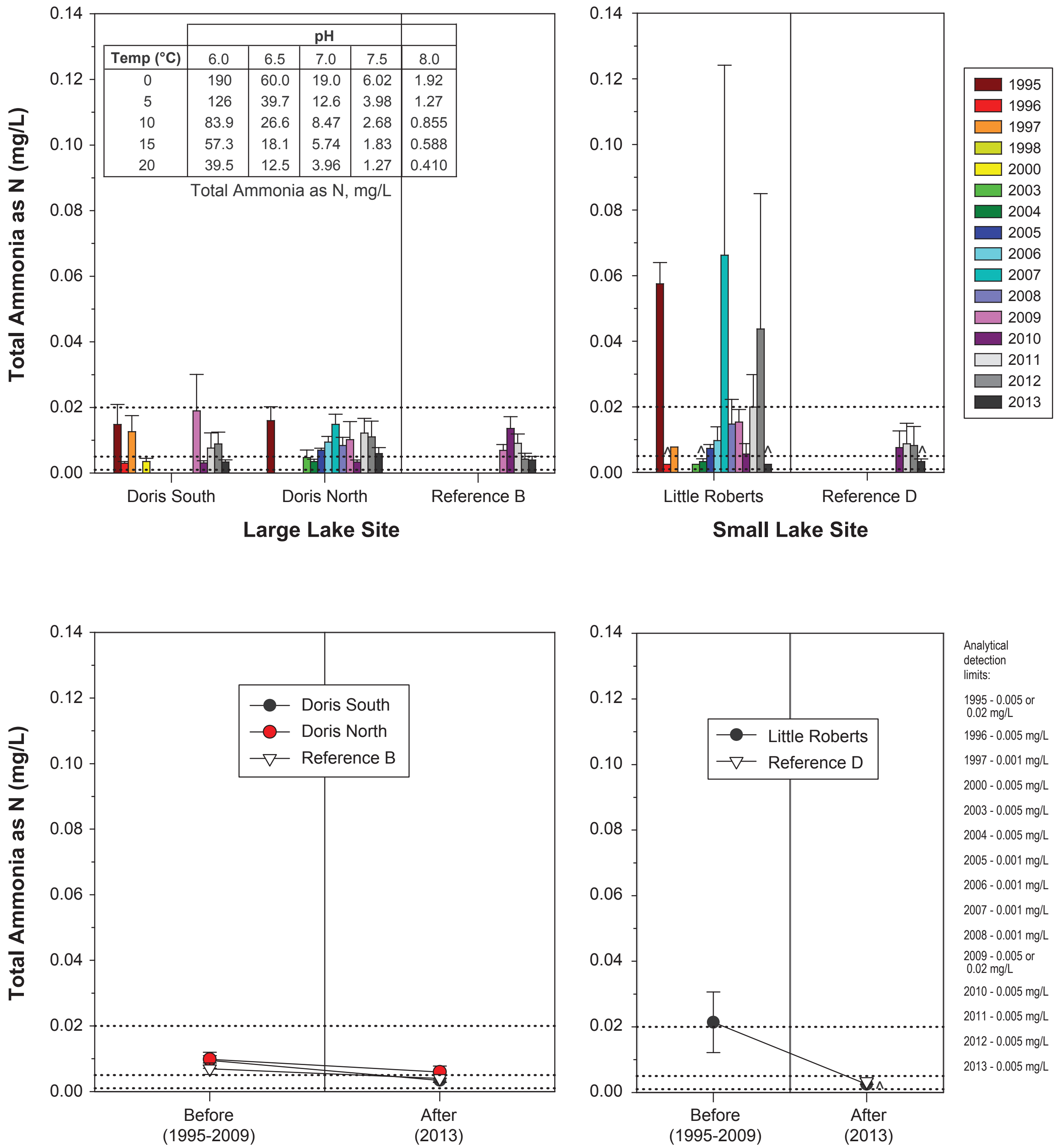


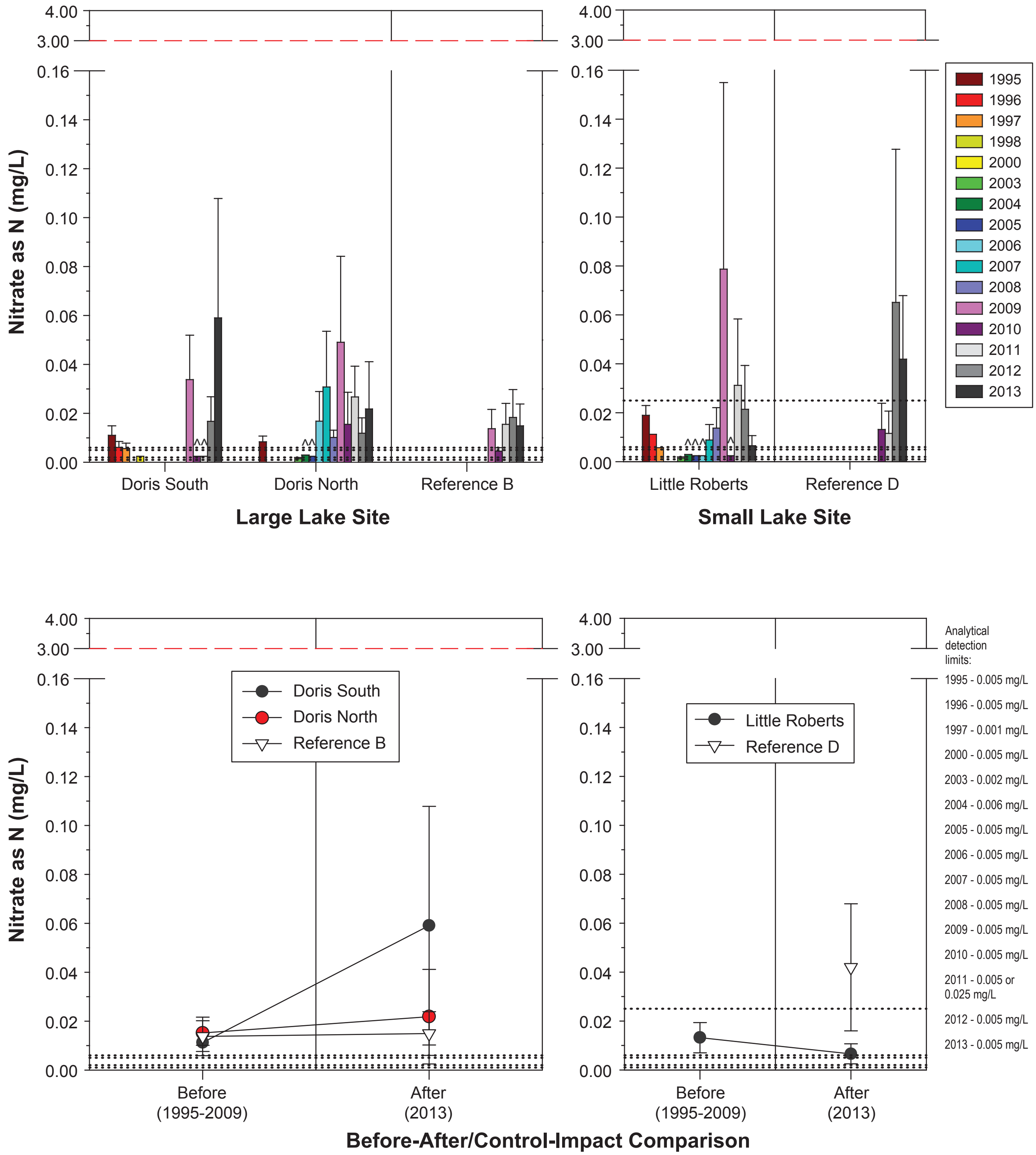
	pH				
Temp (°C)	6.0	6.5	7.0	7.5	8.0
0	190	60.0	19.0	6.02	1.92
5	126	39.7	12.6	3.98	1.27
10	83.9	26.6	8.47	2.68	0.855
15	57.3	18.1	5.74	1.83	0.588
20	39.5	12.5	3.96	1.27	0.410

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.

Figure 3.3-23

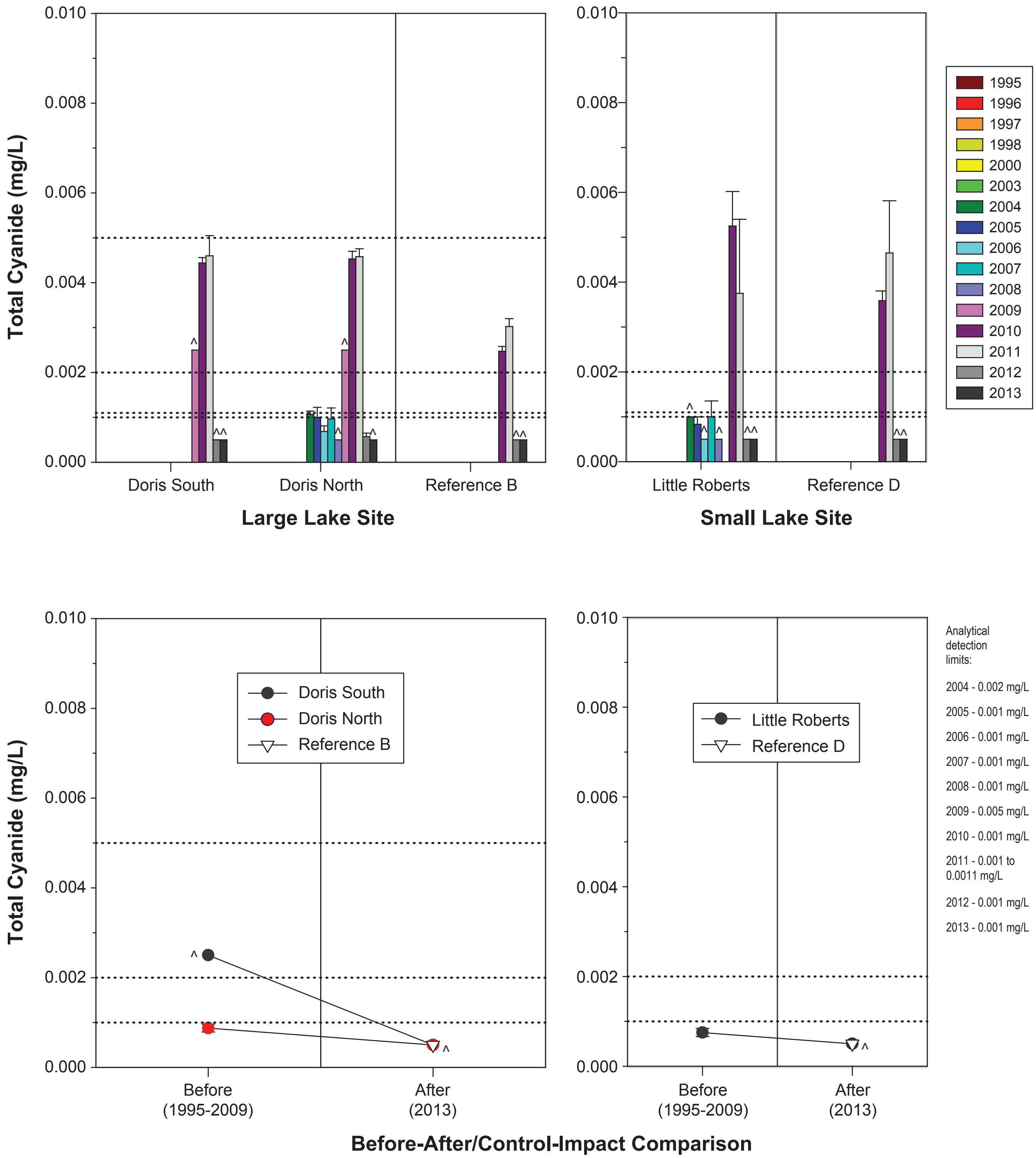
Total Ammonia Concentration in AEMP Lake Sites, Doris North Project, 1995 to 2013



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 (3.0 mg/L; long-term concentration).
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.

Figure 3.3-24

Nitrate Concentration in AEMP Lake Sites, Doris North Project, 1995 to 2013



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.

Figure 3.3-25

Total Cyanide Concentration in AEMP Lake Sites, Doris North Project, 1995 to 2013

Free cyanide concentrations (cyanide existing in the form of HCN and CN-) in lake samples were measured in 2013 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 always below the detection limit of 0.001 mg/L and the CCME guideline (Appendix A). Therefore, the cyanide levels in exposure lakes in 2013 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. All concentrations of radium-226 measured in 2013 at the exposure and reference lakes were near or below the analytical detection limit of 0.01 Bq/L, except at Doris Lake South in July where a concentration of 0.056 Bq/L was measured (Figure 3.3-26 and Appendix A). Statistical analysis results are not presented for radium-226 because more than 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. Based on the before-after plots of radium-226 concentrations in the exposure lake sites (Figure 3.3-26), there was no apparent increase in radium-226 concentrations in exposure lakes in 2013.

3.3.2.9 Total Aluminum

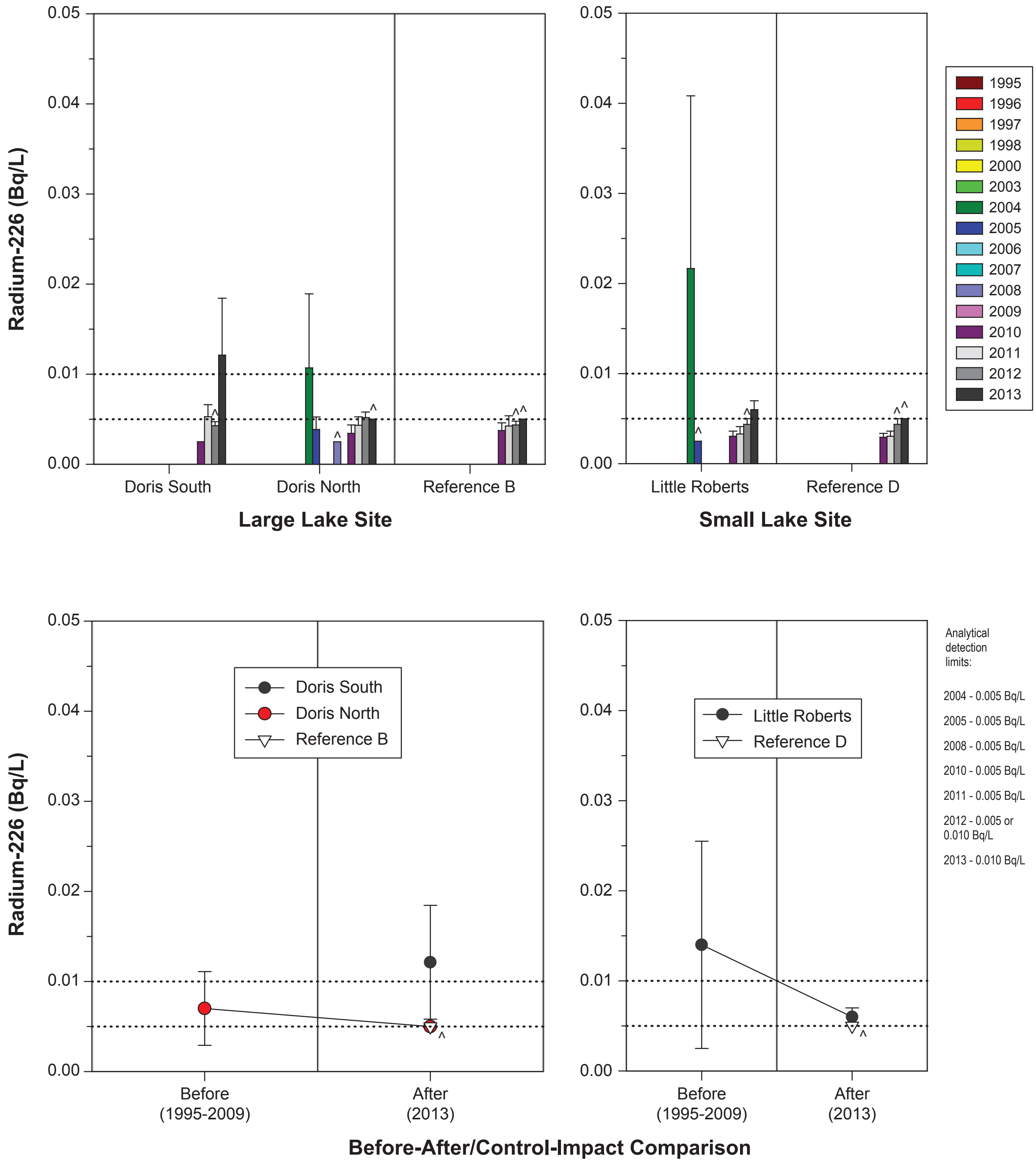
Total aluminum is a required variable for effluent characterization as per Schedule 5, s. 4(1) of the MMER. In the exposure lake sites, mean 2013 total aluminum concentrations were at the low end of the range of baseline means, and below the pH-dependent CCME guideline of 0.1 mg/L (Figure 3.3-27). The before-after analysis confirmed that the mean 2013 concentration was not distinguishable from the baseline mean for any exposure lake site ($p = 0.52$ for Doris Lake South, $p = 0.18$ for Doris Lake North, and $p = 0.39$ for Little Roberts Lake). Therefore, there was no apparent effect of 2013 Project activities on total aluminum concentrations in the exposure lakes.

3.3.2.10 Total Arsenic

Total arsenic is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. Mean 2013 total arsenic concentrations in 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, 2013 activities did not cause an increase in arsenic concentrations in lakes. The before-after comparison indicated that there was no difference between the 2013 mean arsenic concentration and the baseline mean at Doris Lake South ($p = 0.41$) and Little Roberts Lake ($p = 0.69$). The mean 2013 arsenic concentration at Doris Lake North was significantly lower than the baseline mean ($p = 0.0023$); however, this was an artefact of the substitution of values that were below detection with half the analytical detection limit instead of the full detection limit, which would have resulted in the means being indistinguishable from each other ($p = 0.36$). Regardless, since the change was a decrease, there was no adverse effect of 2013 Project activities on arsenic concentrations in the exposure lakes.

3.3.2.11 Total Cadmium

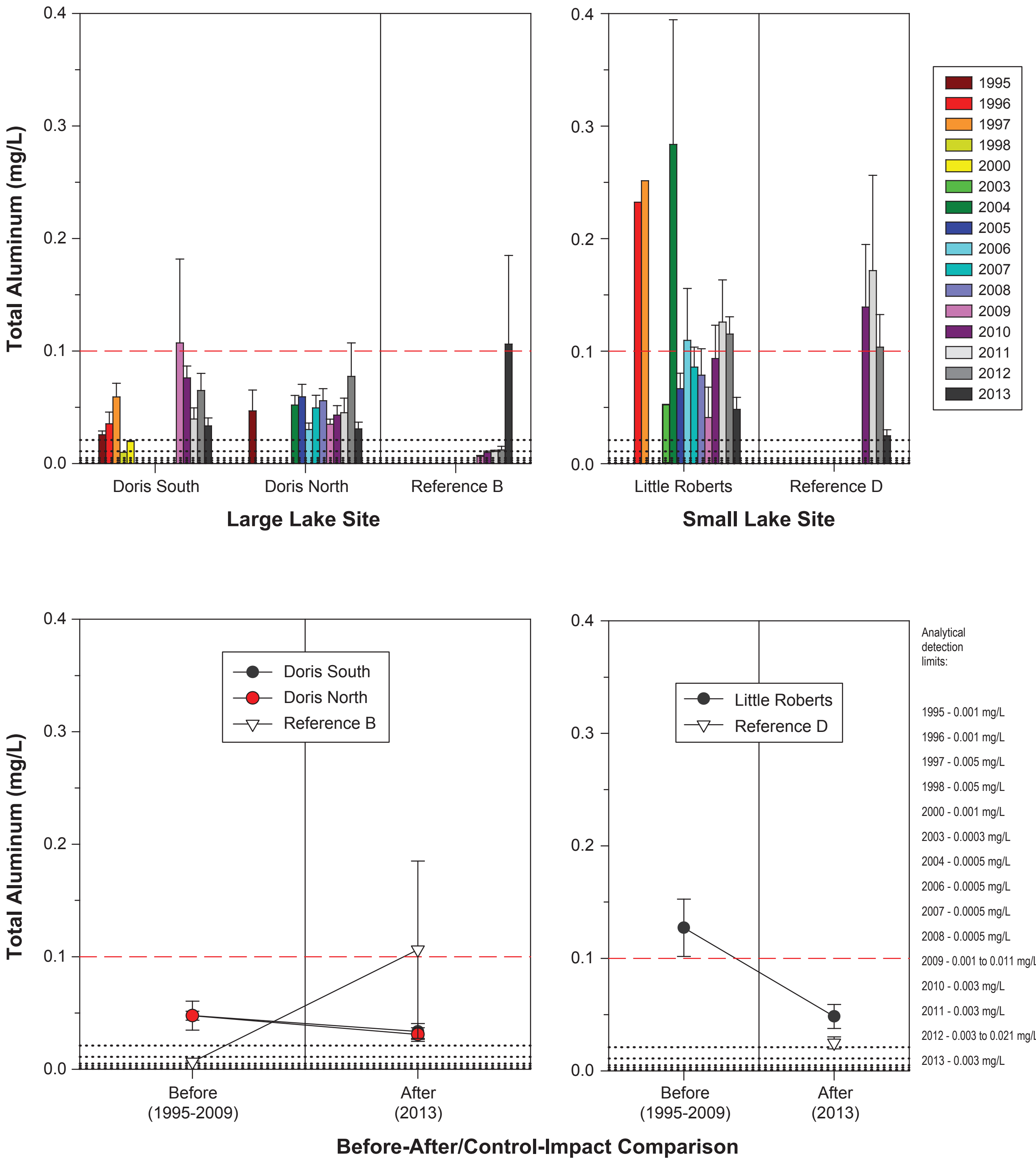
Total cadmium is a required variable for effluent characterization as per Schedule 5, s. 4(1) of the MMER. At both Doris Lake South and Little Roberts Lake, all 2013 cadmium concentrations were below the analytical detection limit of 0.000005 mg/L (Figure 3.3-29; Appendix A), so there was no apparent effect of Project activities on total cadmium at these sites. At Doris Lake North, the total cadmium concentrations in 9 out of 10 samples collected in 2013 were below the detection limit. The single detectable concentration of 0.000047 mg/L in a sample collected in April was higher than the site-specific hardness-dependent CCME guideline for cadmium (Appendix A). However, the mean 2013 cadmium concentration for Doris Lake North was within the range of means calculated for baseline years, so there is no evidence of an effect of 2013 Project activities on total cadmium levels in this lake (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 combined baseline and 2013 datasets for each lake site were below analytical detection limits.



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ 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.

Figure 3.3-26

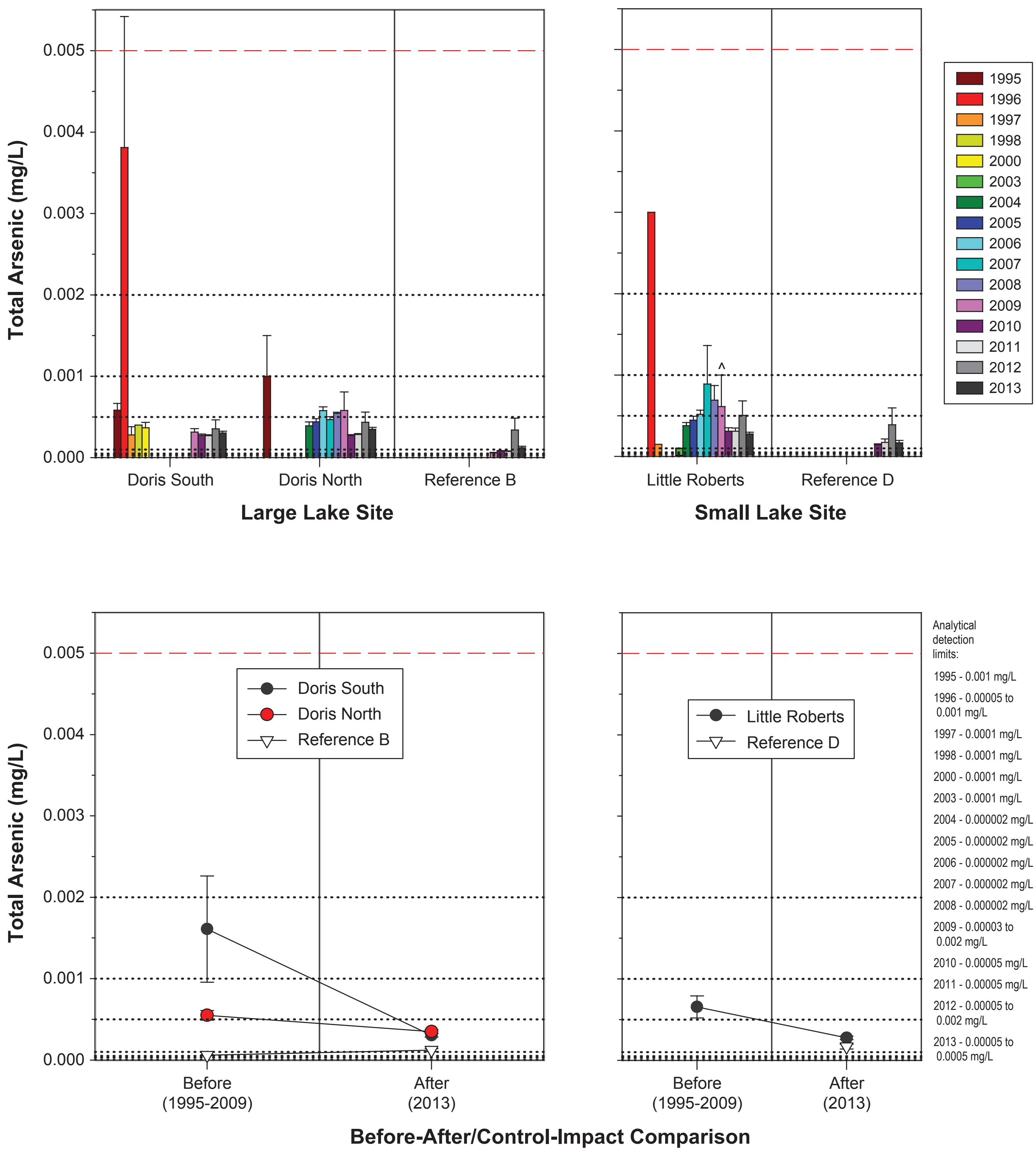
Radium-226 Concentration in AEMP Lake Sites, Doris North Project, 1995 to 2013



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.

Figure 3.3-27

Total Aluminum Concentration in AEMP Lake Sites, Doris North Project, 1995 to 2013



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.

Figure 3.3-28

Total Arsenic Concentration in AEMP Lake Sites, Doris North Project, 1995 to 2013

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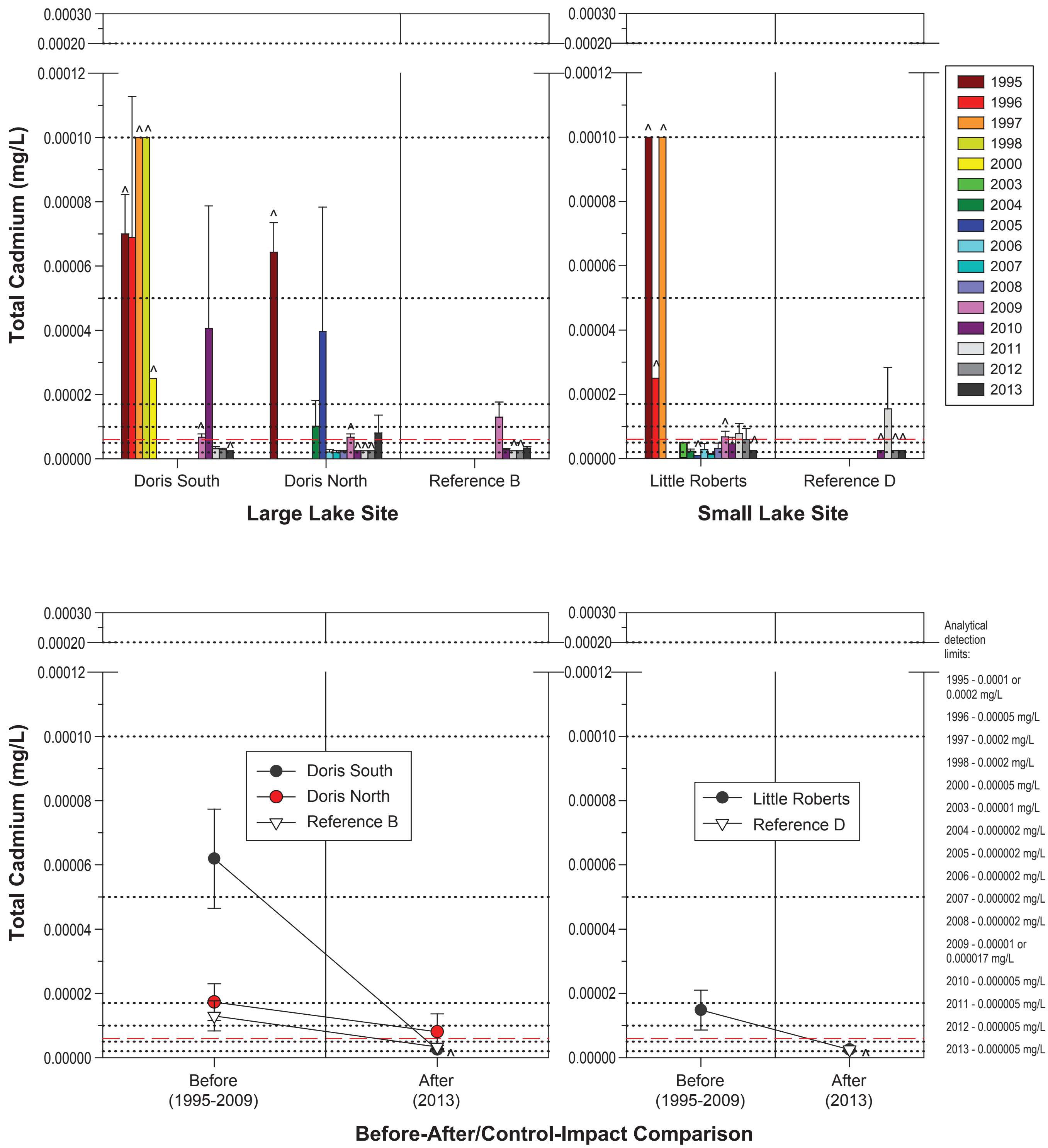


Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
The CCME freshwater guideline for cadmium is hardness dependent.
Red dashed lines represent the minimum CCME freshwater guideline for cadmium based on the minimum hardness measured in exposure lakes between 1996 and 2013 (hardness: 14.3 mg/L; CCME guideline: 0.000006 mg/L).
Total cadmium is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

Figure 3.3-29

Total Cadmium Concentration in AEMP Lake Sites, Doris North Project, 1995 to 2013

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 lake sites, mean 2013 copper concentrations were at the low end of the range of baseline annual means (Figure 3.3-30). Although the total copper concentration in a single sample collected from Doris Lake North in August was slightly greater than the hardness-dependent CCME guideline for copper (Appendix A), the mean 2013 concentrations at all sites were below the minimum CCME guideline of 0.002 mg/L. The before-after analysis found that 2013 mean copper concentrations were not distinguishable from baseline means at the exposure lake sites ($p = 0.29$ for Doris Lake South, $p = 0.49$ for Doris Lake North, and $p = 0.71$ for Little Roberts Lake). Therefore, there was no apparent effect of 2013 Project activities on total copper levels in any exposure lake.

3.3.2.13 Total Iron

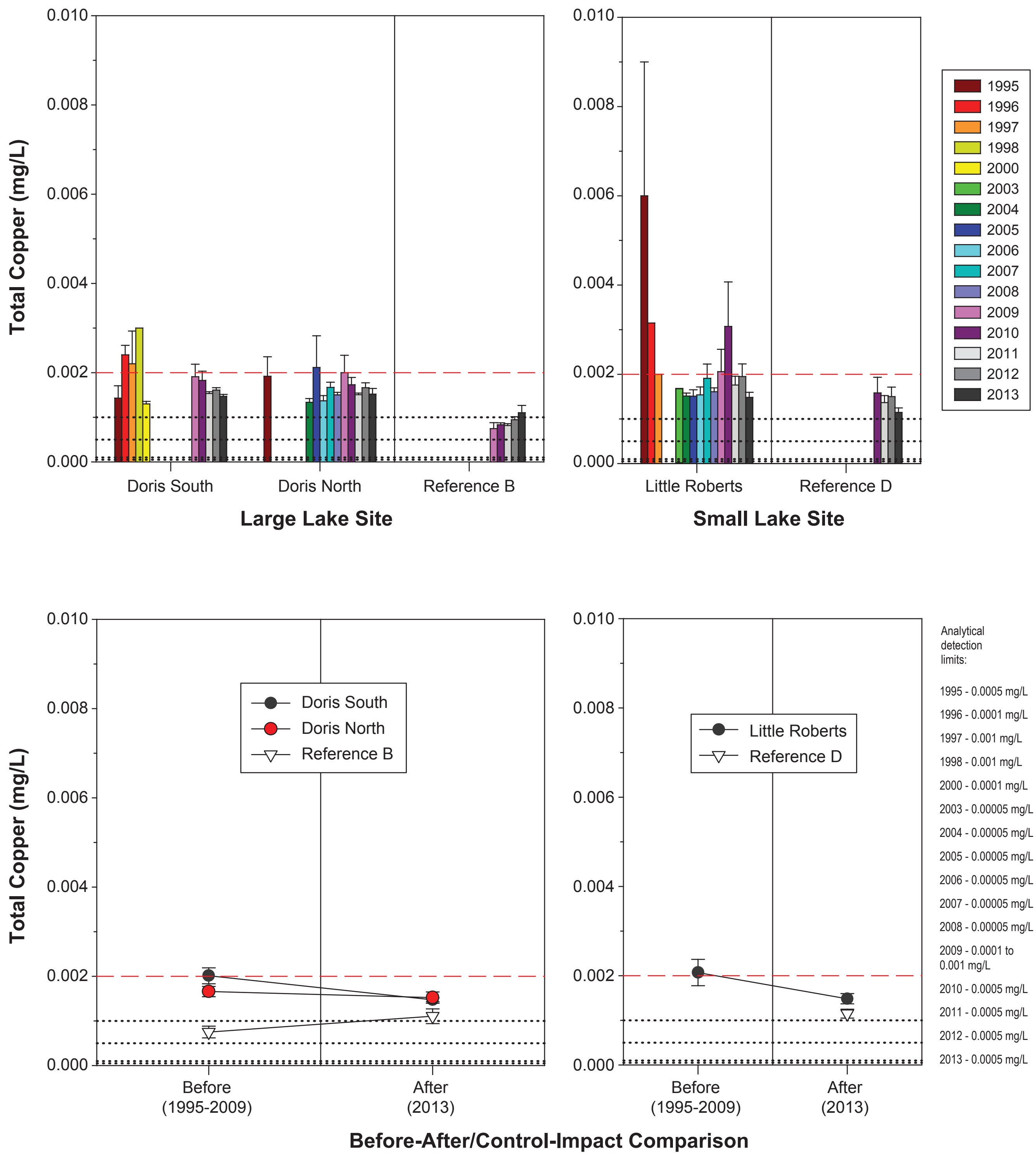
Total iron is a required variable for effluent characterization as per Schedule 5, s. 4(1) of the MMER. Total iron concentrations measured at the exposure lake sites in 2013 were similar to baseline concentrations (Figure 3.3-31). At the exposure lake sites, all total iron concentrations measured in 2013 were below the CCME guideline of 0.3 mg/L, although concentrations in samples collected in April 2013 at the reference lakes did exceed this guideline (Appendix A). For all exposure sites, the before-after analysis showed that mean 2013 total iron concentrations were not distinguishable from mean baseline concentrations ($p = 0.59$ for Doris Lake South, $p = 0.57$ for Doris Lake North, and $p = 0.84$ for Little Roberts Lake), suggesting that 2013 Project activities had no effect on total iron concentrations in exposure lakes (Figure 3.3-31).

3.3.2.14 Total Lead

Total lead is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. Total lead concentrations measured in exposure lakes in 2013 tended to be near or below the detection limit of 0.00005 mg/L and were always below the hardness-dependent CCME guideline (Appendix A). Mean 2013 total lead concentrations for all the exposure lakes were lower than baseline means (Figure 3.3-32), suggesting that there was no adverse effect of Project activities on total lead concentrations in lakes. The before-after analysis showed that there was no significant difference between 2013 and baseline mean concentrations for any exposure lake ($p = 0.32$ for Doris Lake South, $p = 0.31$ for Doris Lake North, and $p = 0.59$ for Little Roberts Lake).

3.3.2.15 Total Mercury

Total mercury is a required variable for effluent characterization as per Schedule 5, s. 4(1) of the MMER. A high proportion of total mercury concentrations in the combined baseline and 2013 datasets for exposure lakes were below analytical detection limits (72% for Doris Lake South, 46% for Doris Lake North, and 57% for Little Roberts Lake). The majority of total mercury concentrations measured in exposure lakes in 2013 were above the ultra-low detection limit of 0.0000005 mg/L, ranging from below detection (< 0.0000005 mg/L) to 0.0000091 mg/L. All 2013 total mercury concentrations in exposure lakes were similar to concentrations in reference lakes and 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. The before-after plot shows that mean 2013 total mercury concentrations at the exposure lake sites were lower than baseline means; however, for Doris Lake South, all baseline concentrations were below analytical detection limits, so this decrease is an artefact of the substitution of half the detection limit for values that were below relatively high detection limits. The before-after analysis showed that there was no difference in means between baseline years and 2013 for Doris Lake North ($p = 0.32$) and Little Roberts Lake ($p = 0.52$). There was no evidence of an effect of Project activities on total mercury concentration in any exposure lake.



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
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 2013

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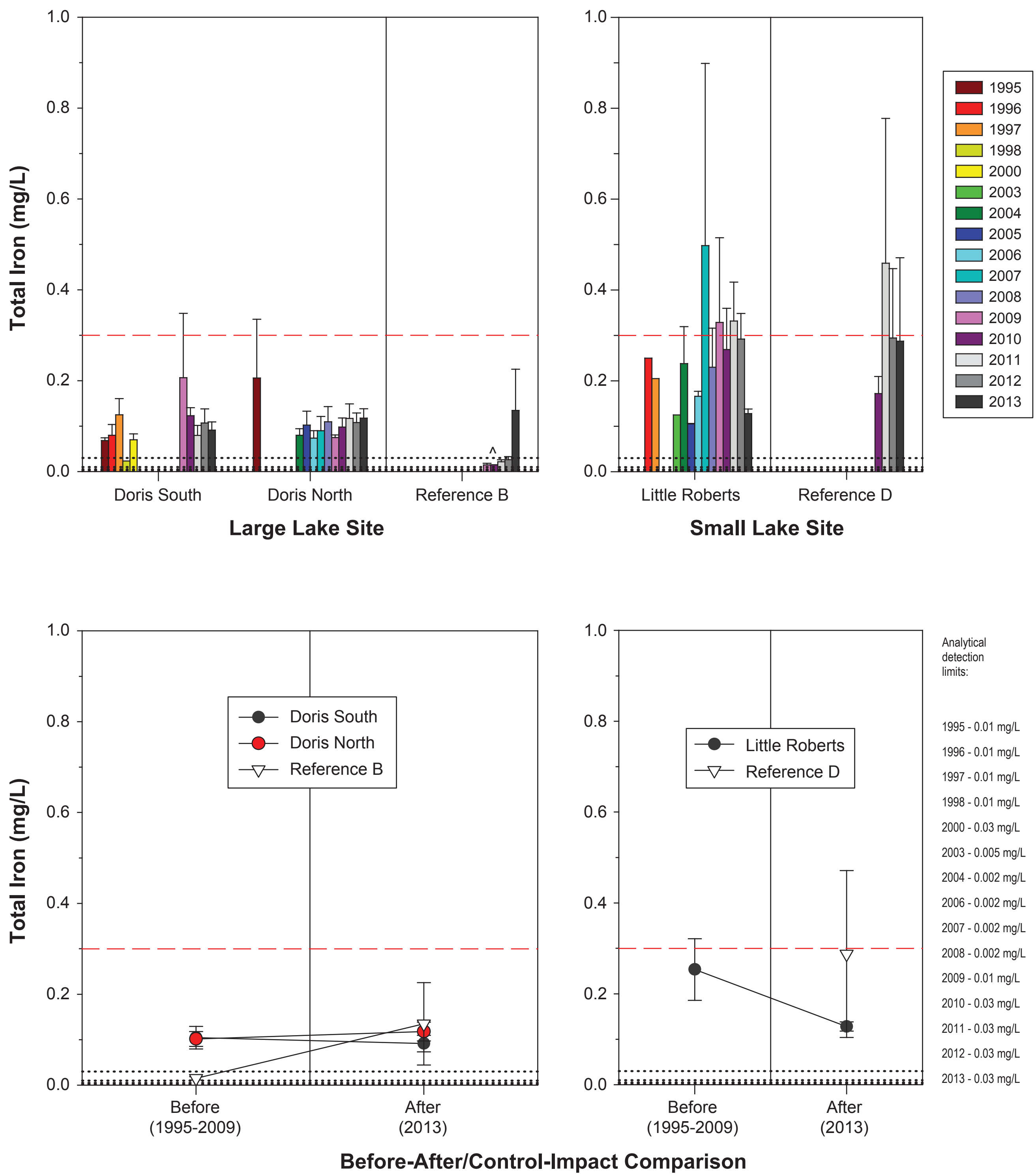
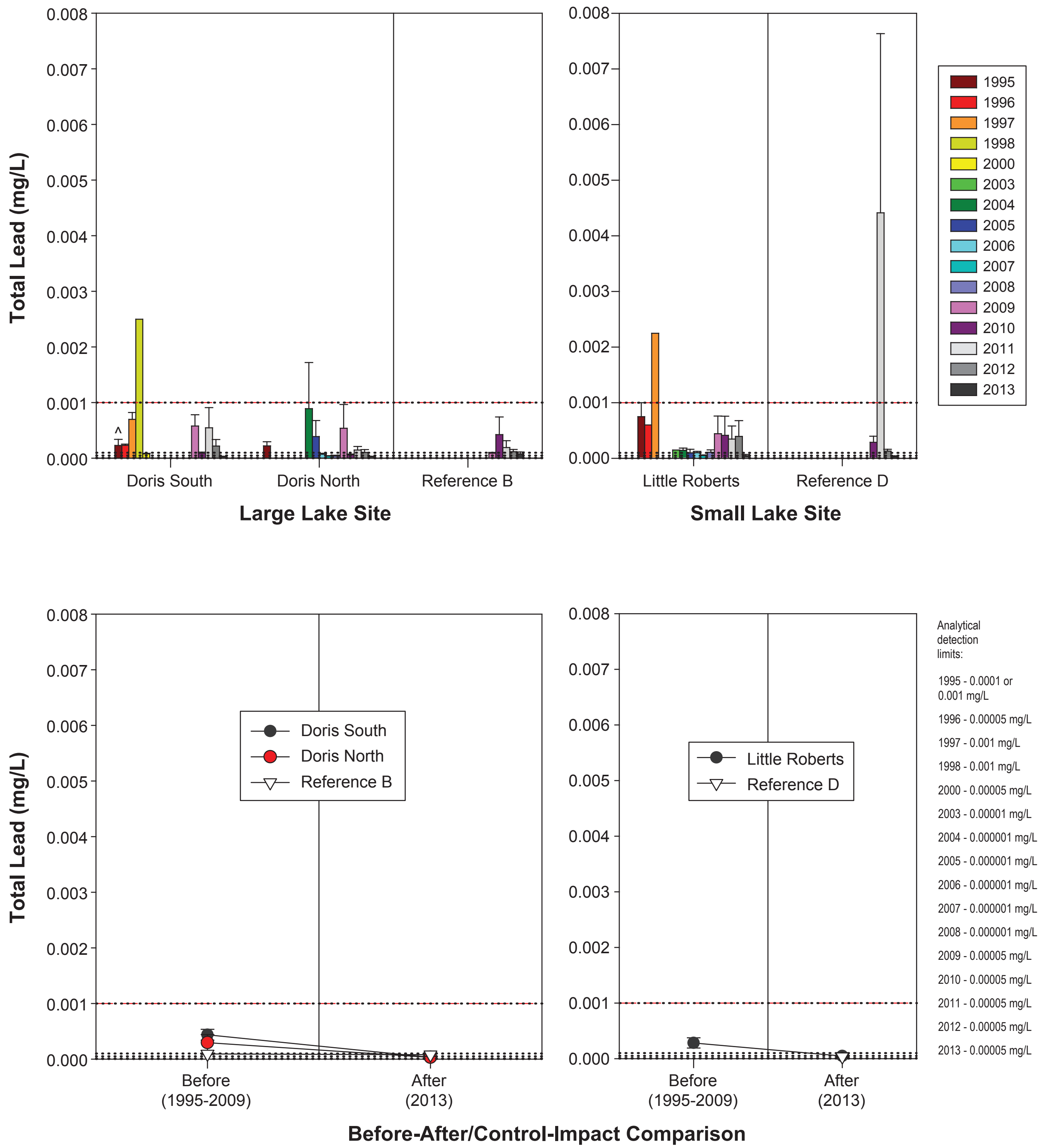


Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed lines represent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

Figure 3.3-31

Total Iron Concentration in AEMP Lake Sites, Doris North Project, 1995 to 2013



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 3.3-32

Total Lead Concentration in AEMP Lake Sites, Doris North Project, 1995 to 2013

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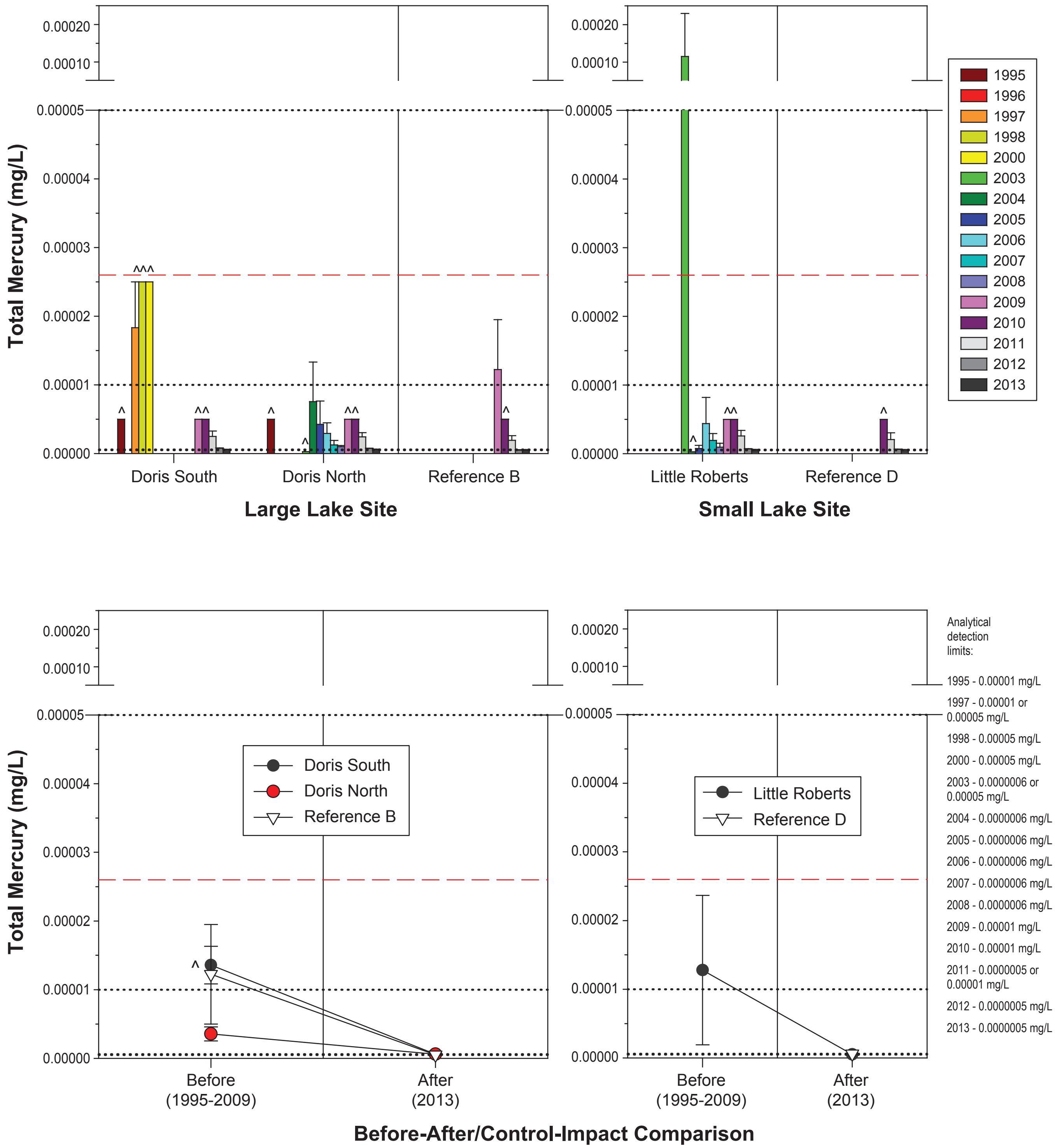

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed lines represent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

Figure 3.3-33

Total Mercury Concentration in AEMP Lake Sites, Doris North Project, 1995 to 2013

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3.3.2.16 Total Molybdenum

Total molybdenum is a required variable for effluent characterization as per Schedule 5, s. 4(1) of the MMER. 2013 total molybdenum concentrations were very similar among exposure streams, and well below the interim CCME guideline of 0.073 mg/L (Figure 3.3-34). In Doris Lake South and Little Roberts Lake, mean 2013 molybdenum concentrations were within the range of baseline means (Figure 3.3-34). The before-after analysis confirmed that mean 2013 total molybdenum concentrations at these sites were not distinguishable from baseline means ($p = 0.95$ for Doris Lake South and $p = 0.20$ for Little Roberts Lake), suggesting that there was no effect of Project activities on total molybdenum levels in these exposure sites.

At Doris Lake North, total molybdenum concentrations increased slightly but consistently over time from 2005 to 2013 (Figure 3.3-34), and the before-after analysis showed that there was a significant difference between baseline and 2013 mean concentrations ($p < 0.0001$). However, the BACI analysis showed that a parallel change occurred at Reference Lake B ($p = 0.046$), so the increase in total molybdenum concentrations was likely unrelated to Project activities.

3.3.2.17 Total Nickel

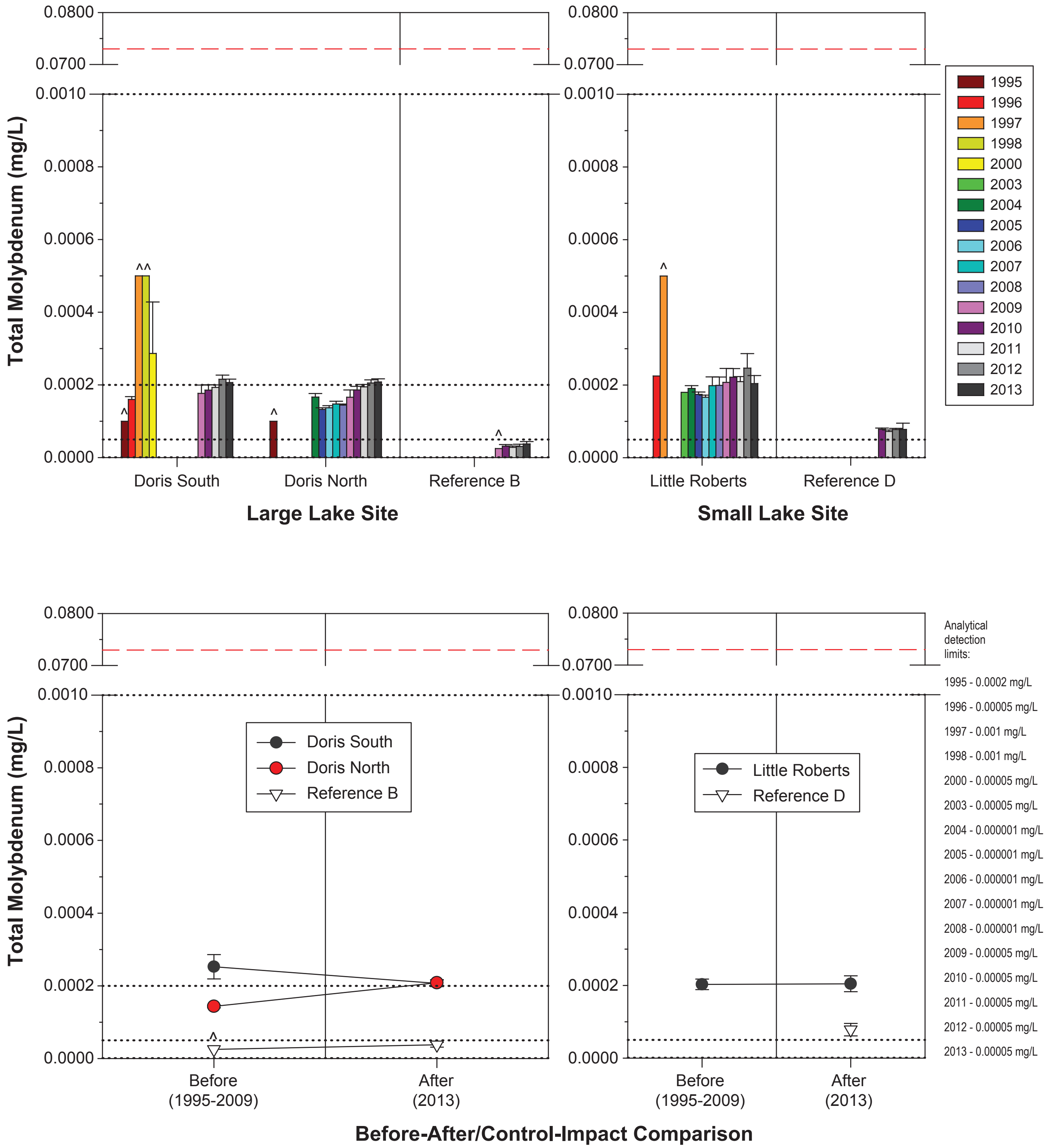
Total nickel is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. Total nickel concentrations measured in exposure lakes in 2013 were well below the hardness-dependent CCME guideline for nickel and within the range of baseline concentrations (Figure 3.3-35). This suggests that 2013 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 2013 compared to baseline years ($p = 0.55$ for Doris Lake South, $p = 0.75$ for Doris Lake North, and $p = 0.77$ 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 2013, the majority of total zinc concentrations measured in exposure lakes were near or below the detection limit of 0.003 mg/L and well below the CCME guideline of 0.03 mg/L (Appendix A). The notable exceptions to this were the total zinc concentrations in two samples collected at Doris Lake North in April 2013 (0.0871 mg/L at the surface and 0.264 mg/L at depth; Appendix A). These concentrations were greater than the CCME guideline, and drove up the 2013 mean total zinc concentration at this site (Figure 3.3-36). The before-after comparison showed that there was a significant difference between baseline and 2013 mean zinc concentrations at Doris Lake North ($p < 0.0001$), but not at Doris Lake South ($p = 0.46$) or Little Roberts Lake ($p = 0.68$). The further BACI analysis done for Doris Lake North showed that a parallel change in total zinc concentrations occurred at Reference Lake B ($p = 0.31$), suggesting that the increase in the mean total zinc concentration in 2013 compared to baseline years was the result of natural variability and was unrelated to Project activities. Therefore, there was no evidence of an increase in zinc in exposure lakes as a result of 2013 Project 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 2013. 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 2013 samples were collected at the surface (0.1 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.



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.

Figure 3.3-34

Total Molybdenum Concentration in AEMP Lake Sites, Doris North Project, 1995 to 2013

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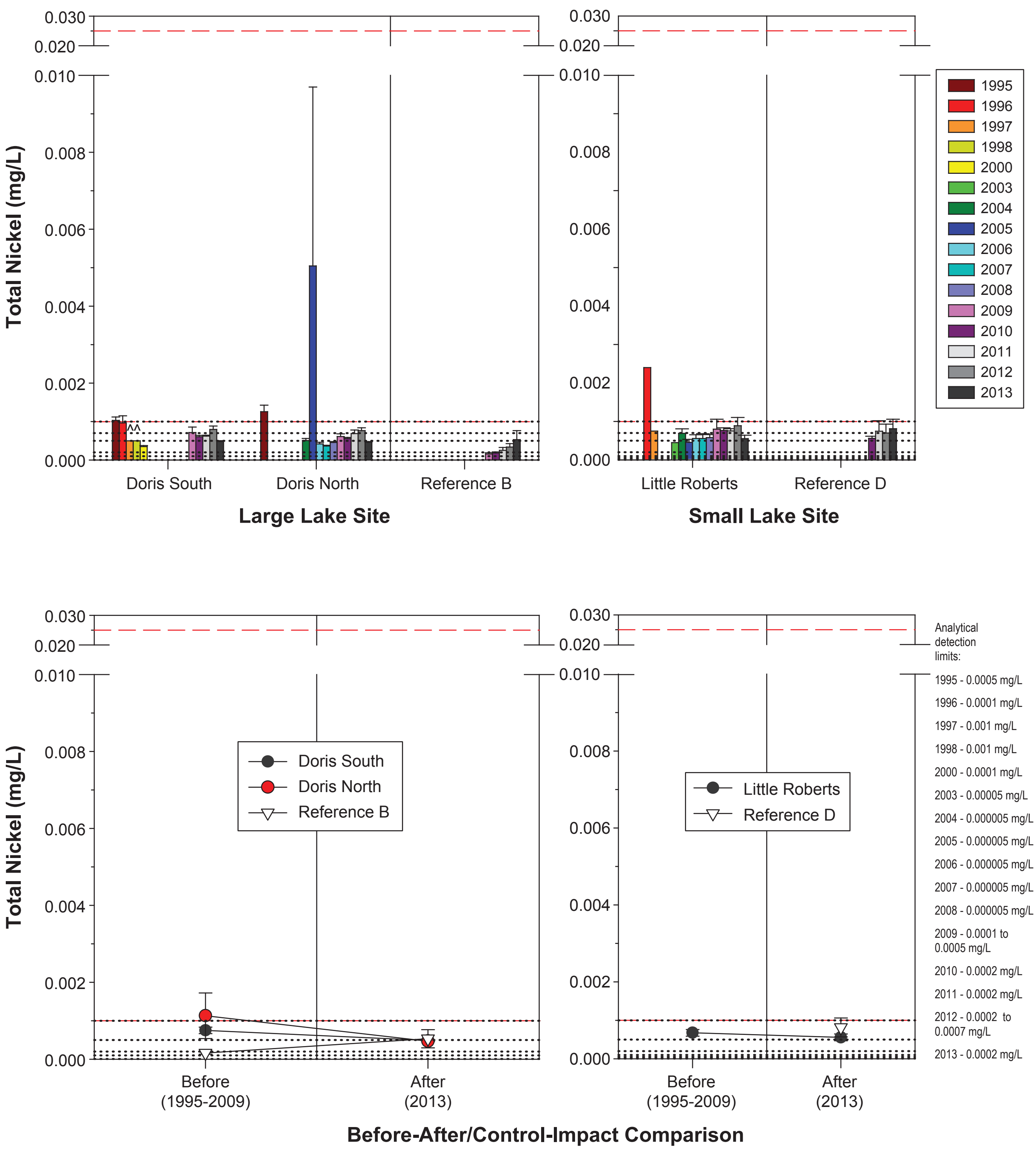
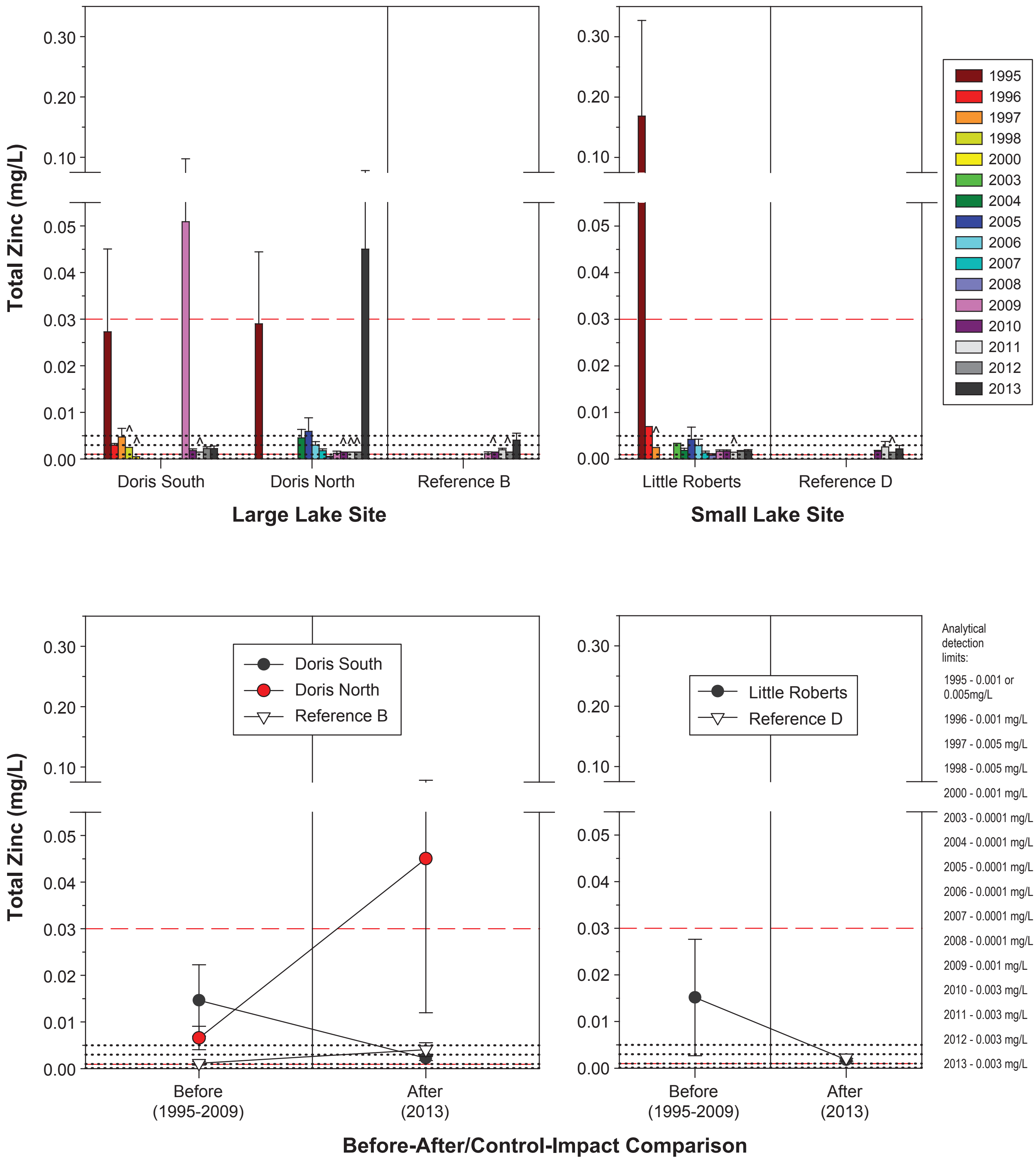


Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
The CCME freshwater guideline for 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 2013



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.

Figure 3.3-36

Total Zinc Concentration in AEMP Lake Sites, Doris North Project, 1995 to 2013

3.3.3.1 pH

pH is a required variable for water quality monitoring as per Schedule 5, s. 7(1)(c) of the MMER. Mean 2013 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 2013 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 is relatively insensitive to change. The before-after comparison confirmed that there was no change in marine pH at the exposure sites in 2013 compared to baseline years ($p = 0.71$ for RBW and $p = 0.92$ for RBE). Therefore, there was no apparent effect of 2013 Project activities on marine pH.

3.3.3.2 Total Alkalinity

Total alkalinity is a required variable 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 2013 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 2013 at RBE compared to baseline levels ($p = 0.044$). 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, 2013 alkalinity levels were generally comparable among the three sites monitored (RBE, RBW, and REF-Marine 1; Figure 3.3-38).

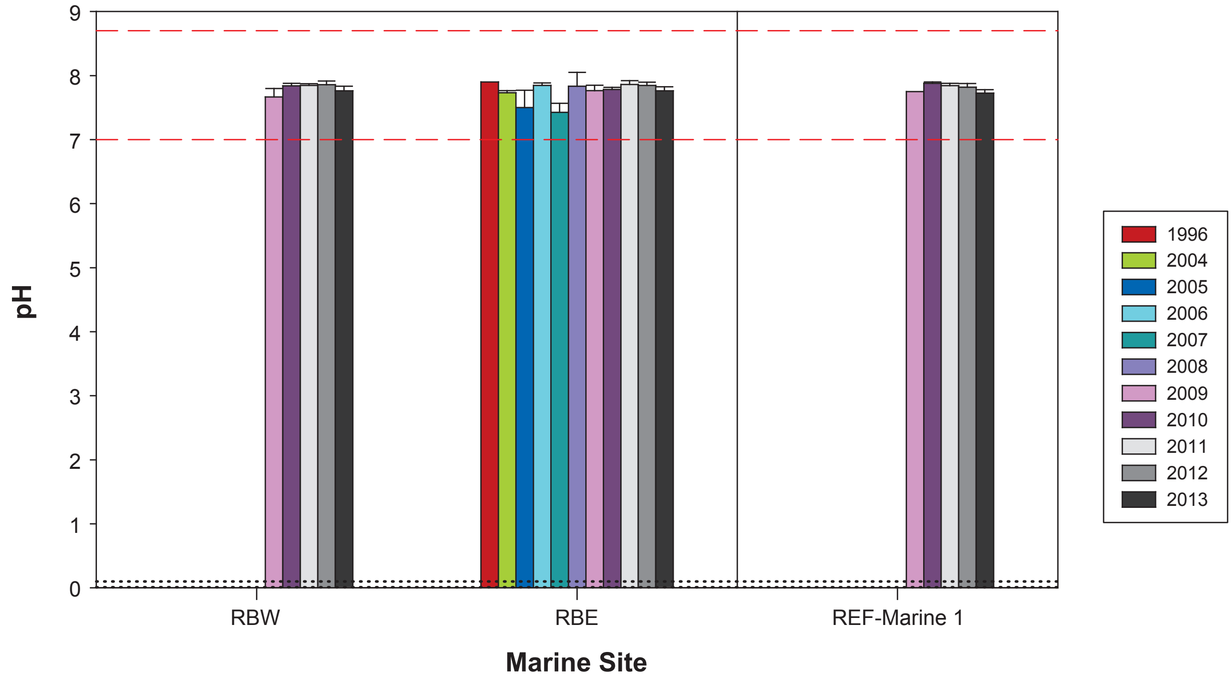
3.3.3.3 Hardness

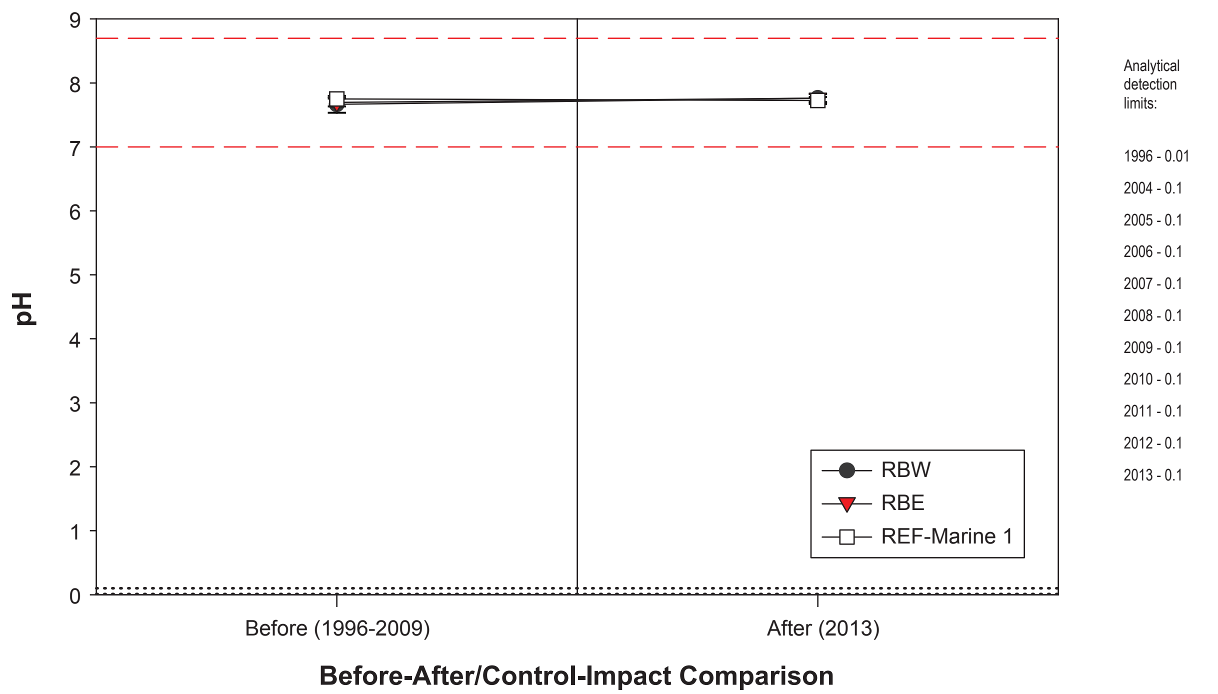
Hardness is a required variable for effluent characterization and water quality monitoring as per Schedule 5, s. 4(1) and s. 7(1)(c) of the MMER. Hardness (as $CaCO_3$) levels measured in 2013 in Roberts Bay sites were generally similar to baseline hardness levels, and were also similar to the hardness levels measured in Ida Bay (REF-Marine-1; Figure 3.3-39). The before-after comparison confirmed that 2013 hardness levels at RBW and RBE were not distinguishable from baseline levels ($p = 0.58$ for RBW and $p = 0.40$ for RBE), suggesting that there was no effect of 2013 Project activities on the hardness of marine waters.

3.3.3.4 Total Suspended Solids

TSS are regulated as deleterious substances in effluents as per Schedule 4 of the MMER. TSS concentrations in the marine environment were highly variable seasonally and inter-annually (Figure 3.3-40 and Appendix A). Mean 2013 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 2013 mean was not statistically distinguishable from the baseline mean ($p = 0.24$). However, the before-after analysis indicated that the mean 2013 concentration at RBW was significantly different from the mean baseline concentration ($p = 0.0056$). In this case, 2013 TSS concentrations were significantly lower than baseline levels, and decreasing TSS concentrations are not of concern. The BACI analysis also showed that a parallel decrease occurred at the reference site ($p = 0.27$). Therefore, there was no apparent adverse effect of 2013 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 2013b). Because there was no increase in TSS concentrations from background levels at either RBW or RBE, 2013 TSS concentrations in marine exposure sites continued to remain below the CCME guideline.





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 2013

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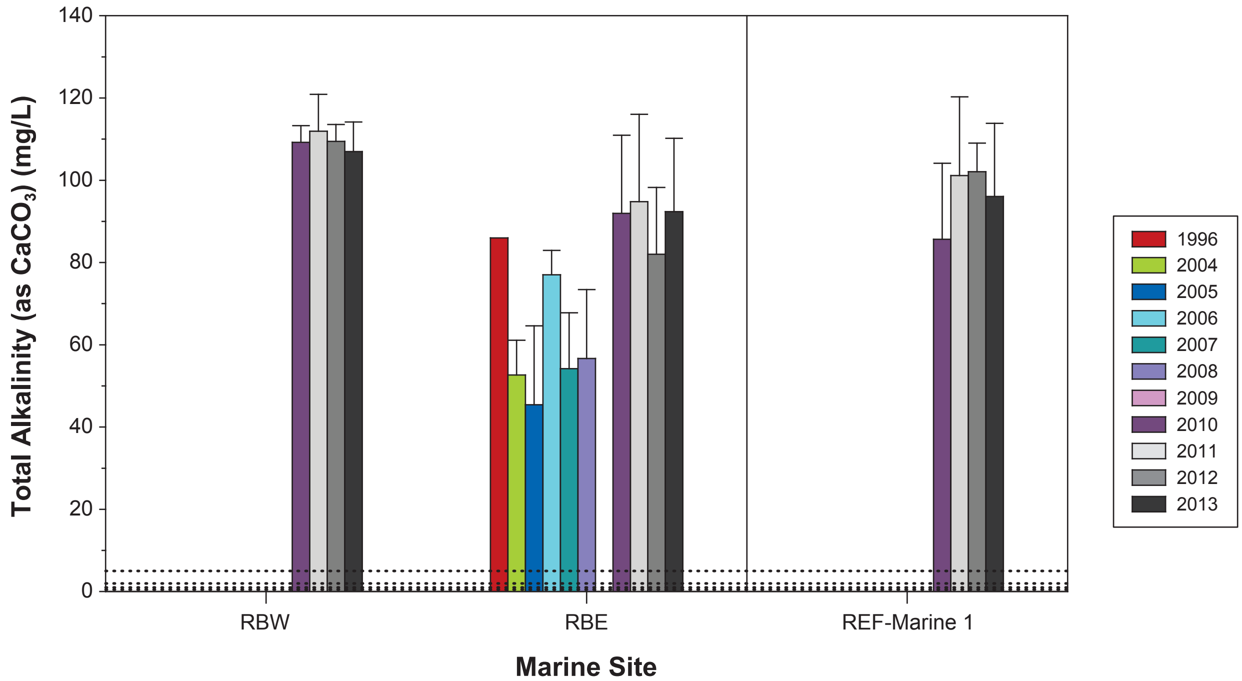
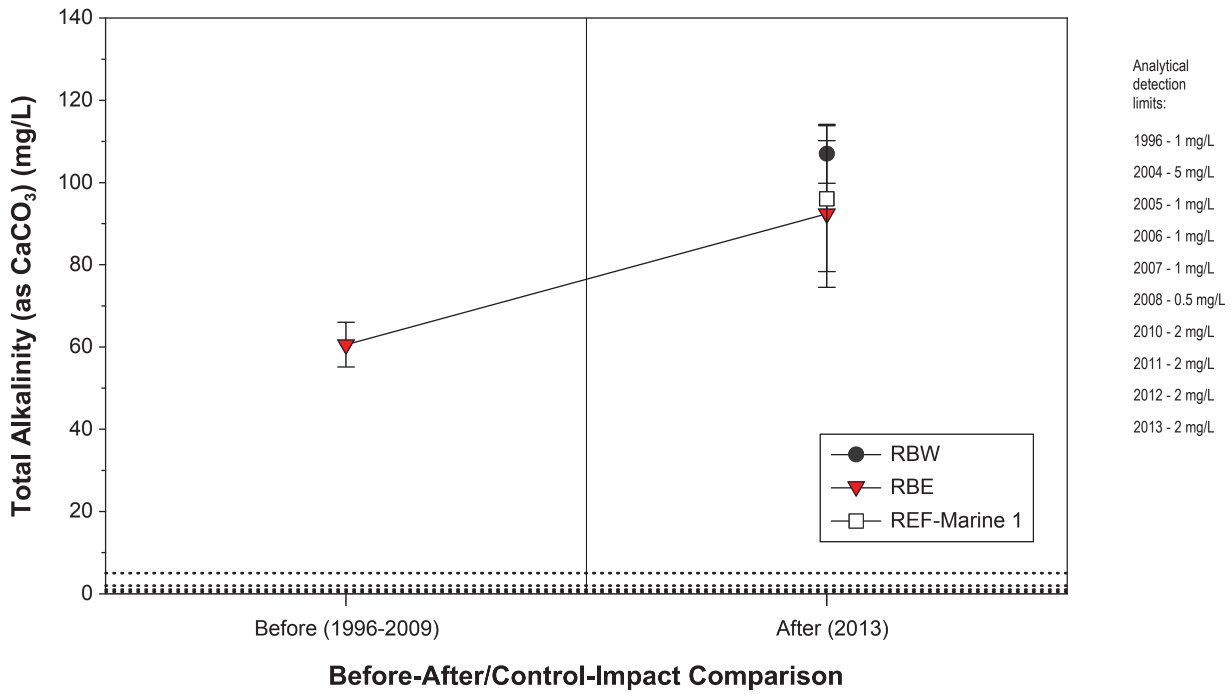
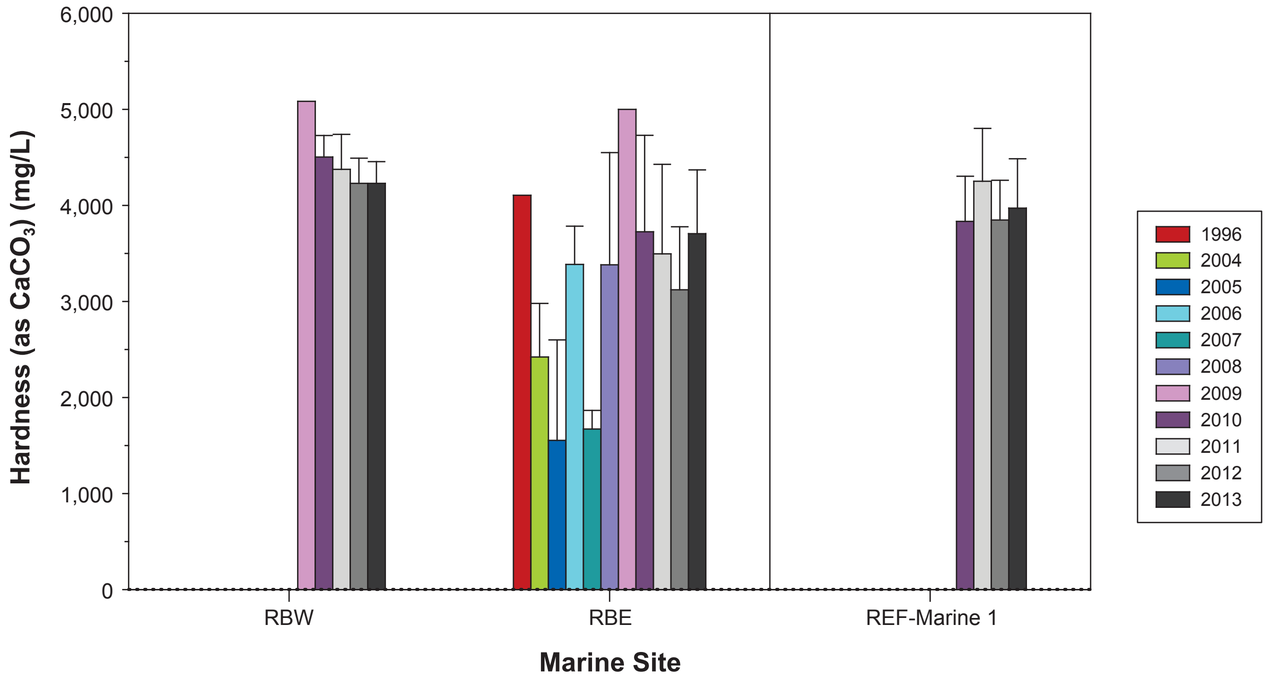


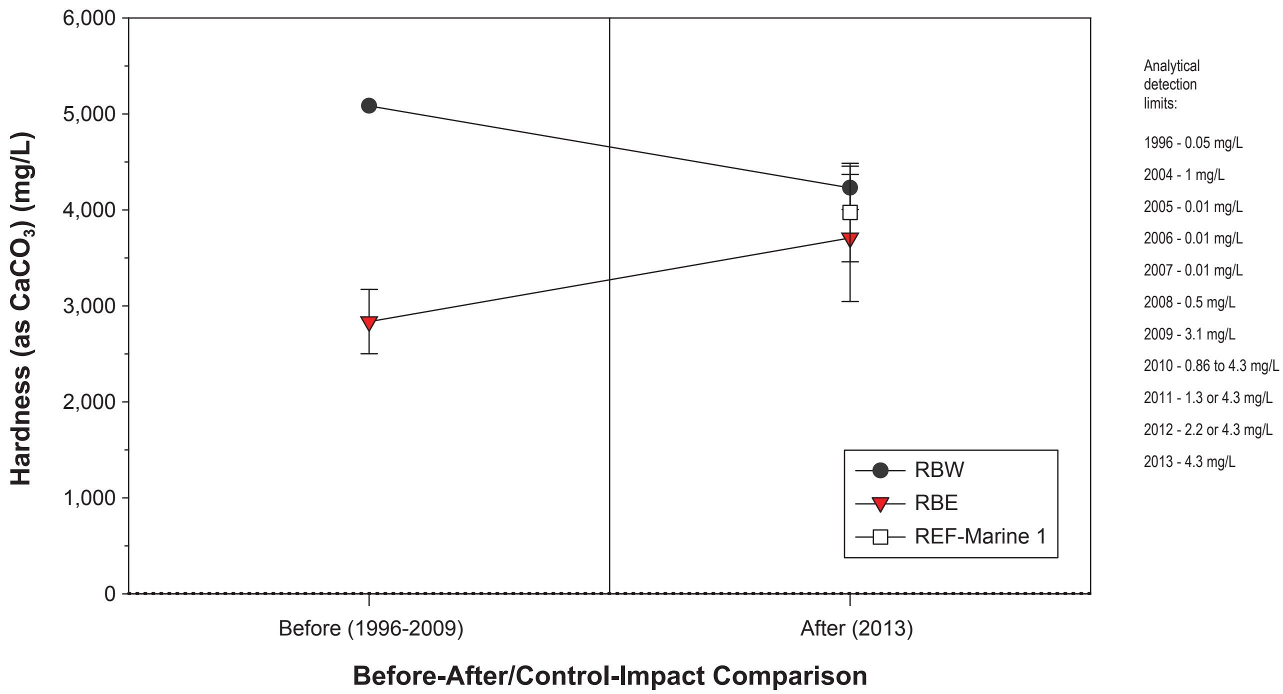


Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
Total alkalinity is a required parameter for effluent characterization and water quality monitoring as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

Figure 3.3-38

Total Alkalinity Concentration in AEMP Marine Sites, Doris North Project, 1996 to 2013





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 2013

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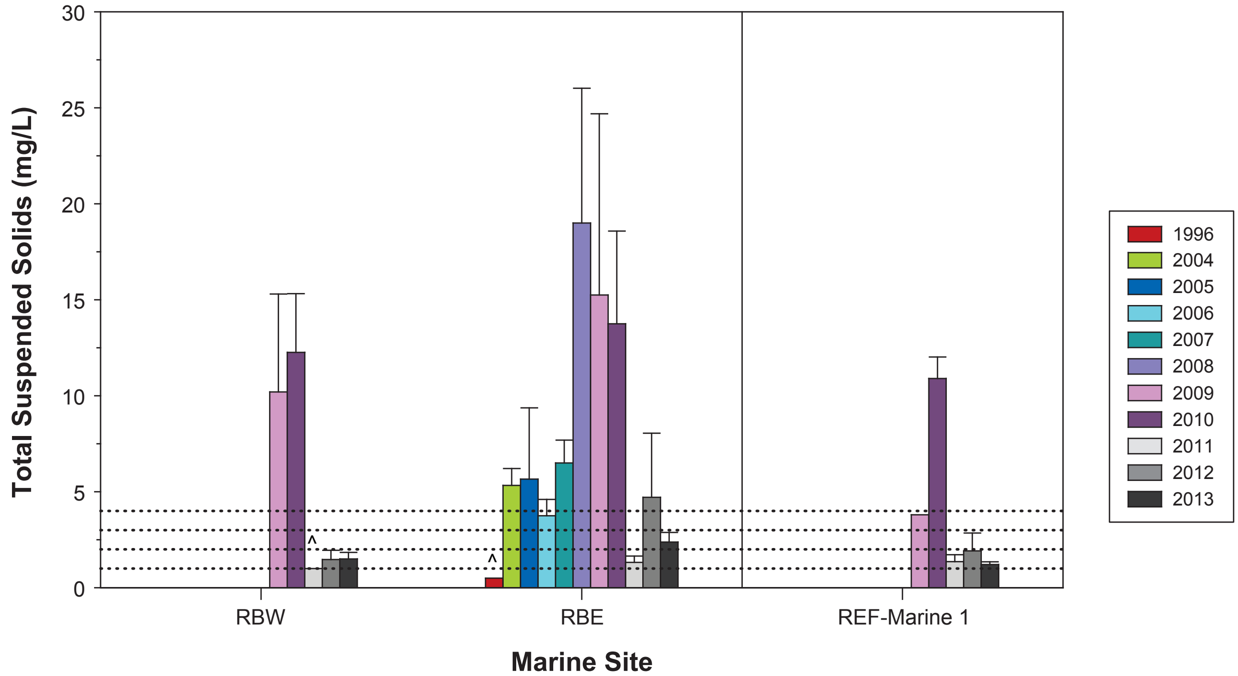

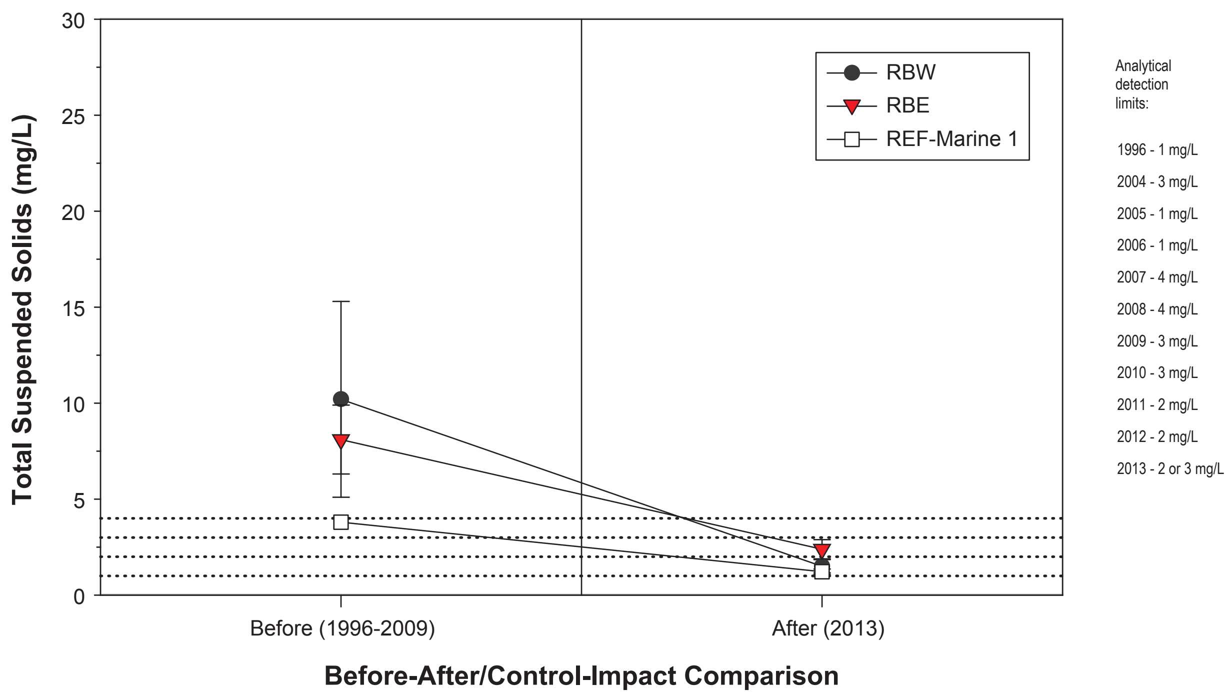

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
The CCME marine guideline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

Figure 3.3-40

Total Suspended Solids Concentration in AEMP Marine Sites, Doris North Project, 1996 to 2013

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3.3.3.5 *Total Ammonia*

Total ammonia is a required variable for effluent characterization as per Schedule 5, s. 4(1) of the MMER. Total ammonia concentrations in all 2013 samples from Roberts Bay were below the analytical detection limit of 0.005 mg ammonia-N/L, except for a single sample collected from RBE that had a total concentration of 0.0062 mg ammonia-N/L (slightly over the detection limit; Figure 3.3-41). At site RBE, baseline ammonia concentrations were widely variable and were most often higher than 2013 concentrations (Figure 3.3-41). The before-after comparison indicated that the 2013 mean total ammonia concentration at RBE was not significantly different from the baseline mean ($p = 0.26$). At site RBW, all baseline and 2013 concentrations were below the analytical detection limit (Figure 3.3-41), so there was no evidence of an effect of Project activities on total ammonia concentrations at the marine exposure sites.

3.3.3.6 *Nitrate*

Nitrate is a required variable for effluent characterization as per Schedule 5, s. 4(1) of the MMER. All 2013 and baseline nitrate concentrations measured in marine reference and exposure sites were well below the marine CCME guideline of 45 mg nitrate-N/L (Figure 3.3-42). Mean 2013 nitrate concentrations at RBW and RBE were within the range of baseline means (Figure 3.3-42). For site RBE, 79% of nitrate concentrations in the combined baseline and 2013 dataset were below analytical detection limits, so the statistical results are considered unreliable. For site RBW, the before-after analysis confirmed that the 2013 and baseline means were not significantly different ($p = 0.83$). There was no apparent effect of 2013 Project activities on nitrate concentrations in the marine exposure sites.

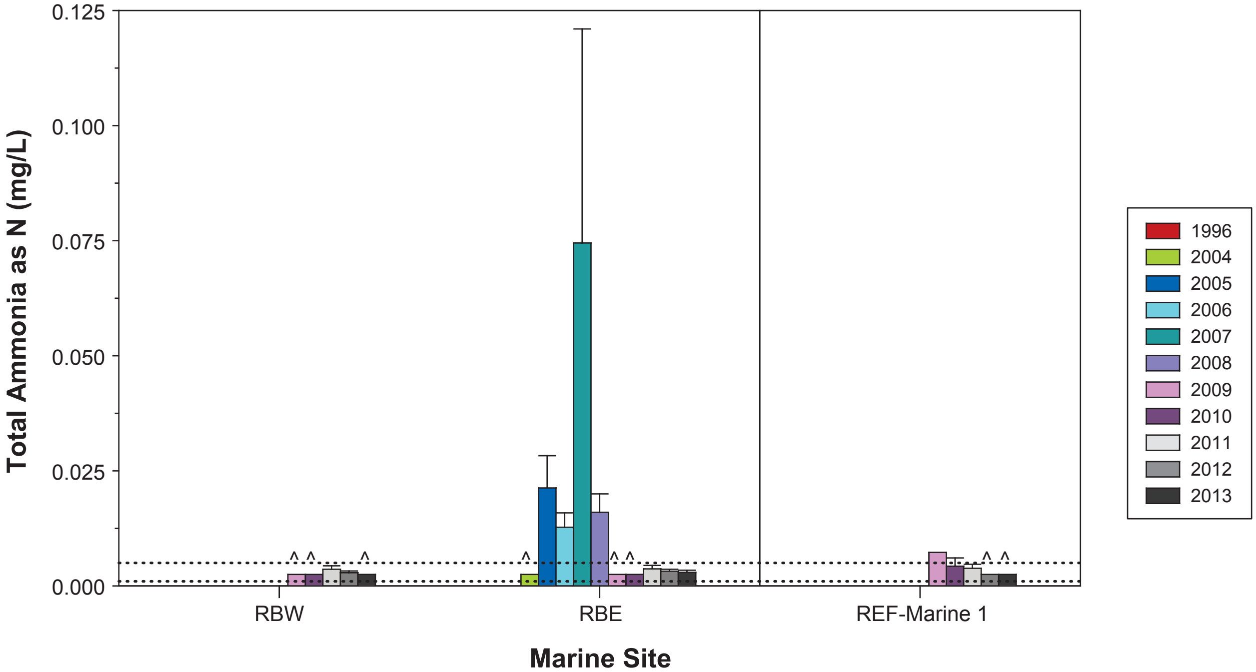
3.3.3.7 *Total Cyanide*

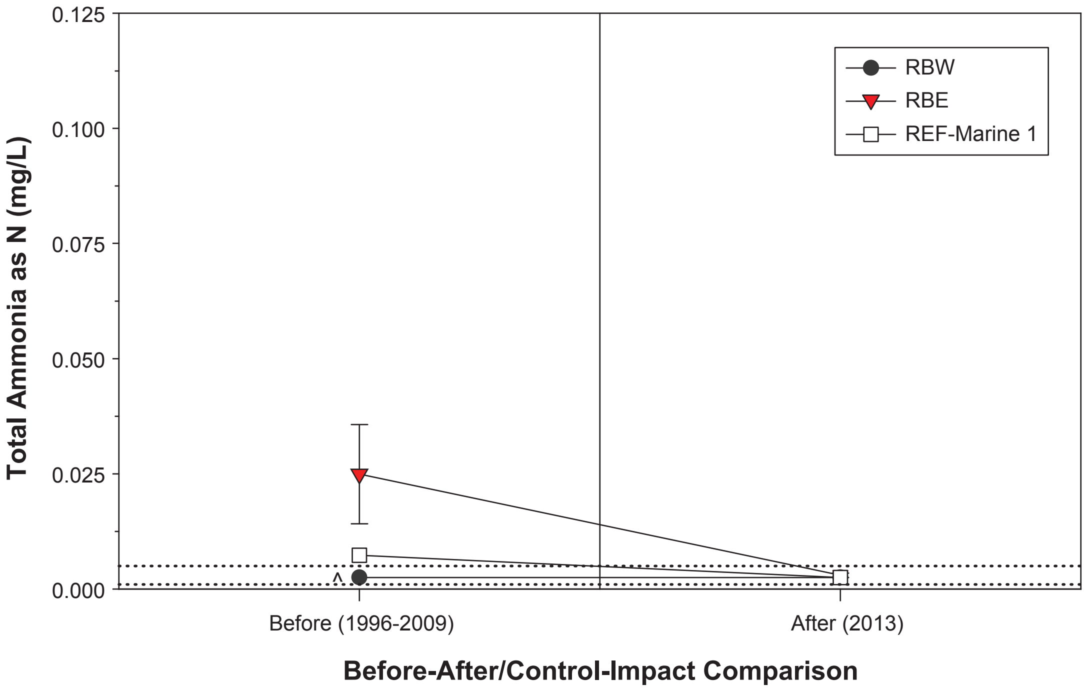
Total cyanide is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. At site RBE, baseline total cyanide concentrations were usually near or below the detection limit, except for some relatively high concentrations measured in 2005, and 2013 concentrations were all below the detection limit of 0.001 mg/L (Figure 3.3-43). Therefore, there was no evidence that 2013 Project activities caused an increase in total cyanide concentrations at RBE.

At site RBW, 2013 concentrations were all near or below the detection limit, except for the samples collected in April, which averaged 0.022 mg/L total cyanide. There is no baseline data available for this site to allow for comparison with 2013 data. Cyanide has never been brought to the Project site, so there is no reason to expect that total cyanide concentrations would increase in either of the marine exposure sites due to Project activities.

3.3.3.8 *Radium-226*

Radium-226 is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. At site RBW, all radium-226 concentrations measured in 2013 were below the analytical detection limit of 0.01 Bq/L (Figure 3.3-44). At site RBE, radium-226 concentrations were below the detection limit in seven out of eight samples collected in 2013, with one detectable concentration of 0.025 Bq/L in a sample collected in April (Appendix A). The mean 2013 radium-226 concentration at site RBE was within the range of baseline concentrations. Therefore, there was no evidence of an increase in radium-226 concentrations in the marine exposure sites as a result of 2013 activities. Statistical analysis results are not discussed because of the high proportion (> 80%) of concentrations that were below detection limits in the datasets for RBW and RBE.





Analytical detection limits:

2004 - 0.005 mg/L
2005 - 0.001 mg/L
2006 - 0.001 mg/L
2007 - 0.001 mg/L
2008 - 0.005 mg/L
2009 - 0.005 mg/L
2010 - 0.005 mg/L
2011 - 0.005 mg/L
2012 - 0.005 mg/L
2013 - 0.005 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.
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.

Figure 3.3-41

Total Ammonia Concentration in AEMP Marine Sites, Doris North Project, 1996 to 2013

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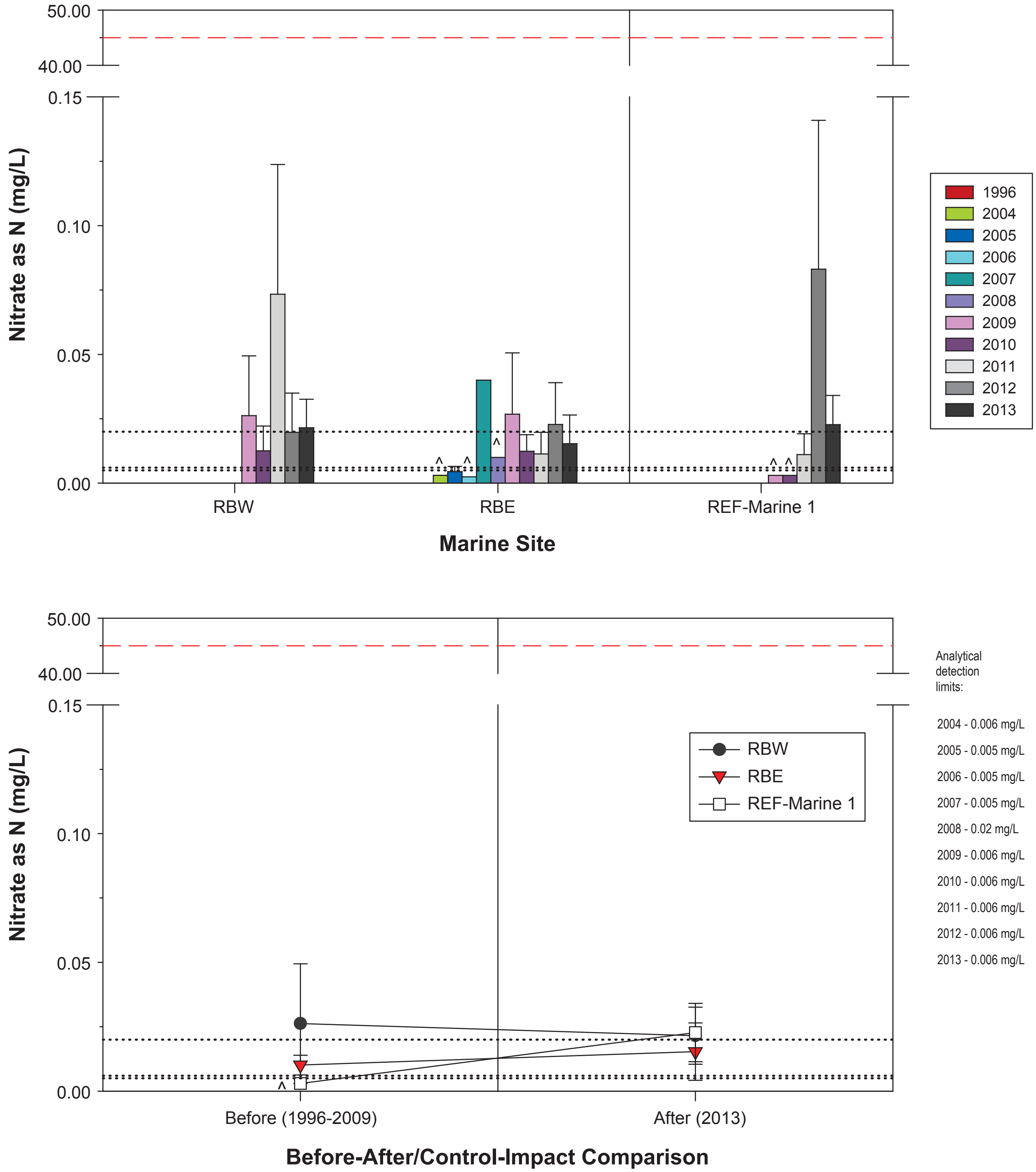

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
Sample concentrations that were below the very high detection limits of 0.1, 0.5, or 2.5 mg/L were excluded from plots.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed line represents the CCME marine guideline for nitrate as N (45 mg/L; long-term concentration).
Nitrate is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

Figure 3.3-42

Nitrate Concentration in AEMP Marine Sites, Doris North Project, 1996 to 2013

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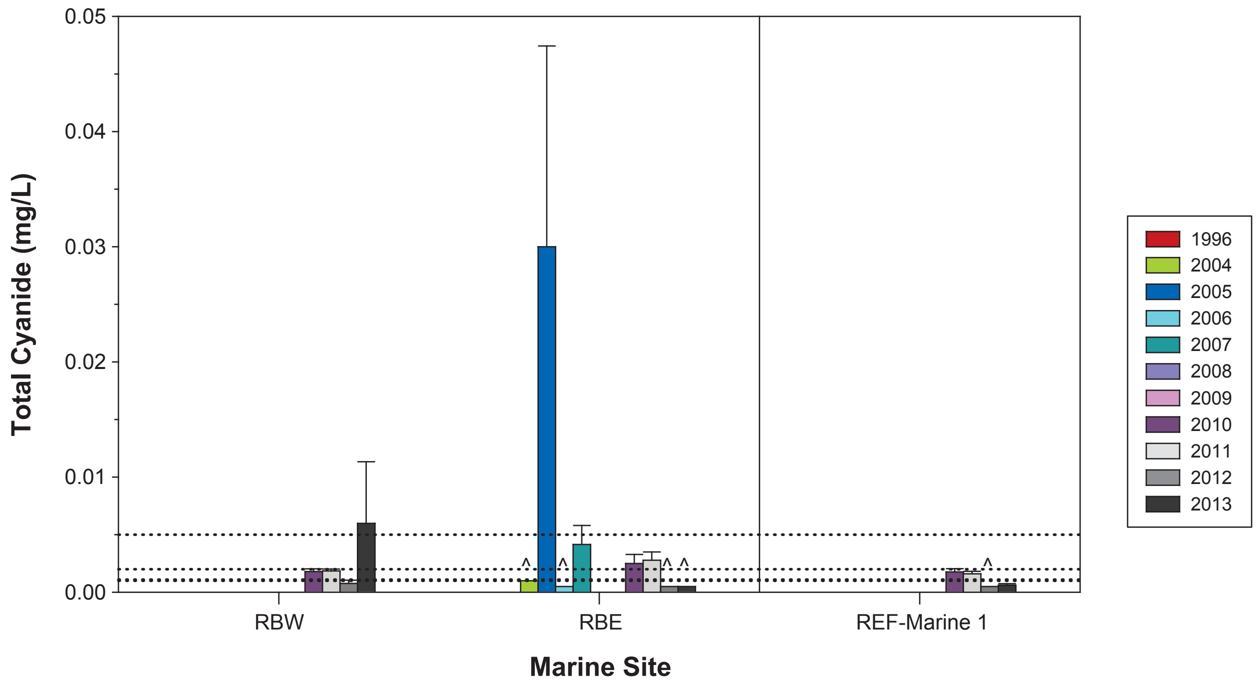
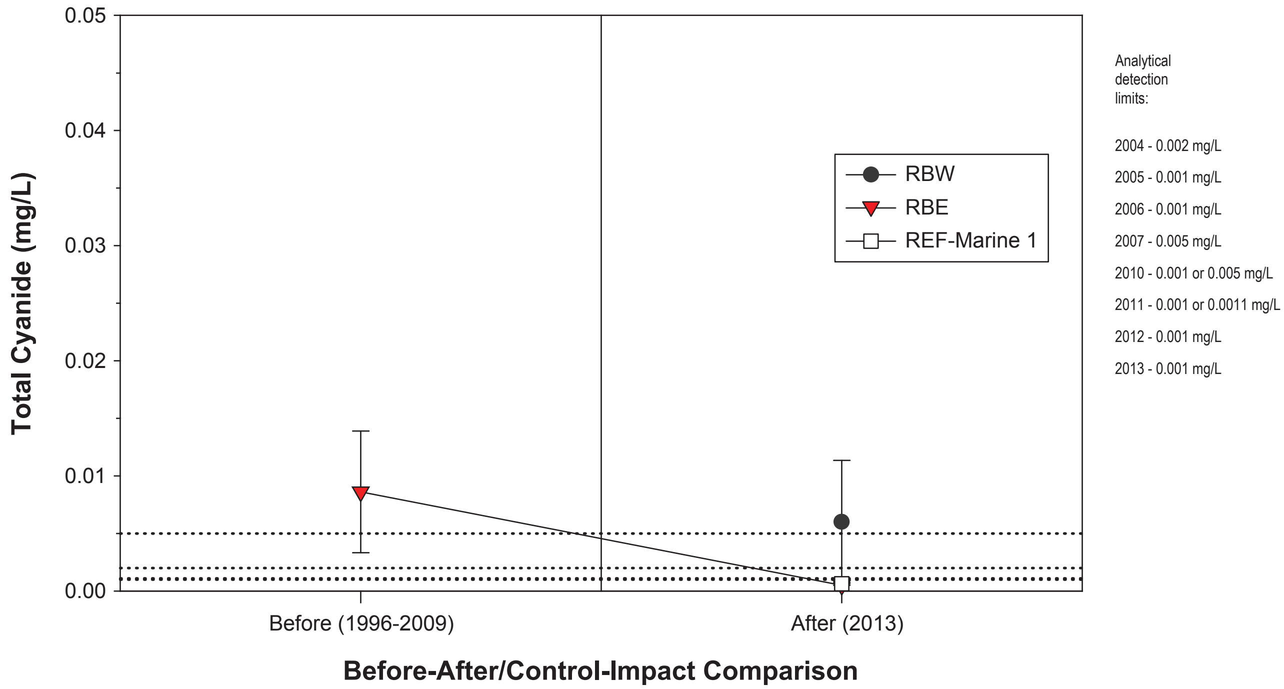
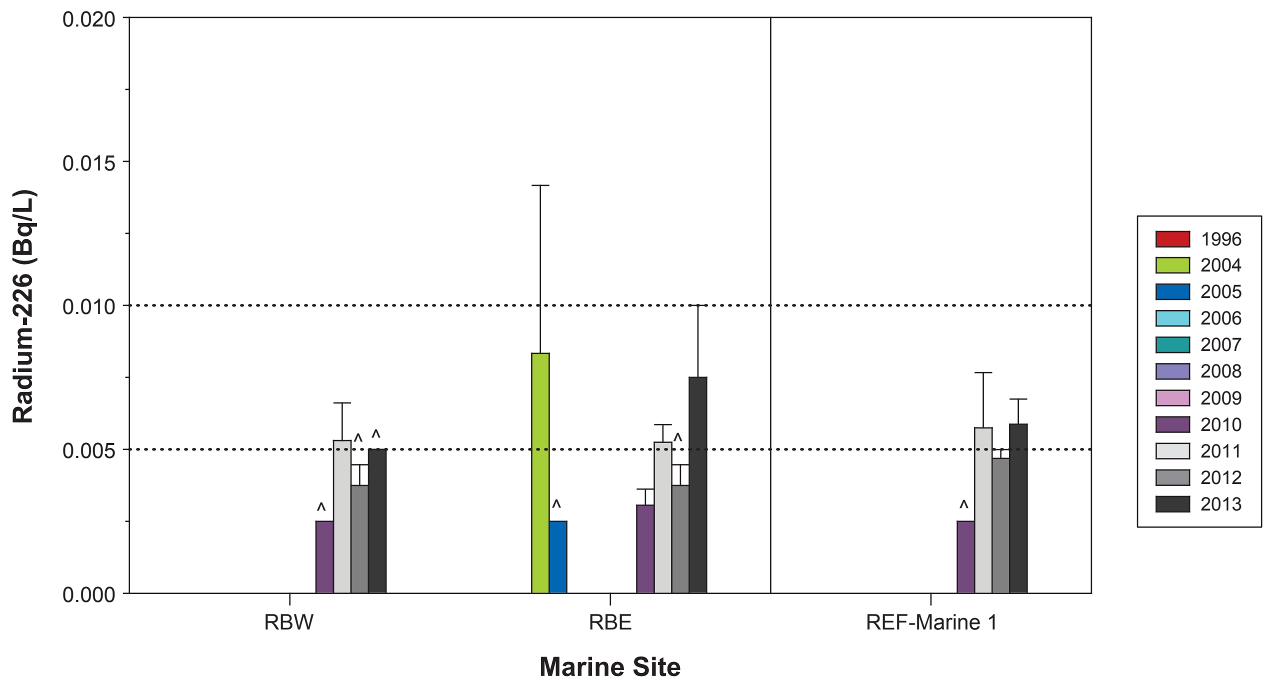


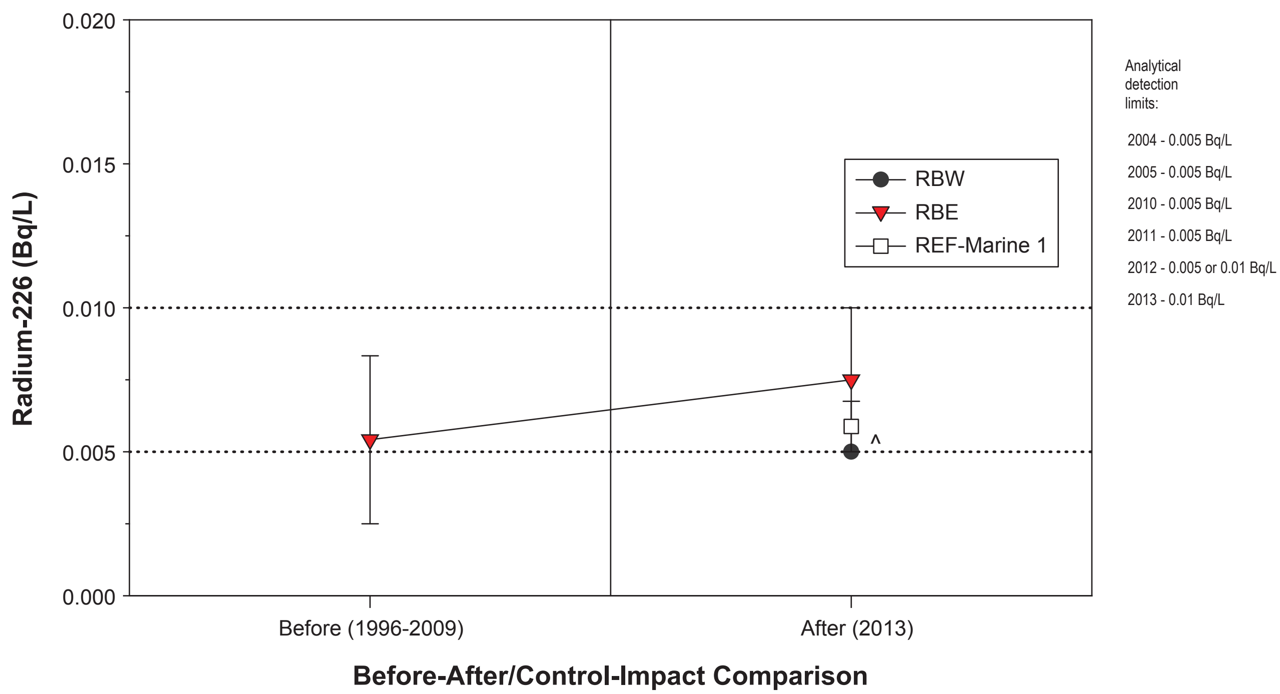


Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
Sample concentrations that were below the very high detection limits of 0.5 or 5 mg/L were excluded from 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 2013





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.

Figure 3.3-44

Radium-226 Concentration in AEMP Marine Sites, Doris North Project, 1996 to 2013

3.3.3.9 Total Aluminum

Total aluminum is a required variable for effluent characterization as per Schedule 5, s. 4(1) of the MMER. At site RBE, the mean 2013 total aluminum concentration was within the range of baseline means (Figure 3.3-45). At site RBW, the 2013 mean was slightly higher than the 2009 mean (Figure 3.3-45). However, the before-after comparison for both marine exposure sites indicated that the 2013 means were not statistically different from the baseline means (p =0.58 for RBW and p = 0.61 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 2013 were well below the marine CCME guideline of 0.0125 mg/L (Figure 3.3-46). Arsenic concentrations measured at the marine exposure sites in 2013 were similar to baseline concentrations measured between 2007 and 2009, but much lower than the anomalously high arsenic concentrations measured at RBE between 2004 and 2006 (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 2013 mean arsenic concentrations at RBW and RBE were not distinguishable from baseline means (p = 0.12 for RBW and p = 0.77 for RBE). Therefore, 2013 Project activities did not affect total arsenic concentrations at the marine exposure sites.

3.3.3.11 Total Cadmium

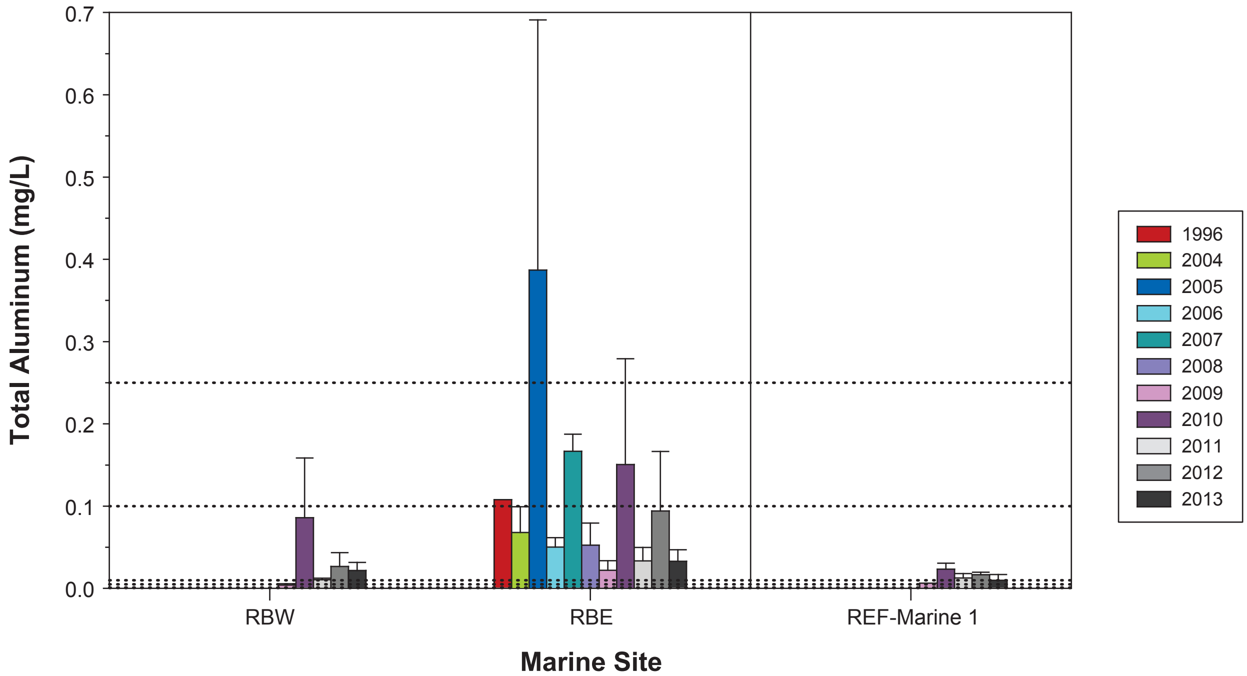
Total cadmium is a required variable for effluent characterization as per Schedule 5, s. 4(1) of the MMER. In 2013, all total cadmium concentrations in samples collected from RBW, RBE, and REF-Marine 1 were below the marine CCME guideline of 0.00012 mg/L (Figure 3.3-47). The before-after plot shows that 2013 mean cadmium concentrations at the exposure sites were similar to baseline means (Figure 3.3-47), and the before-after statistical comparison confirmed that the 2013 and baseline means were not statistically distinguishable from each other (p = 0.38 for RBW and p = 0.74 for RBE). Therefore, there was no apparent effect of 2013 activities on total cadmium concentrations at the marine exposure sites.

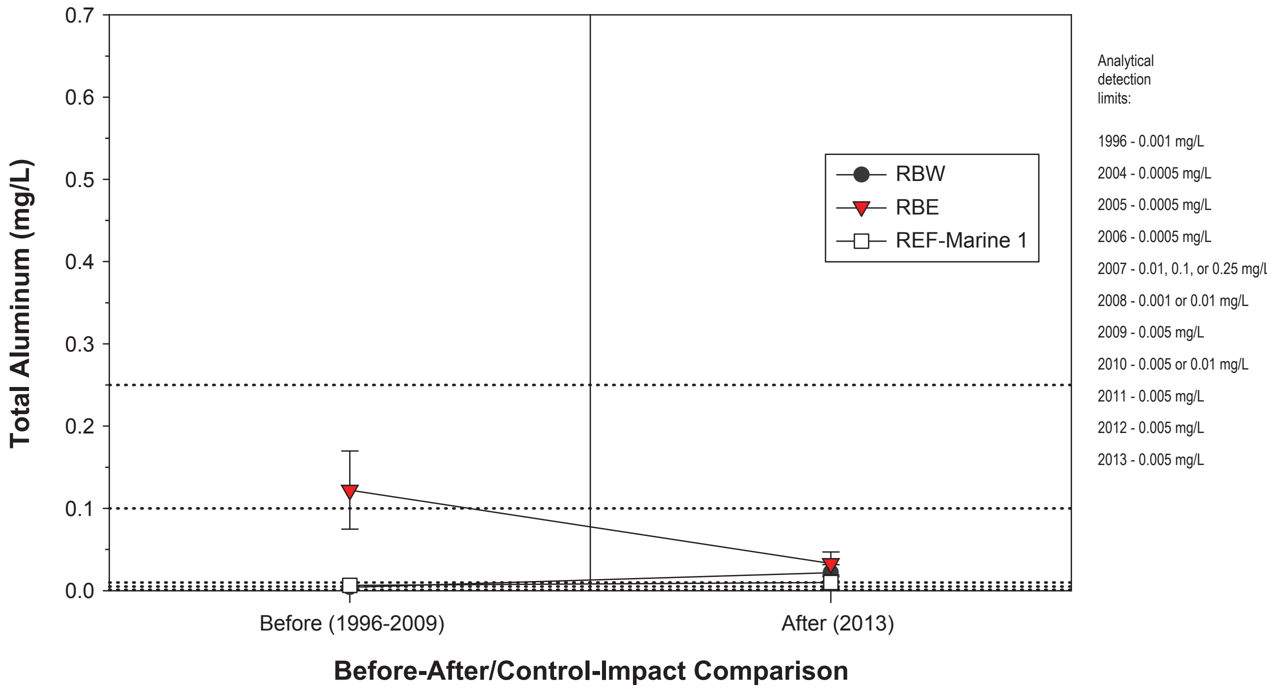
3.3.3.12 Total Copper

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 2013 mean concentration at RBE was at the low end of the range of baseline levels (Figure 3.3-48). At RBW, 2013 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 2013 mean copper concentrations (p = 0.82 for RBW and p = 0.58 for RBE). Therefore, there was no effect of 2013 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 variable for effluent characterization as per Schedule 5, s. 4(1) of the MMER. At site RBE, 2013 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 2013 compared to 2009 (Figure 3.3-49). For both of these Roberts Bay sites, the before-after analysis showed that 2013 means were not distinguishable from baseline means (p = 0.50 for RBW and p = 0.55 for RBE), indicating that there was no effect of 2013 activities on total iron 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.
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 2013

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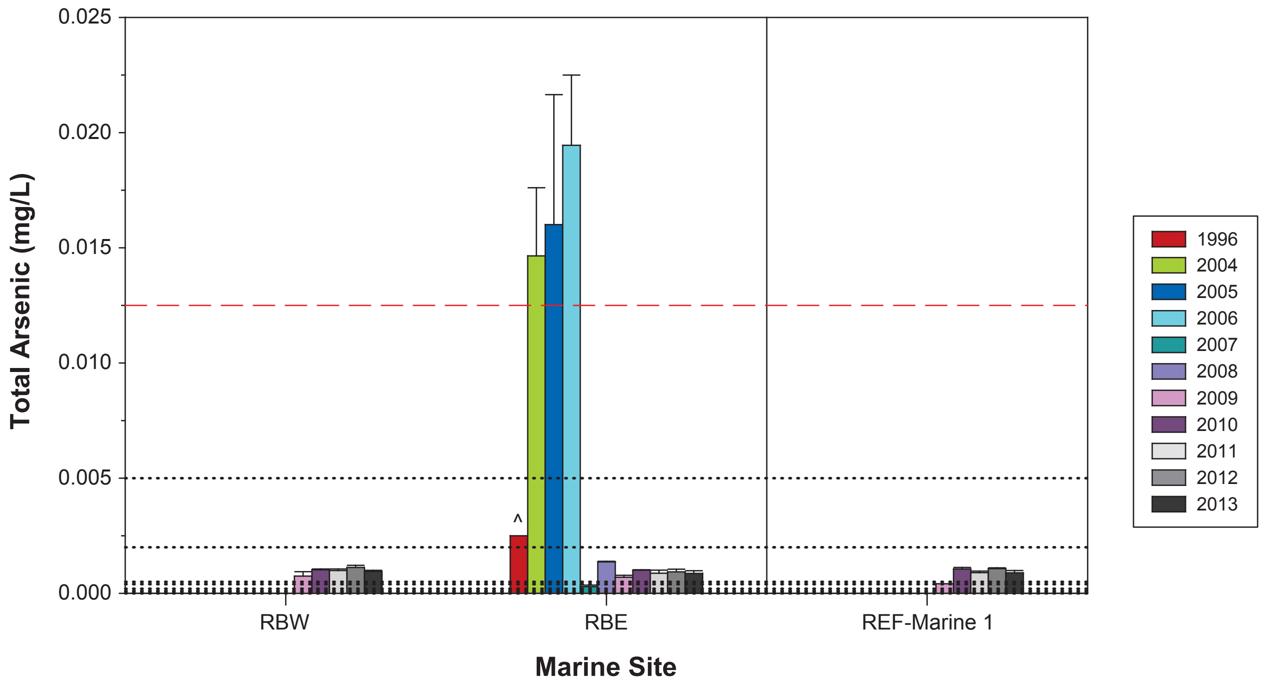

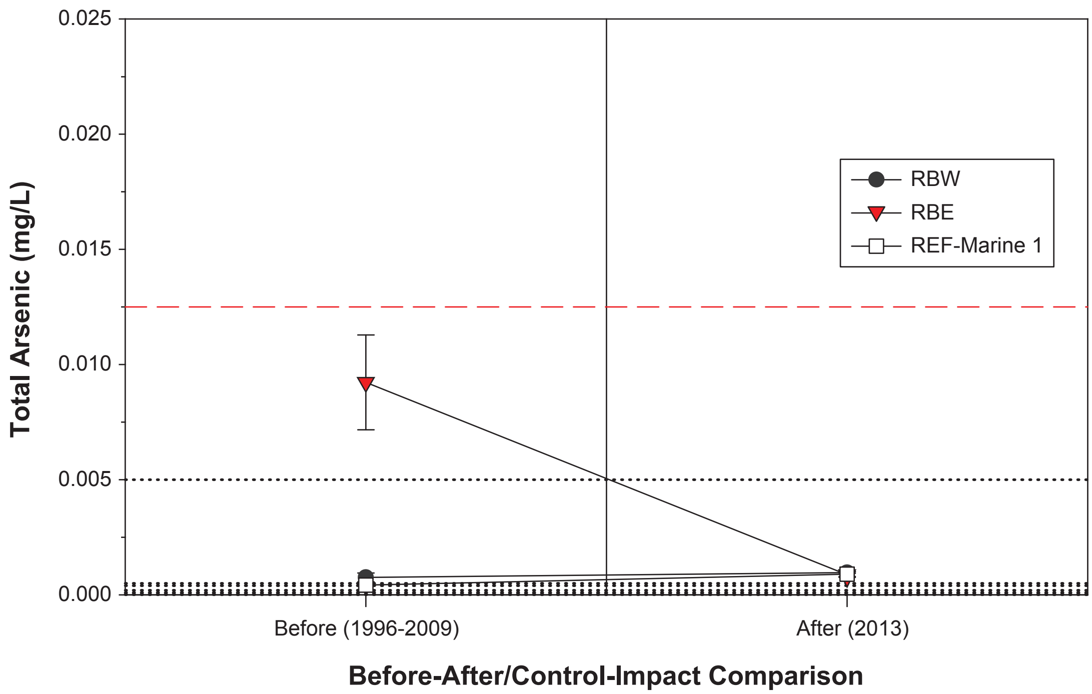

Analytical detection limits:

1996 - 0.005 mg/L
2004 - 0.000002 mg/L
2005 - 0.000002 mg/L
2006 - 0.000002 mg/L
2007 - 0.0002 mg/L
2008 - 0.0001 or 0.0005 mg/L
2009 - 0.0002 mg/L
2010 - 0.0004 or 0.002 mg/L
2011 - 0.0004 mg/L
2012 - 0.0004 mg/L
2013 - 0.0004 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 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.

Figure 3.3-46

Total Arsenic Concentration in AEMP Marine Sites, Doris North Project, 1996 to 2013

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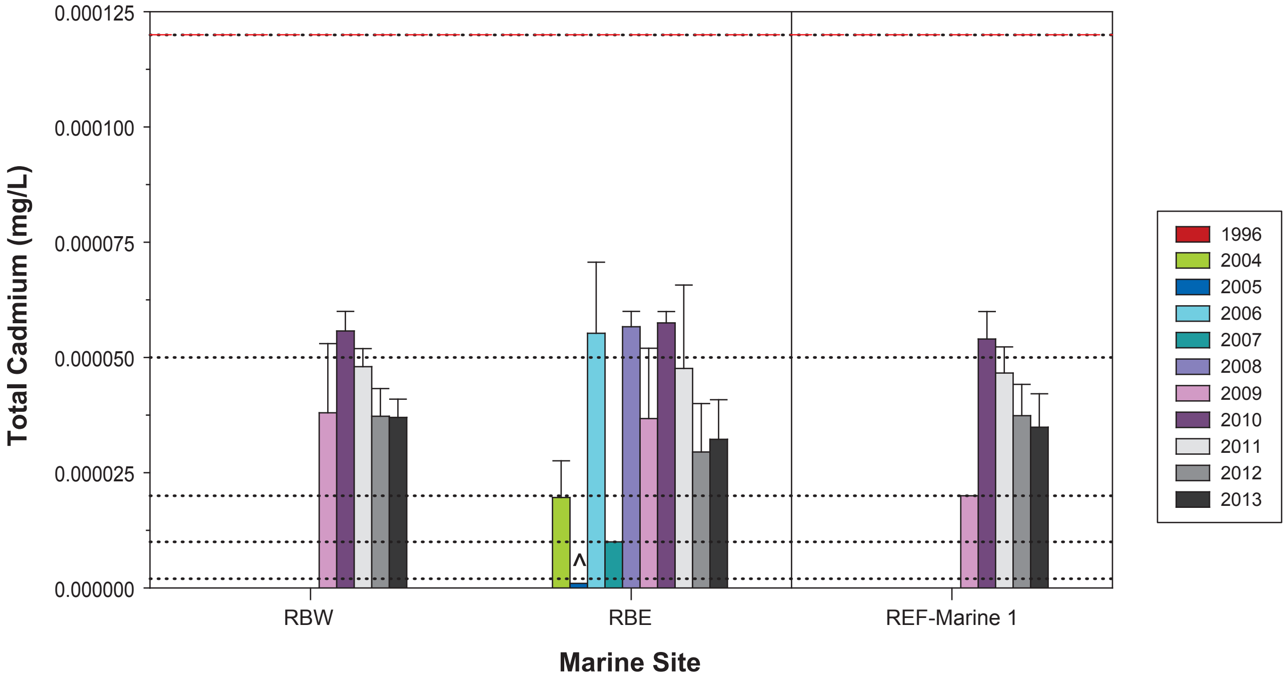
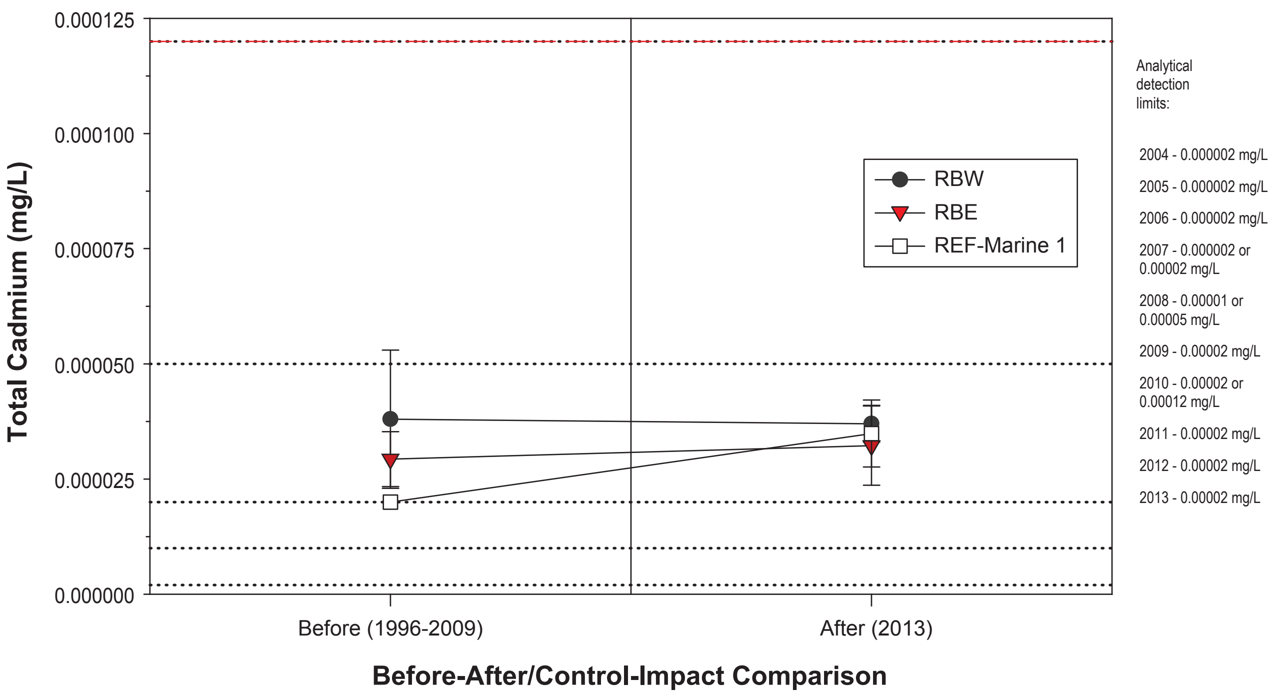
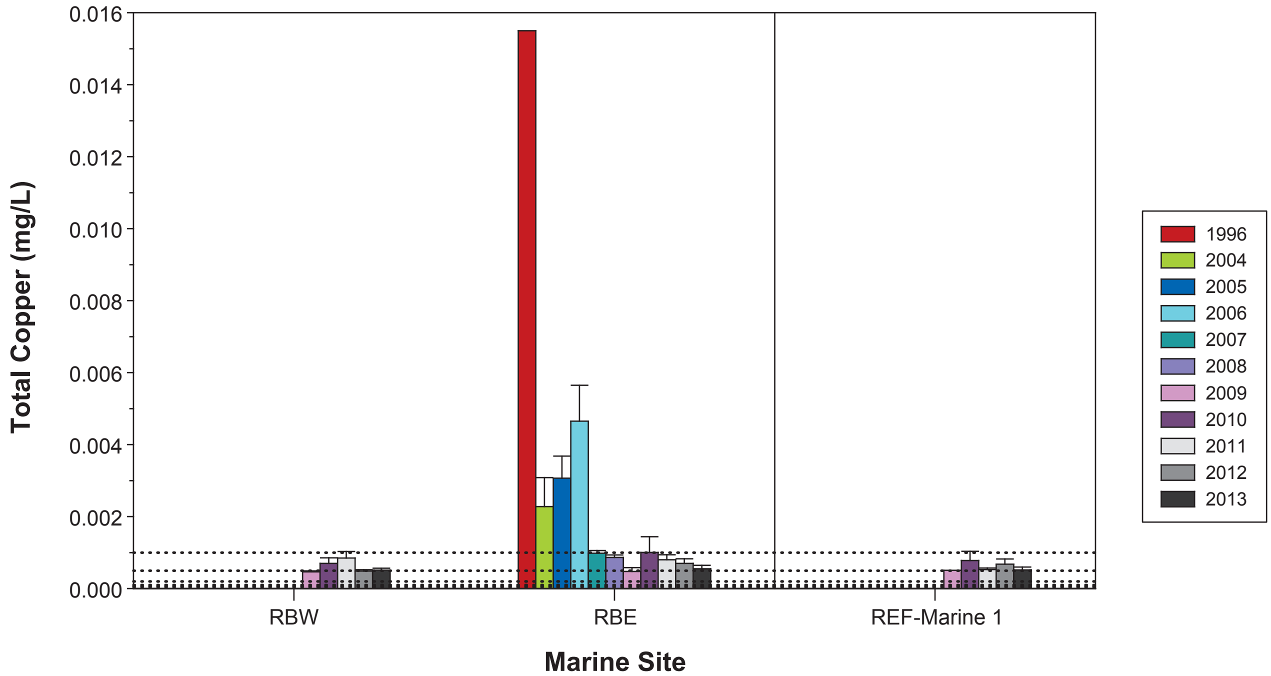


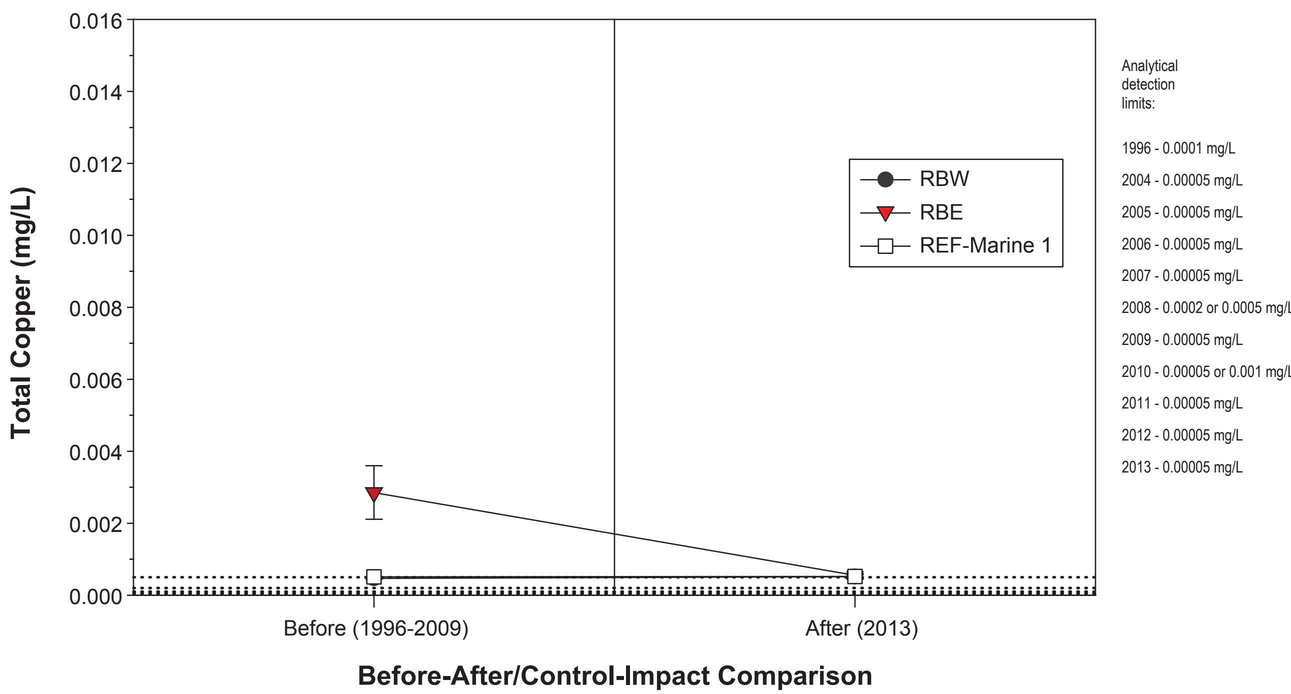


Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed lines represent the CCME 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 2013





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.

Figure 3.3-48

Total Copper Concentration in AEMP Marine Sites, Doris North Project, 1996 to 2013

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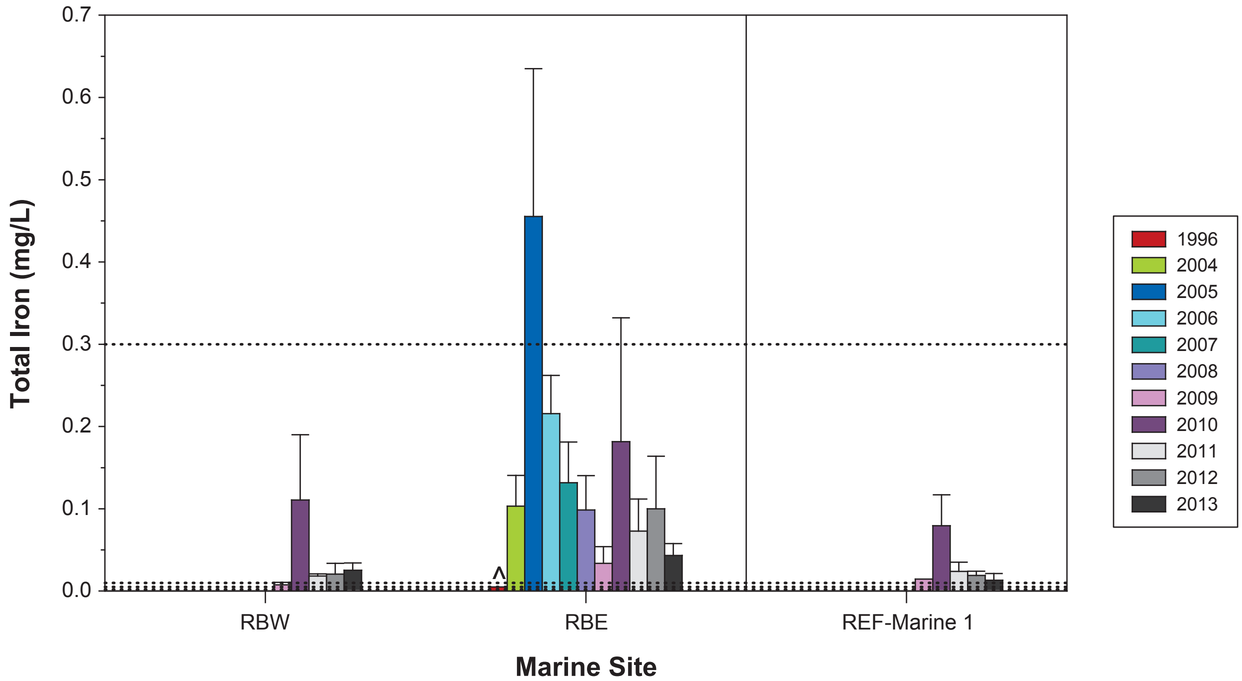

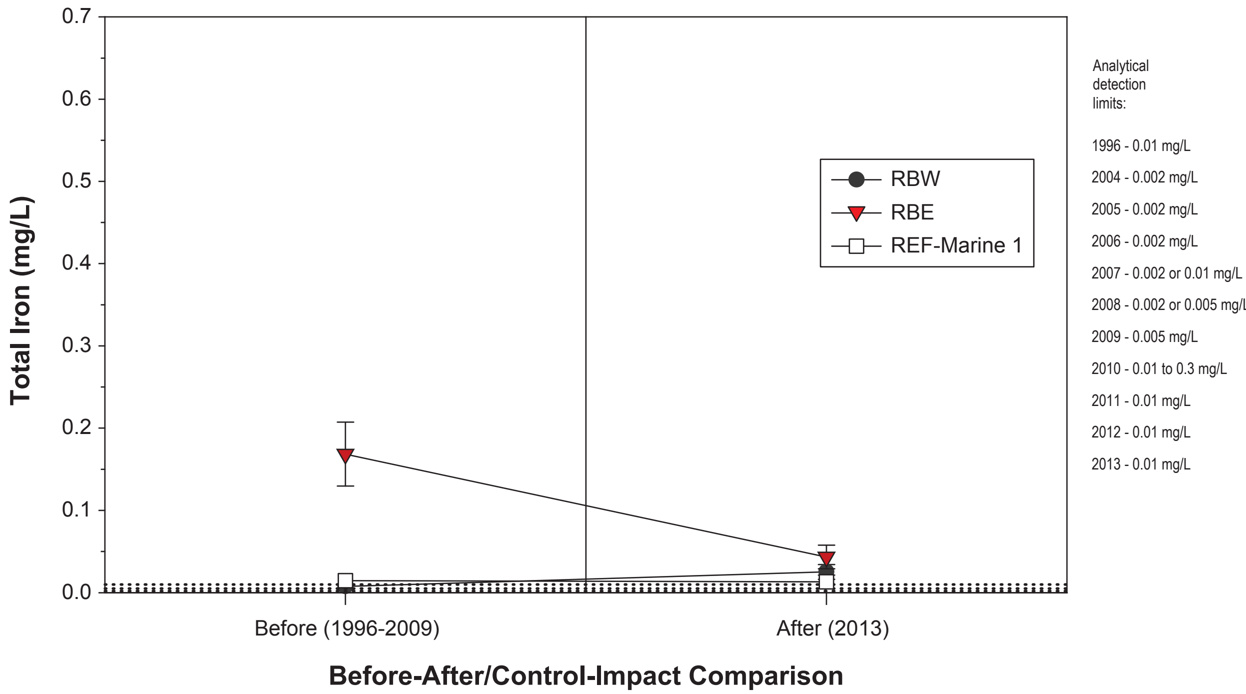

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Total iron is a required 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 2013

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3.3.3.14 Total Lead

Total lead is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. In 2013, total lead concentrations in all marine samples were below the detection limit of 0.00005 mg/L, except for a single sample collected at RBW that had a lead concentration of 0.000071 mg/L (slightly over the detection limit; Figure 3.3-50). At both marine exposure sites, mean 2013 total lead concentrations were lower than baseline means, so there was no evidence of an adverse effect of Project activities on marine lead concentrations. For site RBE, the before-after analysis indicated that the 2013 mean was not distinguishable from the baseline mean ($p = 0.66$). Statistical analysis results are not discussed for site RBW since 73% of concentrations in the combined baseline and 2013 dataset were below analytical detection limits.

3.3.3.15 Total Mercury

Total mercury is a required variable for effluent characterization as per Schedule 5, s. 4(1) of the MMER. In 2013, all total mercury concentrations measured at marine exposure and reference sites were near or below the ultra-low detection limit of 0.0000005 mg/L and well below the interim CCME guideline for inorganic mercury of 0.000016 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 2013 compared to 2009, but this is an artifact of the higher detection limit achieved for 2009 samples (0.00001 mg/L; Figure 3.3-51) since all 2009 concentrations were below the analytical detection limit. At RBE, where baseline concentrations between 2004 and 2008 were also measured using ultra-low detection limits, 2013 concentrations were within the range of baseline levels. The before-after analysis results are not discussed for RBW and RBE because a high proportion (> 70%) of concentrations in the combined baseline and 2013 datasets were below analytical detection limits. There was no apparent effect of 2013 Project activities on marine total mercury concentrations.

3.3.3.16 Total Molybdenum

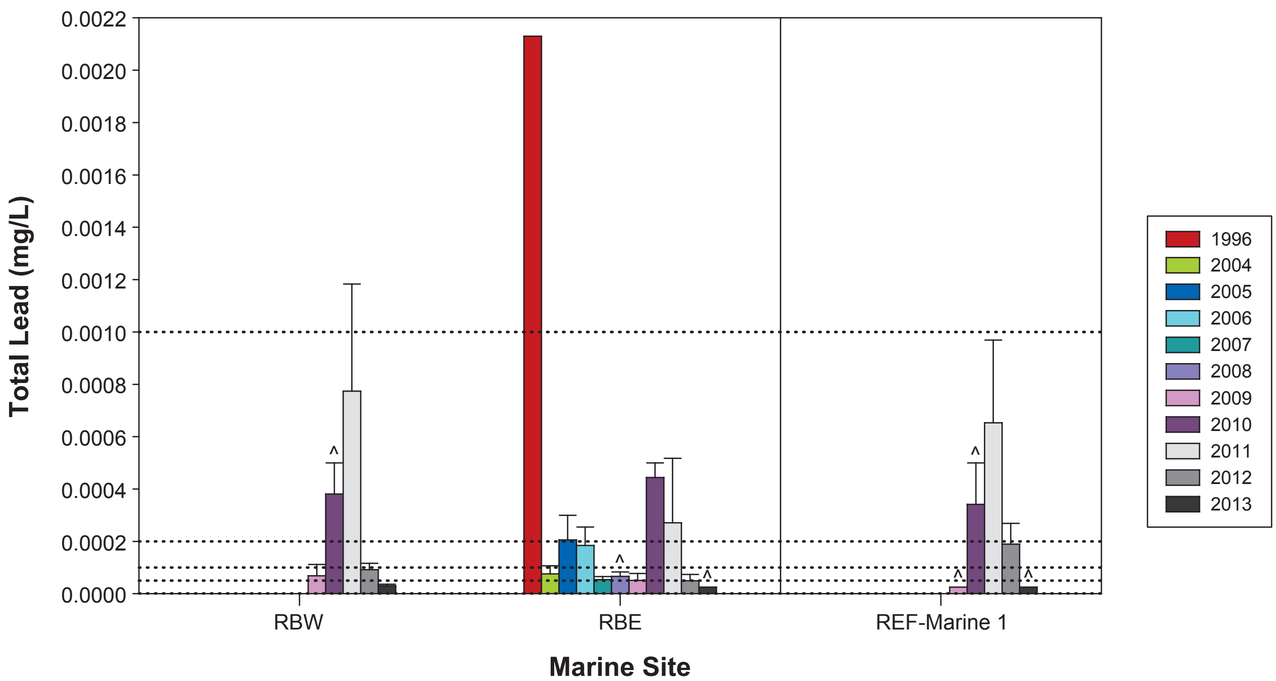
Total molybdenum is a required variable for effluent characterization as per Schedule 5, s. 4(1) of the MMER. Mean 2013 total molybdenum concentrations at the two marine exposure sites were within the range of baseline levels (Figure 3.3-52). The before-after comparison confirmed that there was no difference between 2013 mean concentrations and baseline means for the Roberts Bay sites ($p = 0.17$ for RBW and $p = 0.13$ for RBE). Therefore, 2013 activities had no apparent effect on total molybdenum concentrations at the marine exposure sites.

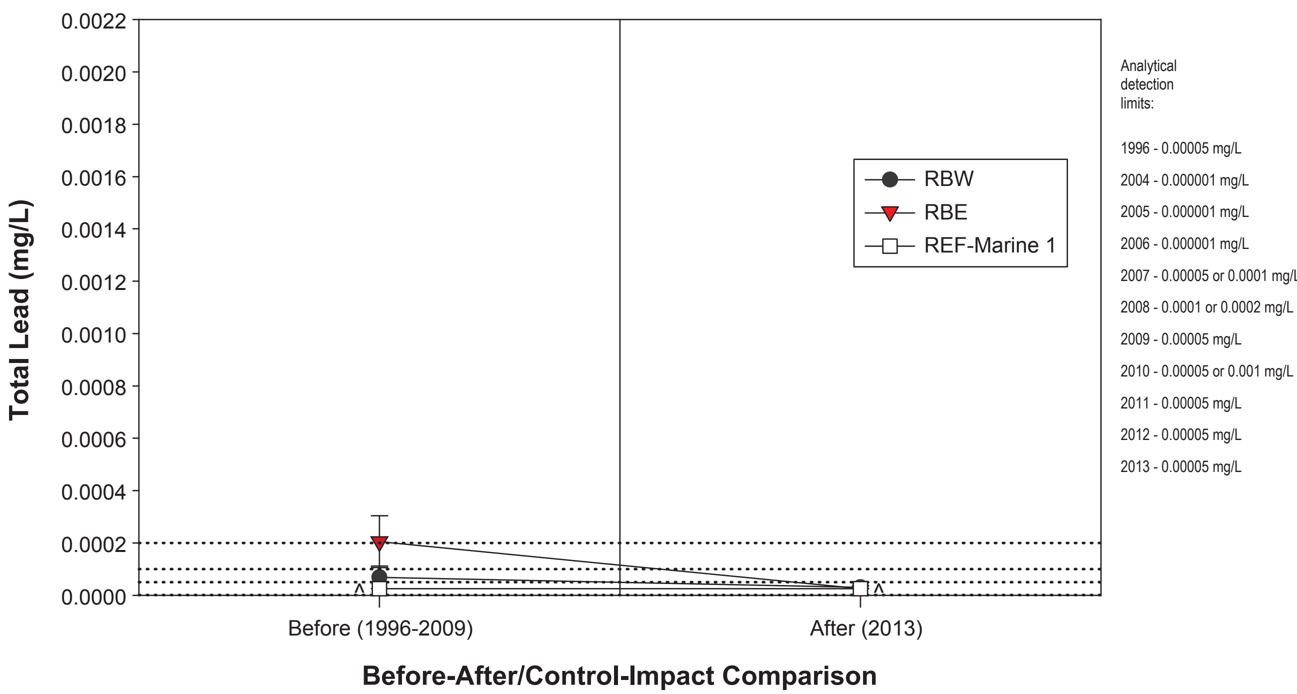
3.3.3.17 Total Nickel

Total nickel is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. At site RBW, 2013 total nickel concentrations were very similar to 2009 concentrations (Figure 3.3-53), and the before-after analysis confirmed that the 2013 mean was not statistically different from the 2009 mean ($p = 0.38$). At site RBE, the mean 2013 total nickel concentration was lower than the baseline mean (Figure 3.3-53), but the before-after analysis revealed that the baseline and 2013 means were not statistically distinguishable ($p = 0.74$). Therefore, there was no effect of 2013 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 2013 than in 2009, while at RBE, the 2013 mean was within the range of means for the baseline years (Figure 3.3-54). The before-after comparison showed that there was no significant difference between baseline and 2013 mean zinc concentrations for either of the Roberts Bay sites ($p = 0.18$ for RBW and $p = 0.69$ for RBE), indicating that 2013 activities did not affect zinc concentrations at the marine exposure sites.

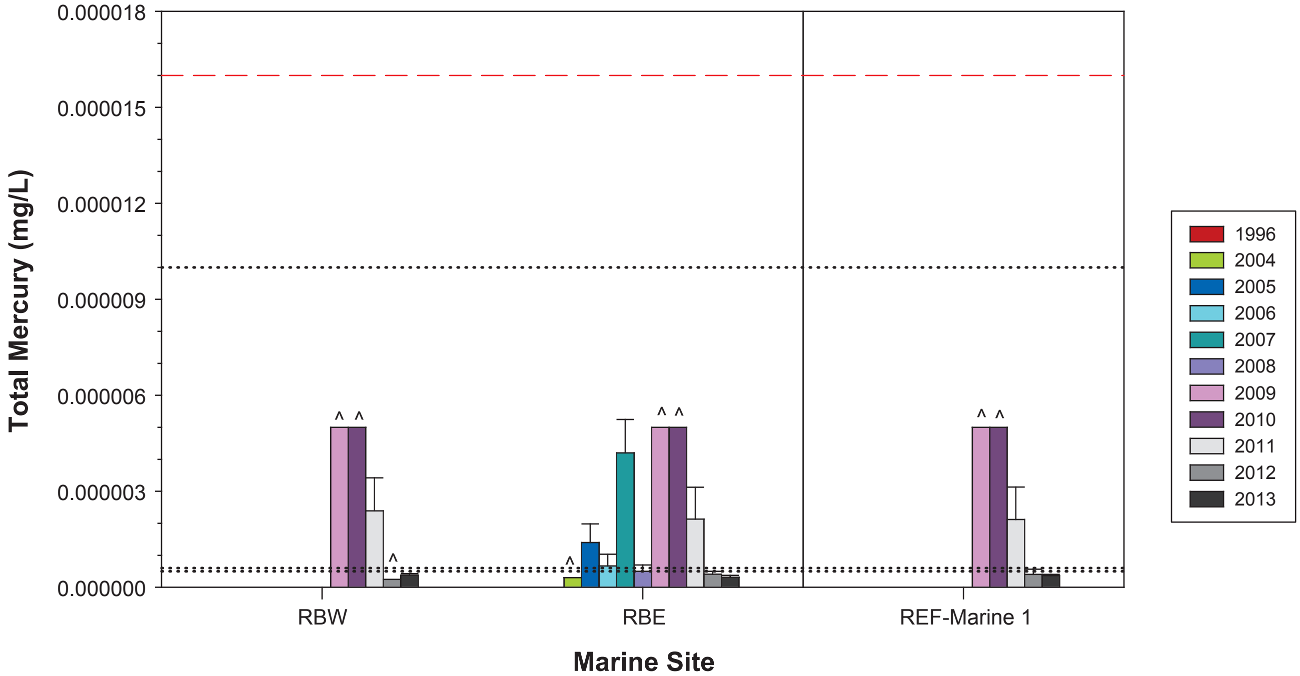


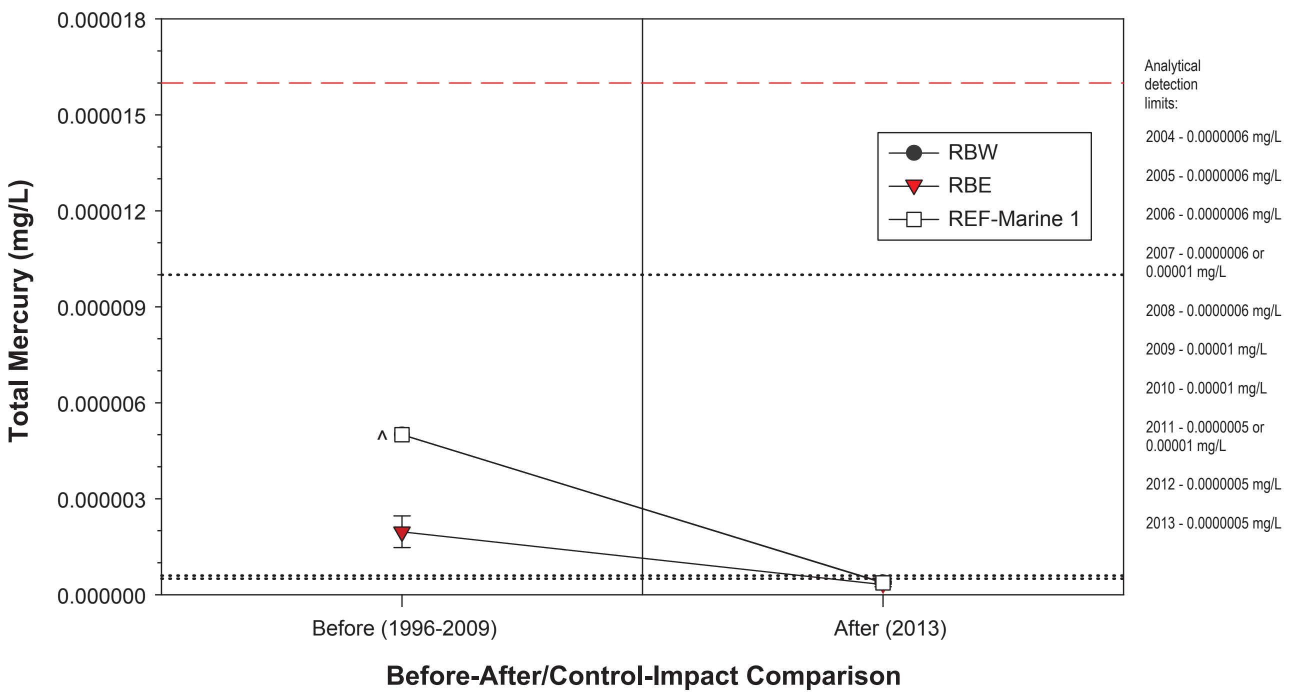


Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Total lead is regulated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

Figure 3.3-50

Total Lead Concentration in AEMP Marine Sites, Doris North Project, 1996 to 2013

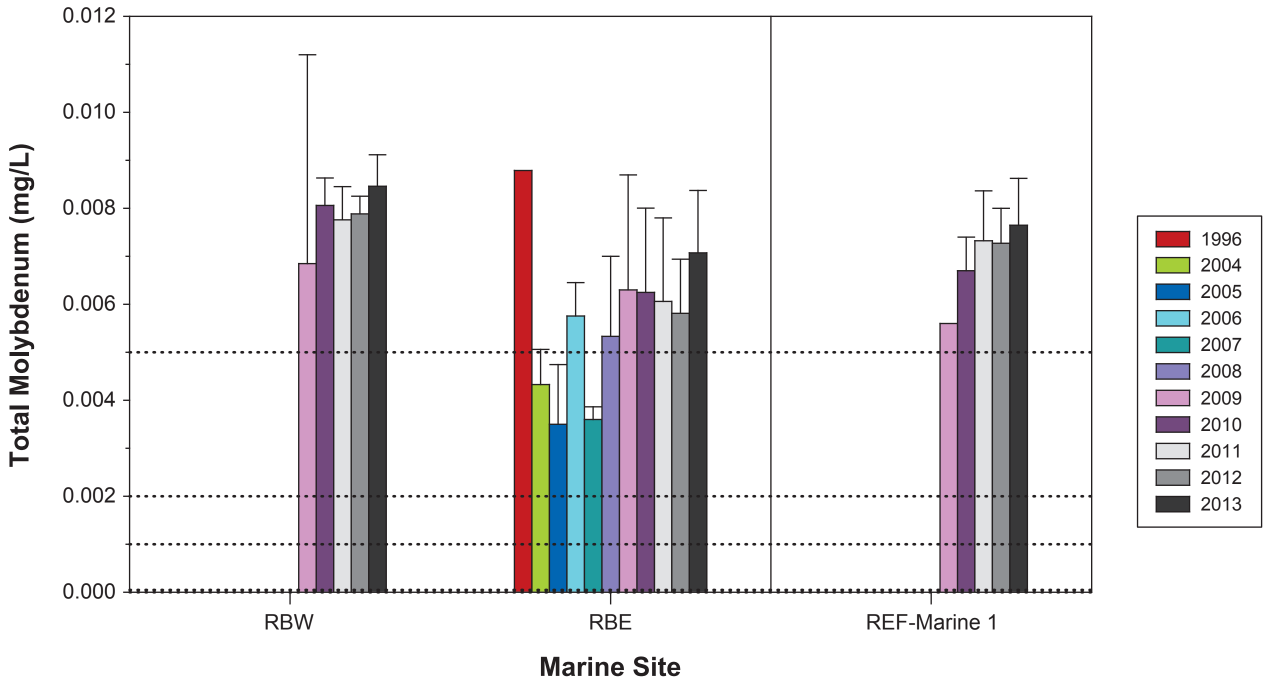


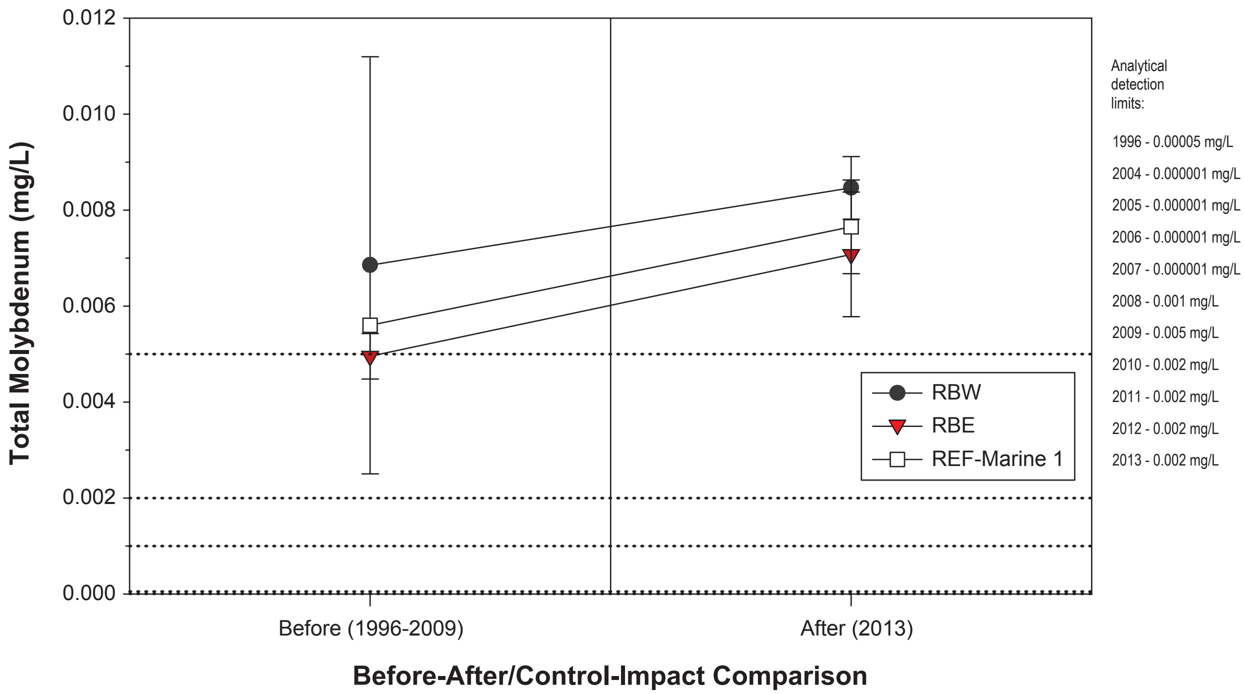


Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed lines represent 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 2013





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.

Figure 3.3-52

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Total Molybdenum Concentration in AEMP Marine Sites, Doris North Project, 1996 to 2013

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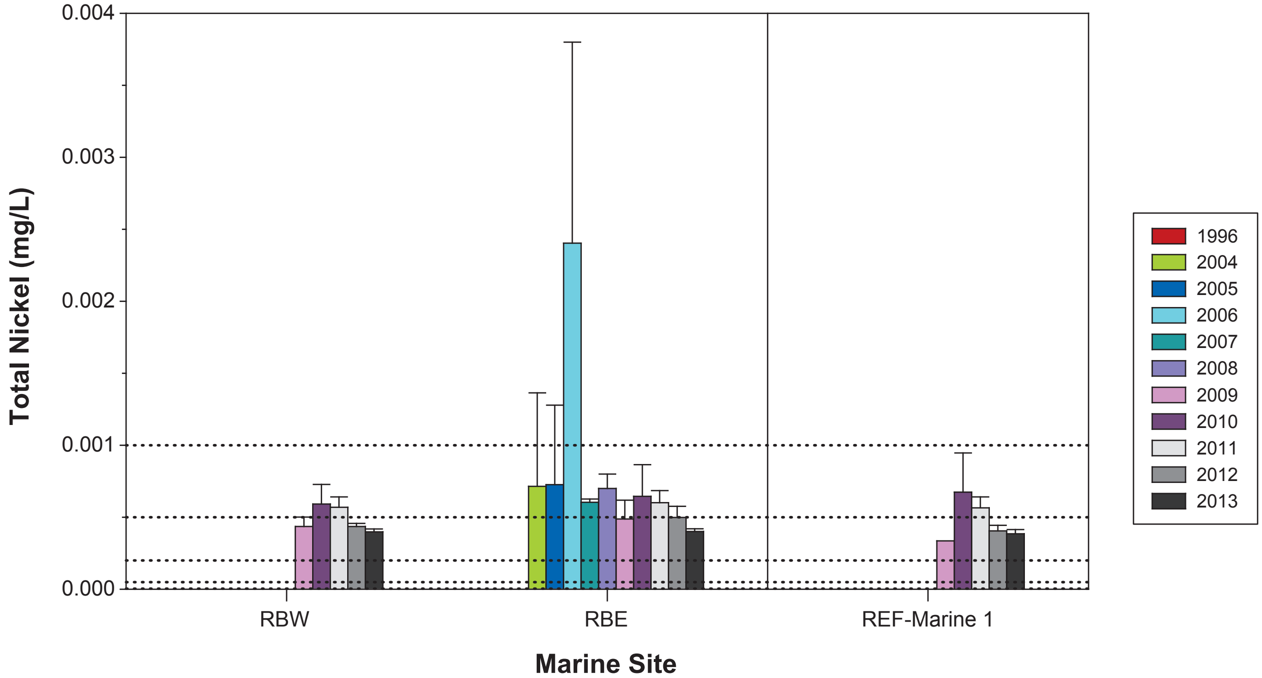

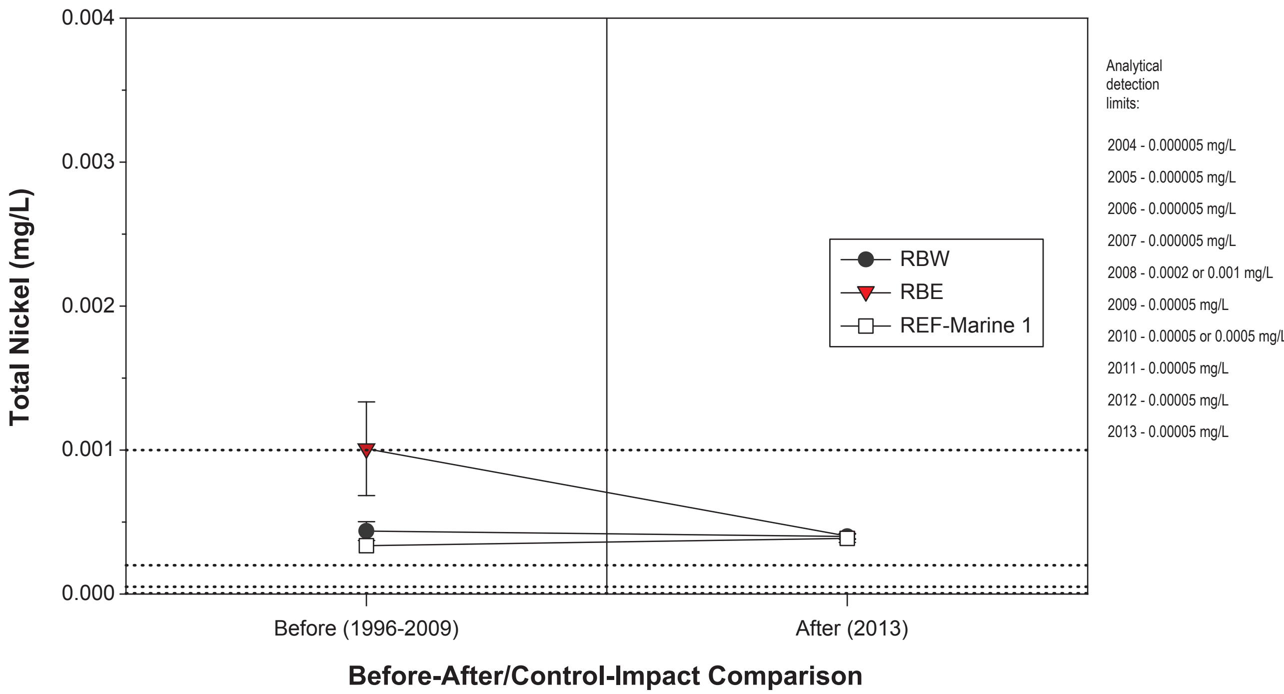

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
The anomalously high total nickel concentration of 0.0215 mg/L reported for RBE in August 1996 was considered 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 2013

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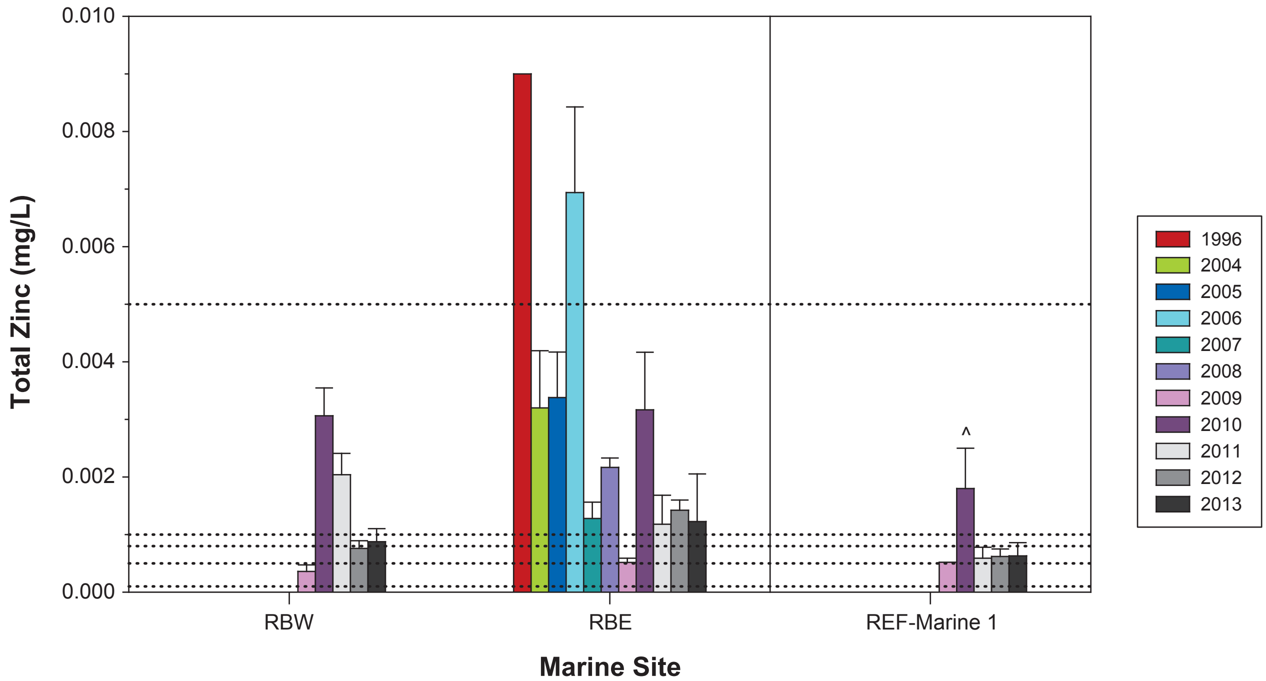

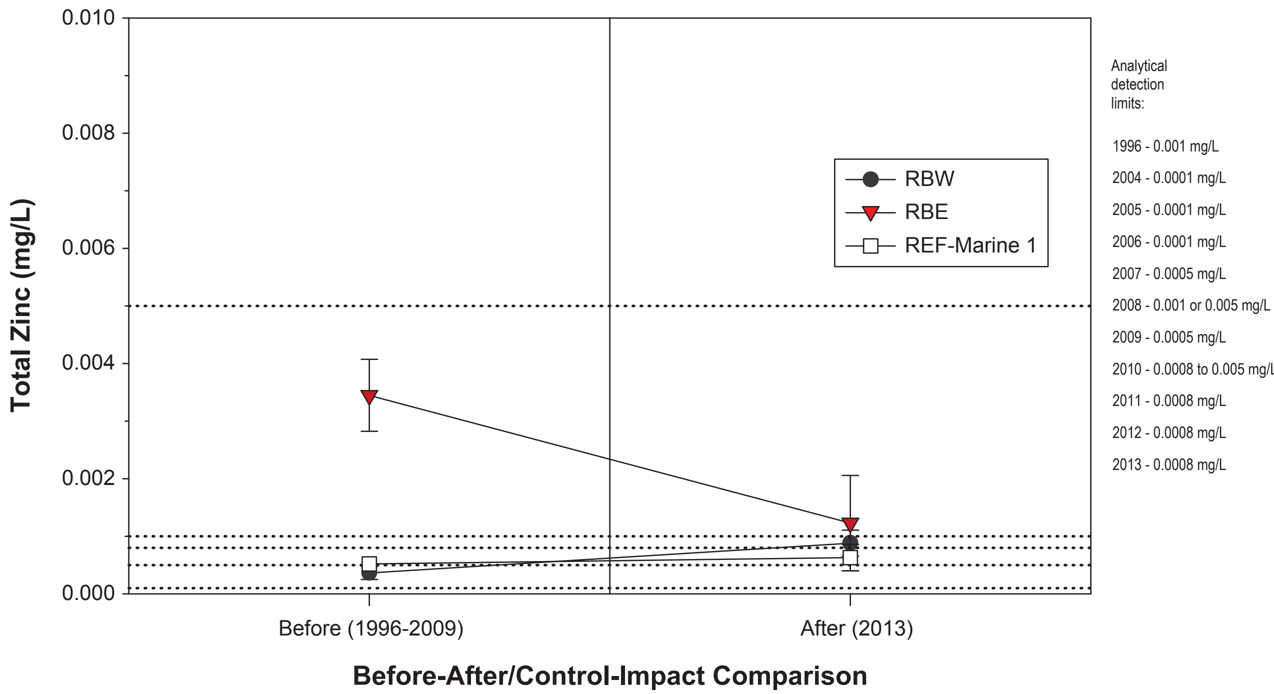

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Total zinc is regulated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

Figure 3.3-54

Total Zinc Concentration in AEMP Marine Sites, Doris North Project, 1996 to 2013

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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 2013 were compared against available baseline information as well as reference sites to evaluate whether 2013 Project activities caused changes to these sediment quality variables. Sediment quality variables for which there are CCME sediment quality guidelines for the protection of aquatic life (CCME 2013a) 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 2013a). Sediment quality variables 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 variables 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 2013 were compared to 2009 to identify potential changes to sediment variables. Stream sediment sampling was conducted in August during both years at the sampled sites. For the calculations of annual means for each variable, all analytical results for stream sediment samples collected in a given year were averaged.

3.4.1.1 Particle Size

Particle size is a required sediment variable 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 2013 compared to 2009 (Figure 3.4-1). This is most likely the result of natural spatial heterogeneity in sediment particle size composition. In both Doris and Reference B outflows, 2013 sediments consisted of a larger proportion of sand and a lower proportion of gravel compared to 2009. The before-after analysis showed that the observed changes in particle size in Doris Outflow sediments were statistically significant ($p = 0.0023$ for gravel and $p = 0.0001$ for sand content). However, the BACI analysis revealed that parallel changes occurred at the reference streams ($p = 0.18$ for gravel and $p = 0.036$ for sand content).

In Little Roberts Outflow, the gravel and sand content was higher and the clay and silt content was lower in 2013 than 2009 (Figure 3.4-1). The before-after analysis showed that the changes in particle size in Little Roberts Outflow sediments were statistically significant for both silt ($p = 0.0003$) and clay content ($p = 0.0005$), but not for gravel ($p = 0.013$) or sand content ($p = 0.093$). The BACI analysis further revealed that there was a differential change in clay content ($p = 0.0009$) in Little Roberts Outflow from 2009 to 2013 that was not paralleled in the reference streams, but the change in silt content was paralleled in the reference streams ($p = 0.023$). Variation in sediment particle size composition is unlikely related to 2013 Project activities, and probably reflects natural spatial heterogeneity in stream sediments. However, any differences between 2009 and 2013 may complicate the evaluation of effects because fine sediments are often associated with higher metal and TOC concentrations than coarse sediments (e.g., Lakhan, Cabana, and LaValle 2003; Secrieri and Oaie 2009). This implies, for example, that the shift in sediment particle composition from finer sediments in 2009 (sand, clay, and silt) to coarser sediments (largely sand and gravel) in 2013 samples collected from Little Roberts Outflow could lead to sediment metal and TOC concentrations being lower in 2013 than in 2009 (which was observed for TOC and many metals, as described in the following sections), though this would be unrelated to Project activities.

3.4.1.2 Total Organic Carbon

TOC content is a required sediment variable 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 2013 TOC content in Doris Outflow sediments was not distinguishable from the 2009 mean ($p = 0.70$). Although Roberts Outflow TOC concentrations could not be statistically evaluated (because no baseline data are available), the mean 2013 TOC content of Roberts Outflow sediments was intermediate to the TOC contents of Reference B Outflow and Reference D Outflow sediments. For Little Roberts Outflow, the before-after comparison showed that the TOC content of sediments decreased significantly in 2013 compared to 2009 ($p = 0.0003$), and the BACI analysis indicated that there was no comparable decrease observed at the reference streams ($p = 0.0001$). This decrease in TOC at Little Roberts Outflow is likely related to the lower proportion of fine sediments in 2013 samples compared to 2009, since TOC concentrations tend to be higher in finer sediments (e.g., Secrieri and Oaie 2009). There is no reason to suspect that 2013 Project activities affected the sediment TOC content of exposure streams.

3.4.1.3 Total Arsenic

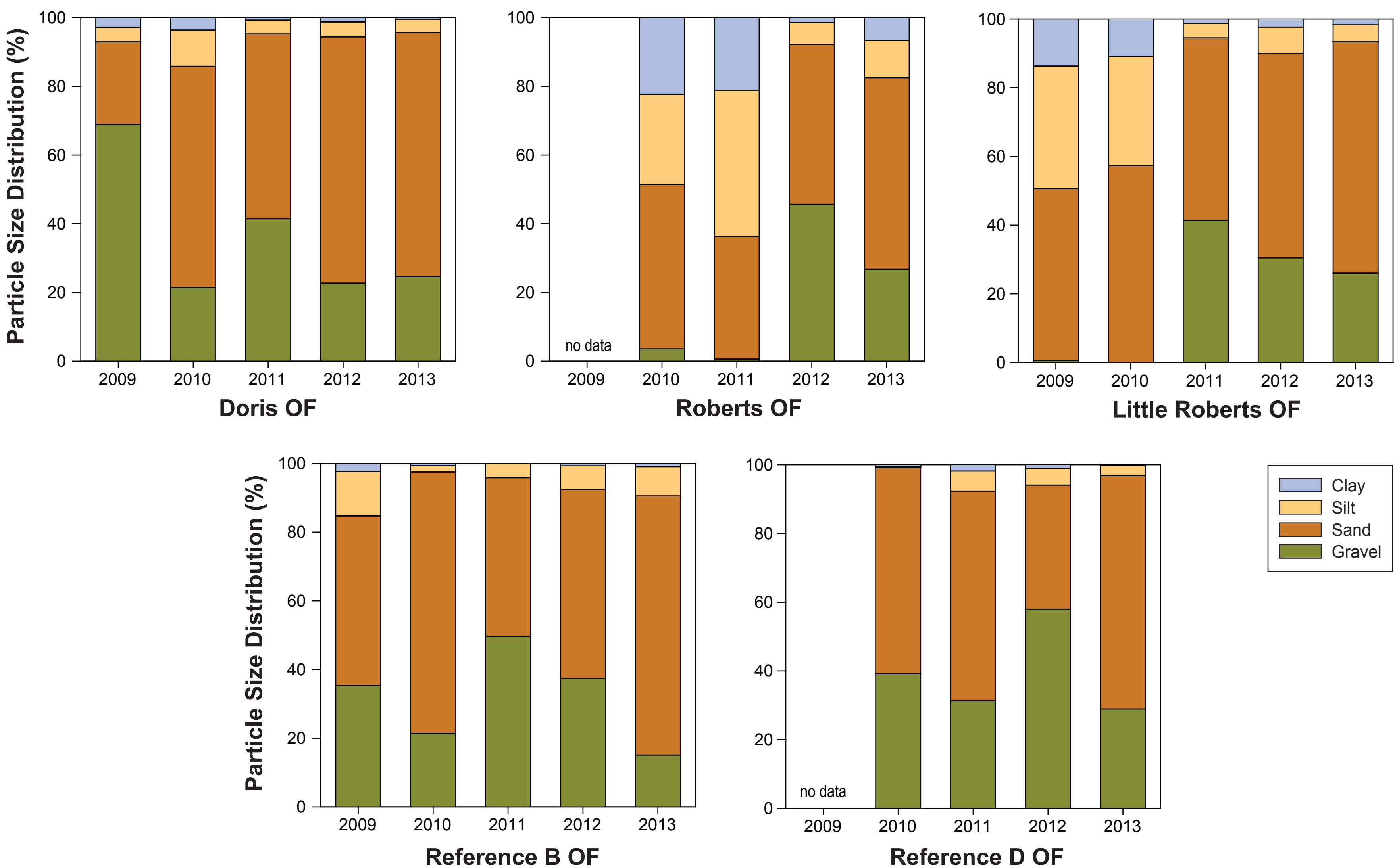
Arsenic concentrations in exposure stream sediments ranged from 0.67 to 2.1 mg/kg in 2013, and were below the CCME ISQG of 5.9 mg/kg and the PEL of 17 mg/kg (Figure 3.4-3). The before-after comparison showed that there were no significant differences between 2009 and 2013 mean total arsenic concentrations at Doris Outflow ($p = 0.49$) or Little Roberts Outflow ($p = 0.063$). Therefore, 2013 activities did not adversely affect arsenic concentrations in the sediments of these exposure streams.

3.4.1.4 Total Cadmium

In Doris, Roberts, and Little Roberts outflows, all 2009 and 2013 sediment total cadmium concentrations were below the analytical detection limits of 0.1 mg/kg (2009) or 0.05 mg/kg (2013), and well below the CCME ISQG of 0.6 mg/kg and the PEL of 3.5 mg/kg (Figure 3.4-4). Therefore, there was no apparent effect of 2013 Project activities on sediment cadmium concentrations in the exposure streams.

3.4.1.5 Total Chromium

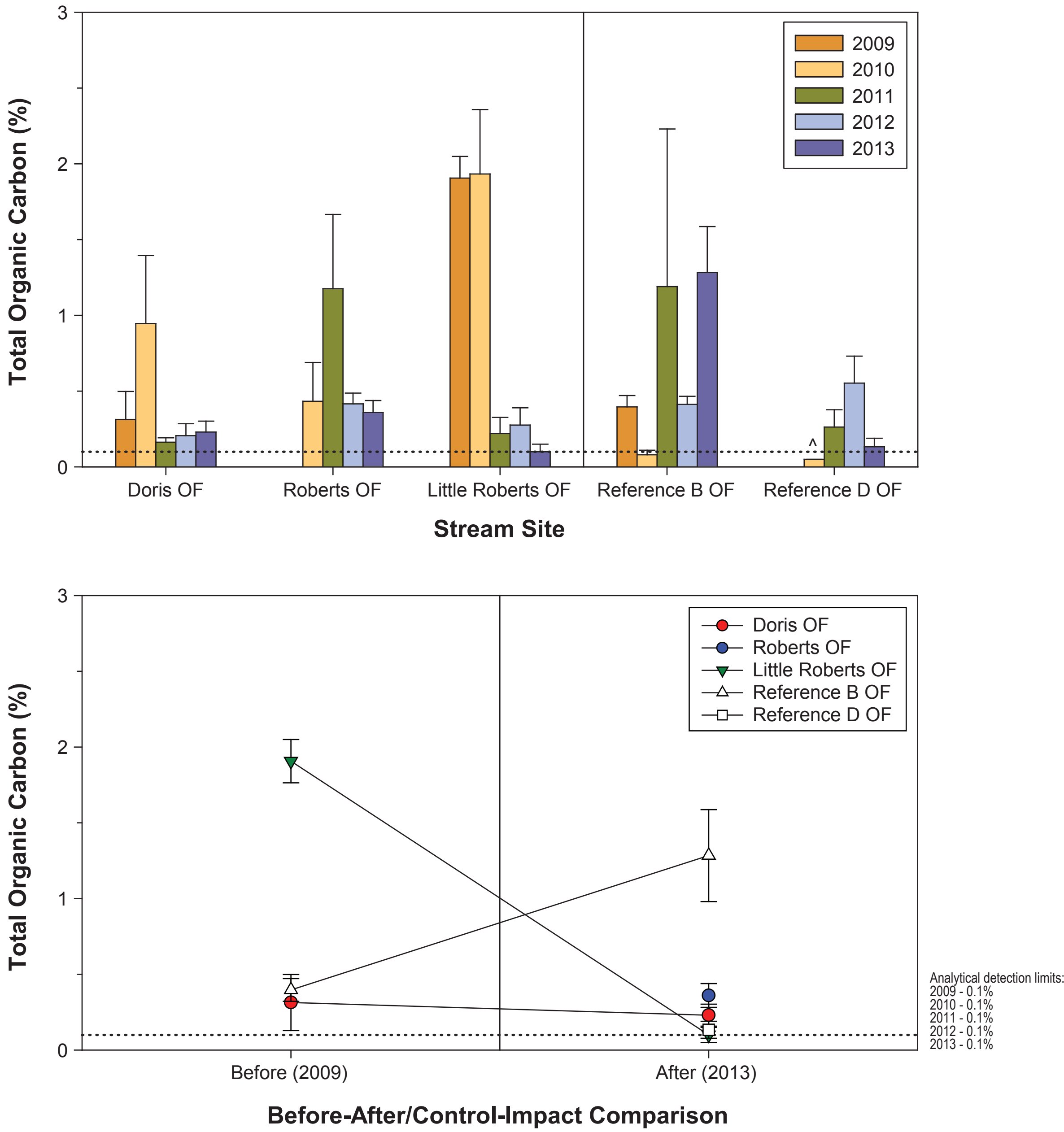
Chromium concentrations in exposure stream sediments in 2013 ranged from 11.5 to 32.1 mg/kg and were below the CCME ISQG of 37.3 mg/kg and the CCME PEL of 90 mg/kg (Figure 3.4-5). Mean 2013 chromium concentrations in Doris Outflow, Little Roberts Outflow, and Reference B Outflow sediments were lower than mean 2009 concentrations (Figure 3.4-5). The before-analysis showed that these decreases were statistically significant for Little Roberts Outflow ($p = 0.0070$) and Reference B Outflow ($p = 0.0033$), but not for Doris Outflow ($p = 0.16$). Although a decrease in sediment chromium concentrations is not of concern, the BACI analysis revealed that the chromium decrease observed in Little Roberts Outflow sediments was parallel to the trend for the reference streams ($p = 0.019$). There was no apparent effect of 2013 Project activities on sediment chromium levels in exposure streams.



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 3.4-1

Particle Size Distribution in AEMP Stream Sediments, Doris North Project, 2009 to 2013



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.

Figure 3.4-2

Total Organic Carbon Concentration in AEMP Stream Sediments, Doris North Project, 2009 to 2013

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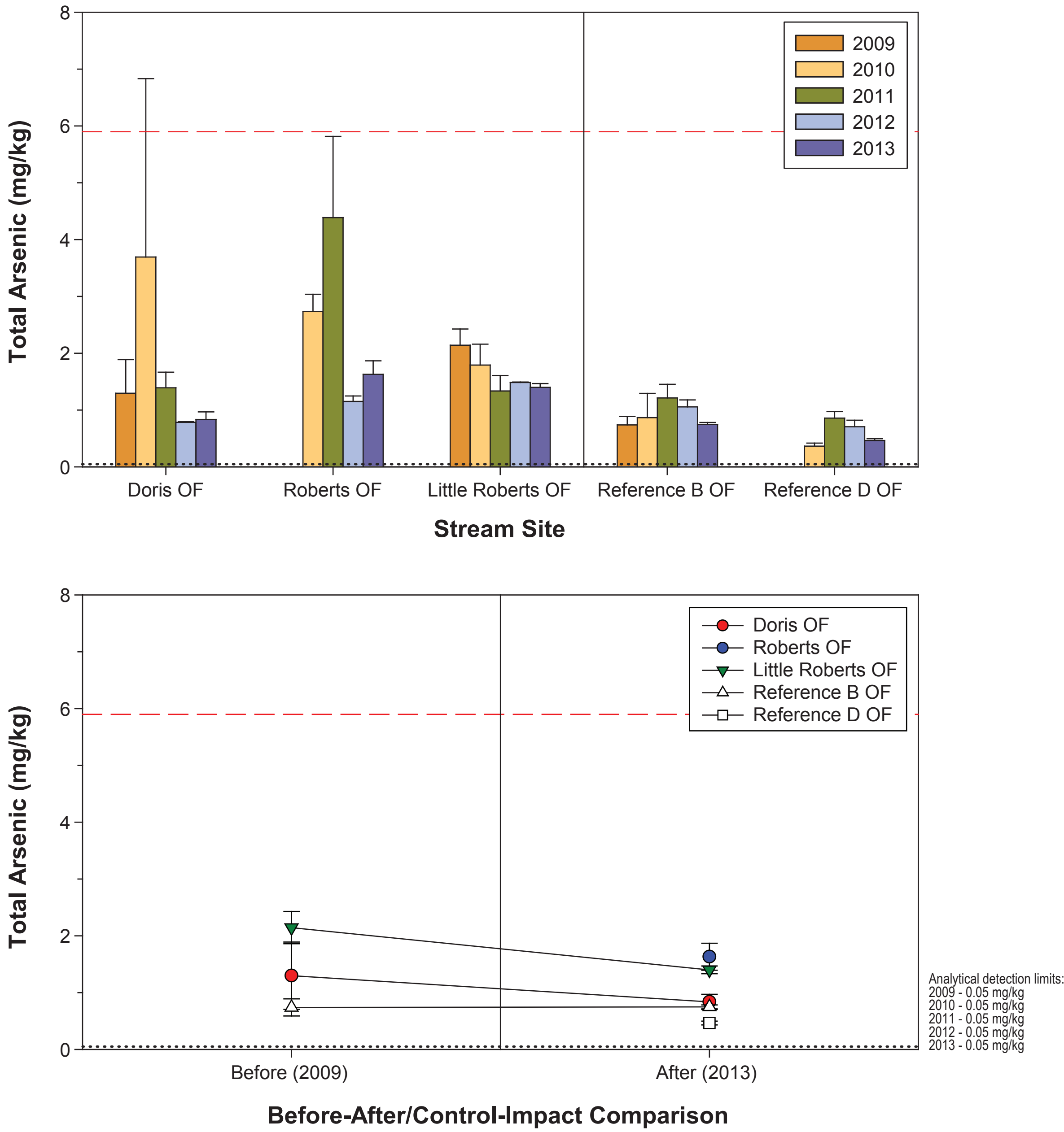

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limit; values below the detection limit are plotted at half the detection limit.
Red dashed lines represent the CCME freshwater interim sediment quality guideline (ISQG) for arsenic (5.9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

Total Arsenic Concentration in AEMP Stream Sediments, Doris North Project, 2009 to 2013

Figure 3.4-3

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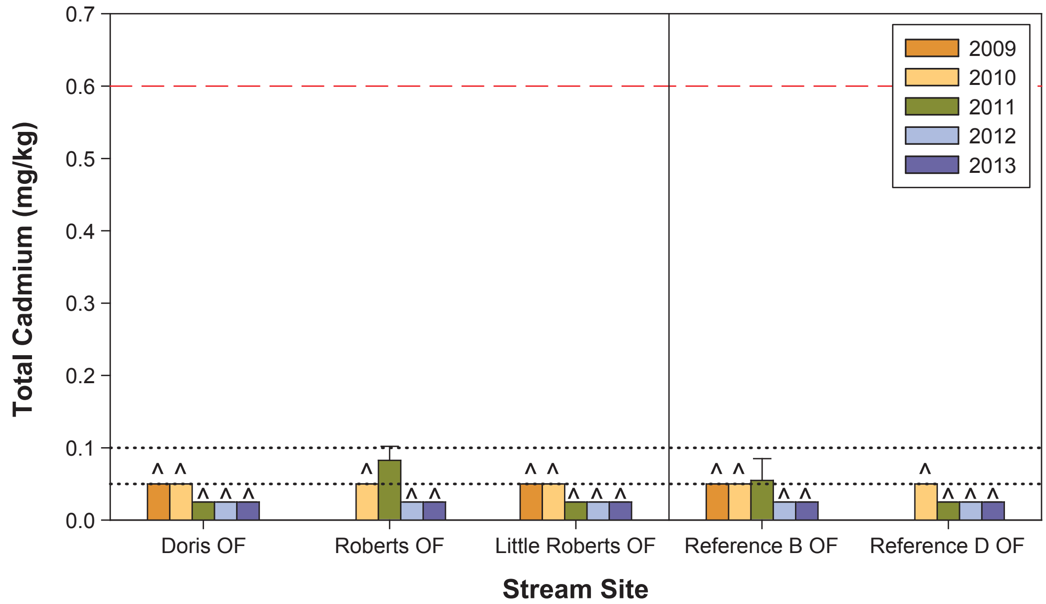

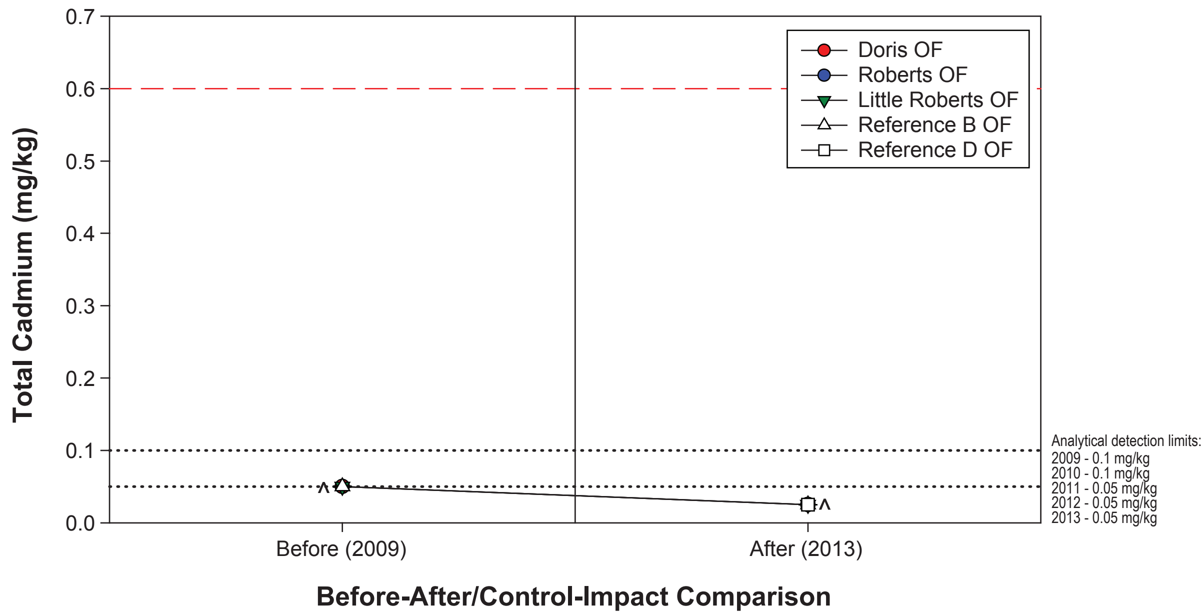

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed lines represent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

Figure 3.4-4

Total Cadmium Concentration in AEMP Stream Sediments, Doris North Project, 2009 to 2013

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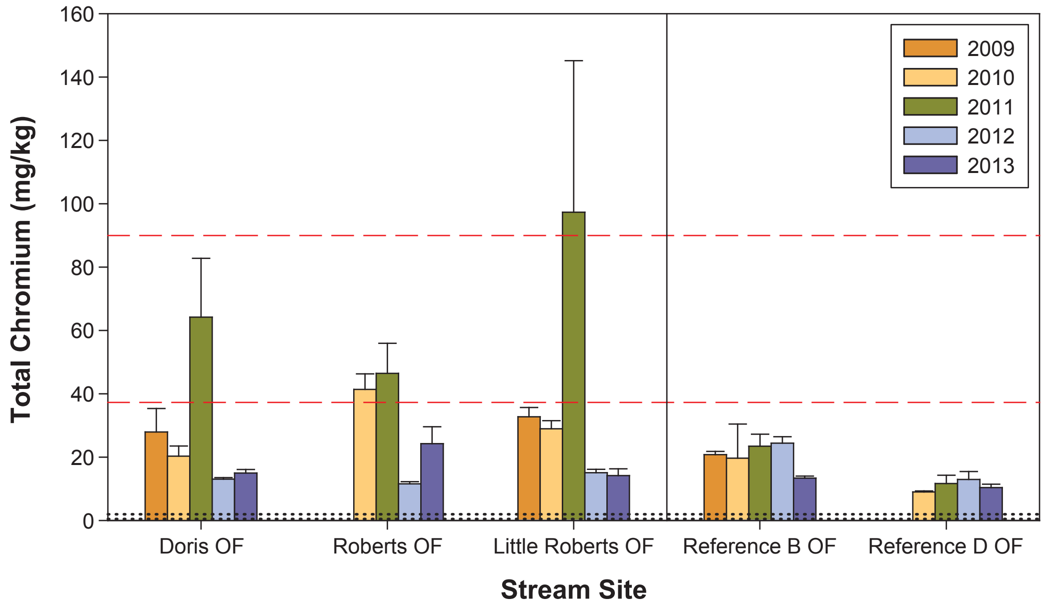

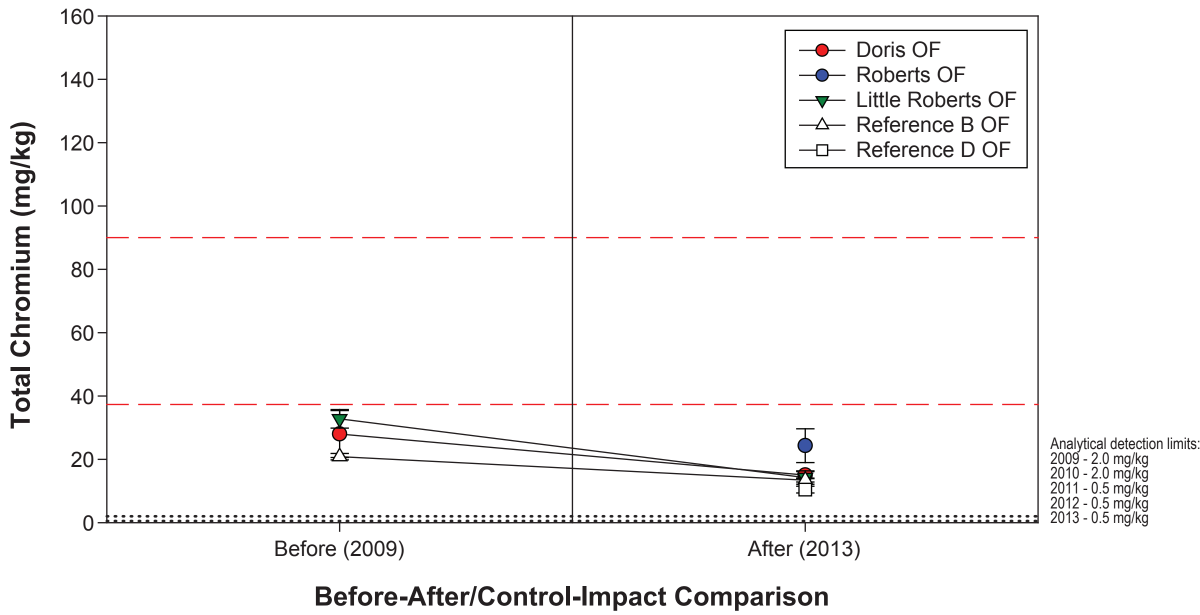

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
Red dashed lines represent the CCME freshwater interim sediment quality guideline (ISQG) for chromium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

Figure 3.4-5

Total Chromium Concentration in AEMP Stream Sediments, Doris North Project, 2009 to 2013

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3.4.1.6 Total Copper

Mean 2013 sediment copper concentrations were generally similar among the exposure and reference streams (ranging from 7.4 to 13.6 mg/kg; Figure 3.4-6). All sediment copper concentrations measured in 2013 were well below the CCME ISQG of 35.7 mg/kg and the PEL of 197 mg/kg (Appendix A). In both Doris Outflow and Little Roberts Outflow, mean total copper concentrations were slightly lower in 2013 than in 2009. However, the before-after analysis indicated that the mean 2013 copper concentration in Doris Outflow sediments was not distinguishable from the 2009 mean ($p = 0.37$), while the mean 2013 copper concentration in Little Roberts Outflow sediments was significantly lower than the 2009 mean ($p = 0.0018$). Although a decrease is not of concern, the BACI analysis showed that the decrease in the copper concentration in Little Roberts Outflow sediments was paralleled at the reference sites ($p = 0.060$). Therefore, 2013 Project activities had no effect on sediment copper concentrations in the exposure streams.

3.4.1.7 Total Lead

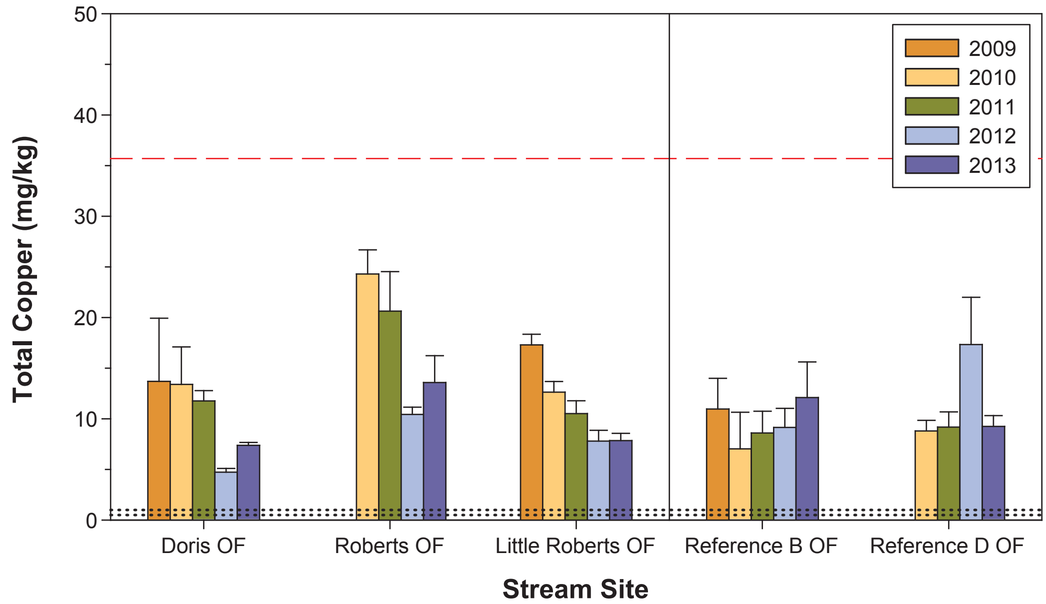
2013 lead concentrations in exposure stream sediments ranged from 0.95 to 4.2 mg/kg, and were well below the CCME ISQG of 35 mg/kg and the PEL of 91.3 mg/kg (Figure 3.4-7). In both Doris Outflow and Little Roberts Outflow, mean total lead concentrations in sediments were lower in 2013 than in 2009 (Figure 3.4-7). For Doris Outflow, the before-after comparison showed that the 2013 mean lead concentration was not distinguishable from the 2009 mean ($p = 0.43$); however, for Little Roberts Outflow, there was a significant difference in means ($p = 0.0021$). The BACI analysis indicated that the decrease in lead concentration in Little Roberts Outflow sediments was not paralleled at the reference streams ($p = 0.0017$). This decrease in lead concentration is not of environmental concern, and is likely related to the coarser nature of the sediments collected in 2013 compared to the finer sediments collected in 2009. There were no apparent adverse effects of 2013 activities on lead concentrations in stream sediments.

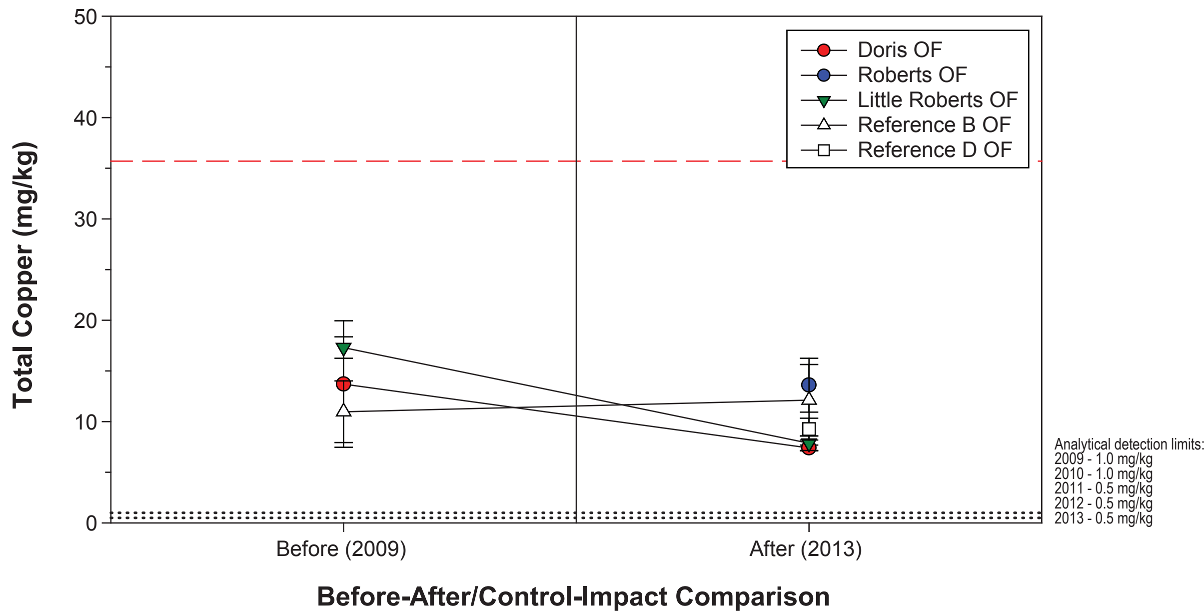
3.4.1.8 Total Mercury

2013 total mercury concentrations measured in Doris Outflow, Roberts Outflow and Little Roberts Outflow sediments ranged from below the analytical detection limit of 0.005 mg/kg to 0.0061 mg/kg (slightly over the detection limit), and were well below the CCME ISQG of 0.17 mg/kg and the PEL of 0.486 mg/kg (Figure 3.4-8). All total mercury concentrations measured in Doris Outflow sediments in 2013 were below the analytical detection limit, so there was no evidence of an effect of Project activities on sediment mercury levels in this stream. Mean 2013 concentrations at Roberts Outflow and Little Roberts Outflow were very similar to concentrations measured in Reference Lake B sediments. The before-after plot for Little Roberts Outflow shows that 2013 sediment mercury concentrations were lower than 2009 concentrations (Figure 3.4-8), but the before-after analysis showed that there was no significant difference between the 2009 and 2013 mean mercury concentrations ($p = 0.011$). There was no apparent effect of 2013 Project activities on total mercury concentrations in the sediments of exposure streams.

3.4.1.9 Total Zinc

In all three exposure streams, 2013 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). The before-after plot showed that 2013 mean concentrations were lower than 2009 means in both Doris Outflow and Little Roberts Outflow (Figure 3.4-9). The before-after comparison indicated that the mean 2013 zinc concentration in Doris Outflow sediments was not distinguishable from the 2009 mean ($p = 0.27$), whereas in Little Roberts Outflow, the 2013 mean was significantly lower than the 2009 mean ($p = 0.0041$). The BACI analysis further revealed that this decrease in zinc in Little Roberts Outflow sediments was significantly different than the 2009 to 2013 trend observed for the reference streams ($p = 0.0018$). This differential decrease in sediment zinc concentration in Little Roberts Outflow is not of environmental concern, and is likely related to the coarser nature of the sediments collected in 2013 compared to the finer sediments collected in 2009. Consequently, there was no evidence that 2013 Project activities adversely affected zinc concentrations in the AEMP exposure stream sediments.

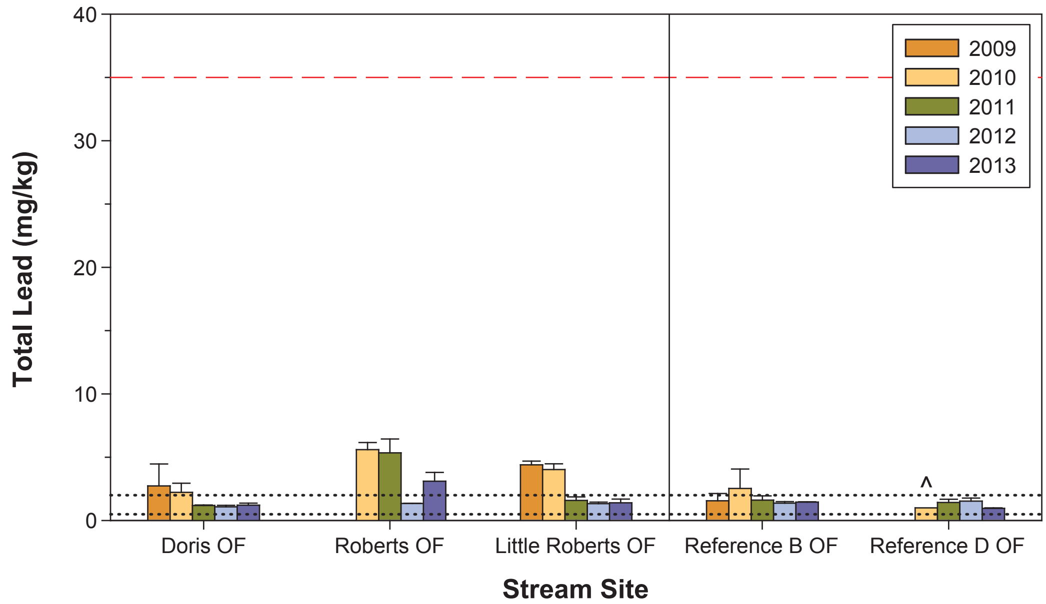


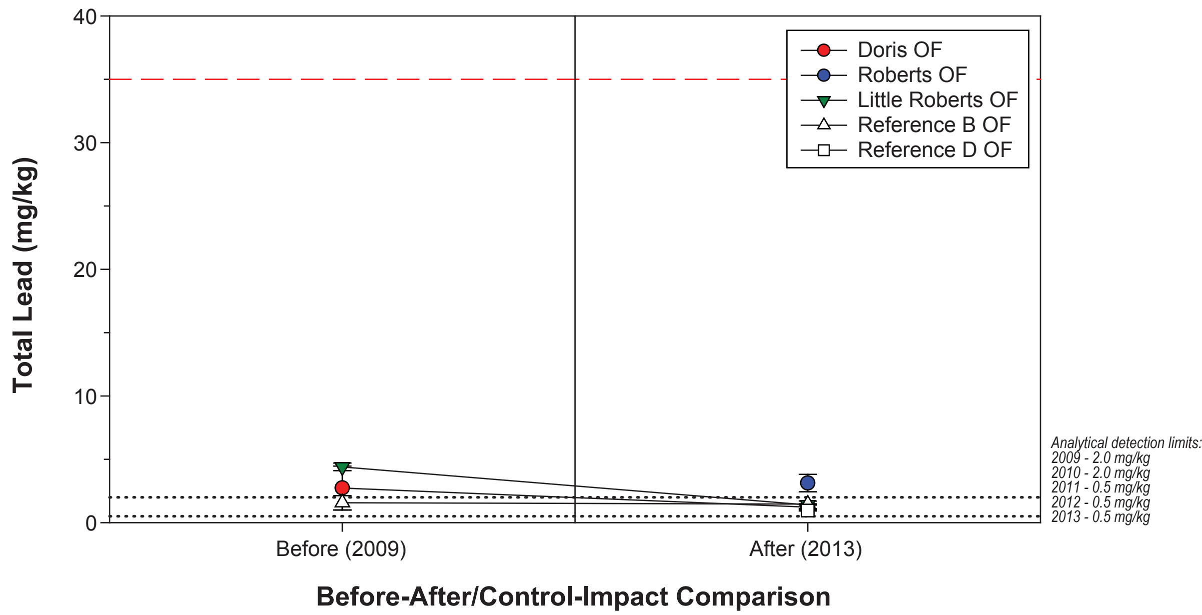


Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
Red dashed lines represent the CCME freshwater interim sediment quality guideline (ISQG) for copper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

Figure 3.4-6

Total Copper Concentration in AEMP Stream Sediments, Doris North Project, 2009 to 2013

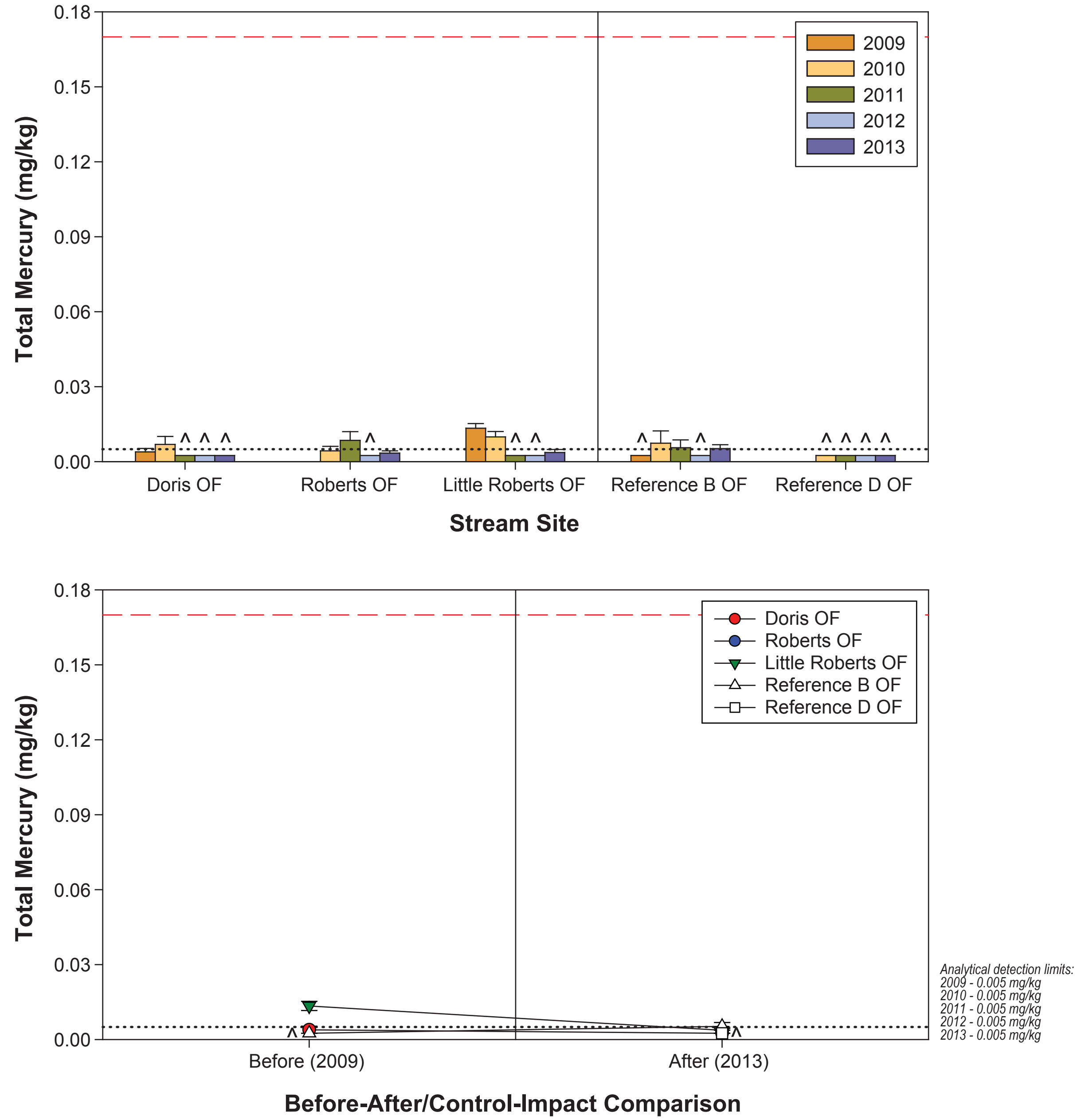




Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed lines represent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

Figure 3.4-7

Total Lead Concentration in AEMP Stream Sediments, Doris North Project, 2009 to 2013



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.

Figure 3.4-8

Total Mercury Concentration in AEMP Stream Sediments, Doris North Project, 2009 to 2013

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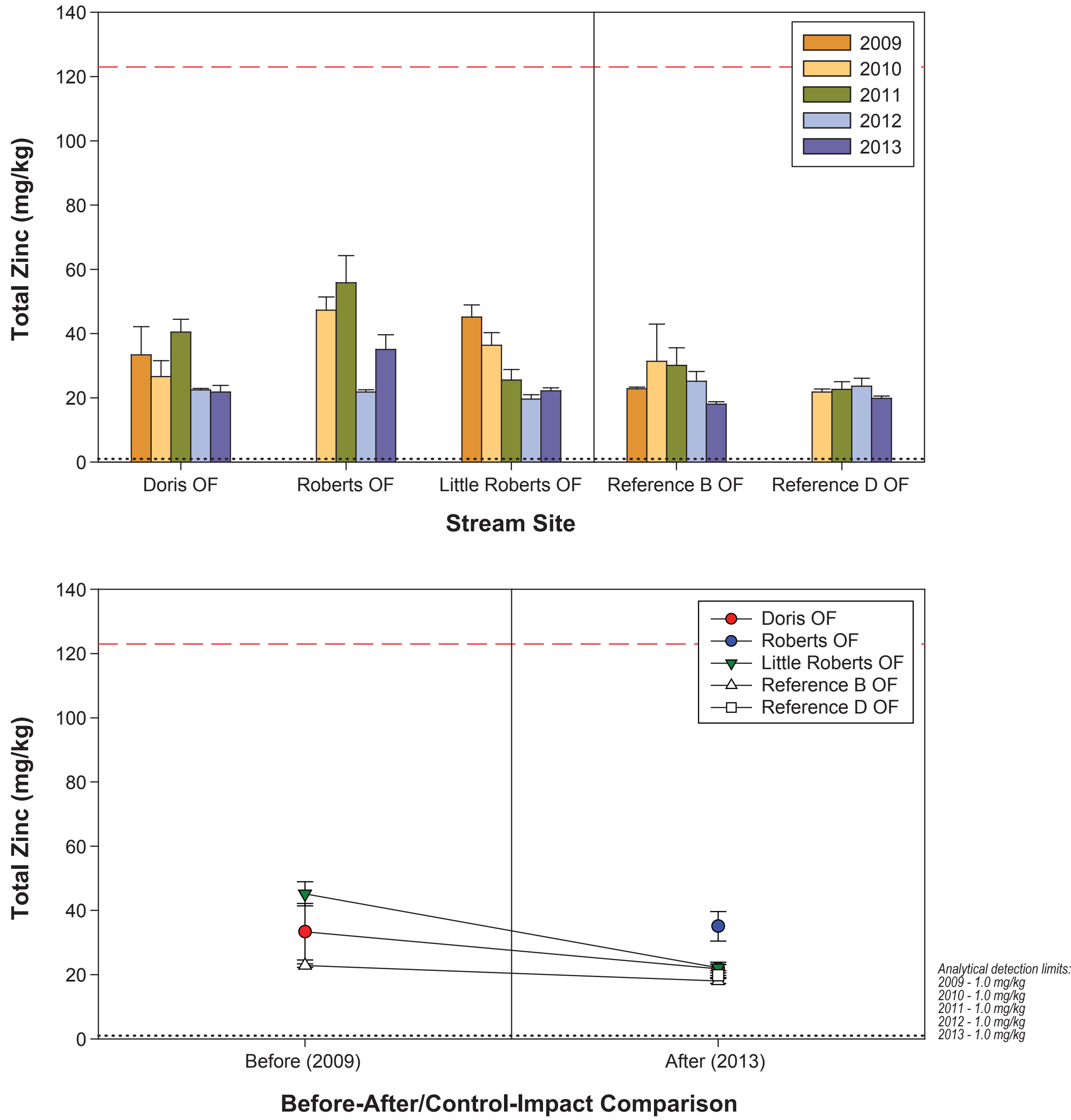

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limit; values below the detection limit are plotted at half the detection limit.
Red dashed lines represent the CCME freshwater interim sediment quality guideline (ISQG) for zinc (123 mg/kg);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

Figure 3.4-9

Total Zinc Concentration in AEMP Stream Sediments, Doris North Project, 2009 to 2013

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3.4.2 Lakes

AEMP sediment quality samples were collected from three exposure sites (Doris Lake North, Doris Lake South, and Little Roberts Lake) and two reference sites (Reference Lake B and Reference Lake D) in 2013. Sediment samples have been collected in the Doris North area since 1996. However, most of the historical data were not directly comparable to 2013 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, while 2009 and 2013 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 variable, all analytical results for lake sediment samples collected in a given year were averaged.

3.4.2.1 Particle Size

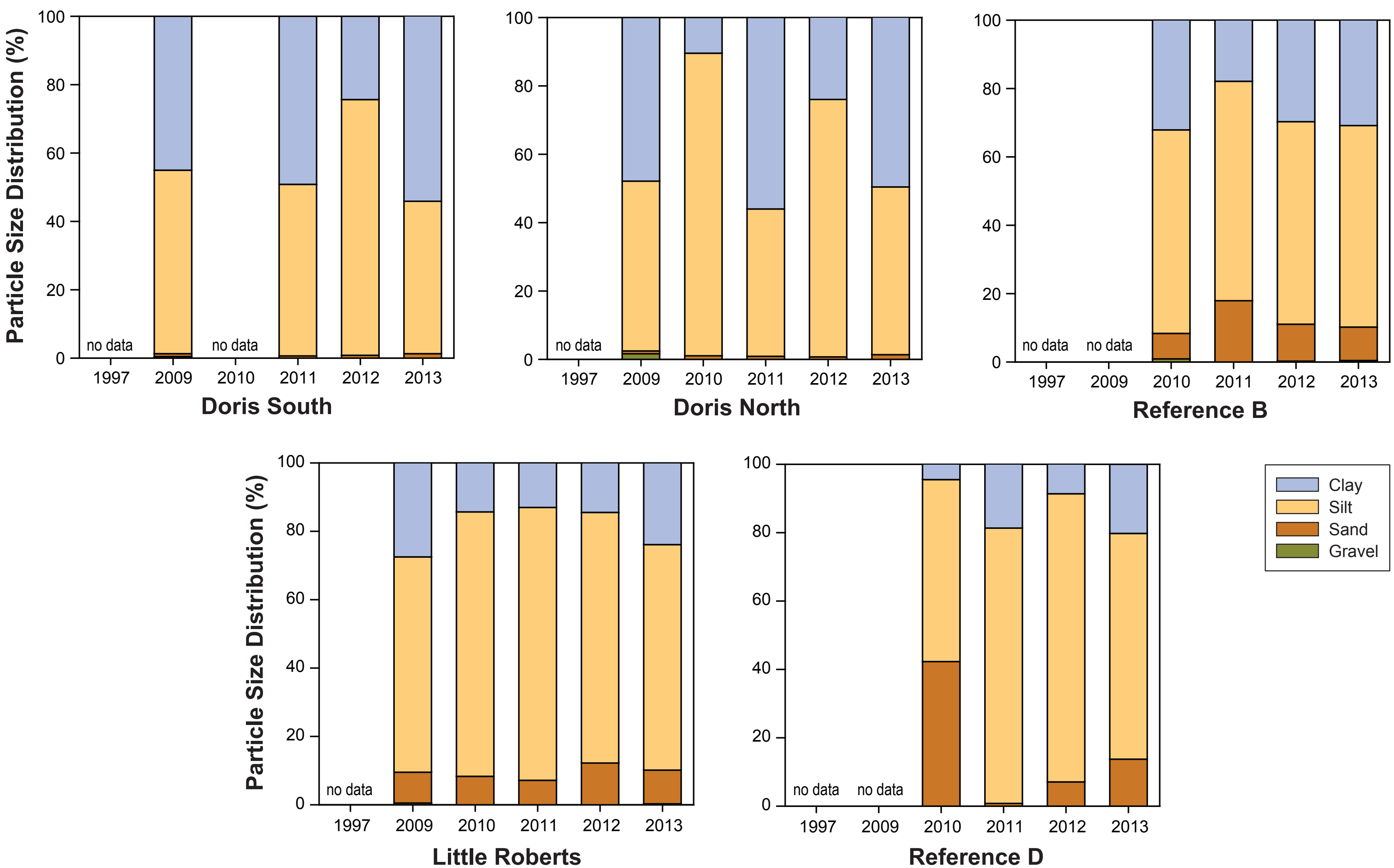
Consistent with previous years, the AEMP lakes were dominated by fine sediments (silt and clay) in 2013 (Figure 3.4-10). In the three exposure lakes, the particle size composition was generally similar between 2009 and 2013. However, the before-after analysis indicated that the silt content decreased significantly ($p = 0.0007$) while the clay content increased significantly ($p = 0.0021$) in 2013 compared to 2009 in sediment samples collected from Doris Lake South. Variation in sediment particle size composition was unlikely related to 2013 Project activities, and probably reflected natural spatial heterogeneity in lake sediments. In the remaining exposure lakes (Doris Lake North and Little Roberts Lake), there were no statistically significant changes in the particle size composition from 2009 to 2013 (Appendix B).

3.4.2.2 Total Organic Carbon

Mean 2013 TOC concentrations in Doris Lake North, Doris Lake South, and Little Roberts Lake sediments were similar to baseline TOC levels (Figure 3.4-11). The before-after comparison confirmed that there was no significant difference between mean baseline and mean 2013 TOC levels in the sediments of any exposure lake ($p = 0.24$ for Doris Lake South, $p = 0.31$ for Doris Lake North, and $p = 0.57$ for Little Roberts Lake). Therefore, there was no effect of 2013 Project activities on the TOC content of exposure lake sediments.

3.4.2.3 Total Arsenic

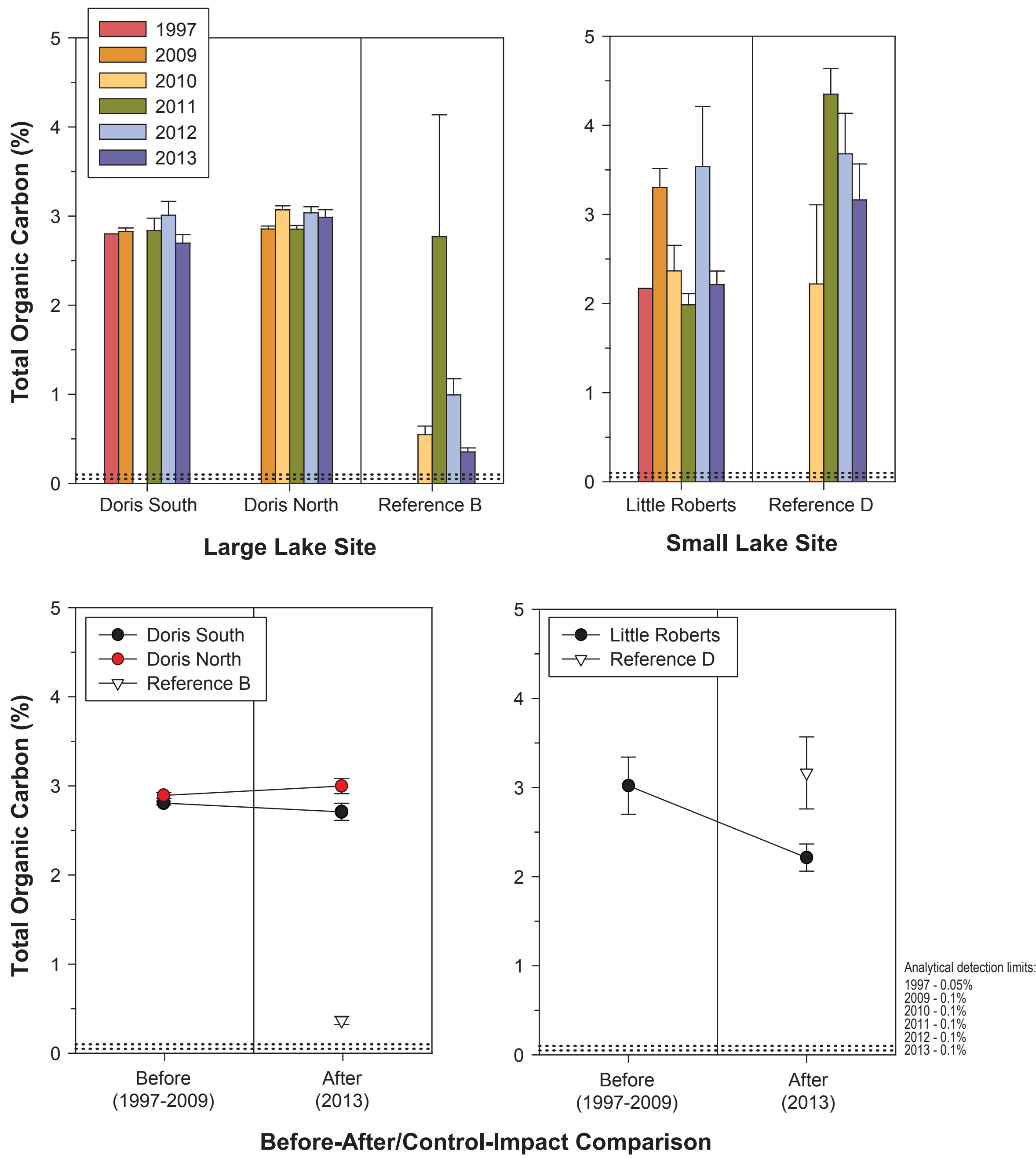
Mean 2013 arsenic concentrations in the exposure lake sediments were similar to baseline means (Figure 3.4-12). The before-after comparison confirmed that 2009 and 2013 mean arsenic levels were not distinguishable for any exposure lake ($p = 0.78$ for Doris Lake South, $p = 0.60$ for Doris Lake North, and $p = 0.19$ for Little Roberts Lake), suggesting that 2013 Project activities did not affect sediment arsenic concentrations in lakes. As observed in baseline years, mean 2013 arsenic concentrations in Doris Lake South sediments (13.9 mg/kg) and Doris Lake North sediments (11.7 mg/kg) were higher than the CCME ISQG of 5.9 mg/kg, but remained below the PEL of 17 mg/kg. The mean 2013 arsenic concentration in Little Roberts Lake sediments (3.4 mg/kg) was lower than both the CCME ISQG and PEL guidelines (Figure 3.4-12).



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

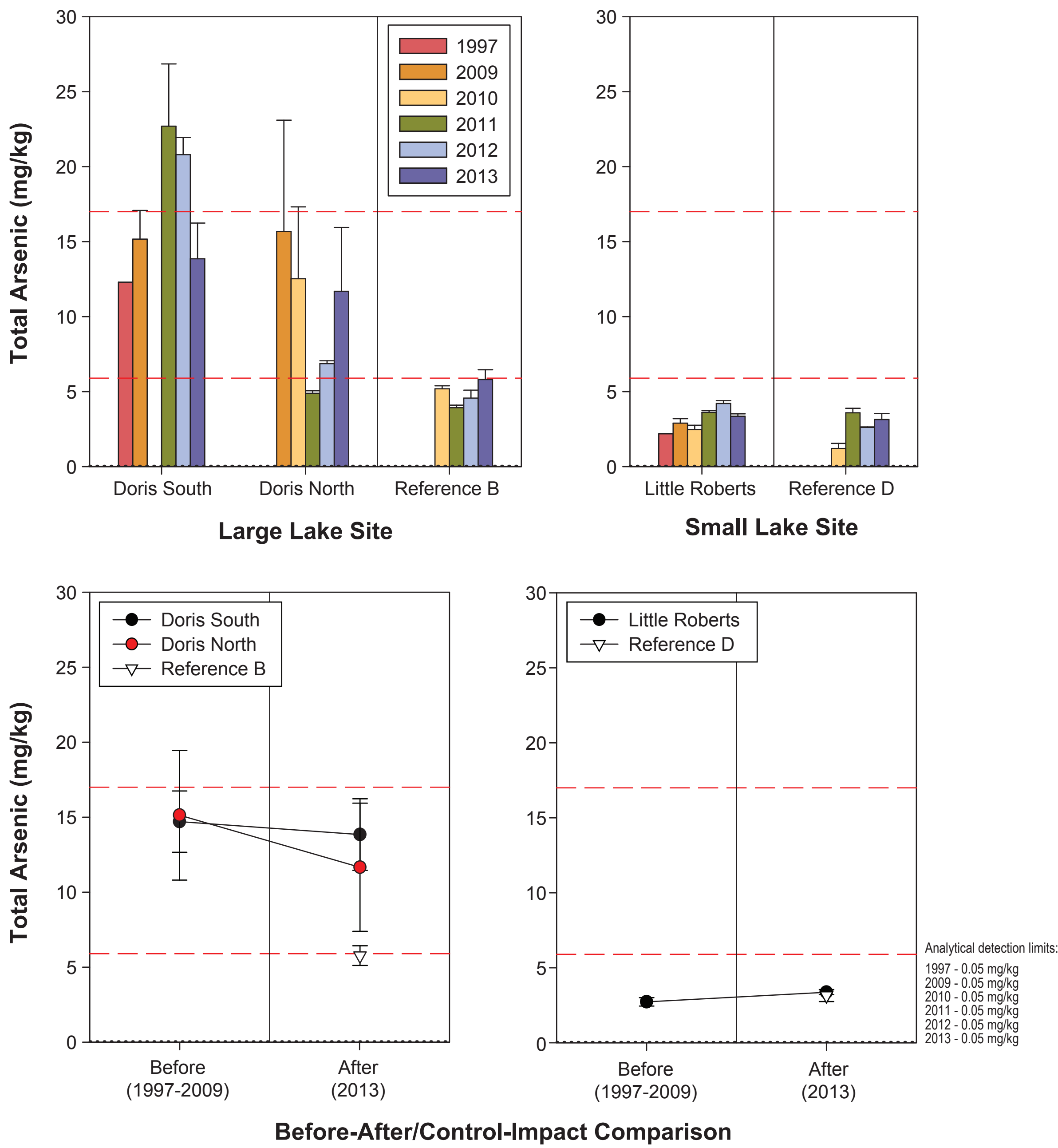
Particle Size Distribution in AEMP Lake Sediments, Doris North Project, 1997 to 2013



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.

Figure 3.4-11

Total Organic Carbon Concentration in AEMP Lake Sediments, Doris North Project, 1997 to 2013



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).

Figure 3.4-12

Total Arsenic Concentration in AEMP Lake Sediments, Doris North Project, 1997 to 2013

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3.4.2.4 Total Cadmium

Mean 2013 cadmium levels in Doris Lake South and Little Roberts Lake sediments were within the range of baseline means, while the mean 2013 cadmium concentration in Doris Lake North sediments was slightly lower than the 2009 mean (Figure 3.4-13). All 2013 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 2013 in the exposure lakes ($p = 0.83$ for Doris Lake South, $p = 0.021$ for Doris Lake North, and $p = 0.85$ for Little Roberts Lake). Therefore, 2013 Project 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 lake sediments, as all baseline and 2013 concentrations were above the CCME ISQG of 37.3 mg/kg, but below the CCME PEL of 90 mg/kg (Figure 3.4-14). In the exposure lakes, mean 2013 sediment chromium concentrations were similar to baseline concentrations, and the before-after analysis confirmed that there was no difference in means between baseline years and 2013 for any exposure lake ($p = 0.57$ for Doris Lake South, $p = 0.36$ for Doris Lake North, and $p = 0.42$ for Little Roberts Lake). Therefore, there was no evidence of an effect of 2013 activities on total chromium concentrations in exposure lake sediments.

3.4.2.6 Total Copper

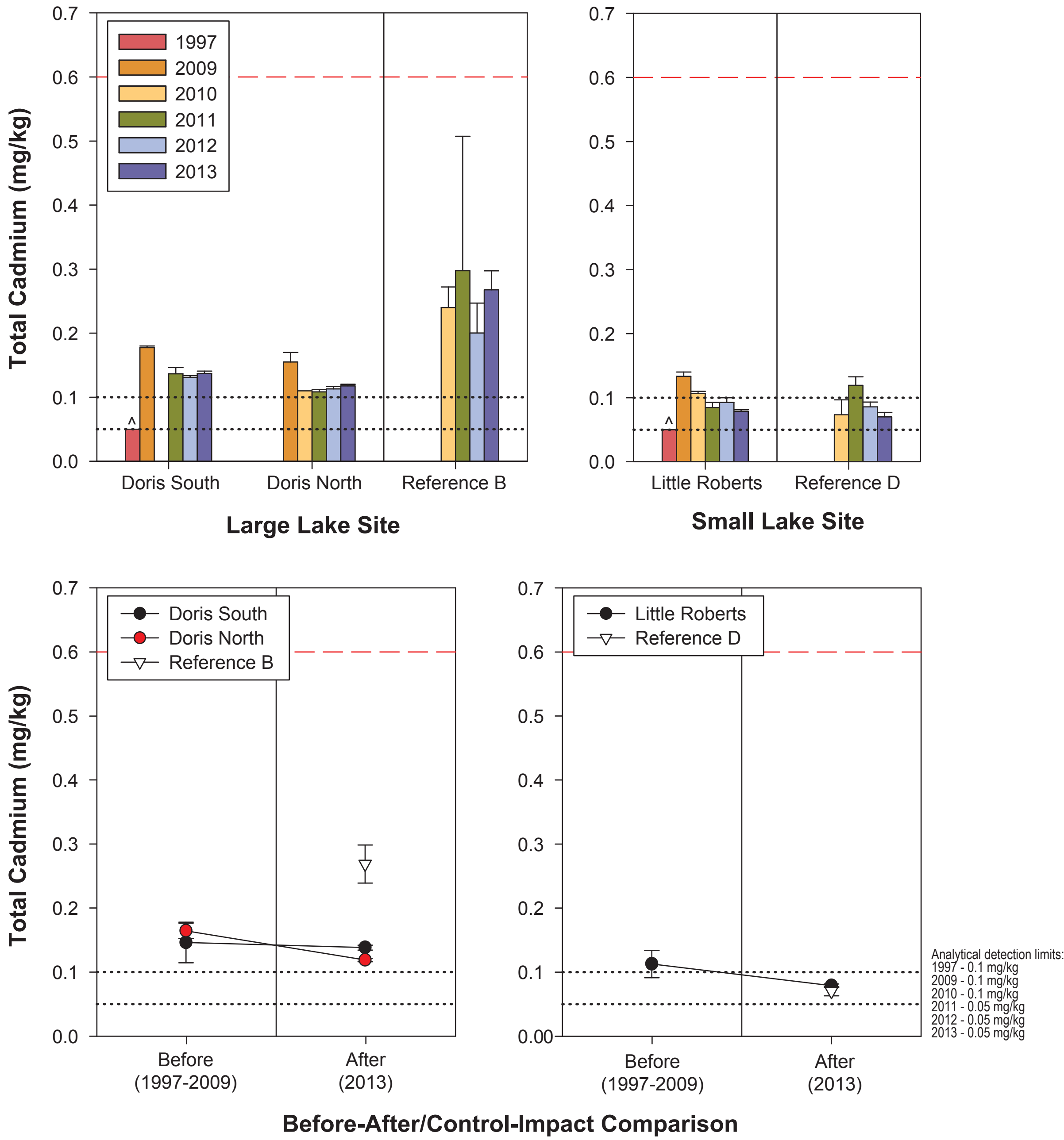
Mean baseline and 2013 copper concentrations in sediments were slightly higher than the CCME ISQG of 35.7 mg/kg in both Doris Lake South and Doris Lake North, but were well below the PEL of 197 mg/L. In Little Roberts Lake, mean baseline and 2013 concentrations were below both the ISQG and PEL guidelines (Figure 3.4-15). At all three exposure lake sites, the before-after plot showed that mean 2013 sediment copper concentrations were lower than baseline means (Figure 3.4-15). The before-after analysis indicated that this decrease was statistically significant for Doris Lake South ($p < 0.0001$) and Doris Lake North sediments ($p = 0.0001$), but that there was no significant difference between the baseline and the 2013 mean for Little Roberts Lake sediments ($p = 0.47$). A decrease in total copper concentrations in Doris Lake South and North sediments is not of concern; therefore, 2013 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 2013, 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 2013 lead concentration in Little Roberts Lake sediments was significantly lower than the baseline mean ($p = 0.0001$), but the 2013 mean was not significantly different from the baseline mean in Doris Lake South ($p = 0.031$) or Doris Lake North ($p = 0.014$). A decrease in sediment lead concentrations in Little Roberts Lake is not of concern; therefore, 2013 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 2013 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 the 2013 mean concentration was not significantly different from the baseline mean for any exposure lake ($p = 0.80$ for Doris Lake South, $p = 0.30$ for Doris Lake North, and $p = 0.93$ for Little Roberts Lake). There was no indication that 2013 Project 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 Concentration in AEMP Lake Sediments, Doris North Project, 1997 to 2013

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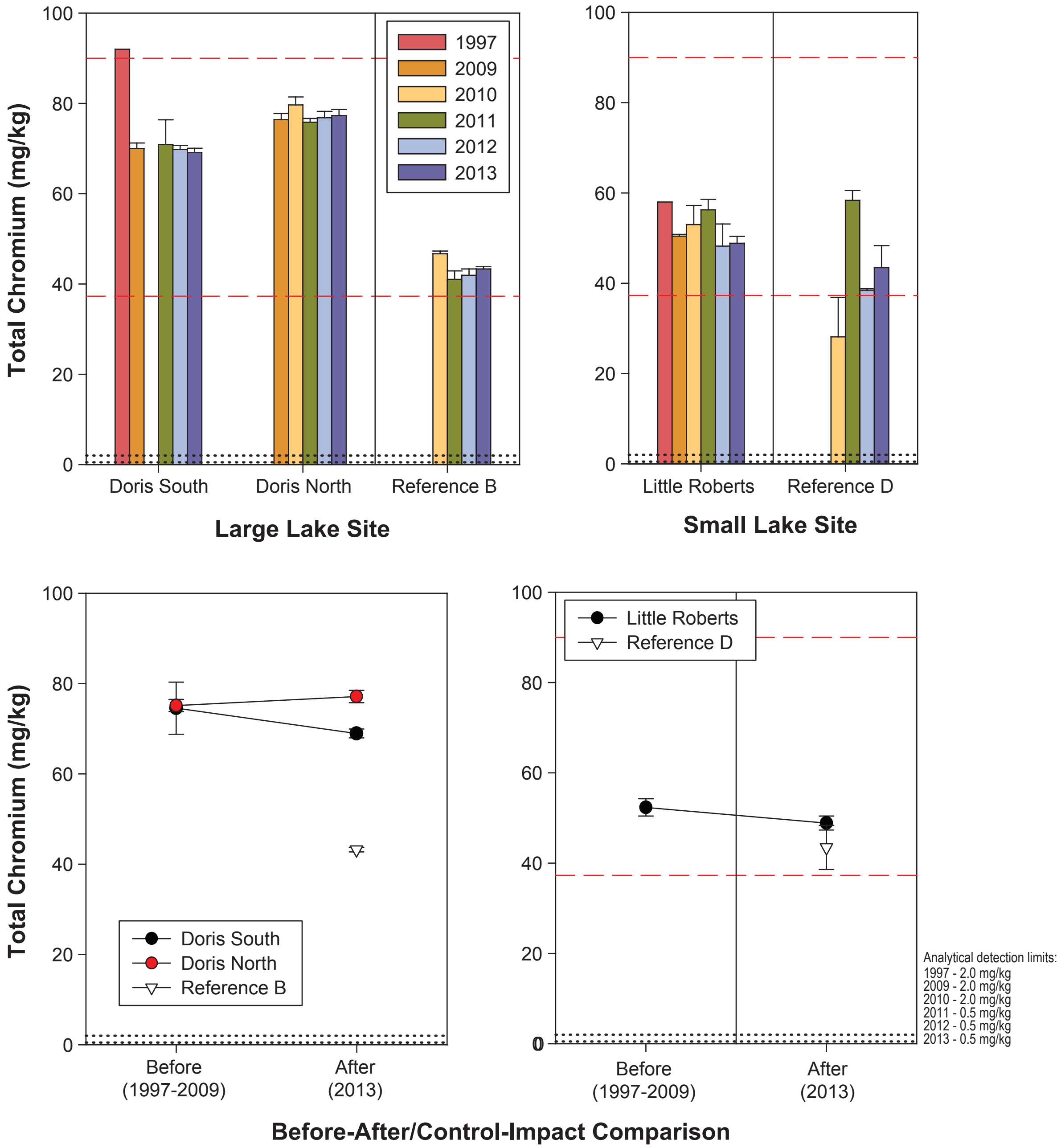

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
Red dashed lines represent the CCME freshwater interim sediment quality guideline (ISQG) for chromium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

Figure 3.4-14

Total Chromium Concentration in AEMP Lake Sediments, Doris North Project, 1997 to 2013

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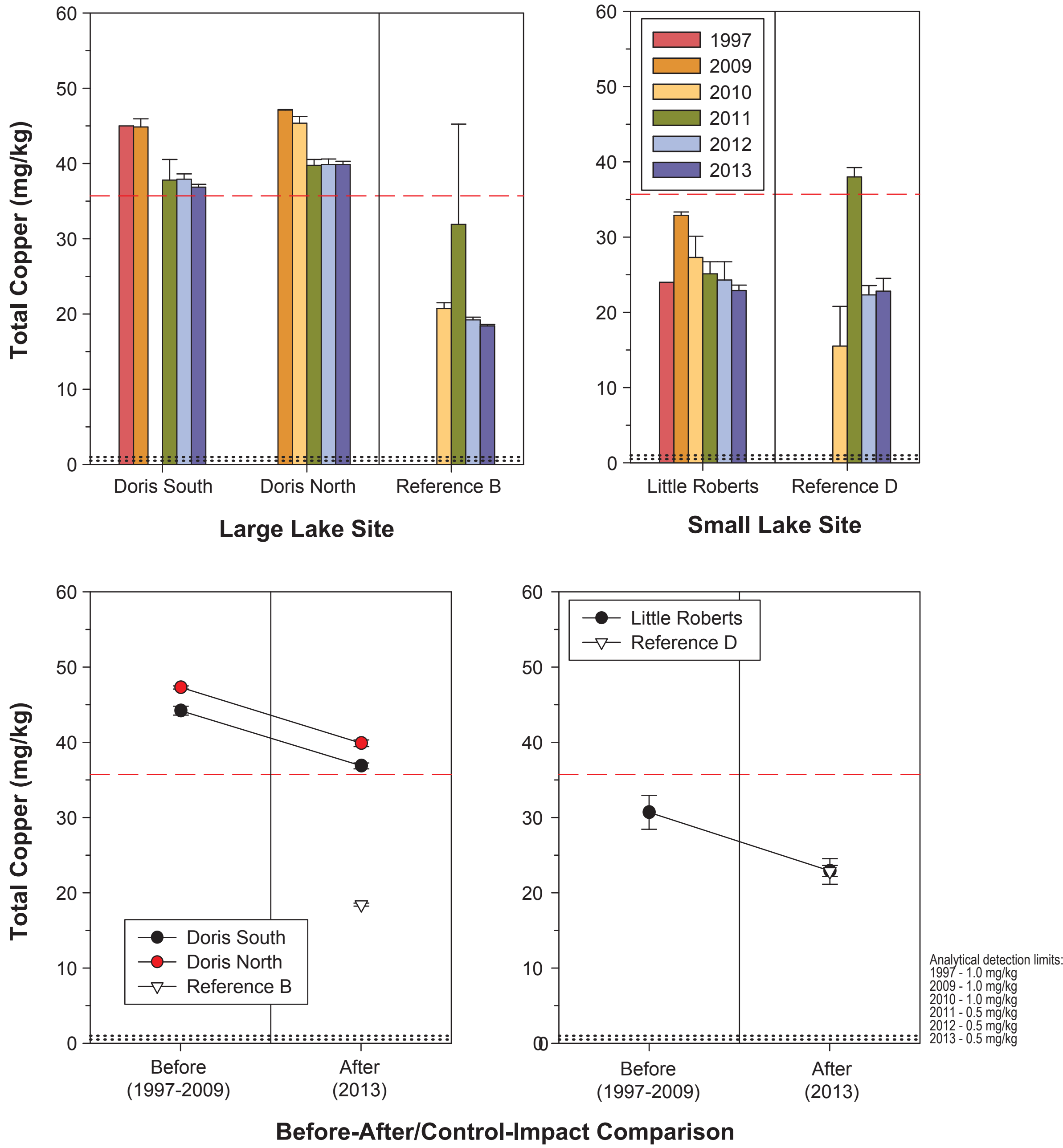

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
Red dashed lines represent the CCME freshwater interim sediment quality guideline (ISQG) for copper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

Figure 3.4-15

Total Copper Concentration in AEMP Lake Sediments, Doris North Project, 1997 to 2013

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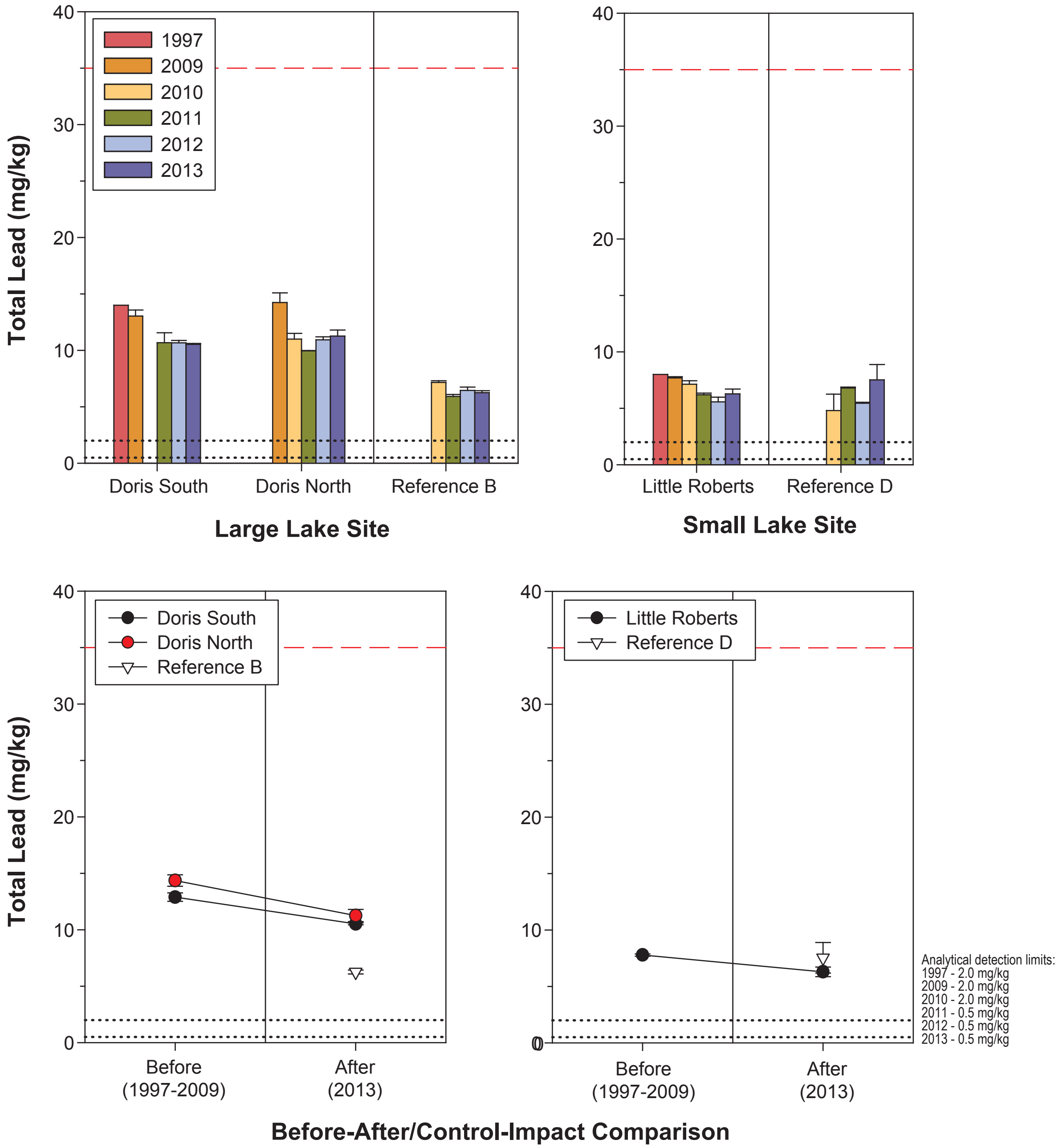
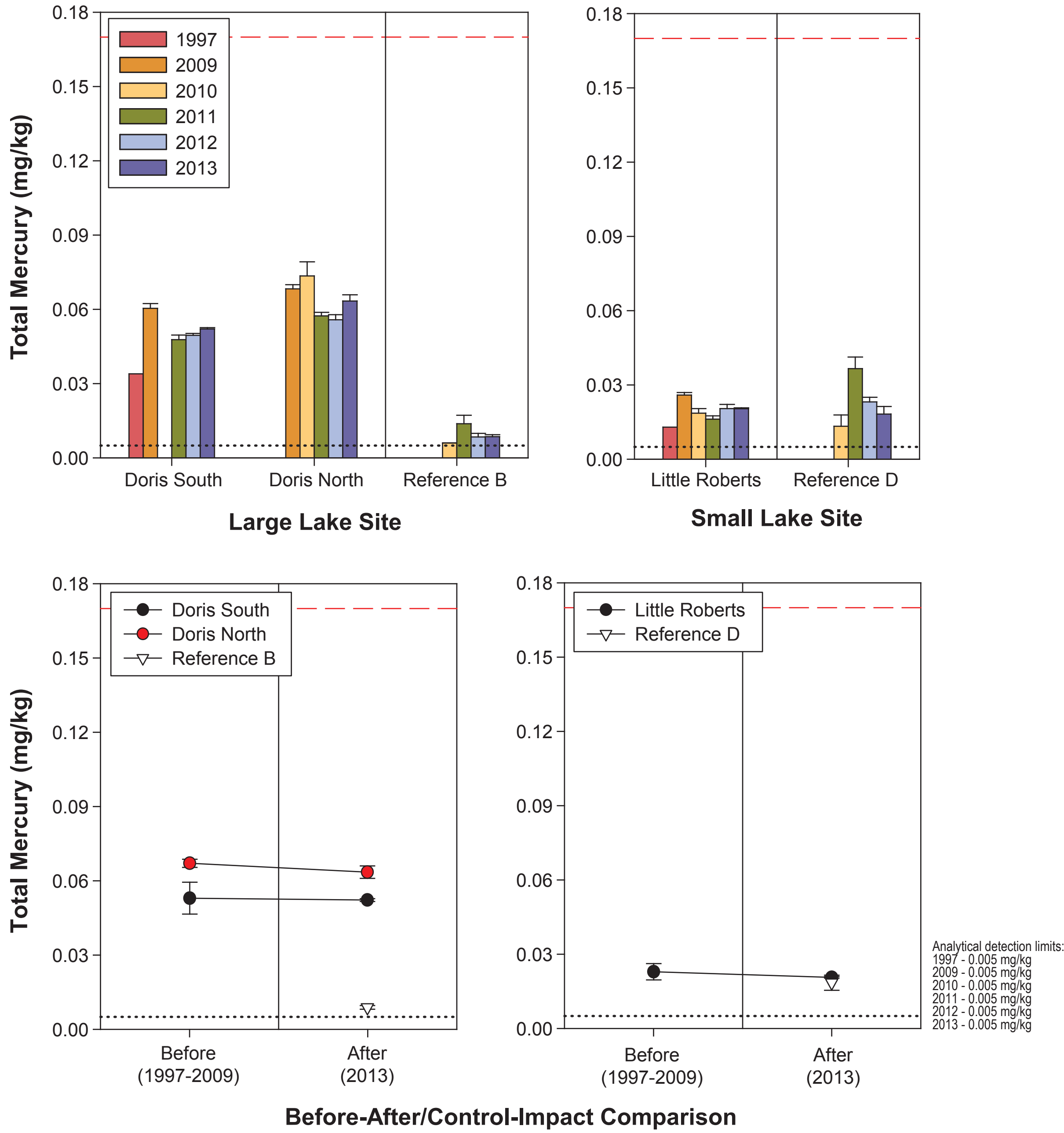


Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
Red dashed lines represent the CCME freshwater interim sediment quality guideline (ISQG) for lead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

Total Lead Concentration in AEMP Lake Sediments, Doris North Project, 1997 to 2013



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 Concentration in AEMP Lake Sediments, Doris North Project, 1997 to 2013

3.4.2.9 Total Zinc

Mean 2013 zinc concentrations in the sediments of the exposure lakes were similar between baseline years and 2013, 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 2013 means ($p = 0.60$ for Doris Lake South, $p = 0.83$ for Doris Lake North, and $p = 0.47$ for Little Roberts Lake). Thus, there were no apparent adverse effects of 2013 activities on zinc concentrations in the sediments of the exposure lakes.

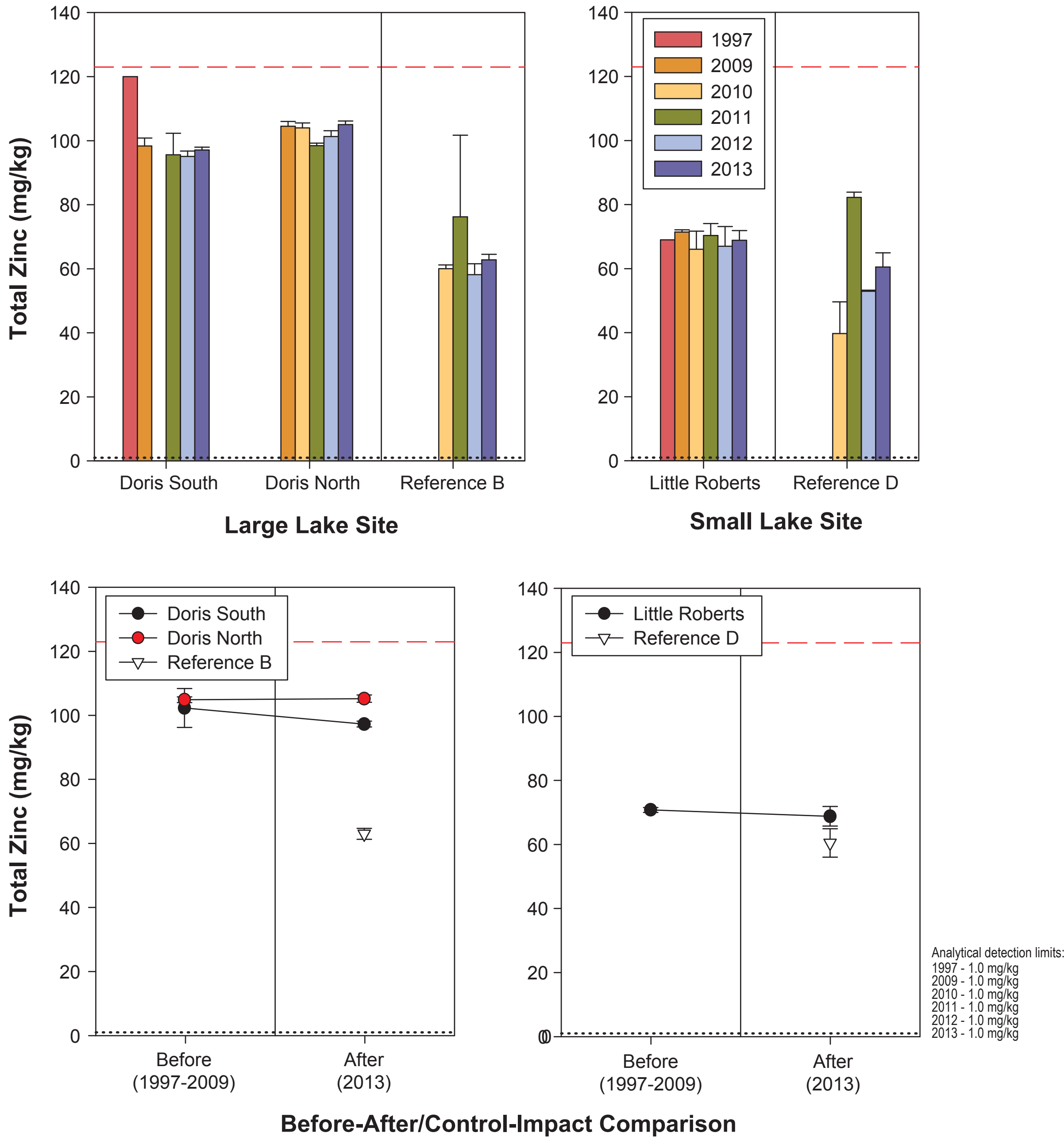
3.4.3 Marine

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 2013 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 2013 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 variable at the exposure site, RBW, from 2002 to 2013 cannot be directly compared to the change at the reference station, REF-Marine 1, between 2009 and 2013. Any change at REF-Marine 1 can only be used to show the inherent inter-annual variability that occurs in the AEMP sediment variables. Also, caution must be exercised when interpreting changes at RBW since there was a ten-year gap between the collection of before and after data. No BACI analysis was possible for RBW because there were too few degrees of freedom in the before period and no before-after or BACI 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

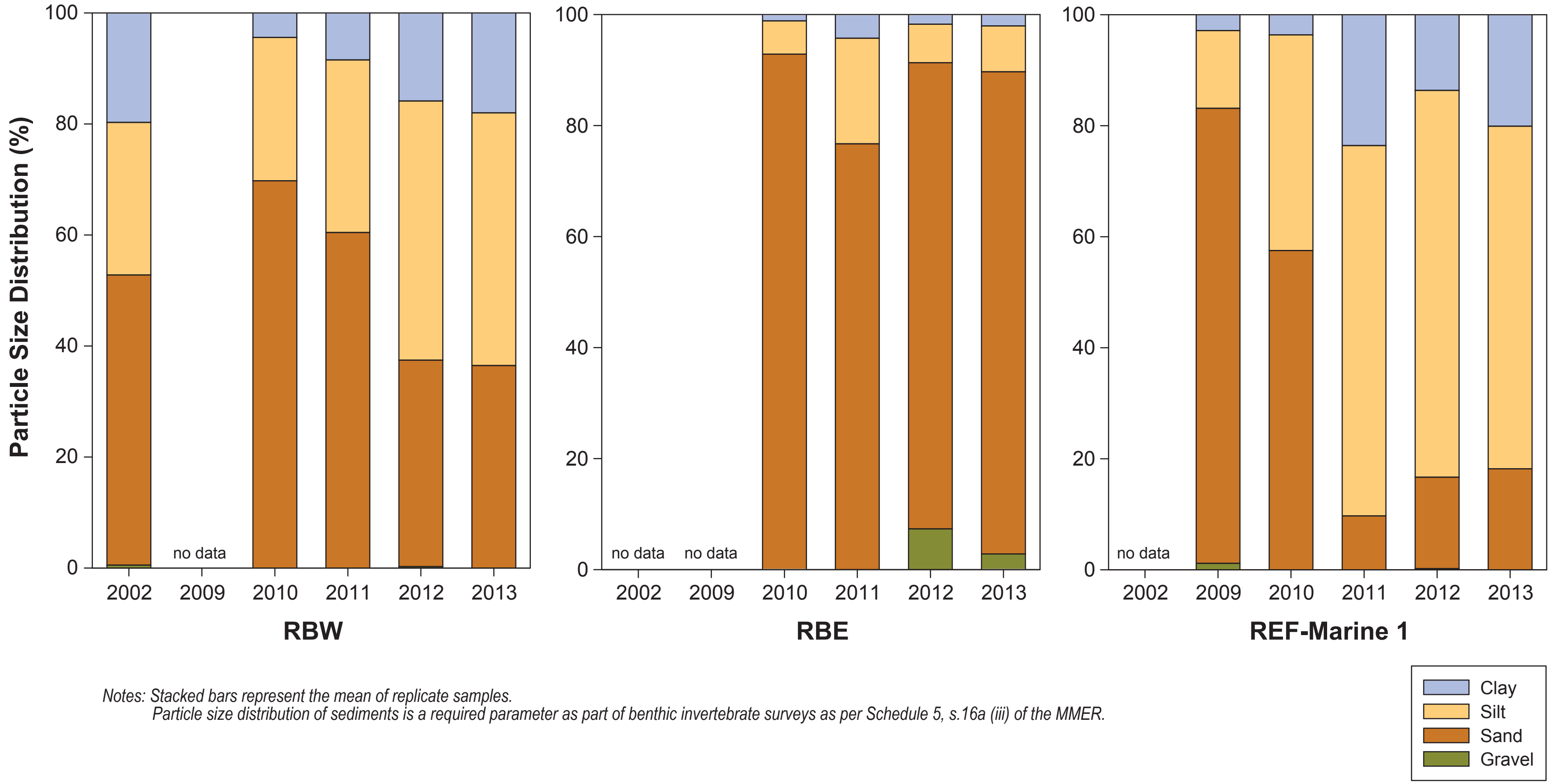
In 2013, sediments at sites RBW and REF-Marine 1 consisted mainly of sand, silt, and clay, with very little gravel, while RBE sediments were largely composed of sand, with some silt, and little gravel and clay (Figure 3.4-19). The before-after comparison showed that the sand content decreased significantly in 2013 sediment samples compared to baseline samples at both RBW ($p = 0.0002$) and REF-Marine 1 ($p < 0.0001$), while the silt content increased significantly at both sites in 2013 ($p < 0.0001$ for both RBW and REF-Marine 1). At REF-Marine 1, the clay content also increased in 2013 compared to baseline conditions ($p = 0.0002$), but the clay content in RBW samples did not change ($p = 0.28$). The observed decrease in sand and increase in silt has important implications for the before-after comparisons of sediment quality variables because metal and TOC concentrations tend to be higher in fine sediments than in coarse sediments (e.g., Lakhan, Cabana, and LaValle 2003; Secrieri and Oaie 2009). As described in the following sections, mean concentrations of TOC and most evaluated metals increased significantly at both RBW and REF-Marine 1 in 2013 compared to baseline years, and this increase was likely associated with the higher proportion of fine sediments in the 2013 sediment samples. There was some damage to the Roberts Bay jetty in 2013 that could have contributed to changes in particle size composition and sediment quality in a localized area, but the similarity between RBW and REF-Marine 1 with respect to increases in silt content, and increases in sediment metal and TOC concentrations from baseline years to 2013 suggests that the observed changes at RBW were naturally occurring and unrelated to the jetty damage or other Project activities. The changes in sediment particle size composition and quality may have been due to regional re-distribution of sediments following a strong storm event that occurred in July 2013 (which was responsible for damaging the jetty), or these changes could also be the product of spatial sediment heterogeneity.



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.

Figure 3.4-18

Total Zinc Concentration in AEMP Lake Sediments, Doris North Project, 1997 to 2013



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 3.4-19

Particle Size Distribution in AEMP Marine Sediments, Doris North Project, 2002 to 2013

Figure 3.4-19

3.4.3.2 Total Organic Carbon

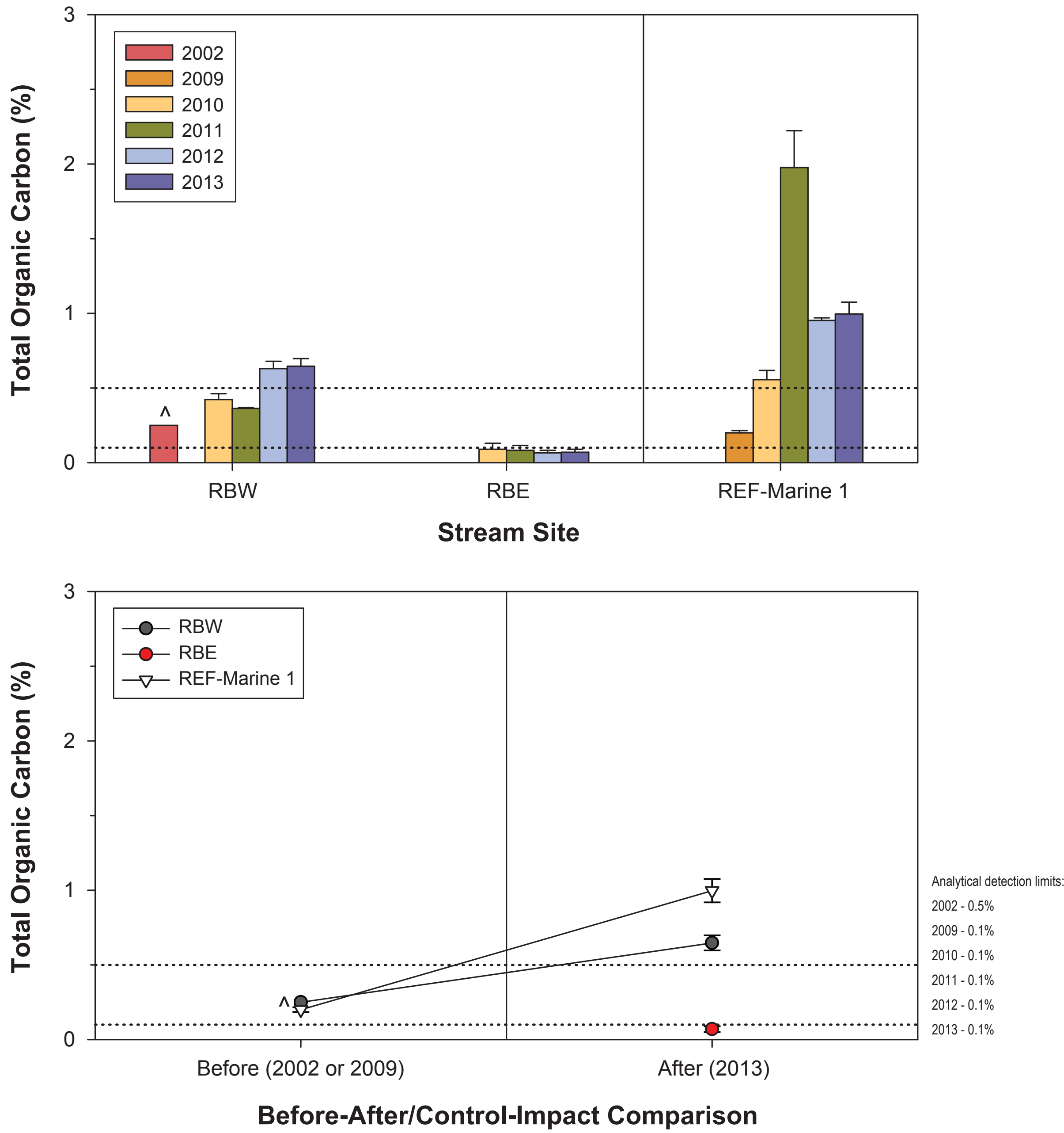
The mean TOC content in sediments from RBW increased from below the detection limit of 0.5% in 2002 to 0.65% 2013 (Figure 3.4-20), and the before-after comparison indicated that this increase was statistically significant ($p < 0.0001$). An increase in the mean TOC from 0.20% in 2009 to 1.0% in 2013 was also observed at REF-Marine 1, and the before-after comparison indicated that these means were also significantly different ($p = 0.0006$). Although a BACI analysis to directly compare the before-after trend at RBW to the trend at the reference site could not be performed (too few degrees of freedom), it is apparent from the before-after plot that the increasing trends were similar at both sites (Figure 3.4-20). This increase in TOC at both RBW and REF-Marine 1 was likely related to the higher proportion of fine sediments in 2013 samples collected from these sites compared to 2009 samples, since fine sediments tend to contain higher concentrations of TOC (Secrieri and Oaie 2009). Sediment samples from the sand-dominated RBE contained very little TOC, as all concentrations were near or below the detection limit of 0.1% and were lower than the TOC content in samples from either RBW or REF-Marine 1. There was no evidence that 2013 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 significantly from 1.9 mg/kg in 2002 to 4.0 mg/kg in 2013 (before-after: $p < 0.0001$; Figure 3.4-21). However, mean arsenic concentrations also increased significantly at REF-Marine 1 from 0.60 mg/kg in 2009 to 3.8 mg/kg in 2013 ($p = 0.0001$). In both cases, the increase in sediment arsenic concentrations was likely related to the significant increase in the proportion of fine sediments in the samples, since fine sediments tend to have higher affinities for metals. This suggests that the change in arsenic concentrations that occurred in sediments from RBW in 2013 was unrelated to Project activities. At RBE, the mean 2013 arsenic concentration in sediments (1.1 mg/kg) was lower than the mean 2013 concentrations in sediments from the other AEMP sites (Figure 3.4-21). All 2013 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 2013 Project activities affected sediment arsenic concentrations at the marine exposure sites.

3.4.3.4 Total Cadmium

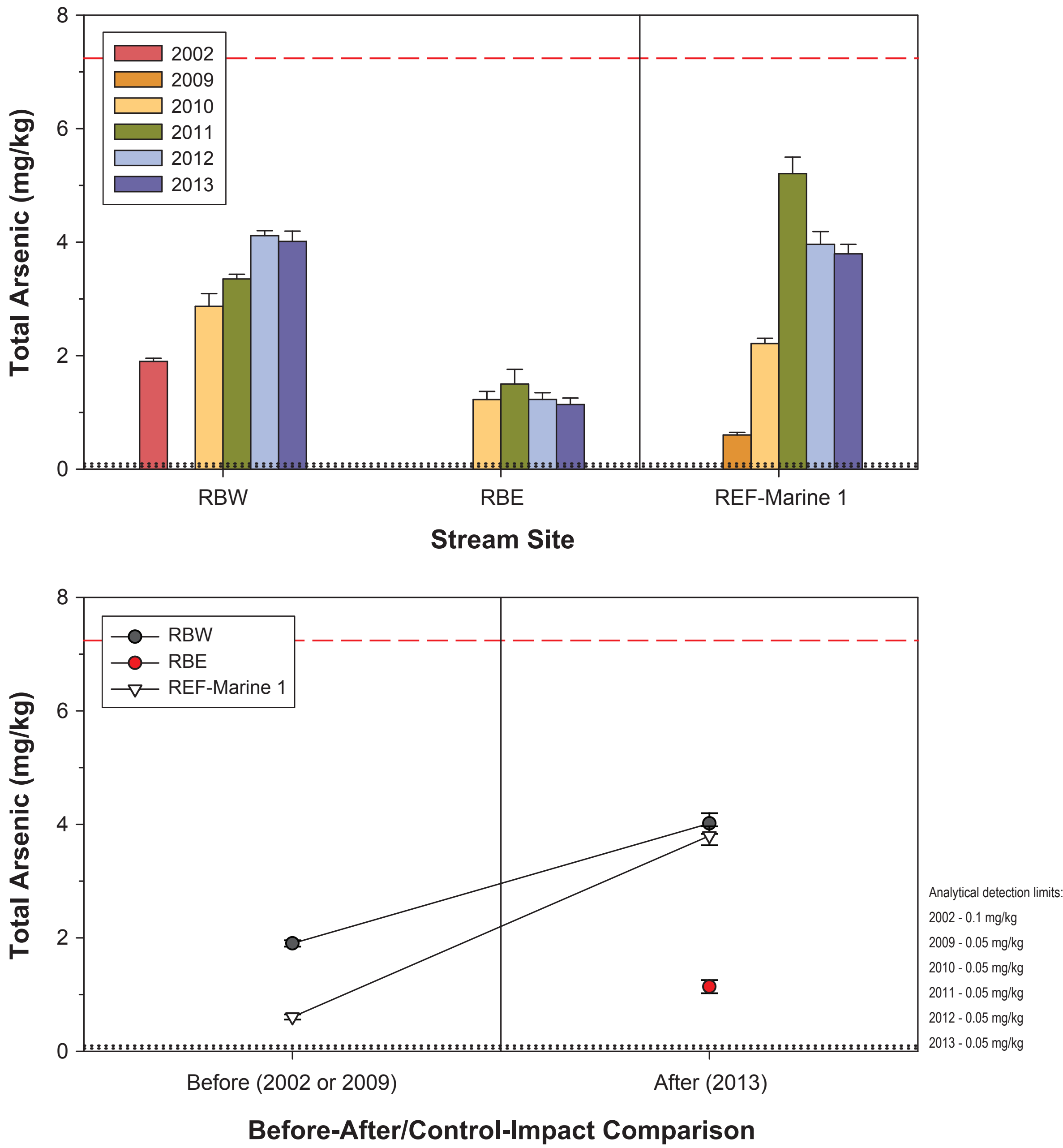
Total cadmium concentrations were below the analytical detection limit (< 0.05 mg/kg) in all sediment samples collected from RBE in 2013. At RBW and REF-Marine 1, sediment cadmium concentrations measured in 2013 were low, ranging from below the detection limit to 0.058 mg/kg (slightly over the detection limit; Figure 3.4-22). All 2013 concentrations were well below the CCME ISQG of 0.7 mg/kg and the PEL of 4.2 mg/kg. Before-after statistical results are not discussed for cadmium because a high proportion (>70%) of the concentrations in the combined baseline and 2013 dataset for each site were below analytical detections limits. Although the before-after plot indicates that 2013 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 2013 (0.05 mg/kg; Figure 3.4-22). There was no indication that 2013 activities had any effect on cadmium concentrations in sediments 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.
^ 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.

Figure 3.4-20

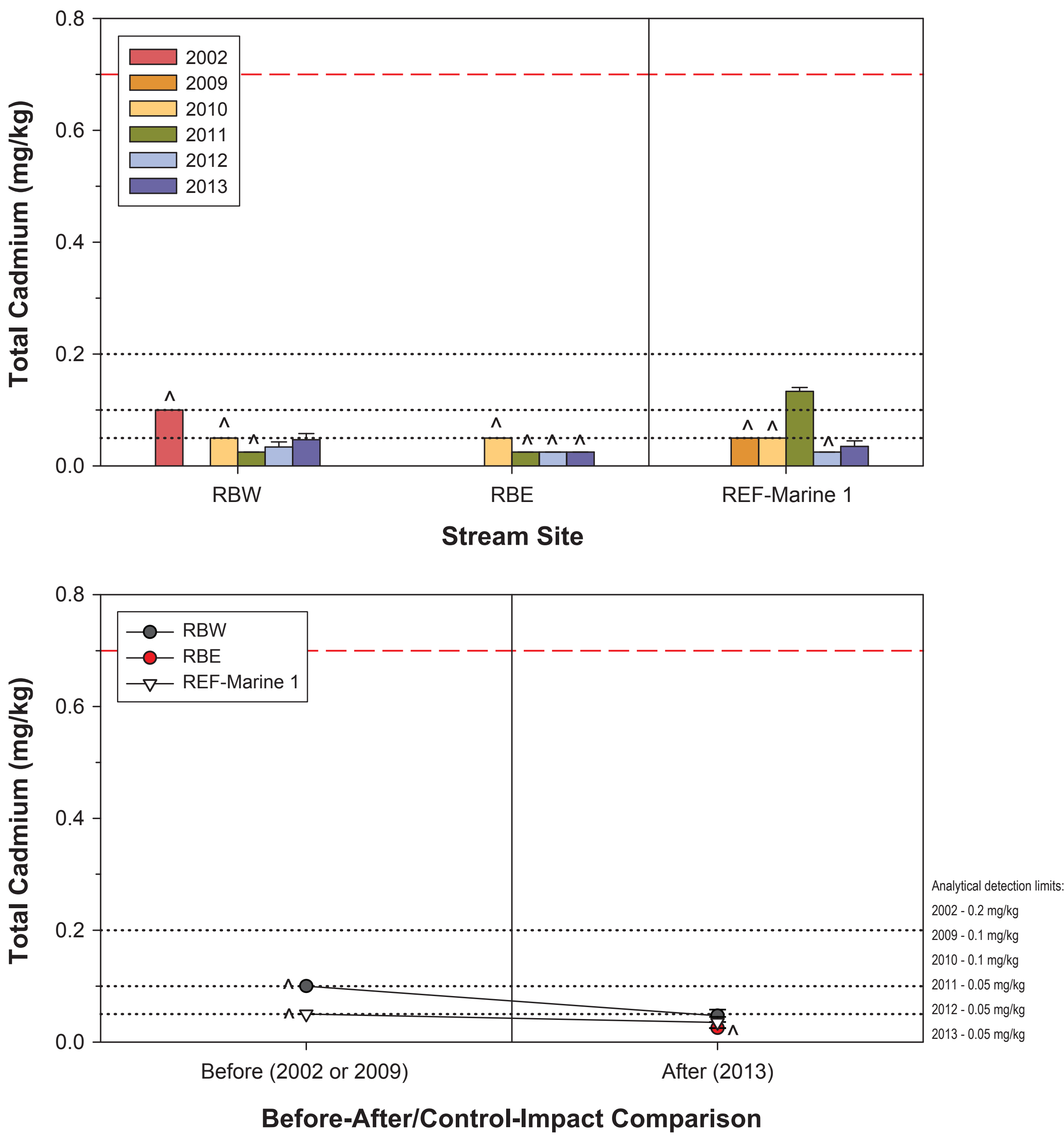
Total Organic Carbon Concentration in AEMP Marine Sediments, Doris North Project, 2002 to 2013



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.

Figure 3.4-21

Total Arsenic Concentration in AEMP Marine Sediments, Doris North Project, 2002 to 2013



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 Concentration in AEMP Marine Sediments, Doris North Project, 2002 to 2013

Figure 3.4-22

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3.4.3.5 Total Chromium

Mean chromium concentrations in RBW sediments increased significantly from 18.2 mg/kg in 2002 to 33.8 mg/kg in 2013 (before-after: $p < 0.0001$; Figure 3.4-23). A significant and larger increase from 9.4 mg/kg in 2009 to 33.1 mg/kg in 2013 (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 likely related to the significant increase in the proportion of fine sediments in the samples, since fine sediments tend to have higher affinities for metals. This suggests that the change in chromium concentrations that occurred in sediments from RBW in 2013 was unrelated to Project activities. At RBE, the mean 2013 chromium concentration in sediments (12.8 mg/kg) was lower than the mean 2013 concentrations in sediments from the other AEMP sites (Figure 3.4-23). All 2013 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 2013 activities on sediment chromium concentrations at the marine exposure sites in Roberts Bay.

3.4.3.6 Total Copper

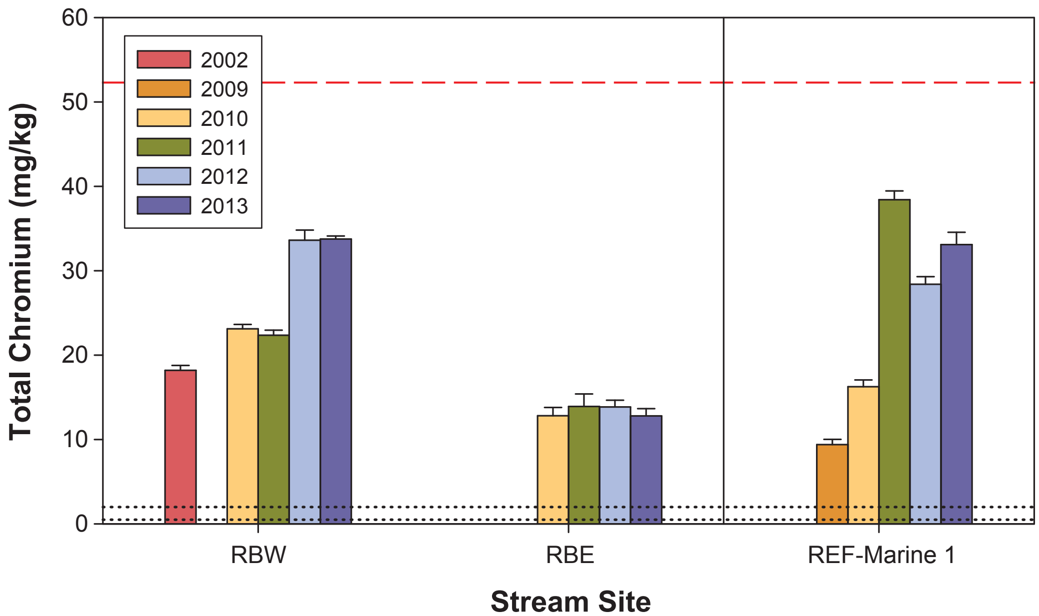
Mean copper concentrations in sediments from RBW increased from 8.4 mg/kg in 2002 to 25.0 mg/kg in 2013, which was above the CCME ISQG of 18.7 mg/kg, but below the PEL of 108 mg/kg. (Figure 3.4-24). This increase was statistically significant ($p < 0.0001$) based on the before-after analysis. However, mean copper concentrations also increased significantly at REF-Marine 1 from 4.9 mg/kg in 2009 to 13.1 in 2013 ($p = 0.0001$). In both cases, the increase in sediment copper concentrations was likely related to the significant increase in the proportion of fine sediments in the samples, since fine sediments tend to have higher affinities for metals. This suggests that the increase in copper concentrations that occurred in sediments from RBW in 2013 was unrelated to Project activities. At RBE, the mean 2013 copper concentration in sediments (9.2 mg/kg) was lower than mean concentrations in sediments from the other AEMP sites, which is consistent with the coarser nature of the sediment at RBE (Figure 3.4-24). There was no indication that 2013 Project activities affected sediment copper concentrations at the marine exposure sites.

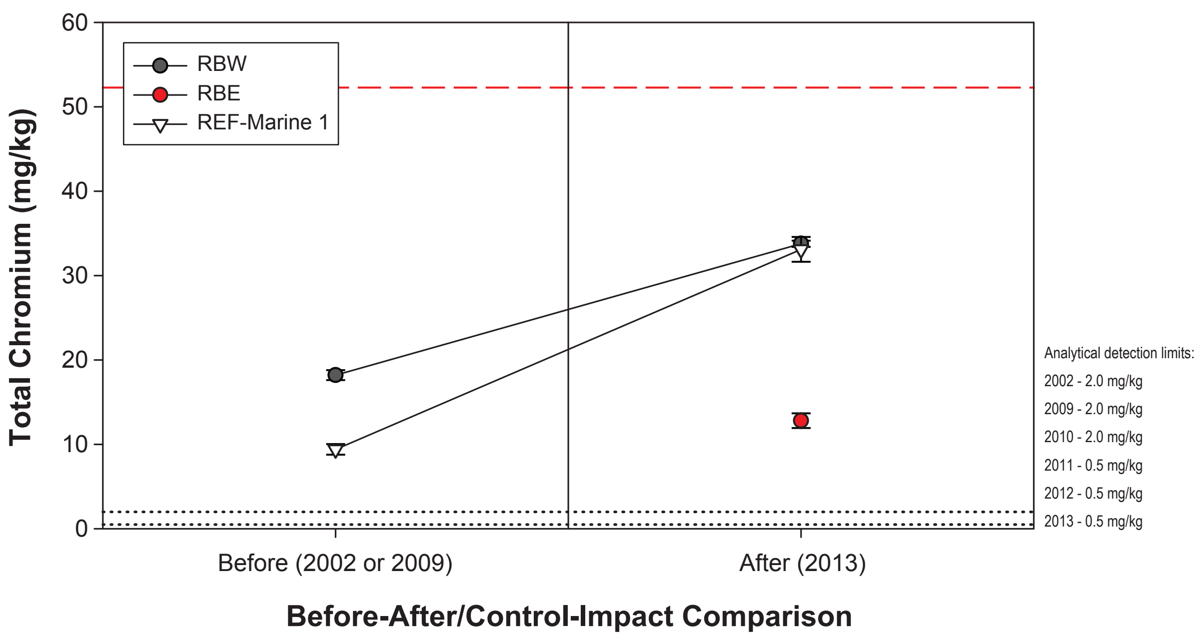
3.4.3.7 Total Lead

All 2013 sediment lead concentrations at the marine sites were well below the CCME ISQG of 30.2 mg/kg and the PEL of 112 mg/kg (Figure 3.4-25). The mean 2013 lead concentration in RBW sediments (4.3 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 the 2013 and 2002 mean lead concentrations ($p = 0.0037$). However, mean lead concentrations also increased significantly at REF-Marine 1 from below the detection limit of 2.0 mg/kg in 2009 to 4.4 mg/kg in 2013 ($p < 0.0001$). In both cases, the increase in sediment lead concentrations was likely related to the significant increase in fine sediments at these sites in 2013, since fine sediments tend to have higher affinities for metals. As observed for all other sediment metal concentrations, sediments from RBE had the lowest mean 2013 concentration of lead (1.3 mg/kg; Figure 3.4-25) compared to the other marine sites. There was no apparent effect of 2013 activities on sediment lead concentrations at the marine exposure sites.

3.4.3.8 Total Mercury

Mean total mercury concentrations in RBW sediments increased from 0.0060 mg/kg in 2002 to 0.0094 mg/kg in 2013 (Figure 3.4-26); however, the before-after analysis found that the 2002 and 2013 means were not significantly different ($p = 0.045$). At site REF-Marine 1, sediment mercury concentrations increased significantly from below the detection limit (< 0.005 mg/kg) in 2009 to 0.016 mg/kg in 2013 ($p = 0.0008$). At site RBE, all 2013 sediment mercury concentrations were below the detection limit of 0.005 mg/kg (Figure 3.4-26). Therefore, there was no indication that 2013 activities had any effect on mercury concentrations in sediments at the marine exposure sites. Total mercury concentrations in all exposure and reference site samples collected in 2013 were well below the CCME ISQG of 0.13 mg/kg and the PEL of 0.7 mg/kg.

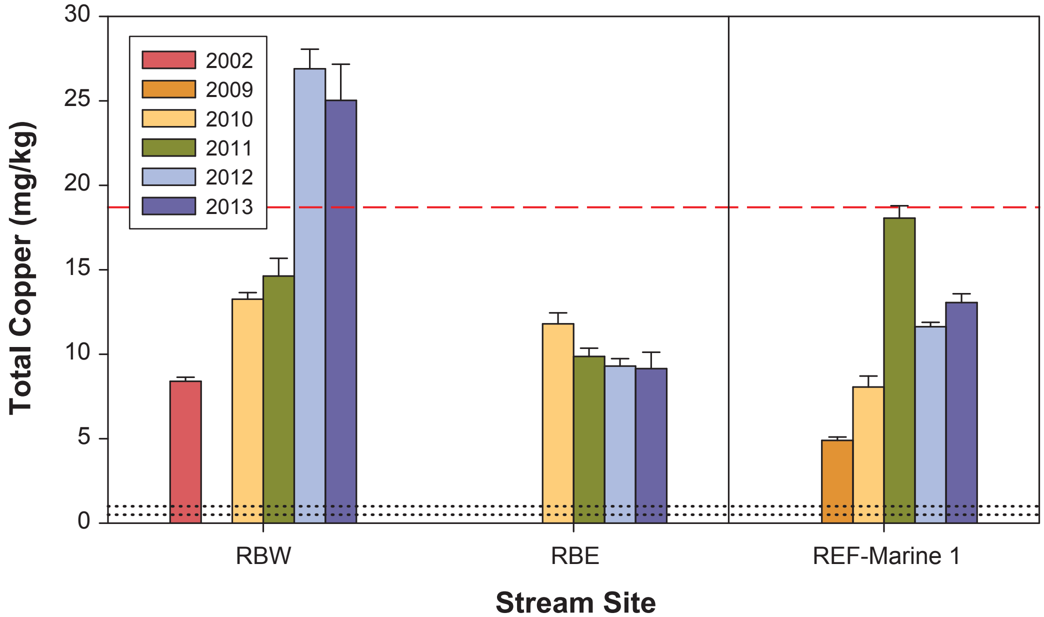


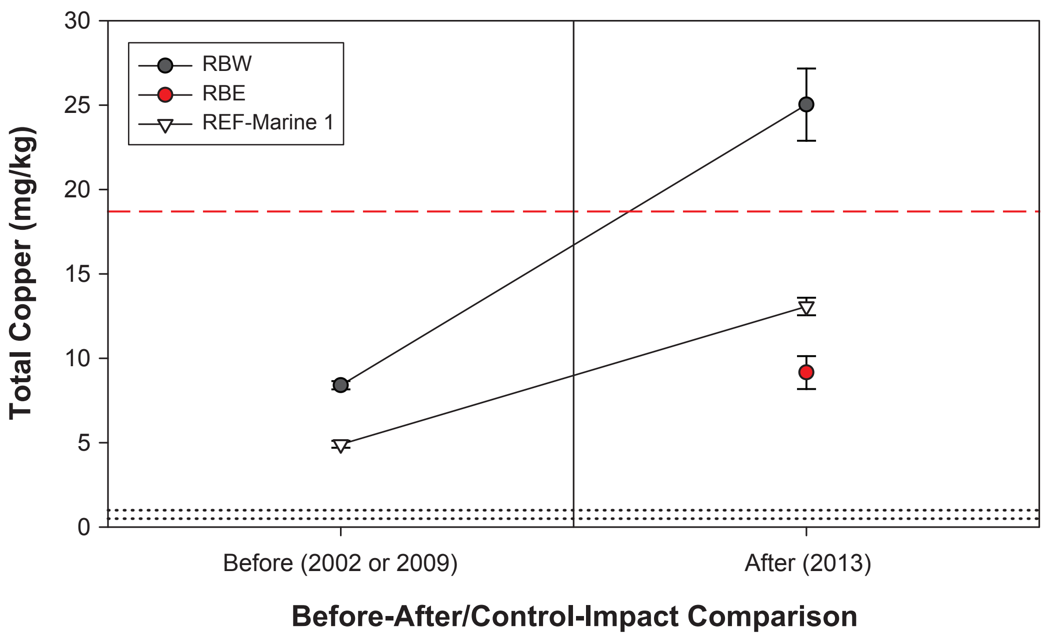


Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
Red dashed lines represent the CCME marine and estuarine interim sediment quality guideline (ISQG)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

Figure 3.4-23

Total Chromium Concentration in AEMP Marine Sediments, Doris North Project, 2002 to 2013



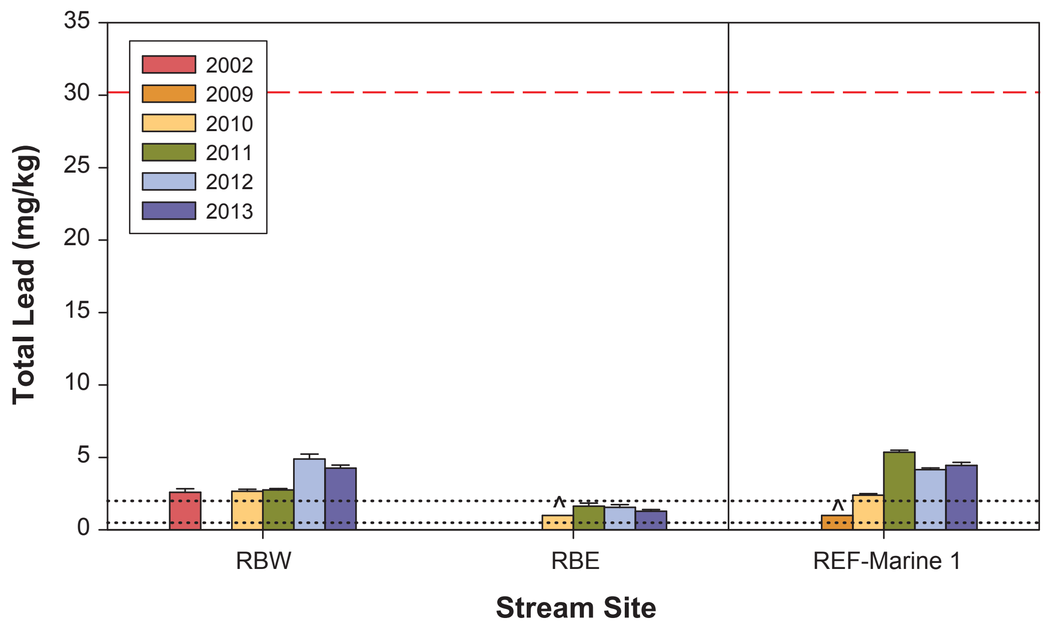


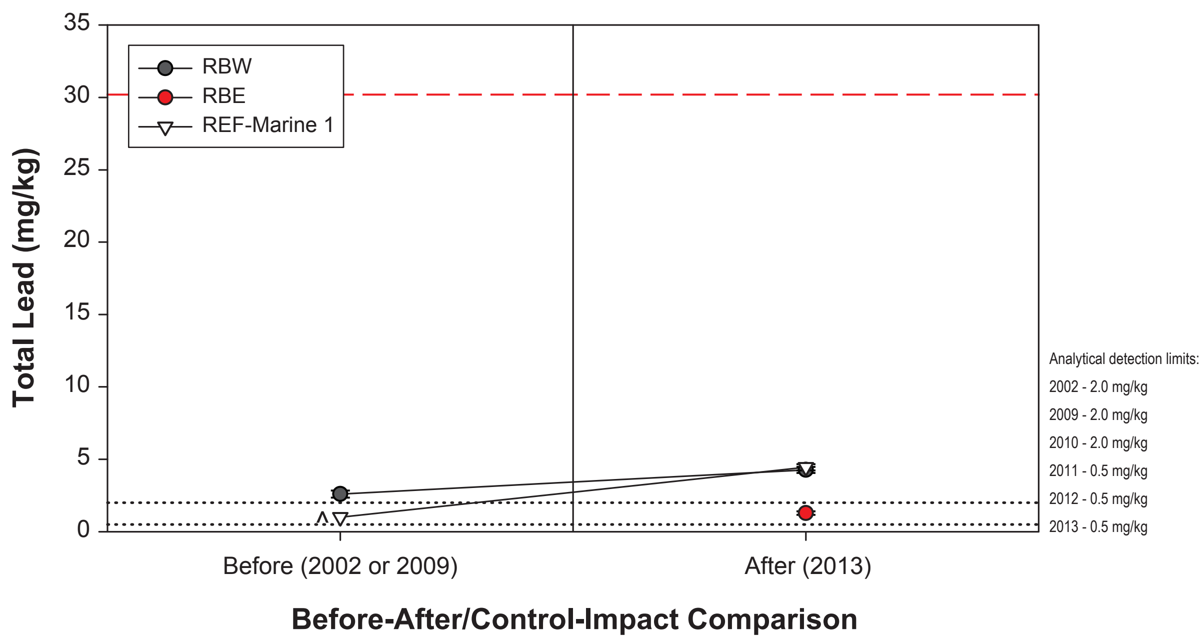
Analytical detection limits:
2002 - 1.0 mg/kg
2009 - 1.0 mg/kg
2010 - 1.0 mg/kg
2011 - 0.5 mg/kg
2012 - 0.5 mg/kg
2013 - 0.5 mg/kg

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.

Figure 3.4-24

Total Copper Concentration in AEMP Marine Sediments, Doris North Project, 2002 to 2013





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.

Figure 3.4-25

Total Lead Concentration in AEMP Marine Sediments, Doris North Project, 2002 to 2013

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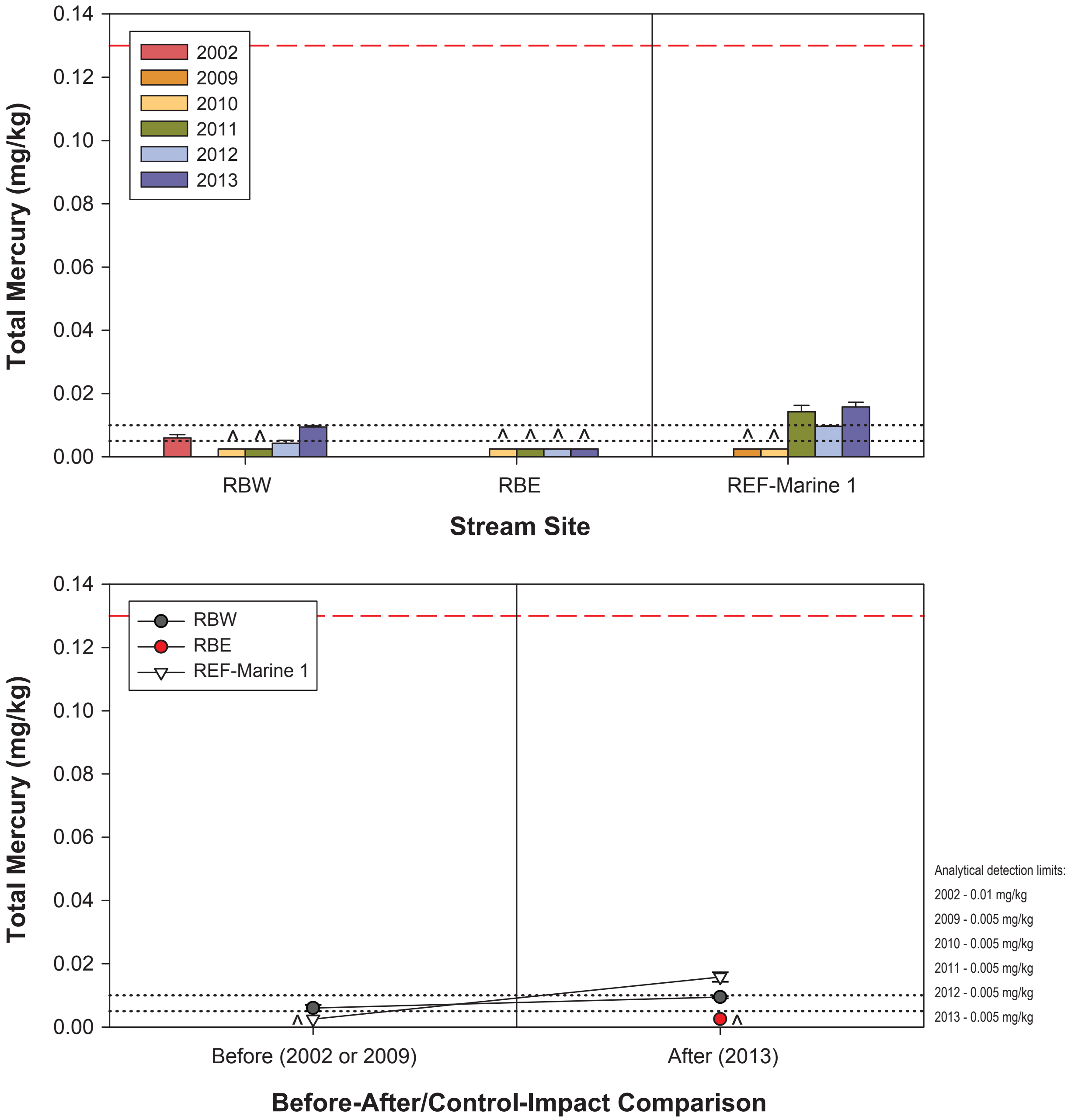

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed lines represent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

Figure 3.4-26

Total Mercury Concentration in AEMP Marine Sediments, Doris North Project, 2002 to 2013

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3.4.3.9 *Total Zinc*

The mean 2013 zinc concentration (38.2 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 = 0.0004). However, mean zinc concentrations also increased significantly at REF-Marine 1 from 15.0 mg/kg in 2009 to 39.2 mg/kg in 2013 (p = 0.0002). In both cases, the increase in sediment zinc concentrations was likely related to the significant increase in the proportion of fine sediments in the samples, since fine sediments tend to have higher affinities for metals. Compared to the other marine sites, sediments from RBE had the lowest mean 2013 concentration of zinc (13.7 mg/kg; Figure 3.4-27), which is consistent with the coarser nature of the sediment at RBE. All 2013 sediment zinc concentrations measured in samples from the marine sites 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 2013 activities on sediment zinc concentrations at the marine exposure sites.

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 effects were the proximity of baseline sampling sites to 2013 AEMP sampling sites and that sampling methodologies were comparable.

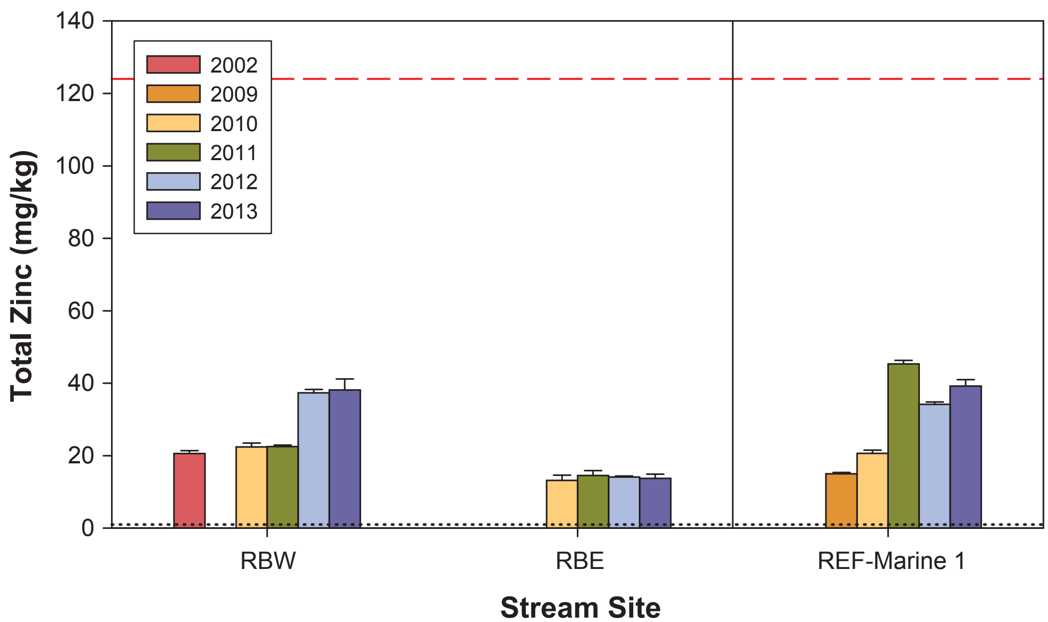
Graphical analyses, before-after comparisons, and BACI analyses (where possible) were all used to determine if there were changes in primary producer biomass in the Doris North Project area. For all graphical and statistical analyses, replicate samples collected on the same date were averaged prior to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

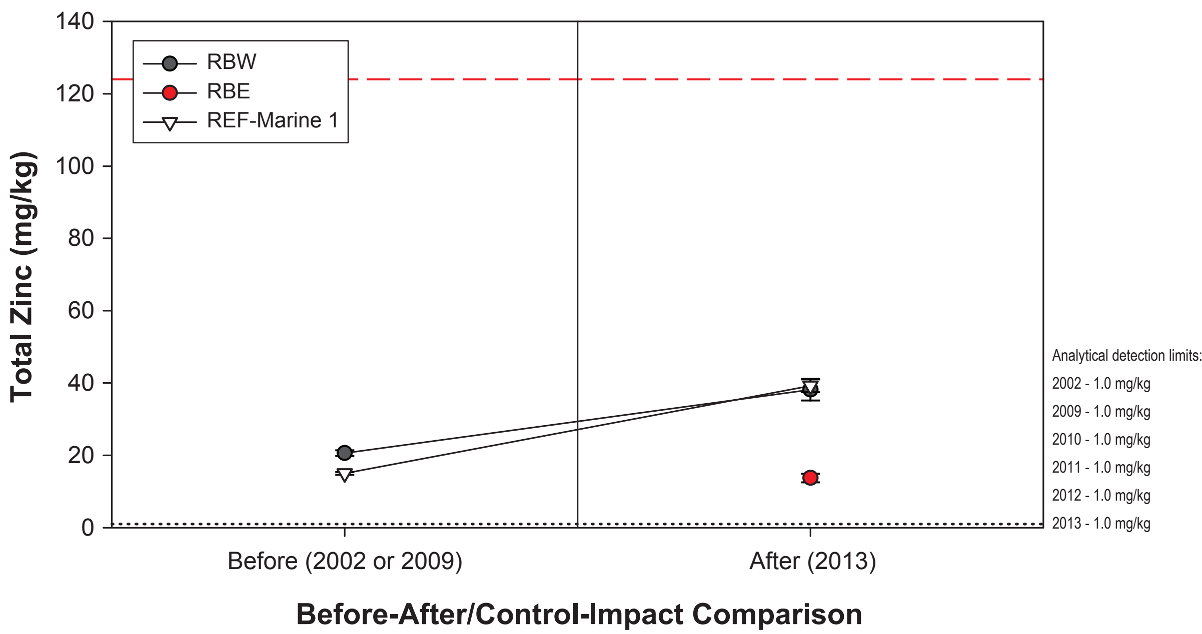
3.5.1 Stream Periphyton Biomass

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 2013 data in terms of sampling locations and methodologies were available from 1997, 2000, and 2009 for Doris Outflow, and from 2009 for Little Roberts and Reference B Outflows (Appendix B). No baseline data were available for Roberts Outflow or Reference D Outflow, so before-after and BACI analyses could not be performed for these streams. Also, there were too few degrees of freedom in the before period for Little Roberts and Reference B outflows, so before-after analyses could not be performed for periphyton data from these streams; however, there were sufficient degrees of freedom to conduct a BACI analysis.

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. Mean 2013 periphyton biomass levels at Doris Outflow were intermediate to 2000 and 2009 mean biomass levels, and the before-after analysis confirmed that there was no significant difference between the baseline mean biomass and the 2013 mean biomass at this site (p = 0.25).

At Little Roberts Outflow, 2013 biomass levels were higher than 2009 levels (Figure 3.5-1). Although a before-after analysis could not be performed, the BACI analysis found that the before-after trend at Little Roberts Outflow paralleled the before-after trend for the reference streams (p = 0.081); therefore, the difference in biomass levels at Little Roberts Outflow between 2009 and 2013 was unrelated to Project activities.

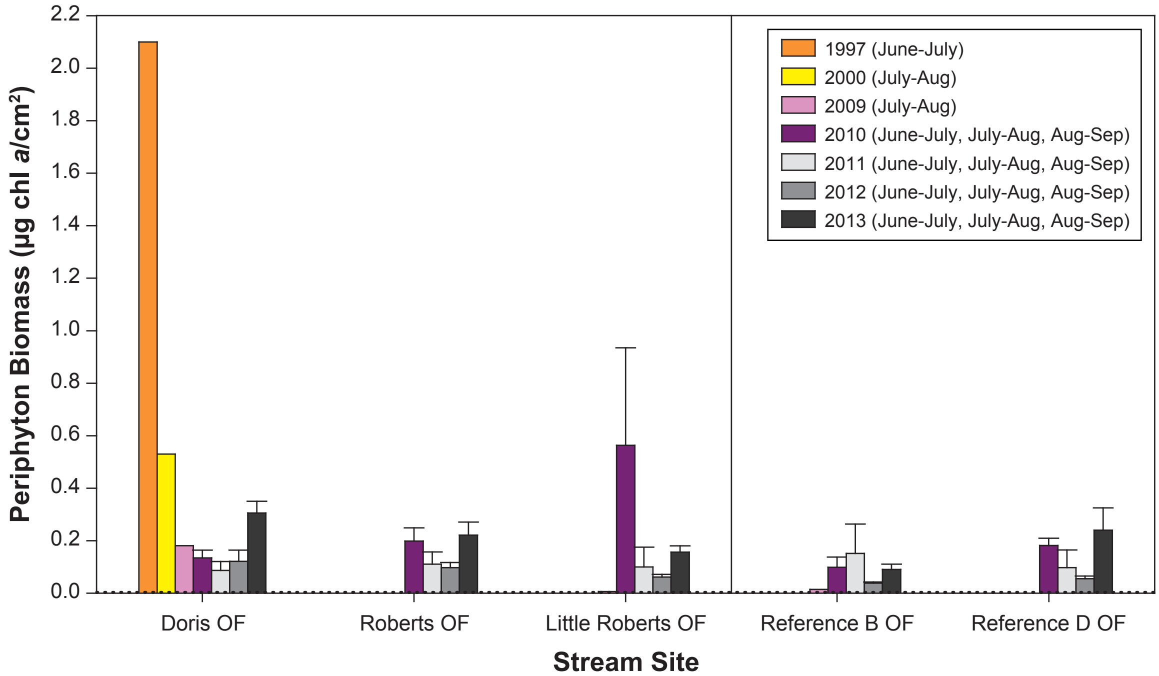


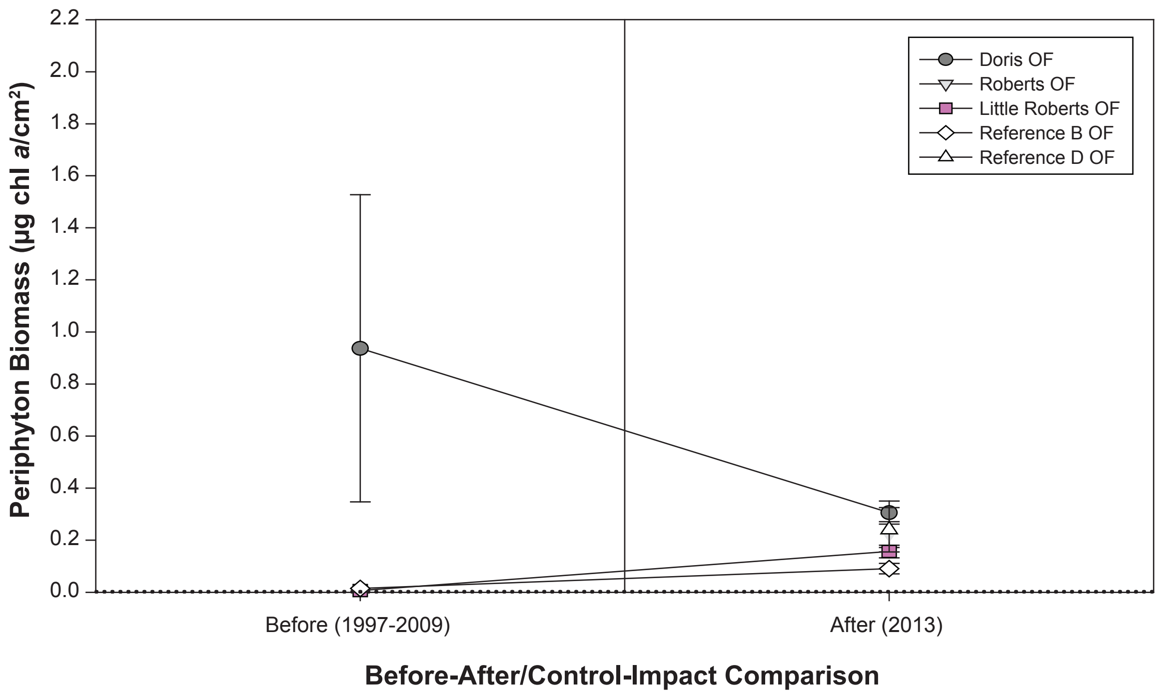


Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
Red dashed lines represent the CCME marine and estuarine interim sediment quality guideline (ISQG) for zinc (124 mg/kg); the probable effects level (PEL) for zinc (271 mg/kg) is not shown.

Figure 3.4-27

Total Zinc Concentration in AEMP Marine Sediments, Doris North Project, 2002 to 2013





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
2013 - 0.0001 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 µg chl a/cm² reported for Doris Outflow in July-August 1997 was considered an outlier and was excluded from plots and statistical analyses.

Figure 3.5-1

Periphyton Biomass (as Chlorophyll *a*) in AEMP Stream Sites, Doris North Project, 1997 to 2013

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Periphyton biomass levels at Roberts Outflow in 2013 were within the range of biomass levels measured 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 three exposure lake sites (Doris Lake South, Doris Lake North, and Little Roberts Lake) and two reference lake sites (Reference Lake B and Reference Lake D) in 2013. Baseline data for lake phytoplankton biomass that were comparable to 2013 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 Reference Lake D, so a BACI analysis could not be performed for Little Roberts Lake.

At all of the exposure lake sites, mean 2013 phytoplankton biomass levels were within the range of baseline means (Figure 3.5-2). The before-after analysis confirmed that the mean 2013 biomass level was not significantly different from the mean baseline level at any exposure lake site ($p = 0.48$ for Doris Lake South, $p = 0.78$ for Doris Lake North, and $p = 0.99$ for Little Roberts Lake). Accordingly, there was no apparent effect of 2013 activities on phytoplankton biomass in the AEMP exposure lakes.

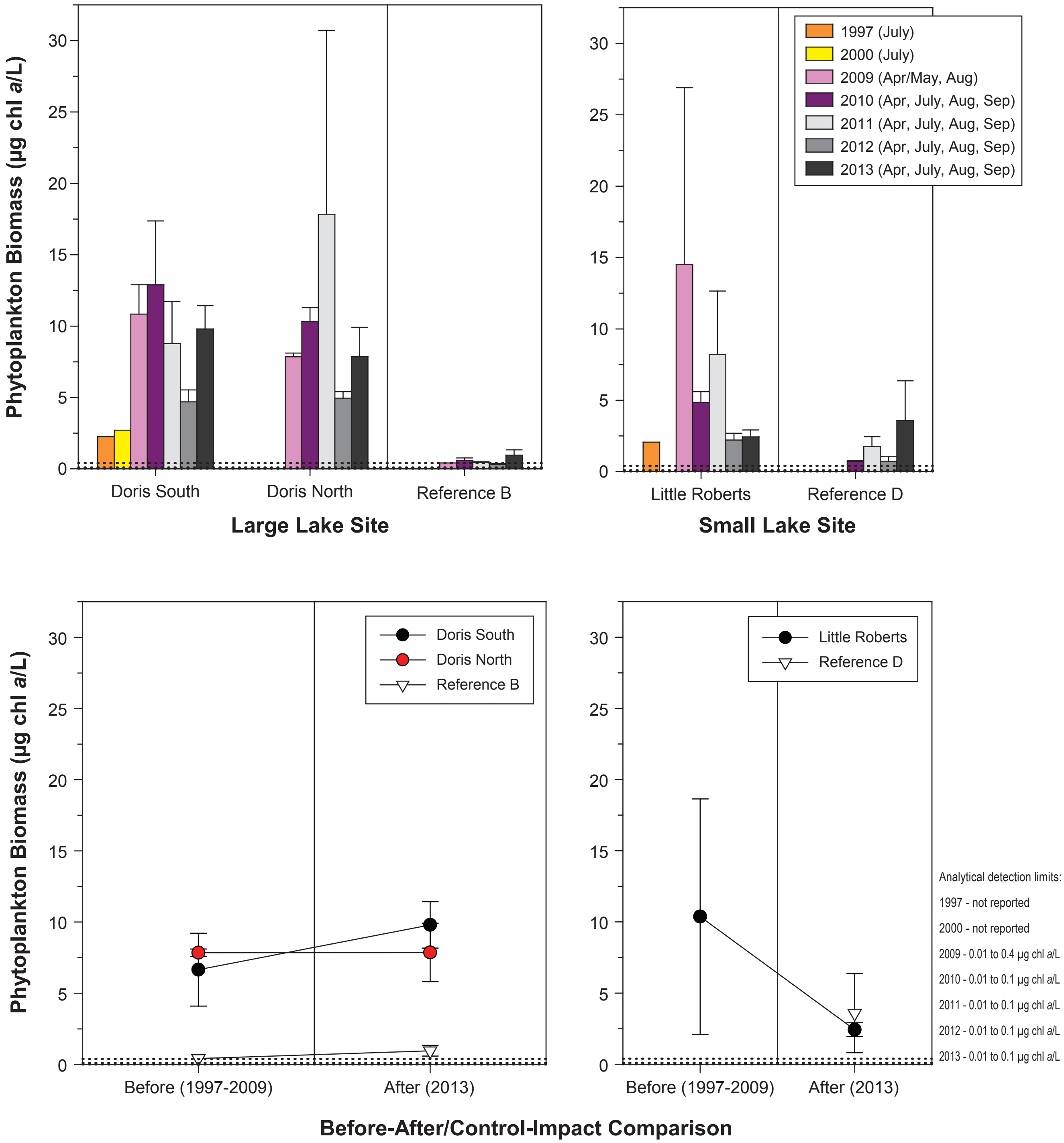
3.5.3 Marine Phytoplankton Biomass

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 2013. Historical phytoplankton biomass data have been collected in Roberts Bay since 2006. However, only baseline data from 2009 were considered comparable to 2013 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.

Marine phytoplankton biomass levels were lower at all sites in 2009 than in 2013 (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 slightly above the detection limit at REF-Marine 1 (0.045 µg chl *a*/L). In 2013, mean biomass levels at the marine sites were: 0.34 µg chl *a*/L at RBW, 0.60 µg chl *a*/L at RBE, and 0.17 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 2013 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 2013 (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 2013 trends observed at the exposure sites were parallel to the 2009 to 2013 trend observed at the reference site ($p = 0.27$ for RBW and $p = 0.78$ for RBE). Therefore, the increase in phytoplankton biomass at RBW and RBE cannot be attributed to 2013 Project activities.

3.6 BENTHOS

As required in Schedule 5 of the MMER, benthic invertebrate community surveys were conducted in 2013 at AEMP stream, lake, and marine sites, and the data gathered were 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.

Figure 3.5-2

Phytoplankton Biomass (as Chlorophyll *a*) in AEMP Lake Sites, Doris North Project, 1997 to 2013

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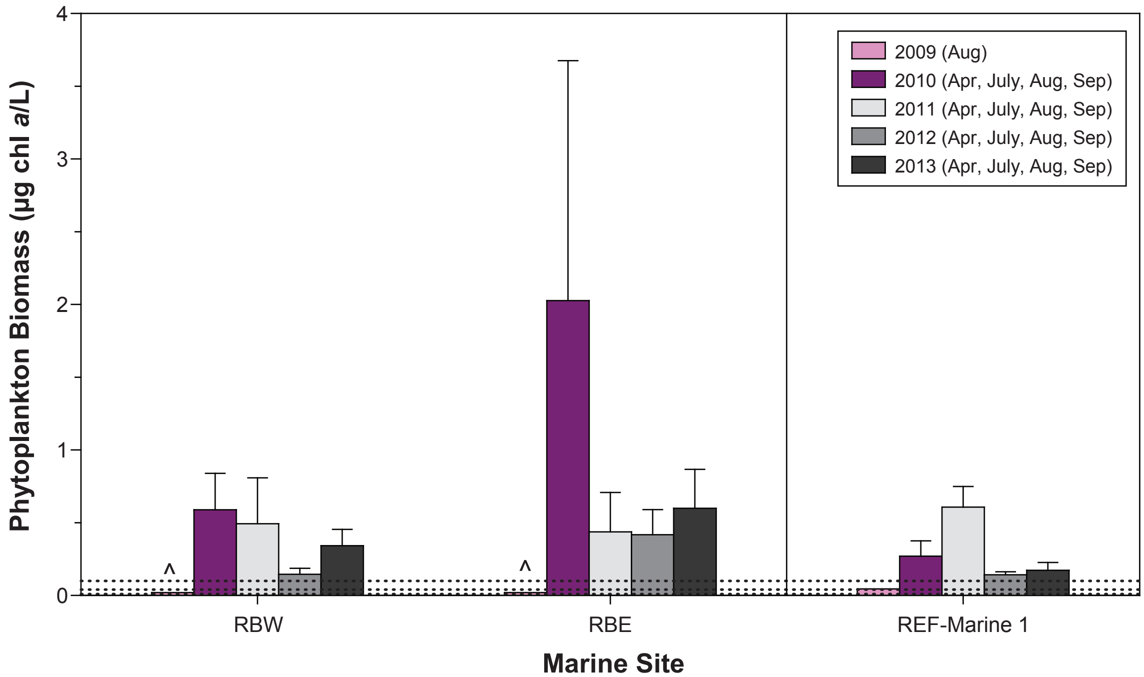

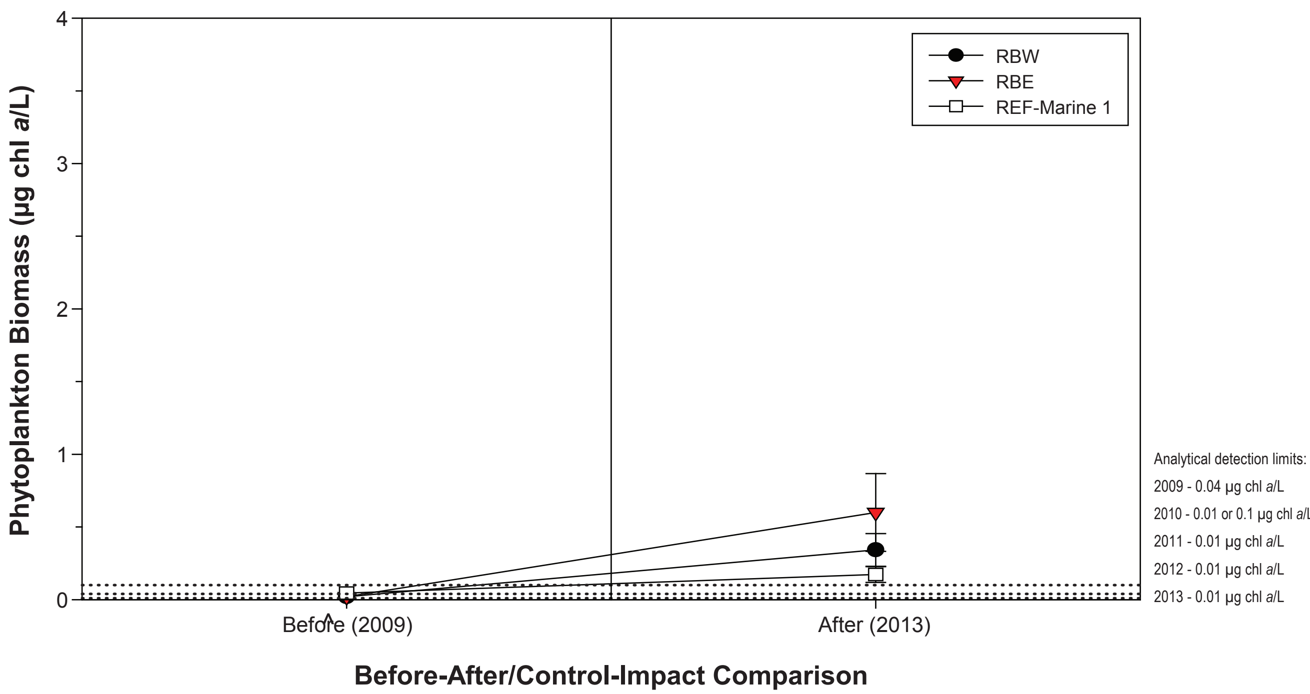

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.

Figure 3.5-3

Phytoplankton Biomass (as Chlorophyll *a*) in AEMP Marine Sites, Doris North Project, 2009 to 2013

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The evaluation of effects for benthos required a different approach than that used for the other evaluated variables because of the lack of comparable baseline data for benthos. The method used to collect benthos samples from 2010 to 2013 involved the pooling of three subsamples for each of five replicate samples; therefore, data collected since 2010 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 2013 were compared to the 2010 to 2013 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

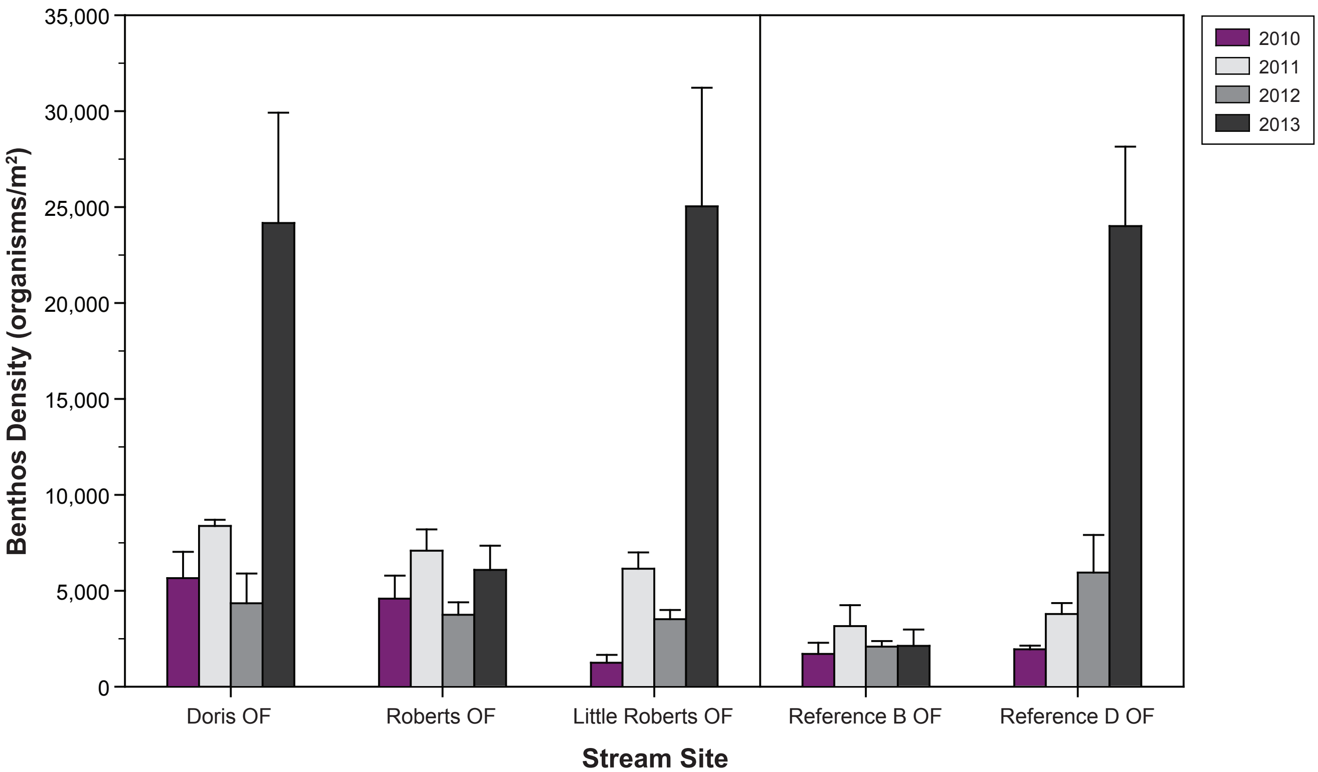
At both Roberts Outflow and Reference B Outflow, benthic invertebrate density in 2013 was within the range of densities recorded from 2010 to 2012 (Figure 3.6-1). At Doris Outflow, Little Roberts Outflow, and Reference D Outflow, 2013 benthos density was markedly higher than previous years (Figure 3.6-1). However, there was no evidence of non-parallelism between the exposure and reference streams ($p = 0.18$ for Doris Outflow, $p = 0.045$ for Roberts Outflow, and $p = 0.044$ for Little Roberts Outflow), indicating that the annual variability in density was a natural phenomenon and was not related to Project activities.

3.6.1.2 Community Richness, Evenness, and Diversity

2013 benthos family richness was similar to previous years in all exposure and reference streams (Figure 3.6-2), and there was no evidence of non-parallelism in trends between the exposure streams and the reference streams ($p = 0.33$ for Doris Outflow, $p = 0.41$ for Roberts Outflow, and $p = 0.34$ for Little Roberts Outflow).

For all exposure and reference streams, the mean 2013 Simpson's Evenness Index calculated for the benthos community was similar to the evenness calculated in previous years (Figure 3.6-2). At Doris Outflow, although the 2013 Simpson's Evenness Index of 0.38 was similar to the 2010 evenness of 0.40, evenness levels were higher in 2011 and 2012, and there was evidence of non-parallelism over time between this stream and the reference streams ($p = 0.0007$). Similar to previous years, 2013 evenness was consistently higher at Doris OF compared to the other streams; therefore, there was no evidence of an adverse effect of 2013 Project activities on evenness at this site. At the other exposure streams, there was no evidence of non-parallelism in evenness trends relative to the reference streams ($p = 0.35$ for Roberts Outflow and $p = 0.27$ for Little Roberts Outflow).

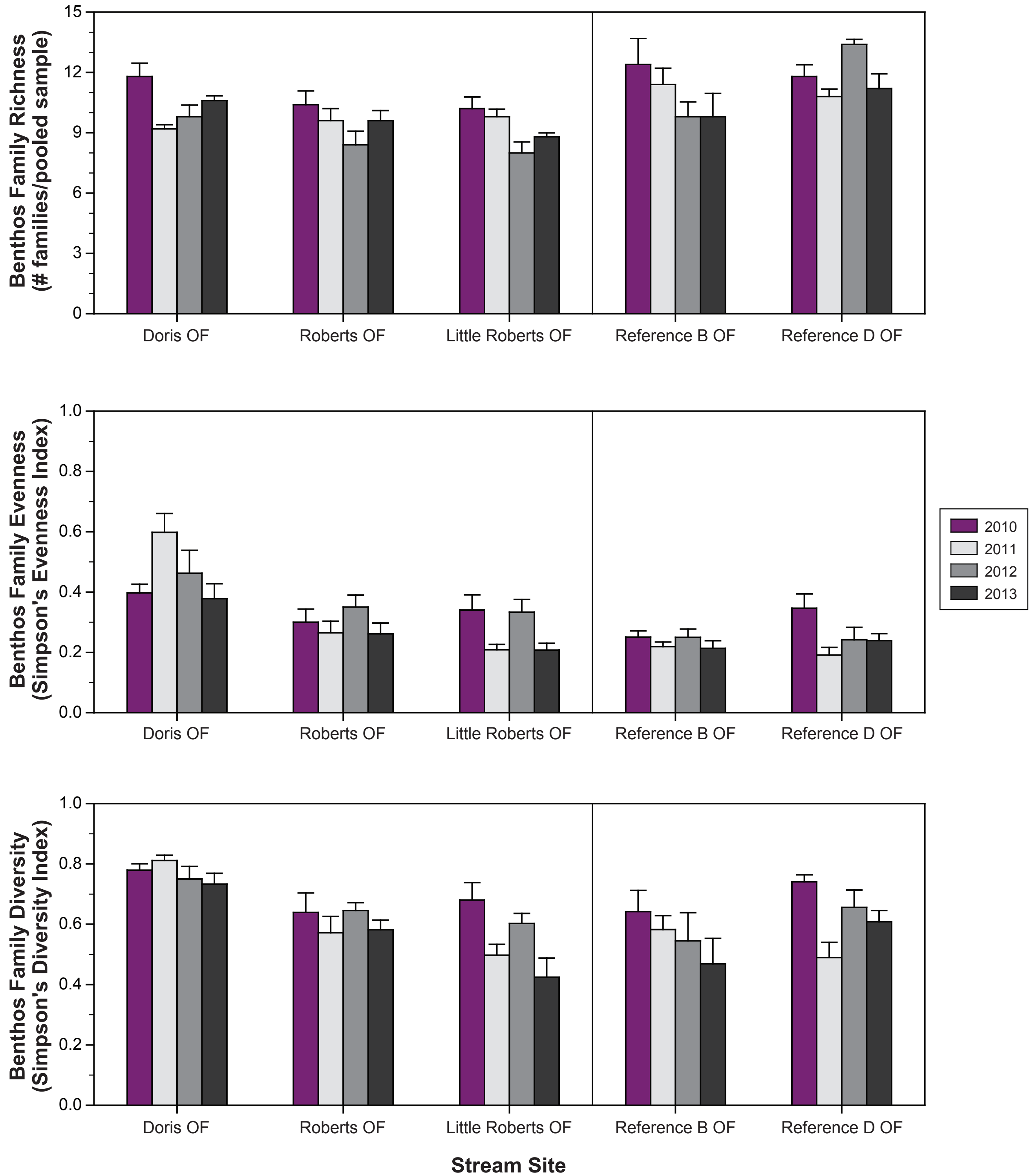
Trends in the Simpson's Diversity Index between 2010 and 2013 were similar between exposure and reference streams (Figure 3.6-2; $p = 0.26$ for Doris Outflow, $p = 0.73$ for Roberts Outflow, and $p = 0.67$ for Little Roberts Outflow), suggesting that there were no Project effects on benthic community diversity in the exposure lakes.



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

Figure 3.6-1

Benthos Density in AEMP Stream Sites, Doris North Project, 2010 to 2013



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

Figure 3.6-2

Benthos Richness, Evenness, and Diversity in AEMP Stream Sites, Doris North Project, 2010 to 2013

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 among sites in 2013 (Figure 3.6-3). The exception to this was Roberts Outflow, where the 2013 Bray-Curtis Index was relatively low, suggesting that the community composition at this site was the most similar to the median reference community composition. Because of the decreasing trend in the Bray-Curtis Index over time at Roberts Outflow compared to the increasing trend at the reference streams (Figure 3.6-3), Roberts Outflow was the only stream for which there was evidence of non-parallelism over time relative to the reference streams ($p < 0.0001$ for Roberts Outflow, $p = 0.047$ for Doris Outflow, and $p = 0.44$ for Little Roberts Outflow). Increasing similarity between the benthos community composition at Roberts Outflow and the median reference benthos community composition does not suggest that Project activities are adversely affecting benthic invertebrates in Roberts Outflow (though increasing dissimilarity might be of concern). This is likely the result of natural annual variability or patchiness in the benthic assemblage.

3.6.2 Lake Benthos

At Doris Lake South, 2010 data were collected from a shallow site, whereas 2011 to 2013 data were collected from a deep site in the southern section of Doris Lake. Therefore, 2010 data were excluded from the analyses.

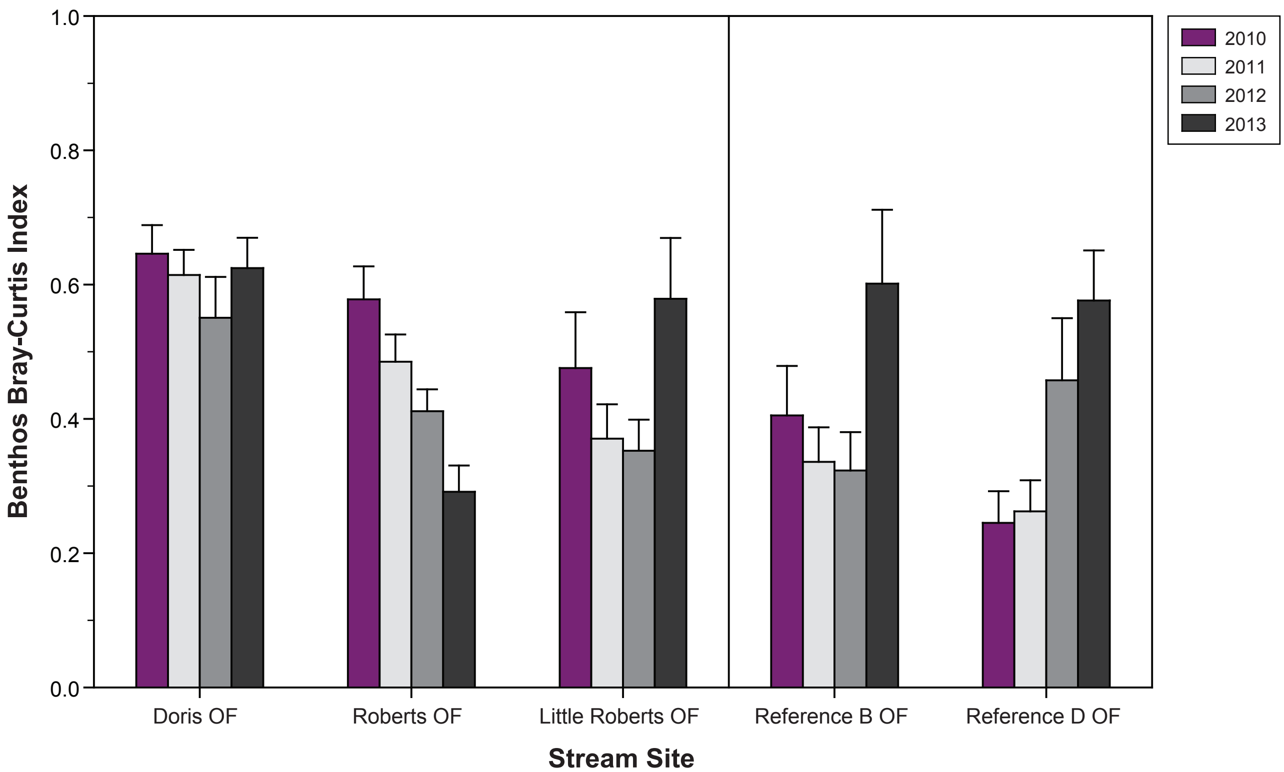
3.6.2.1 Density

Benthic invertebrate density was consistently 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, and Reference Lake B) between 2010 and 2013 (Figure 3.6-4). Although there was some inter-annual variability in benthos density, there was no evidence of non-parallelism in density trends over time between the exposure and reference lakes ($p = 0.020$ for Doris Lake South, $p = 0.11$ for Doris Lake North, and $p = 0.52$ for Little Roberts Lake), suggesting that there were no Project-related effects on benthos density in AEMP exposure lakes.

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, and Reference Lake B; Figure 3.6-5). However, family richness was generally similar over time at each site, and there was no evidence of non-parallelism in trends between the exposure lakes and reference lakes ($p = 0.10$ for Doris Lake South, $p = 0.050$ for Doris Lake North, and $p = 0.043$ for Little Roberts Lake).

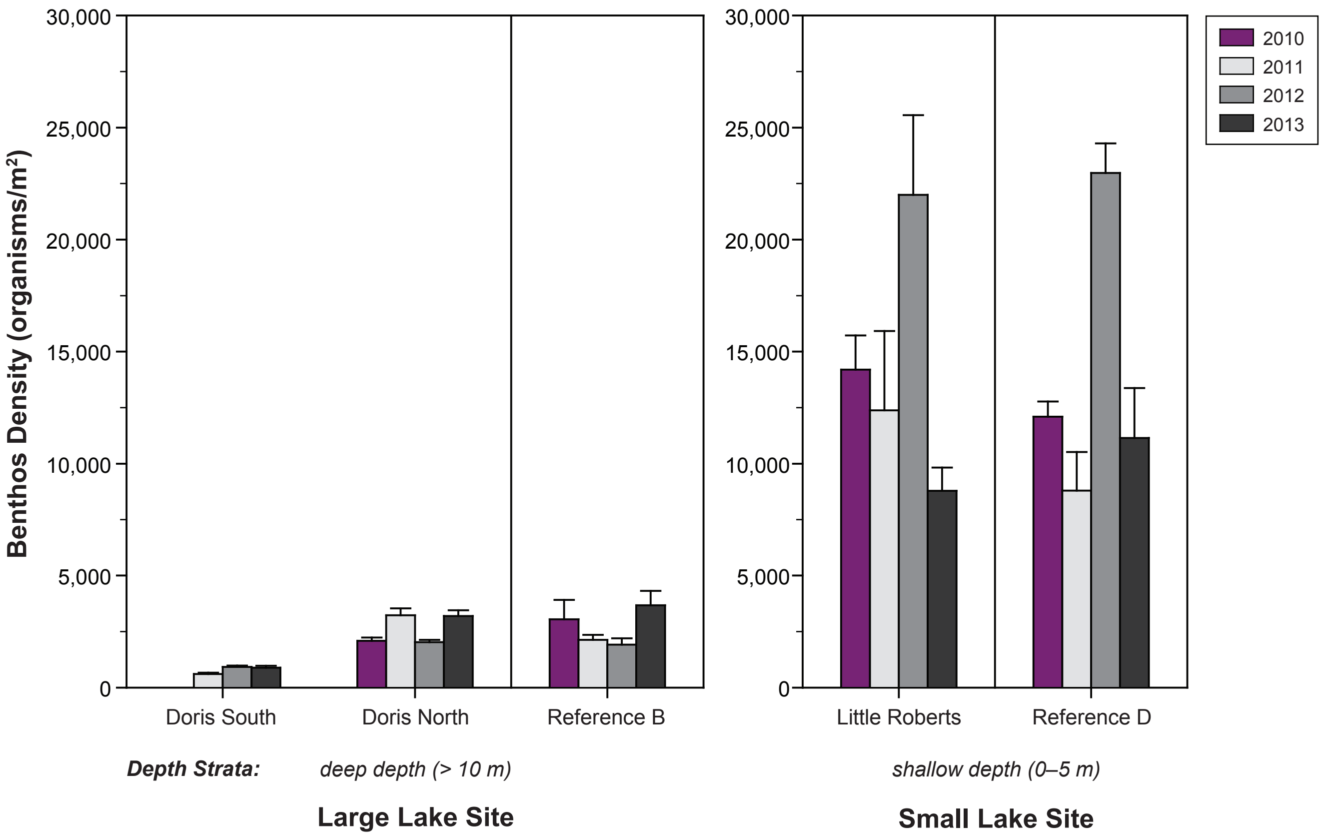
Simpson's Evenness and Diversity indices were generally similar over time within each lake site (Figure 3.6-5). There was no evidence of non-parallelism in trends between exposure and reference lakes for either evenness ($p = 0.067$ for Doris Lake South, $p = 0.77$ for Doris Lake North, and $p = 0.066$ for Little Roberts Lake) or diversity ($p = 0.10$ for Doris Lake South, $p = 0.013$ for Doris Lake North, and $p = 0.30$ for Little Roberts Lake); therefore, there was no apparent effect of 2013 activities on benthos evenness and diversity in the exposure lakes.



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

Figure 3.6-3

Benthos Bray-Curtis Index for AEMP Stream Sites, Doris North Project, 2010 to 2013



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

Figure 3.6-4

Benthos Density in AEMP Lake Sites, Doris North Project, 2010 to 2013

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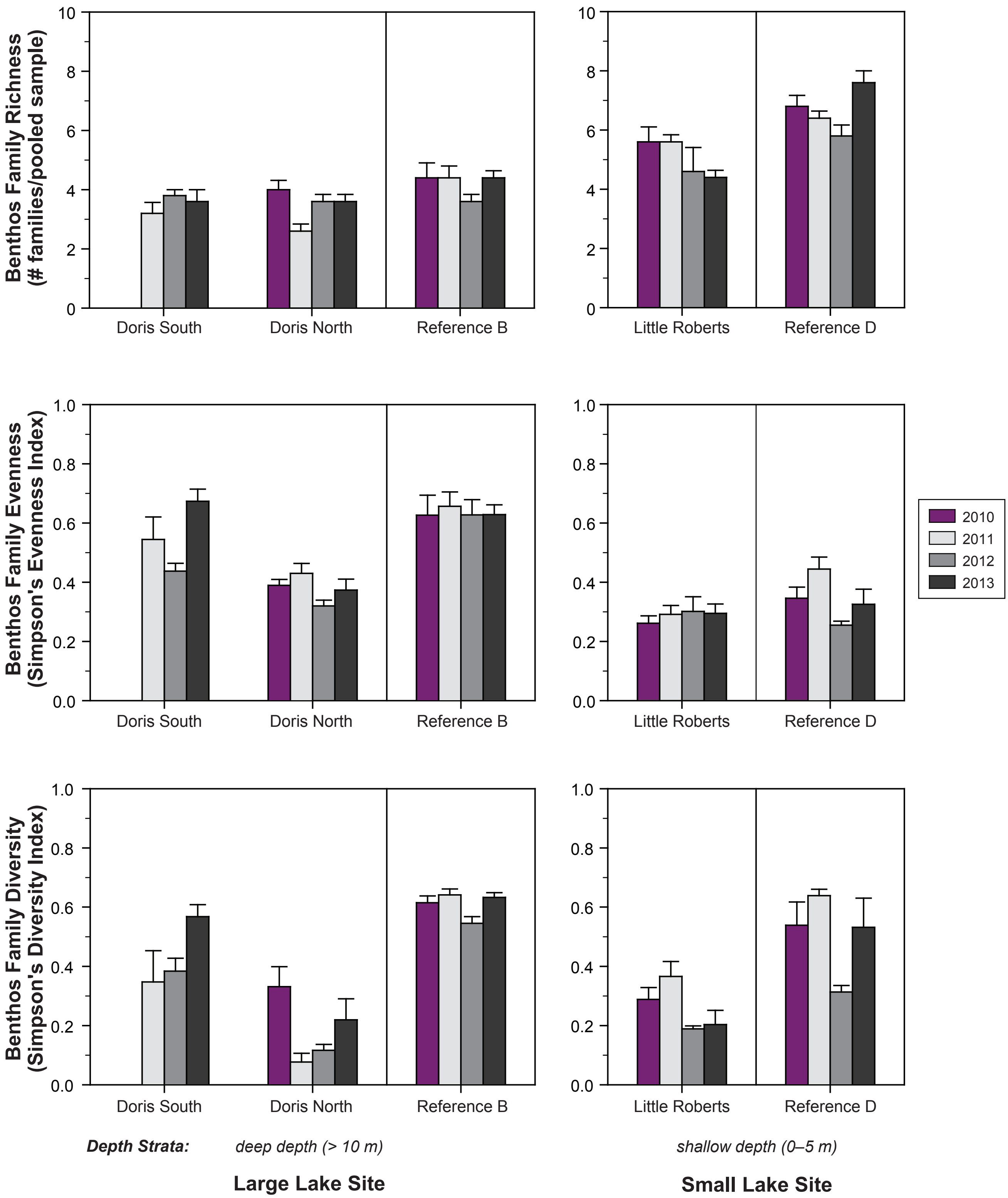

Notes: Error bars represent the standard error of the mean of replicates.

Figure 3.6-5

Benthos Richness, Evenness, and Diversity in AEMP Lake Sites, Doris North Project, 2010 to 2013

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3.6.2.3 Bray-Curtis Index

The Bray-Curtis Index was highly inter-annually variable at the large lake exposure sites Doris Lake South and Doris Lake North (Figure 3.6-6). At Doris Lake South, the mean 2013 Bray-Curtis Index of 0.69 was similar to the mean for 2011 (0.70), but more than three-fold higher than the 2012 mean (0.20; Figure 3.6-6). At Doris Lake North, the mean 2013 Bray-Curtis Index of 0.62 was lower than the mean for 2011 (0.84), but nearly two-fold higher than the means for 2010 and 2012 (Figure 3.6-6). There was evidence of non-parallelism in the Bray-Curtis Index over time at both Doris Lake South and Doris Lake North (both $p < 0.0001$) relative to the trend at Reference Lake B. However, given the high variability over time, the Bray-Curtis trends at these sites are not clear, and there was no obvious indication that Project activities adversely affected the Bray-Curtis Index at these sites in 2013.

For Little Roberts Lake, the mean 2013 Bray-Curtis Index of 0.40 was within range of previous years (Figure 3.6-6), and the Bray-Curtis trend over time was parallel to the trend at Reference Lake D ($p = 0.66$). Therefore, there were no Project-related effects on the Bray-Curtis Index in this lake.

3.6.3 Marine Benthos

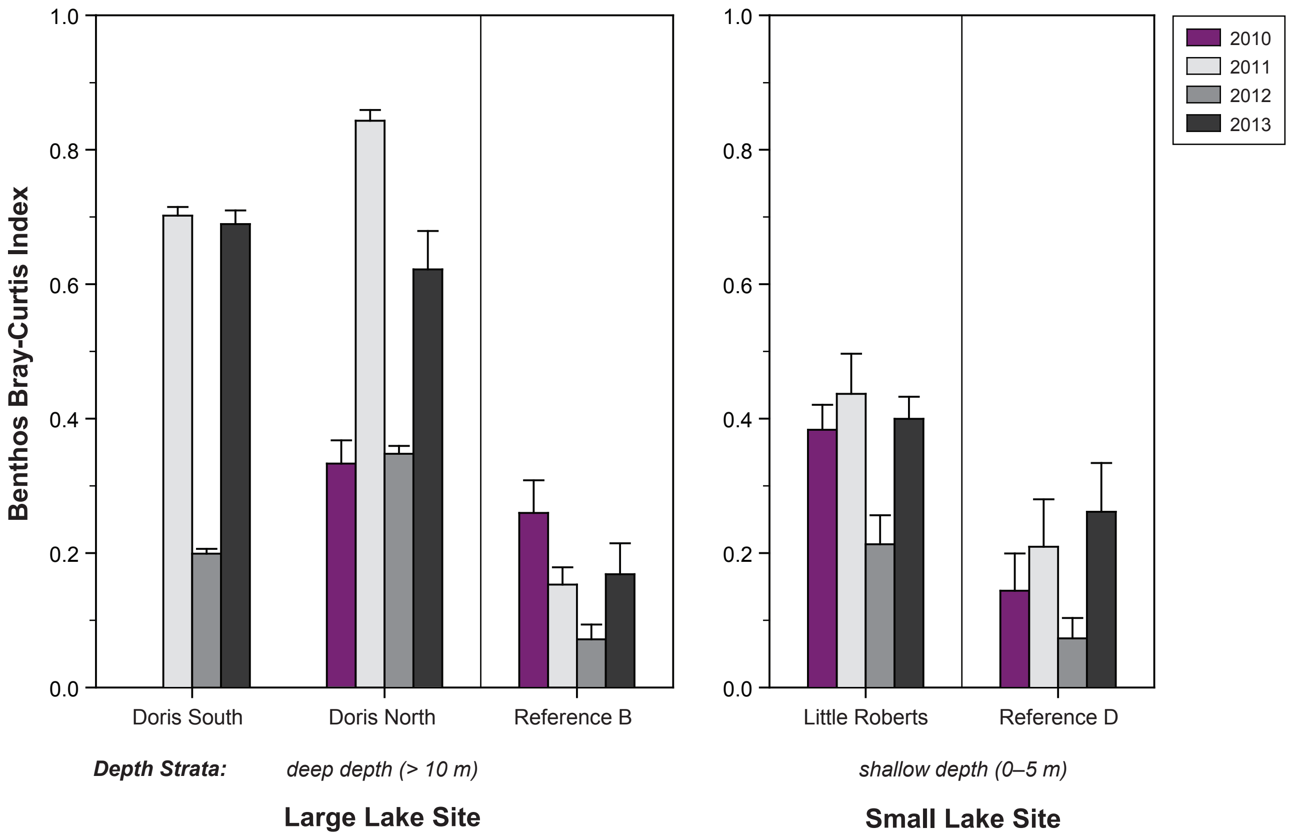
As recommended in the EEM guidance document (Environment Canada 2011), the marine benthos community was analyzed for the whole community (adults and juveniles) as well as for the adult community in isolation because juvenile benthos can respond differently to environmental disturbances than adult benthos.

3.6.3.1 Density

Between 2011 and 2013, whole community as well as adult benthos densities were similar between marine sites RBW and REF-Marine 1, but comparatively low at site RBE (Figure 3.6-7). In both the whole community and the adult subset, there was evidence of non-parallelism in the 2010 to 2013 benthos density trends between RBW and REF-Marine 1 (both $p < 0.0001$). Whole community 2010 to 2013 density trends between RBE and REF-Marine 1 were parallel ($p = 0.24$); however, adult densities showed evidence of non-parallelism over time at RBE compared to REF-Marine 1 ($p < 0.0001$). These non-parallel results were largely driven by the relatively high densities observed in 2010 compared to later years at the exposure sites and the correspondingly low 2010 density at the reference site compared to later years.

As only four years of data are available for the analysis of trends, it is difficult to separate potential Project-related effects from natural annual variability in the benthos density at marine exposure sites. At site RBE, whole community and adult densities in 2013 were within range of previous years, and there were no apparent Project-related changes to water quality, sediment quality, or primary producer biomass that could have affected benthos density; therefore, it is unlikely that non-parallelism in density compared to the reference site was related to Project activities. There were also no significant disturbances to the seabed during this period.

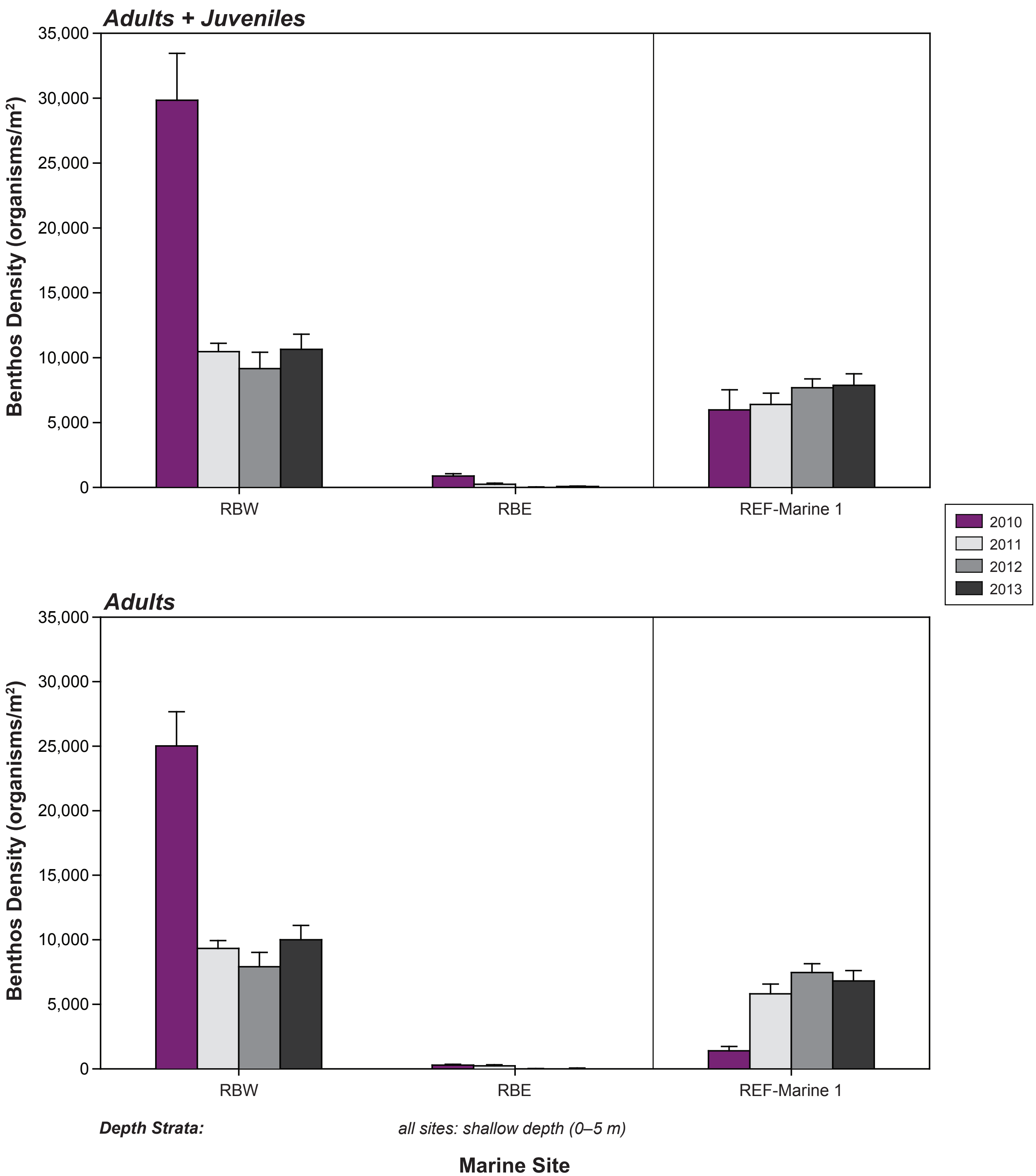
At site RBW, there were no apparent Project-related changes to the water quality or primary producer biomass, but there was some jetty erosion that could have affected benthos density. The relatively consistent benthos density observed at RBW between 2011, 2012, and 2013 suggests that the jetty erosion that occurred in 2013 did not adversely affect benthos density at this site.



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

Figure 3.6-6

Benthos Bray-Curtis Index for AEMP Lake Sites, Doris North Project, 2010 to 2013



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

Figure 3.6-7

Benthos Density in AEMP Marine Sites, Doris North Project, 2010 to 2013

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 2013 at the exposure site RBW and the reference site REF-Marine 1 (Figures 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 the 2010 to 2013 benthos family richness between REF-Marine 1 and RBW (whole community: $p = 0.0022$, adults: $p = 0.0007$). However, given that increases occurred at both sites, there was no apparent adverse effect of Project activities on family richness at RBW.

Aside from a slight increase in family richness in 2011, both whole community and adult family richness were similarly low in 2010, 2012, and 2013 at site RBE (Figures 3.6-8a and 3.6-8b). Since richness increased at the reference site between 2010 and 2013, there was evidence of non-parallelism in family richness between RBE and the reference site ($p < 0.00001$ for both the whole community and adult only dataset). However, since 2013 richness was within range of previous years at RBE, there was no apparent adverse effect of 2013 Project activities on family richness at this site.

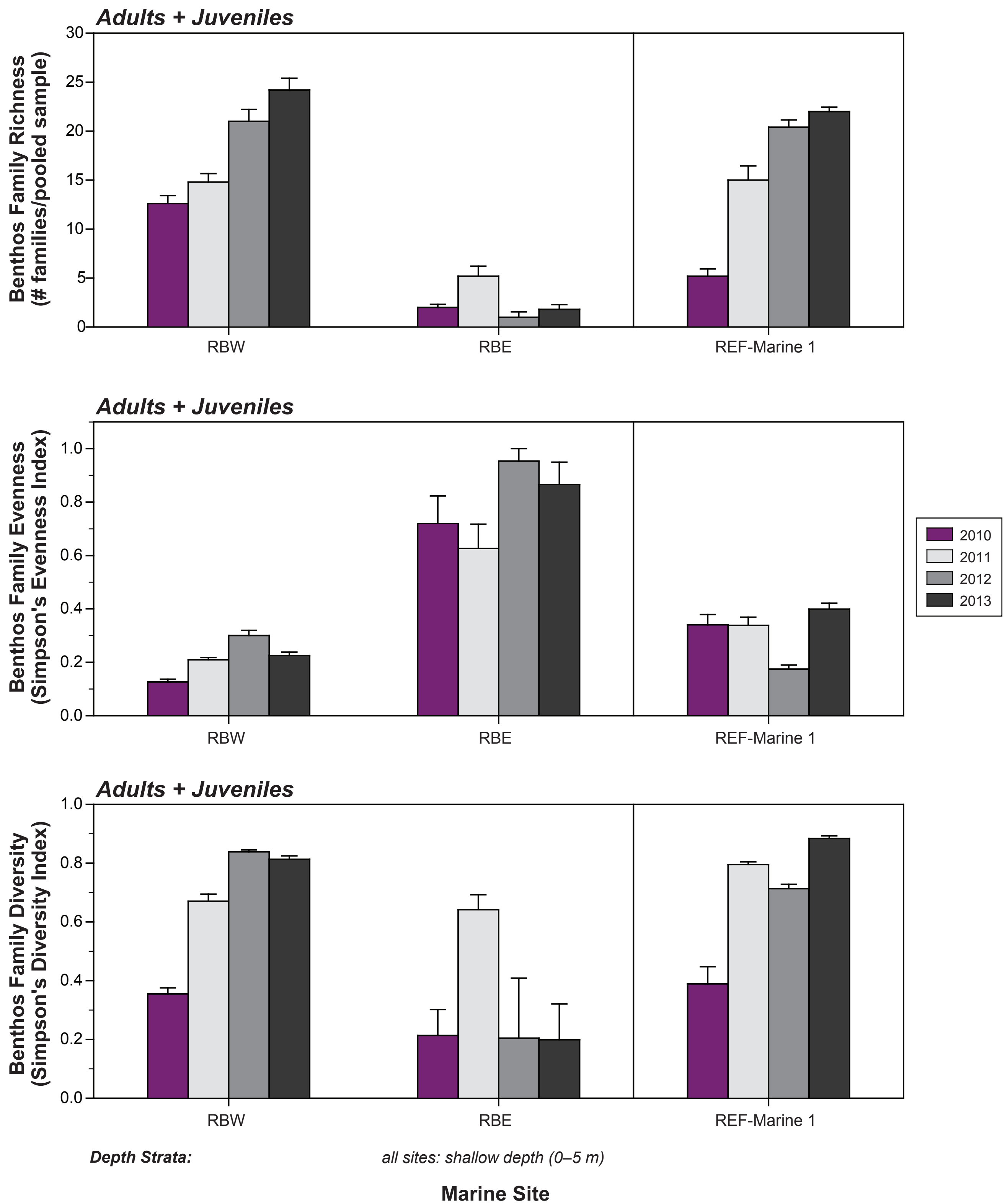
In both the whole community and adult datasets, family evenness and diversity were inter-annually variable at all AEMP marine sites (Figures 3.6-8a and 3.6-8b). The impact level-by-time analysis showed that there was evidence of non-parallelism in the 2010 to 2013 evenness and diversity trends between the exposure sites and the reference site for both the whole community dataset (evenness: $p < 0.0001$ for RBW, and $p = 0.0081$ for RBE; diversity: $p = 0.0002$ for RBW, and $p = 0.0026$ for RBE) and the adult subset (evenness: $p < 0.0001$ for RBW, and $p = 0.0015$ for RBE; diversity: $p < 0.0001$ for RBW, and $p = 0.0004$ for RBE).

As only four 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 RBE that could have affected benthos richness, evenness or adult diversity in 2013; therefore, it is unlikely that the changes in richness, evenness and diversity from 2010 to 2013 were related to Project activities. At site RBW, whole community and adult benthos family richness, evenness, and diversity in 2013 were either higher than or within range of previous years, so there was no evidence that jetty erosion adversely affected the benthos community at this site.

3.6.3.3 Bray-Curtis Index

The benthos Bray-Curtis Index measured for each marine site in 2013 fell within the range of previous years for both the whole community dataset and the adult subset (Figure 3.6-9). However, as observed for nearly all other marine benthos parameters, there was evidence of non-parallelism in the Bray-Curtis Index over time for both the whole community ($p = 0.0048$ for RBW, and $p = 0.0001$ for RBE) and the adult datasets ($p = 0.0087$ for RBW, and $p < 0.0001$ for RBE).

At site RBE, the 2013 Bray-Curtis Indices for both the whole community and the adults were within range of previous years, and there were no apparent Project-related changes to the water quality, sediment quality, or primary producer biomass that could have affected the community composition of benthic invertebrates; therefore, it is unlikely that non-parallelism in the Bray-Curtis Index compared to the reference site was related to Project activities. At site RBW, the whole community and adult Bray-Curtis Indices were within range of previous years, so there was no evidence that jetty erosion adversely affected the benthos community at this site.



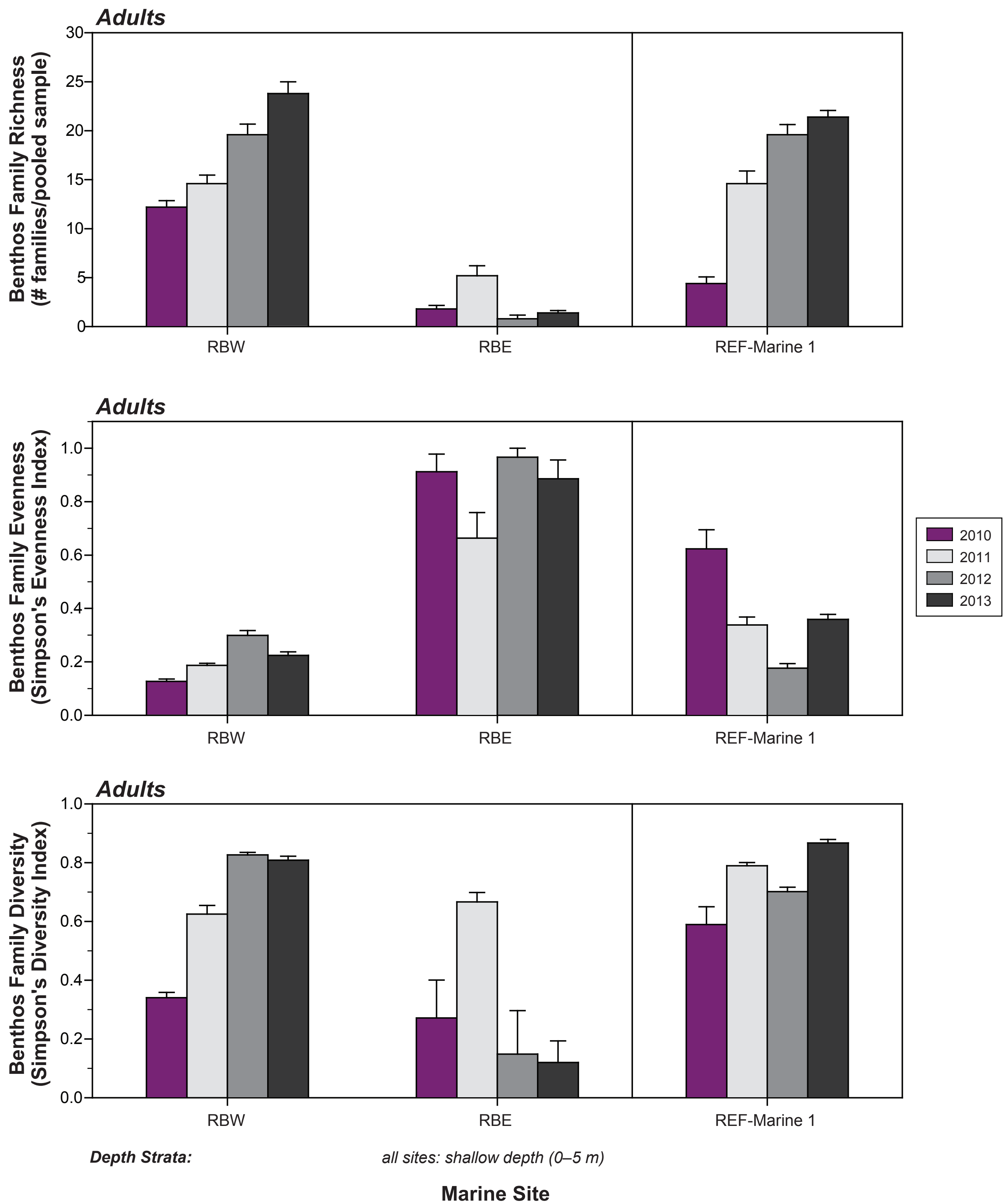
Notes: Error bars represent the standard error of the mean of replicates.

Figure 3.6-8a

Benthos Richness, Evenness, and Diversity in AEMP Marine Sites, Doris North Project, 2010 to 2013

TMAC RESOURCES

Rescan an ERM company



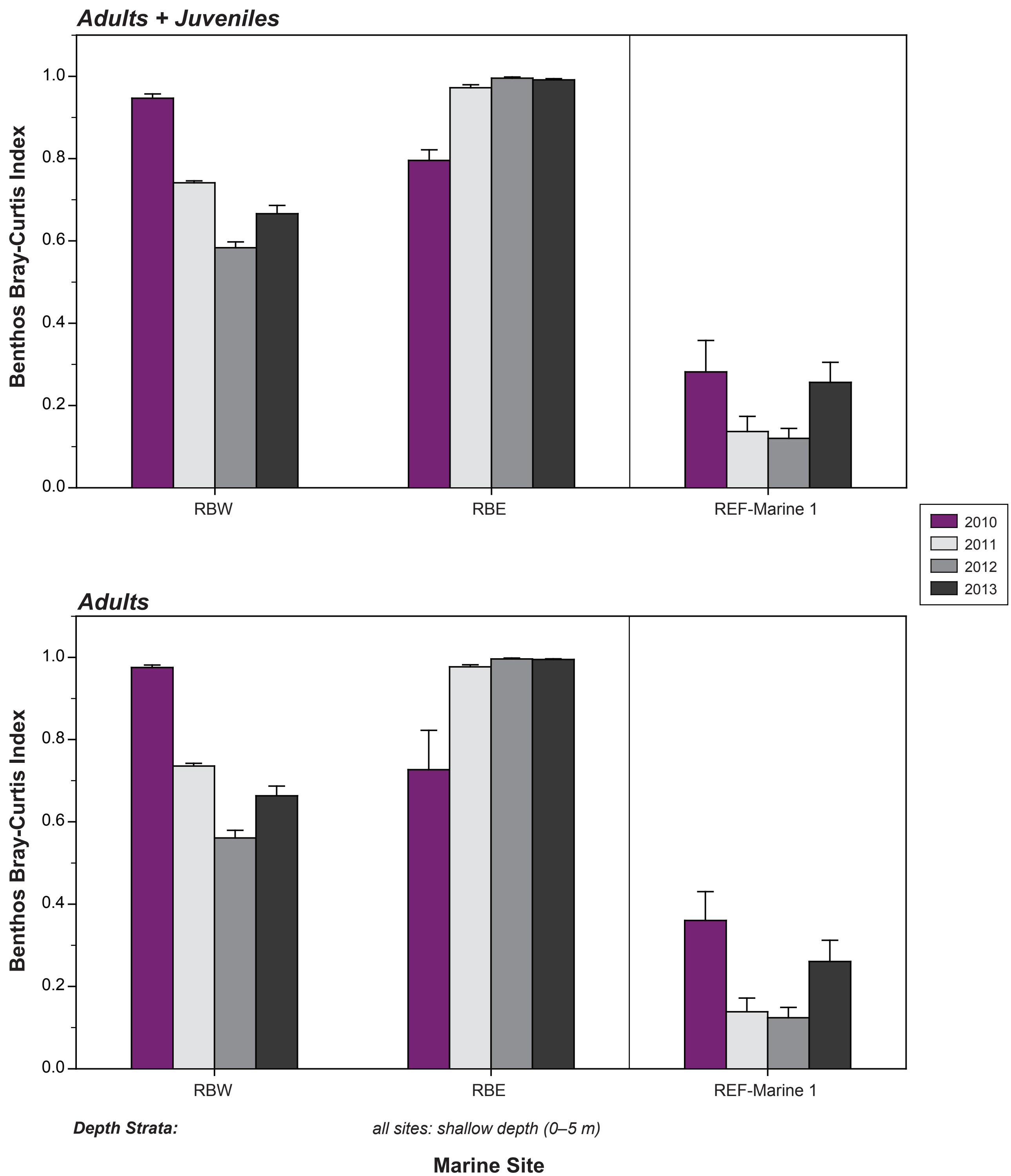
Notes: Error bars represent the standard error of the mean of replicates.

Figure 3.6-8b

Benthos Richness, Evenness, and Diversity in AEMP Marine Sites, Doris North Project, 2010 to 2013

TMAC RESOURCES

Rescan an ERM company



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

Figure 3.6-9

Benthos Bray-Curtis Index for AEMP Marine Sites, Doris North Project, 2010 to 2013

TMAC RESOURCES

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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 2013. When historical information was available, before (baseline, pre-2010) and after (evaluation year, 2013) data for specific variables were first compared at each of the exposure sites to determine whether there was a discernible change in evaluated variables in 2013 compared to baseline years. 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 effects for specific variables to determine if the effect was likely naturally occurring or Project related.

4.1 STREAMS

Table 4.1-1 provides a summary of the 2013 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 variables in the AEMP exposure streams.

Mean 2013 water quality variable concentrations in AEMP exposure streams were all below CCME guidelines. Out of the 18 water quality variables that were evaluated, total arsenic at Roberts Outflow and total aluminum at Little Roberts Outflow were the only variables that changed significantly from baseline years to 2013. In both cases, concentrations decreased from baseline years to 2013, which is of no concern environmentally. Therefore, there were no apparent adverse effects of 2013 Project activities on the water quality of the exposure streams.

Mean 2013 sediment quality concentrations in AEMP exposure streams were all below CCME ISQGs and PELs. At Doris and Little Roberts outflows, there were some differences in the particle size composition of sediment samples collected in 2013 compared to the particle size composition of baseline samples. Variation in sediment particle size composition was unlikely related to 2013 Project activities, and probably reflects natural spatial heterogeneity in stream sediments. At Little Roberts Outflow, sediments in 2013 contained lower concentrations of TOC, chromium, copper, lead, and zinc than did baseline sediments. These decreases are likely attributable to the significant decrease in the proportion of fine sediments in 2013 samples compared to baseline samples, since fine sediments tend to be associated with higher concentrations of TOC and metals than coarse sediments (e.g., Lakhan, Cabana, and LaValle 2003; Secrieri and Oaie 2009). Decreases in sediment metal concentrations are not of concern. Therefore, there were no apparent adverse effects of 2013 Project activities on the sediment quality of exposure streams.

There was no indication that 2013 Project activities affected periphyton biomass in the exposure streams.

There was evidence of non-parallelism in the 2010 to 2013 benthos family evenness trend between Doris Outflow and the reference streams and in the 2010 to 2013 Bray-Curtis Index between Roberts Outflow and the reference streams. However, this non-parallelism did not indicate that the Project was adversely affecting the benthos community at these sites. Doris Outflow benthos evenness remained higher than all other streams in 2013, and the Roberts Outflow Bray-Curtis Index was relatively low in 2013 compared to previous years, indicating that there was increased similarity between the benthos at Roberts Outflow and the median reference community in 2013. These differences in trends likely reflect natural annual variability or patchiness in the composition of the benthos community within streams. 2010 to 2013 trends in total density, family richness, and Simpson's Diversity Index at exposure streams paralleled the trends observed for the reference streams, indicating that there were no effects of 2013 Project activities on these benthos community descriptors.

4.2 LAKES

Table 4.2-1 presents the summary of the 2013 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 variables in the AEMP exposure lakes.

There was no evidence of an effect of 2013 Project activities on either under-ice dissolved oxygen concentrations or Secchi depths in the AEMP exposure lakes.

Mean 2013 water quality variable concentrations in AEMP exposure lakes were below CCME guidelines, except for the mean 2013 total zinc concentration in Doris Lake North. There was evidence of a change between baseline years and 2013 in water hardness (increase) at Doris Lake South, and in the concentrations of total arsenic (decrease), total molybdenum (increase), and total zinc (increase) at Doris Lake North. However, in all these instances, the BACI analysis showed that parallel changes from baseline years to 2013 also occurred at the reference lake (Reference Lake B). Thus, there was no evidence that these changes were due to 2013 Project activities.

Mean 2013 sediment quality variable concentrations were generally below CCME ISQGs, except for total arsenic, total chromium, and total copper, which were higher than ISQGs at several lake sites. At Doris Lake South, there were some differences in the particle size composition in the sediment samples collected in 2013 compared to the particle size composition of baseline samples. Variation in sediment particle size composition was unlikely related to 2013 Project activities, and probably reflects natural spatial heterogeneity in lake sediments. There was evidence of a decrease between baseline years and 2013 in copper concentrations in sediments from Doris Lake South and Doris Lake North, as well as a decrease in the lead concentration in Little Roberts Lake sediments. However, decreases in sediment heavy metal concentrations are not of environmental concern. Therefore, there were no apparent adverse effects of 2013 Project activities on the sediment quality of exposure lakes.

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 2013 benthos Bray-Curtis Index trends in Doris Lake North and Doris Lake South relative to Reference Lake B. However, given the high inter-annual variability in the Bray-Curtis Index at these sites, the temporal trends at these sites are not clear, and there was no obvious indication that 2013 Project activities adversely affected the Bray-Curtis Index at these sites. 2010 to 2013 trends in total density, family richness, and Simpson's evenness and diversity indices at exposure lakes paralleled the trends observed for the reference lakes, indicating that there were no effects of 2013 Project activities on these benthos community descriptors.

Table 4.1-1. Summary of Evaluation of Effects for the AEMP Streams, Doris North Project, 2013

Variable	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
Water Quality												
pH	GA, BA	No difference	No difference	No difference	No difference	-	☐	☐	☐	No effect	No effect	No effect
Alkalinity, Total	GA, BA	No difference	No difference	No difference	No difference	-	☐	☐	☐	No effect	No effect	No effect
Hardness	GA, BA	No difference	No difference	No difference	No difference	-	☐	☐	☐	No effect	No effect	No effect
Total Suspended Solids	GA, BA	No difference	No difference	No difference	-	-	-	-	-	No effect	No effect	No effect
Ammonia (as N)	GA, BA	No difference	No difference	No difference	-	-	-	-	-	No effect	No effect	No effect
Nitrate (as N)	GA, BA	-	-	-	No difference	-	-	-	-	No effect	No effect	No effect
Cyanide, Total	GA	-	-	-	-		-	-	-	No effect	No effect	No effect
Radium-226	GA	-	-	-	-	-	-	-	-	No effect	No effect	No effect
Aluminum, Total	GA, BA, BACI	No difference	No difference	**Decrease**	No difference	-	☐	☐	Parallel	No effect	No effect	No effect
Arsenic , Total	GA, BA, BACI	No difference	**Decrease**	No difference	No difference	-	☐	Parallel	☐	No effect	No effect	No effect
Cadmium, Total	GA, BA	-	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 effect	No effect	No effect
Mercury, Total	GA, BA	-	No difference	No difference	No difference	-	-	☐	☐	No effect	No effect	No effect
Molybdenum, Total	GA, BA	No difference	No difference	No difference	-	-	-	-	-	No effect	No effect	No effect
Nickel, Total	GA, BA	No difference	No difference	No difference	No difference	-	☐	☐	☐	No effect	No effect	No effect
Zinc, Total	GA, BA	No difference	No difference	No difference	-	-	-	-	-	No effect	No effect	No effect
Sediment Quality												
% Gravel (>2 mm)	GA, BA, BACI	**Decrease**	-	No difference	No difference		Parallel	-	☐	No effect	No effect	No effect
% Sand (2.0 mm - 0.063 mm)	GA, BA, BACI	**Increase**	-	No difference	No difference		Parallel	-	☐	No effect	No effect	No effect
% Silt (0.063 mm - 4 µm)	GA, BA, BACI	No difference	-	**Decrease**	No difference		☐	-	Parallel	No effect	No effect	No effect
% Clay (<4 µm)	GA, BA, BACI	No difference	-	**Decrease**	No difference	-	☐	-	**Non-parallel**	No effect	No effect	No effect[d]
Total Organic Carbon	GA, BA, BACI	No difference	-	**Decrease**	No difference	-	☐	-	**Non-parallel**	No effect	No effect	No effect[d]
Arsenic	GA, BA	No difference	-	No difference	No difference	-	☐	-	☐	No effect	No effect	No effect
Cadmium	GA	-	-	-	-	-	-	-	-	No effect	No effect	No effect
Chromium	GA, BA, BACI	No difference	-	**Decrease**	**Decrease**	-	☐	-	Parallel	No effect	No effect	No effect
Copper	GA, BA, BACI	No difference	-	**Decrease**	No difference	-	☐	-	Parallel	No effect	No effect	No effect
Lead	GA, BA, BACI	No difference	-	**Decrease**	No difference	-	☐	-	**Non-parallel**	No effect	No effect	No effect
Mercury	GA, BA	-	-	No difference	No difference	-	-	-	☐	No effect	No effect	No effect
Zinc	GA, BA, BACI	No difference	-	**Decrease**	**Decrease**	-	☐	-	**Non-parallel**	No effect	No effect	No effect
Periphyton												
Biomass	GA, BA, BACI	No difference	-	-	-	-	☐	-	Parallel	No effect	No effect	No effect
							2010 to 2013 Trend Relative to Reference Sites (Impact Level-by-Time analysis)[a]					
Benthic Invertebrates												
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	-	-	-	-	-	**Non-parallel**	Parallel	Parallel	No effect[d]	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	**Non-parallel**	Parallel	No effect	No effect[d]	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 variables, 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 variables 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, too few degrees of freedom for the analysis, or the lack of variation in a variable 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 2013 means.

Table 4.2-1. Summary of Evaluation of Effects for the AEMP Lakes, Doris North Project, 2013

Variable	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 difference	-	□	□	-	No effect	No effect	No effect
Water Quality												
pH	GA, BA	No difference	No difference	No difference	No difference	-	□	□	-	No effect	No effect	No effect
Alkalinity, Total	GA, BA	No difference	No difference	No difference	No difference	-	□	□	-	No effect	No effect	No effect
Hardness	GA, BA, 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	-	-	-	-	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	-	-	-	-	-	-	-	-	No effect	No effect	No effect
Radium-226	GA	-	-	-	-	-	-	-	-	No effect	No effect	No effect
Aluminum, Total	GA, BA	No difference	No difference	**Increase**	No difference	-	□	□	-	No effect	No effect	No effect
Arsenic , Total	GA, BA, BACI	No difference	**Decrease**	No difference	No difference	-	□	Parallel	-	No effect	No effect	No effect
Cadmium, Total	GA	-	-	-	-	-	-	-	-	No effect	No effect	No effect
Copper, Total	GA, BA	No difference	No difference	No difference	No difference	-	□	□	-	No effect	No effect	No effect
Iron , Total	GA, BA	No difference	No difference	**Increase**	No difference	-	□	□	-	No effect	No effect	No effect
Lead, Total	GA, BA	No difference	No difference	No difference	No difference	-	□	□	-	No effect	No effect	No effect
Mercury, Total	GA, BA	-	No difference	**Decrease**	No difference	-	-	□	-	No effect	No effect	No effect
Molybdenum, Total	GA, BA, BACI	No difference	**Increase**	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, BACI	No difference	**Increase**	No difference	No difference	-	□	Parallel	-	No effect	No effect	No effect
Sediment Quality												
% Gravel (>2 mm)	GA	-	-	-	-	-	-	-	-	No effect	No effect	No effect
% Sand (2.0 mm - 0.063 mm)	GA, BA	No difference	No difference	-	No difference	-	-	-	-	No effect	No effect	No effect
% Silt (0.063 mm - 4 µm)	GA, BA	**Decrease**	No difference	-	No difference	-	-	-	-	No effect[d]	No effect	No effect
% Clay (<4 µm)	GA, BA	**Increase**	No difference	-	No difference	-	-	-	-	No effect[d]	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, 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	No difference	-	**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 2013 Trend Relative to Reference Sites (Impact Level-by-Time analysis)[a]					
Benthic Invertebrates												
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	-	-	-	-	-	**Non-parallel**	**Non-parallel**	Parallel	No effect[d]	No effect[d]	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 variables, 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 variables 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, too few degrees of freedom for the analysis, or the lack of variation in a variable 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 2013 means.

4.3 MARINE

Table 4.3-1 presents the summary of the 2013 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 variables in the marine exposure sites.

There was no evidence of an effect of 2013 Project activities on under-ice dissolved oxygen concentrations at the marine exposure sites in Roberts Bay, and 2013 concentrations remained above the CCME interim guideline for the minimum concentration of dissolved oxygen in marine and estuarine waters (8.0 mg/L).

At the marine exposure sites, mean 2013 concentrations of the 18 evaluated water quality variables were all below CCME guidelines. The only variable concentration that changed significantly from baseline years to 2013 was TSS at Roberts Bay West. However, TSS concentrations at this site decreased from baseline years to 2013, and the BACI analysis showed that a parallel decrease occurred at the reference site. Therefore, there were no adverse Project-related effects on water quality at the marine exposure sites in Roberts Bay.

At site RBW near the jetty and at the reference site REF-Marine 1, there were some differences in the particle size composition of the sediment samples collected in 2013 compared to the particle size composition of samples collected in 2002 or 2009. In particular, the proportion of silt increased while the proportion of sand decreased from baseline years to 2013 at both sites. This shift to finer sediments in 2013 had important implications as metal and TOC concentrations tend to be higher in fine sediments than in coarse sediments (e.g., Lakhan, Cabana, and LaValle 2003; Secrieri and Oaie 2009). As expected, concentrations of TOC and most evaluated metals (arsenic, chromium, copper, lead, and zinc) increased significantly at both RBW and REF-Marine 1 in 2013 compared to baseline years. There was some damage to the Roberts Bay jetty in 2013 that could have contributed to changes in particle size composition and sediment quality in a localized area, but the similarity between RBW and REF-Marine 1 with respect to increases in silt content, and increases in sediment metal and organic carbon concentrations from baseline years to 2013 suggests that the observed changes at RBW were naturally occurring and unrelated to the jetty damage or other Project activities. The changes in sediment particle size composition and quality may have been due to regional re-distribution of sediments following a strong storm event that occurred in July 2013 (which was responsible for damaging the jetty), or these changes could also be the product of spatial sediment heterogeneity. All measured sediment quality variables in marine exposure sites were below CCME ISQGs and PELs, except for total copper concentrations at RBW which were above the ISQG, but well below the PEL.

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) and the adult subset, non-parallelism was detected for all evaluated benthos community descriptors at RBW and RBE relative to the REF-Marine 1, except for the whole community benthos density at RBE. Most 2013 benthos community descriptors were within range of previous years, and there was no indication that benthos communities in 2013 were adversely effected by Project activities (i.e., there was no evidence of an increase in the Bray-Curtis Index or of a decrease in density, richness, or evenness in 2013 compared to previous years). The non-parallelism in trends was likely attributable to the high inter-annual variability in most evaluated parameters.

Table 4.3-1. Summary of Evaluation of Effects for the AEMP Marine Sites, Doris North Project, 2013

Variable	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)
<u>Physical Oceanography</u>								
Winter Dissolved Oxygen	GA	-	-	-	-	-	No effect	No effect
<u>Water Quality</u>								
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	-	Parallel	□	No effect	No effect
Ammonia (as N)	GA, BA	-	No difference	-	-	-	No effect	No effect
Nitrate (as N)	GA, BA	No difference	-	No difference	□	-	No effect	No effect
Cyanide, Total	GA	-	-	-	-	-	No effect	No effect
Radium-226	GA	-	-	-	-	-	No effect	No effect
Aluminum, Total	GA, BA	No difference	No difference	No difference	□	□	No effect	No effect
Arsenic , Total	GA, BA	No difference	No difference	No difference	□	□	No effect	No effect
Cadmium, Total	GA, BA	No difference	No difference	No difference	□	□	No effect	No effect
Copper, Total	GA, BA	No difference	No difference	No difference	□	□	No effect	No effect
Iron , Total	GA, BA	No difference	No difference	No difference	□	□	No effect	No effect
Lead, Total	GA, BA	-	No difference	-	-	-	No effect	No effect
Mercury, Total	GA, BA	-	-	**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	**Increase**	□	□	No effect	No effect
<u>Sediment Quality</u>								
% Gravel (>2 mm)	GA, BA	-	-	No difference	-	-	No effect	No effect
% Sand (2.0 mm - 0.063 mm)	GA, BA	**Decrease**	-	**Decrease**	-	-	No effect[d]	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	**-**	-	-	-	-	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
<u>Phytoplankton</u>								
Biomass	GA, BACI	-	**-**	-	Parallel	Parallel	No effect	No effect
					2010 to 2013 Trend Relative to Reference Sites (Impact Level-by-Time analysis)[a]			
<u>Benthic Invertebrates (Adults + Juveniles)</u>								
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[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**	**Non-parallel**	No effect[d]	No effect[d]
Bray-Curtis Index	GA, ILBT	-	-	-	**Non-parallel**	**Non-parallel**	No effect[d]	No effect[d]
<u>Benthic Invertebrates (Adults)</u>								
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**	**Non-parallel**	No effect[d]	No effect[d]
Bray-Curtis Index	GA, ILBT	-	-	-	**Non-parallel**	**Non-parallel**	No effect[d]	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 variables, 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 variables 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, too few degrees of freedom for the analysis, or the lack of variation in a variable 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 2013 means.

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Appendix A
2013 Data Report

ERM

Appendix A. 2013 Data Report

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Appendix A. 2013 Data Report

A.1 OVERVIEW OF REPORT

This report presents the raw data as well as graphs and tables of the results of the 2013 Aquatic Effects Monitoring Program (AEMP) for the Doris North Gold Mine Project. The 2013 AEMP included the following: 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 2013 AEMP report. Figure A.1-1 shows an overview map of all the sampling sites included in the 2013 program and Figures A.1-2 to A.1-7 show detailed maps of each AEMP lake and marine sampling site, including sampling details and bathymetric contours (if available).

PROJECT # 0194098-0005   GIS # HB-01-110   November 29 2013

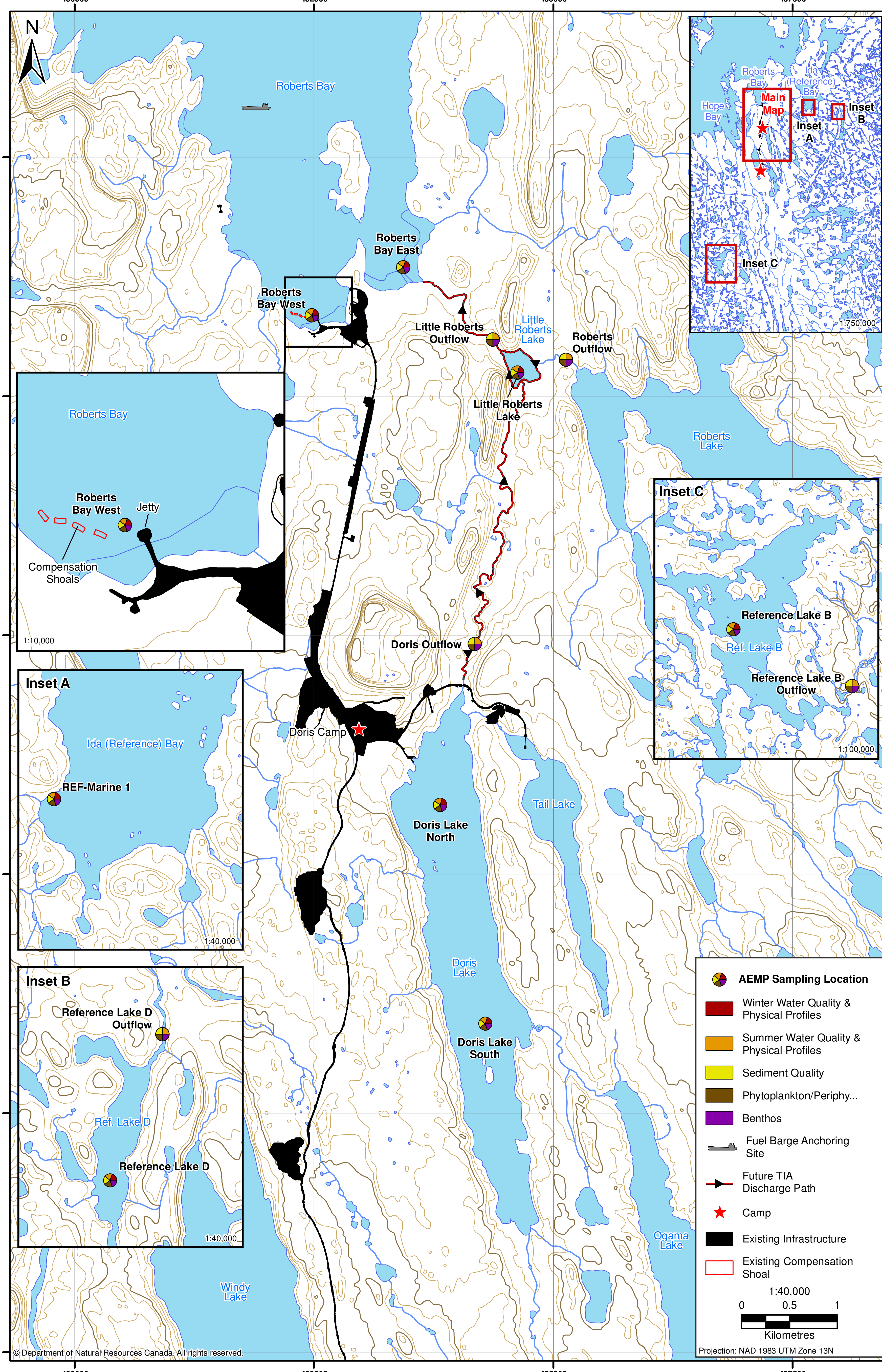

Figure A.1-1

AEMP Sampling Locations, Doris North Project, 2013

MAC RESOURCES

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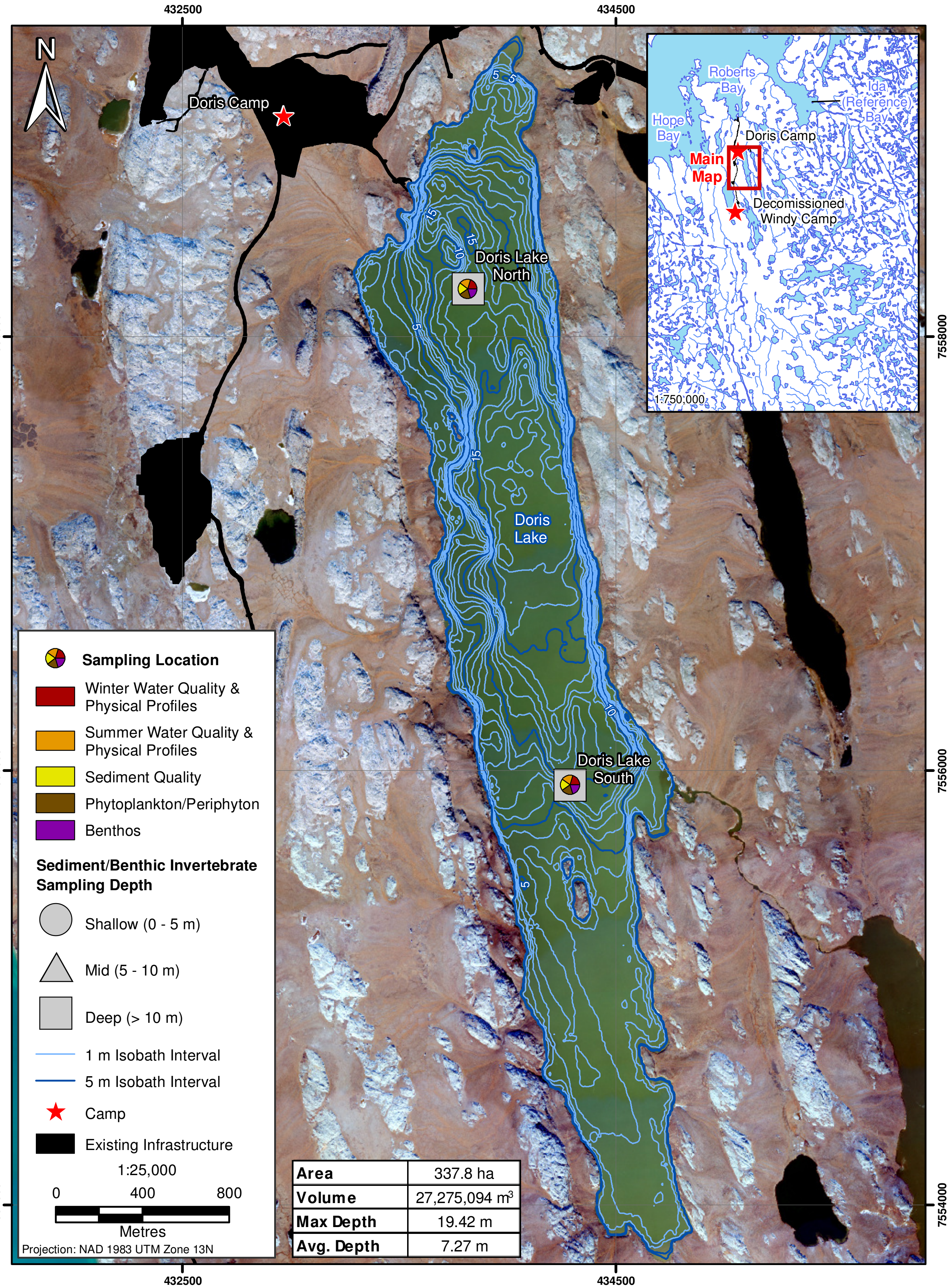


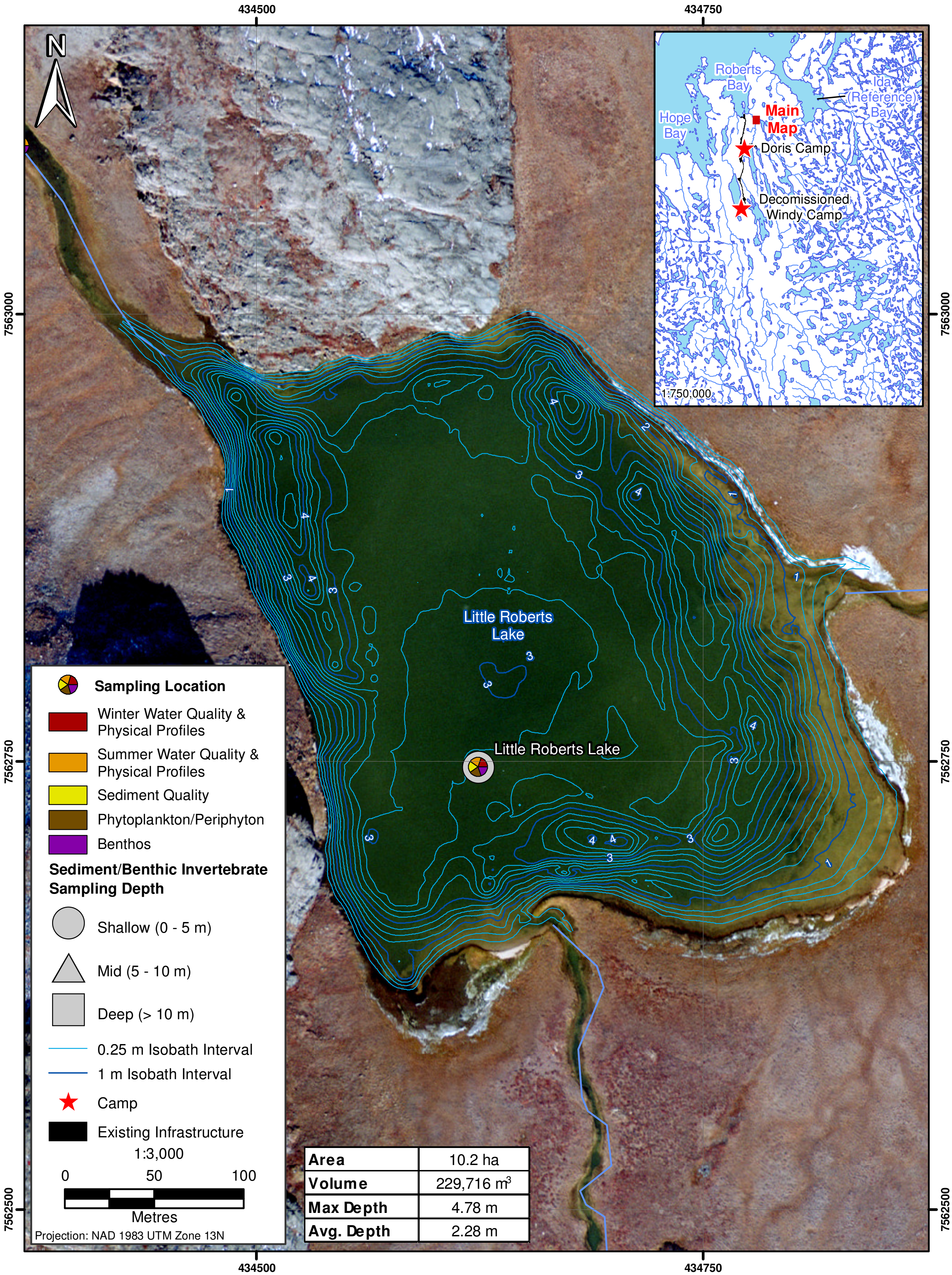
Area	337.8 ha
Volume	27,275,094 m^3
Max Depth	19.42 m
Avg. Depth	7.27 m

Figure A.1-2

Sampling Locations in Doris Lake, Doris North Project, 2013

TMAC RESOURCES

Rescan an ERM company



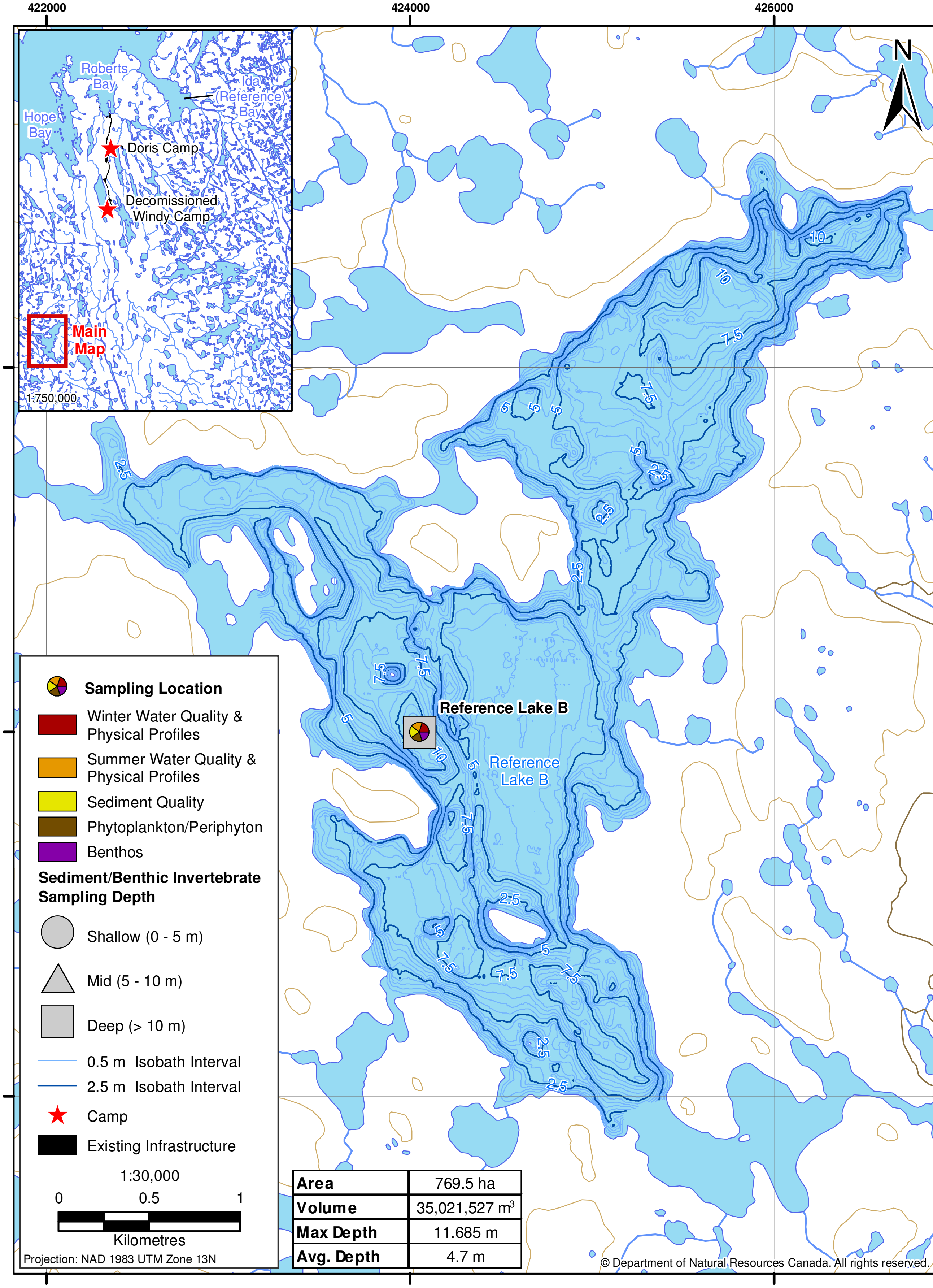
Area	10.2 ha
Volume	229,716 m^3
Max Depth	4.78 m
Avg. Depth	2.28 m

TMAC RESOURCES

Sampling Location in Little Roberts Lake, Doris North Project, 2013

Figure A.1-3

Rescan an ERM company



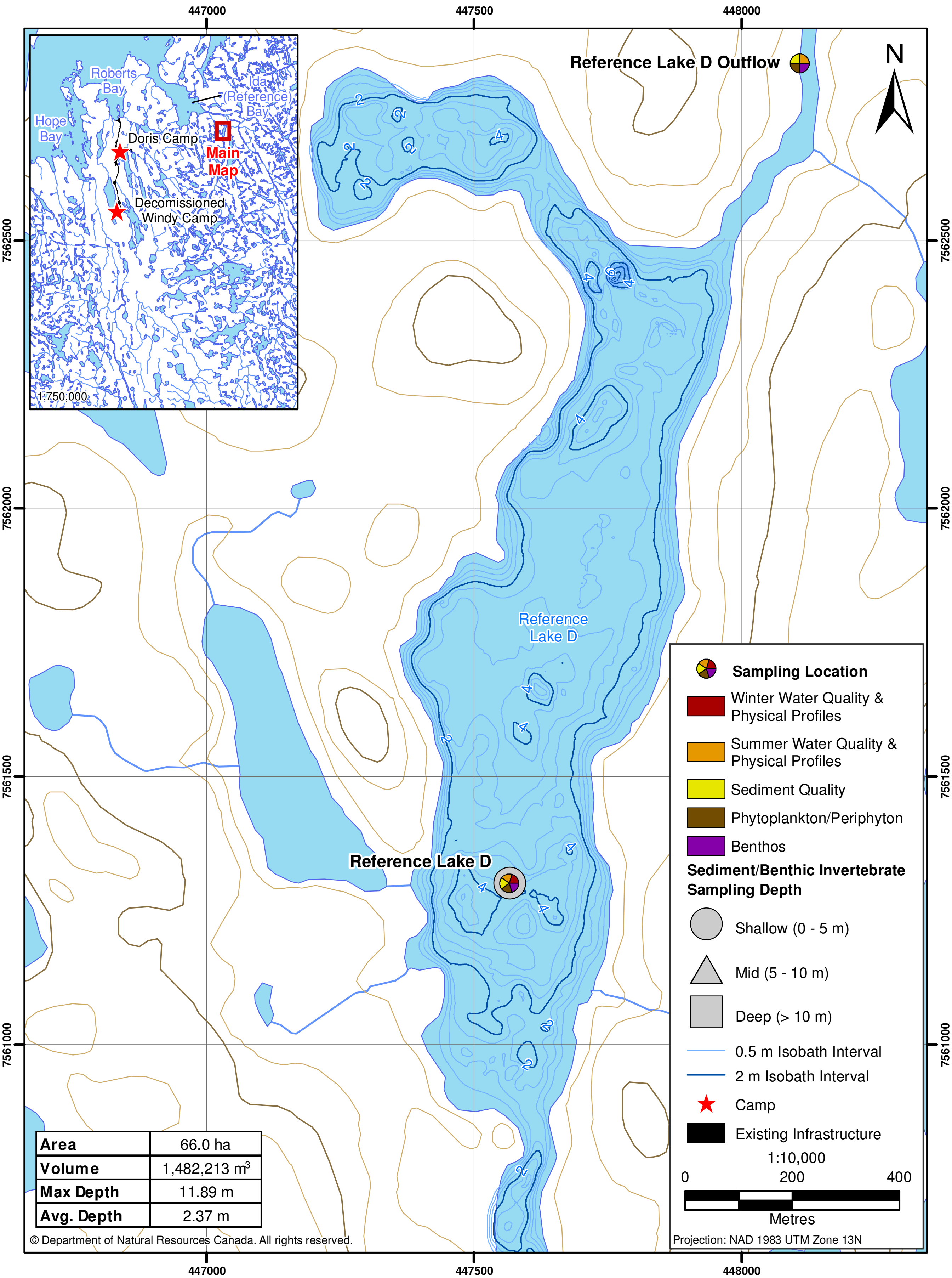
Area	769.5 ha
Volume	35,021,527 m^3
Max Depth	11.685 m
Avg. Depth	4.7 m

Figure A.1-4

Sampling Location in Reference Lake B, Doris North Project, 2013

TMAC RESOURCES

Rescan an ERM company



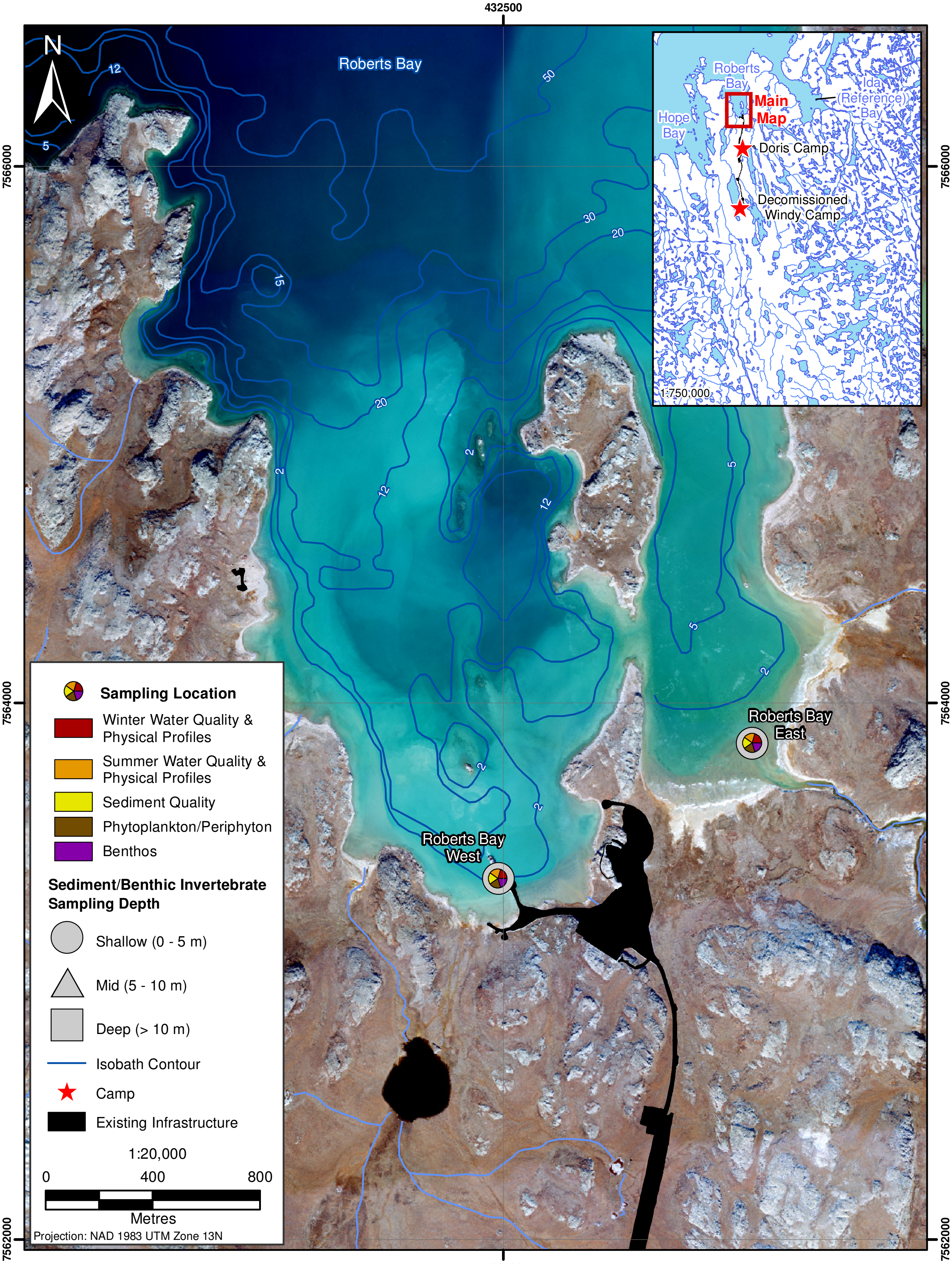
Area	66.0 ha
Volume	1,482,213 m^3
Max Depth	11.89 m
Avg. Depth	2.37 m

Figure A.1-5

Sampling Location in Reference Lake D, Doris North Project, 2013

TMAC RESOURCES

Rescan an ERM company



MAC RESOURCES

Sampling Locations in Roberts Bay, Doris North Project, 2013

Figure A.1-6

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an ERM company

PROJECT # 0194096-0005 GIS # HB-01-109f

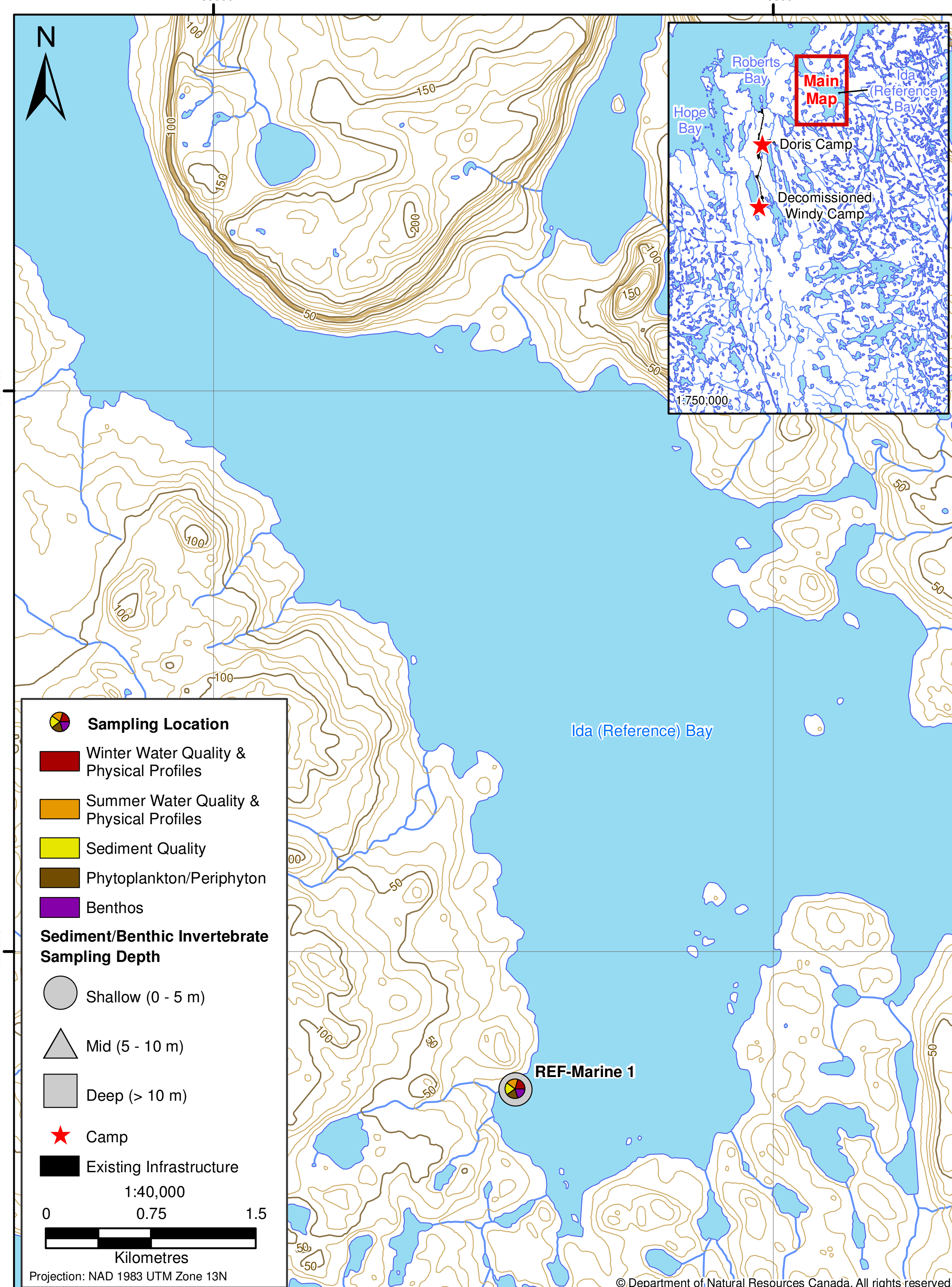


Figure A.1-7

Sampling Location in Ida (Reference) Bay, Doris North Project, 2013

TMAC RESOURCES

Rescan an ERM company

A.2 2013 PHYSICAL PROFILES AND SECCHI DEPTH

The following sections present the Secchi depth data and the physical profiles collected between April and September 2013 in stream, lake, and marine sites.

A.2.1 Stream Data

Stream water temperatures measured between June 12 and September 23, 2013 are shown in Table A.2-1.

Table A.2-1. Stream Water Temperature, Doris North Project, 2013

	Date			
Stream	**June 12-13**	**July 17-19**	**August 16-22**	**September 17-23**
Doris Outflow	6.4°C	9.0°C	11.8°C	3.7°C
Roberts Outflow	3.8°C	8.3°C	12.3°C	4.0°C
Little Roberts Outflow	3.3°C	9.9°C	11.6°C	3.2°C
Reference B Outflow	5.1°C	13.7°C	8.6°C	2.4°C
Reference D Outflow	4.6°C	11.4°C	12.4°C	3.0°C

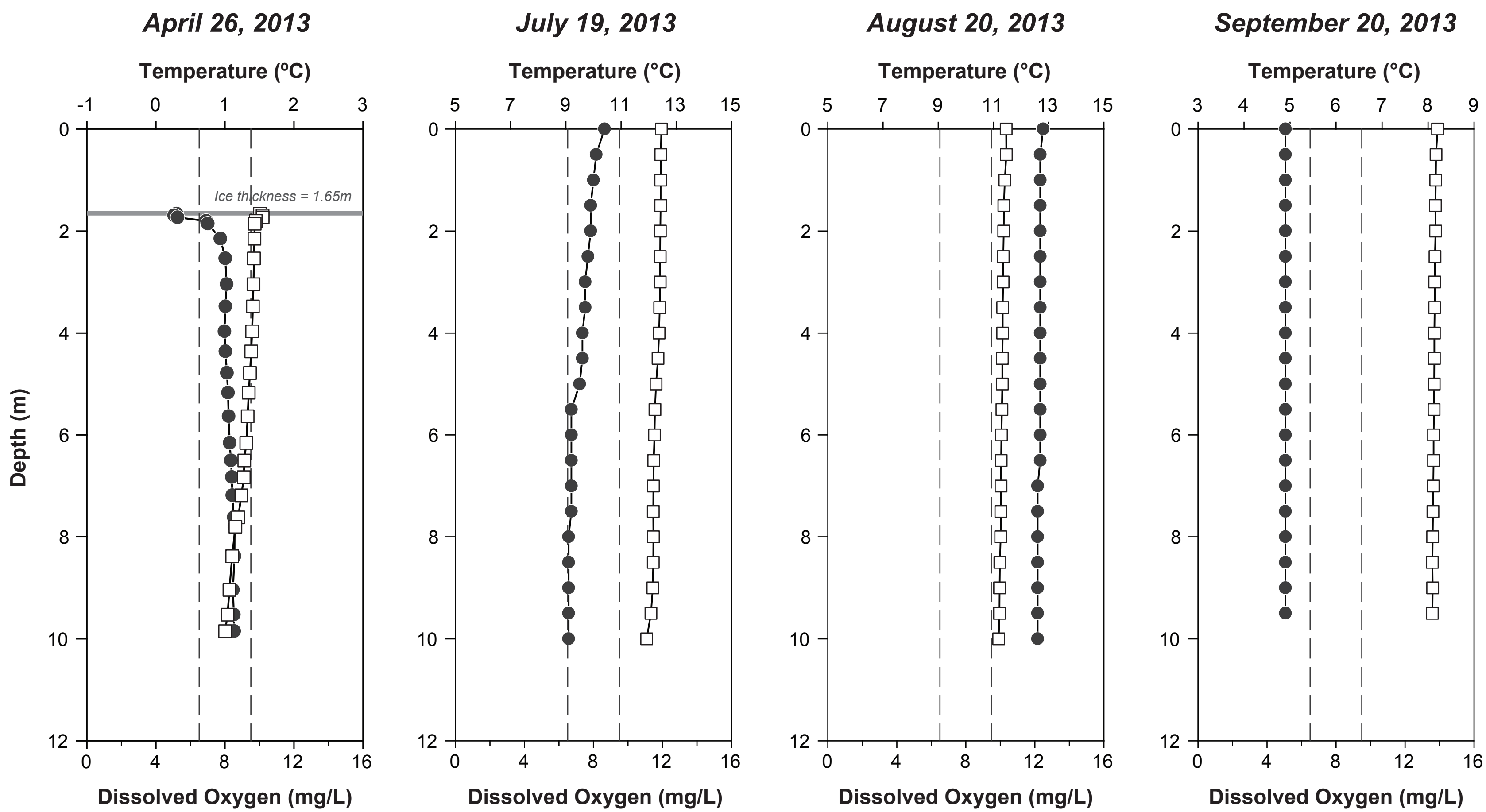
A.2.2 Lake Data

Lake Secchi depths and calculated euphotic zone depths (1% light level) are shown in Table A.2-2. Figures A.2-1 to A.2-5 show the temperature and dissolved oxygen profiles collected at lake sites between April and September 2013; Annex A.2-1 provides the raw physical profile data.

Table A.2-2. Lake Secchi Depths and Euphotic Zone Depths, Doris North Project, 2013

Lake Site	Sampling Date	Secchi Depth (Ds) (m)	Euphotic Zone Depth 1% Light Level (m)
Large Lake Site			
Doris Lake South	July 19, 2013	1.25	3.4
	August 20, 2013	1.5	4.1
	September 20, 2013	1.5	4.1
Doris Lake North	July 17, 2013	1.35	3.6
	August 21, 2013	1.0	2.7
	September 20, 2013	1.3	3.5
Reference Lake B	July 19, 2013	6.3	17.0*
	August 18, 2013	7.6	20.6*
	September 23, 2013	8.0	21.6*
Small Lake Site			
Little Roberts Lake	July 20, 2013	2.05	5.5*
	August 21, 2013	Bottom (2.1)	-
	September 19, 2013	1.75	4.7*
Reference Lake D	July 21, 2013	Bottom (3.5)	-
	August 18, 2013	Bottom (3.8)	-
	September 21, 2013	Bottom (3.7)	-

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



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

Figure A.2-1

Temperature and Dissolved Oxygen Profiles in Doris Lake South, Doris North Project, 2013

TMAC RESOURCES

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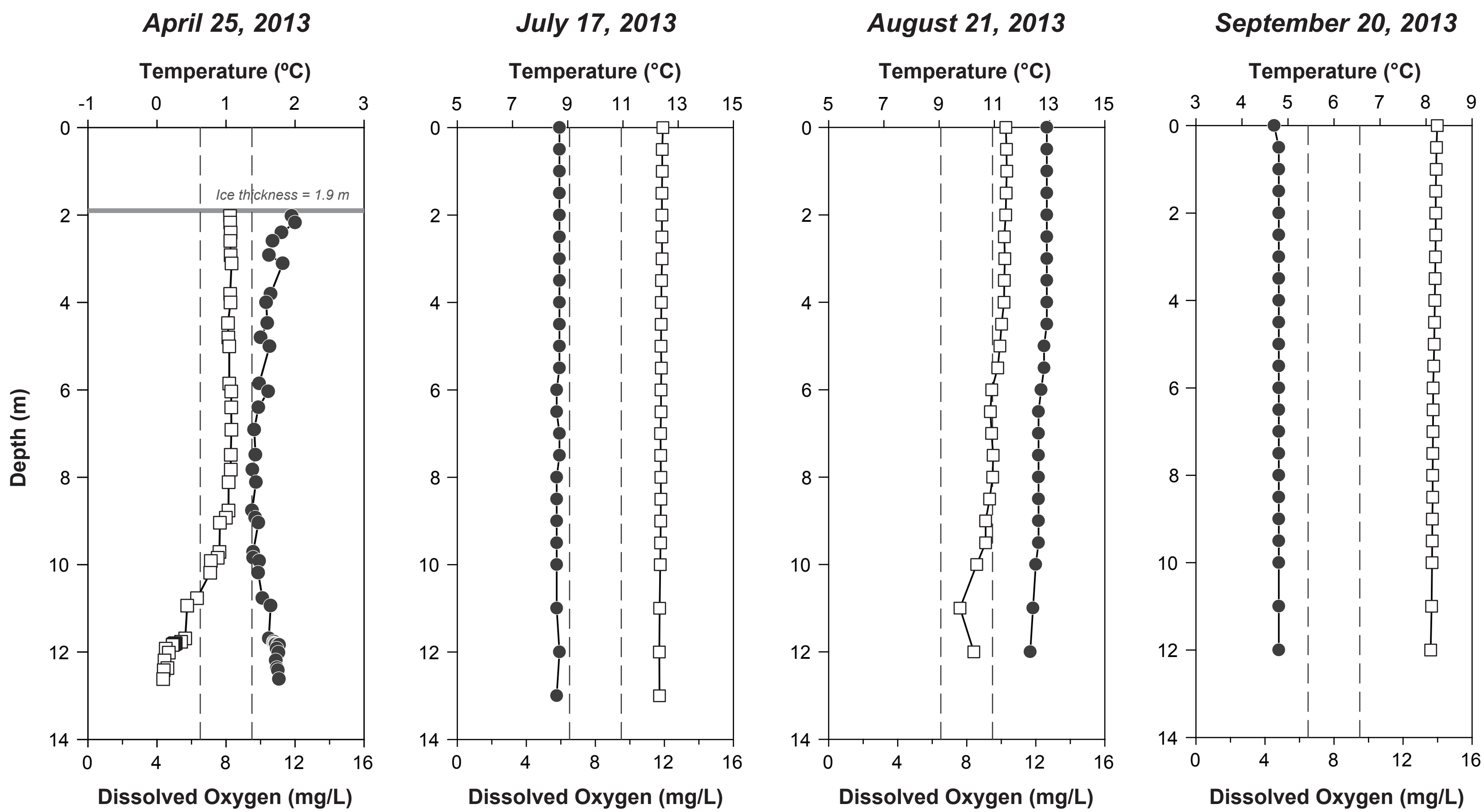
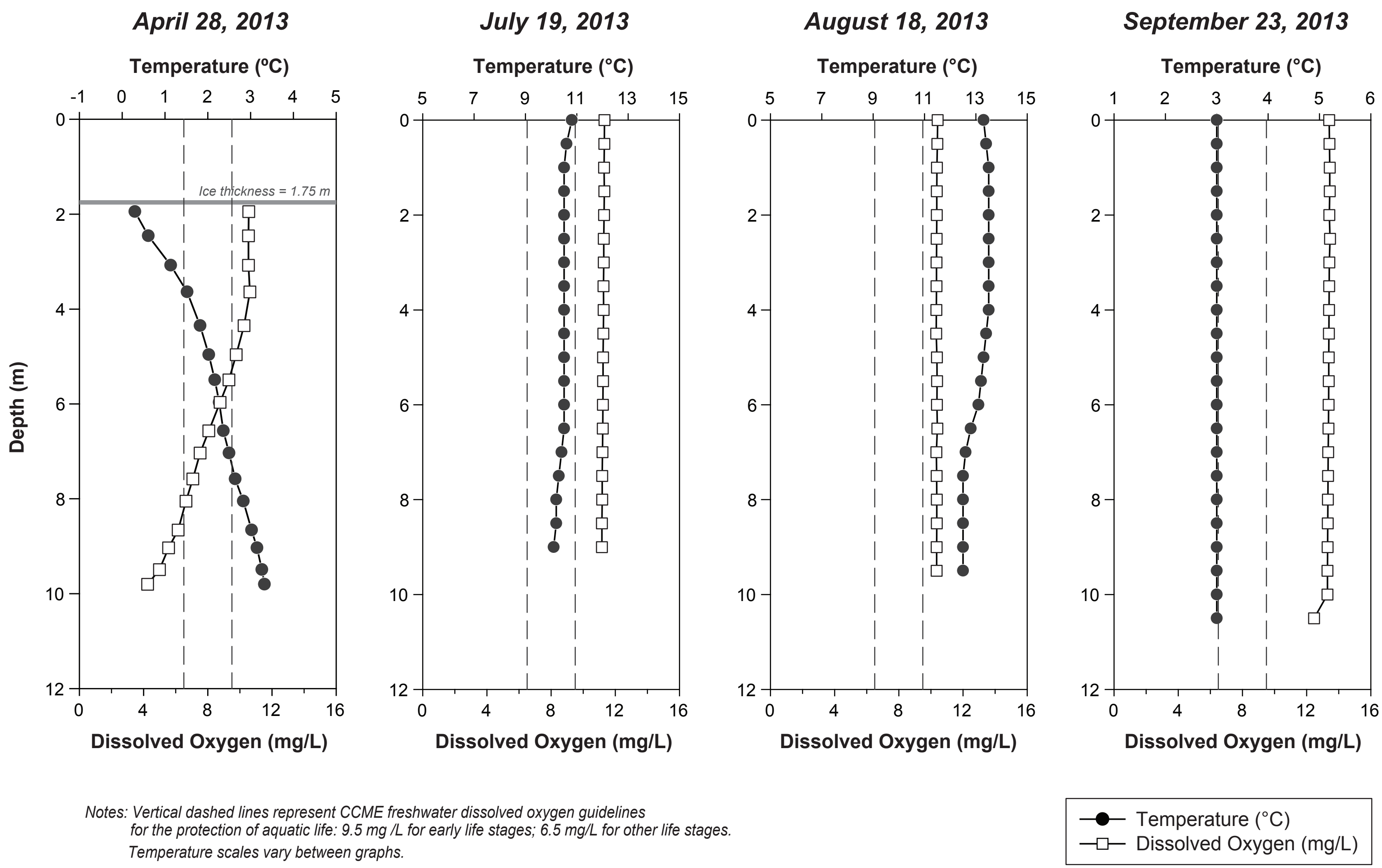


Notes: *Vertical dashed lines represent CCME freshwater dissolved oxygen guidelines for the protection of aquatic life: 9.5 mg /L for early life stages; 6.5 mg/L for other life stages. Temperature scales vary between graphs.*

Temperature and Dissolved Oxygen Profiles in Doris Lake North, Doris North Project, 2013

Figure A.2-2

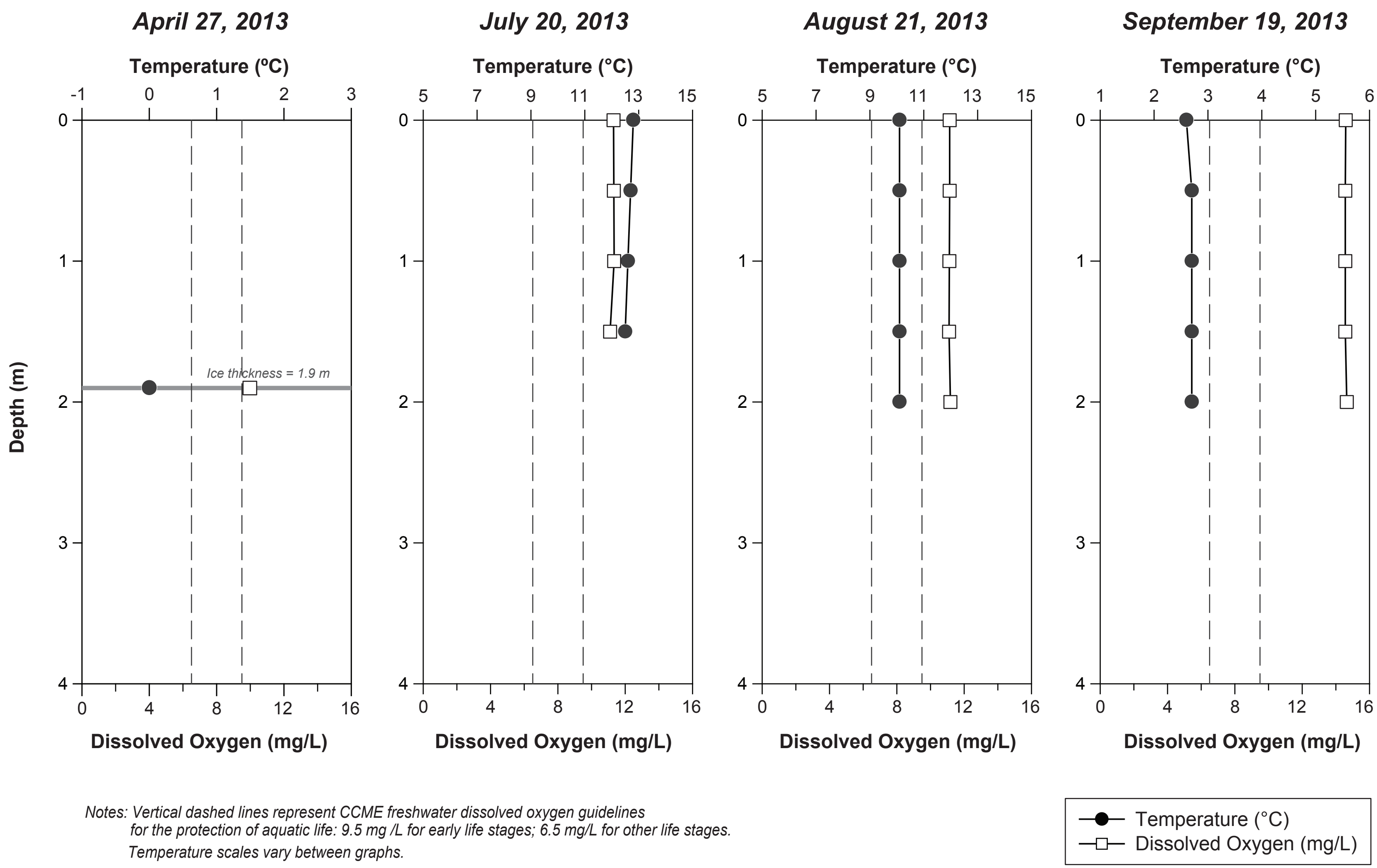


Notes: Vertical dashed lines represent CCME freshwater dissolved oxygen guidelines for the protection of aquatic life: 9.5 mg /L for early life stages; 6.5 mg/L for other life stages.
Temperature scales vary between graphs.

Figure A.2-3

Temperature and Dissolved Oxygen Profiles in Reference Lake B, Doris North Project, 2013

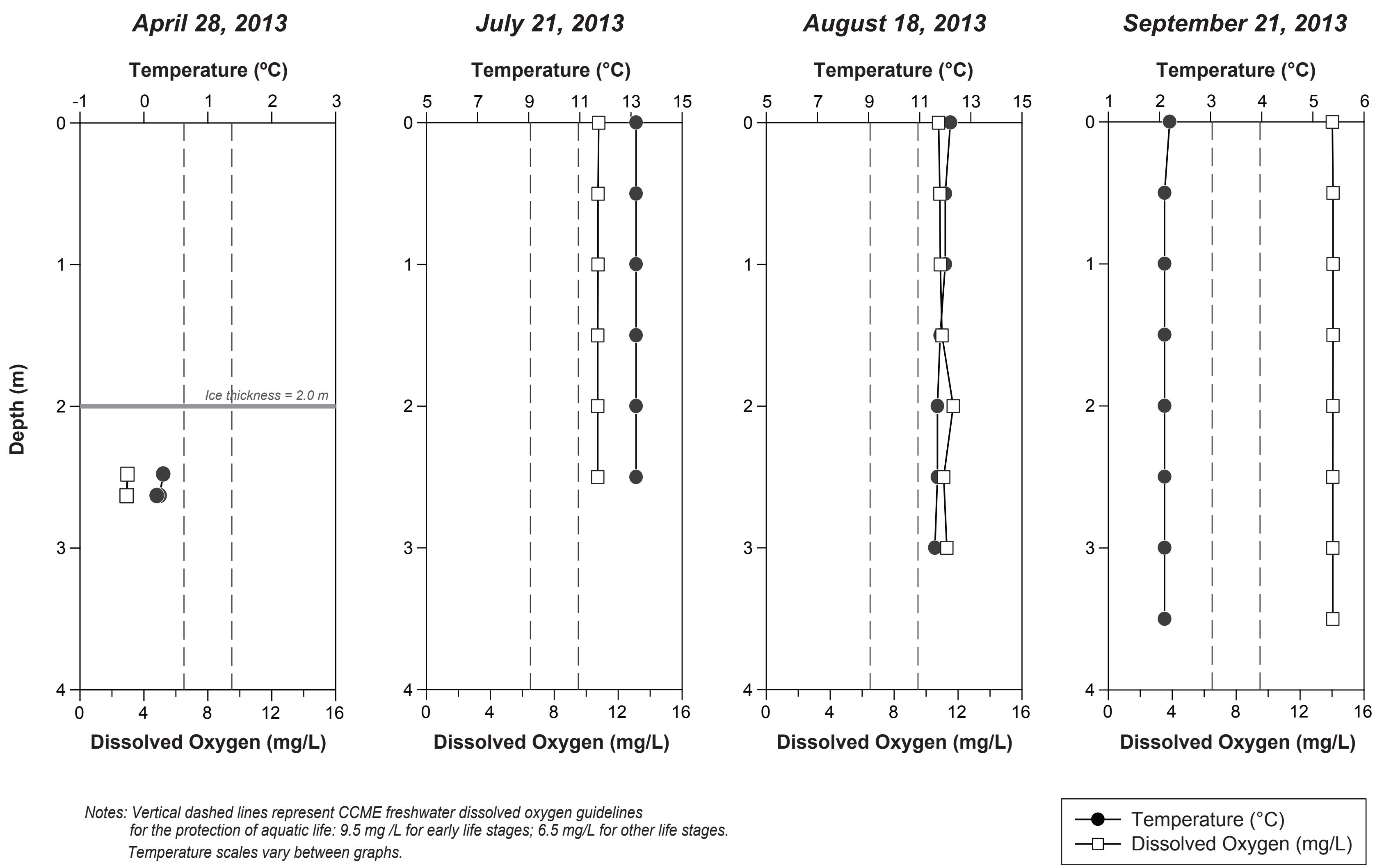
Figure A.2-3



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 A.2-4

Temperature and Dissolved Oxygen Profiles in Little Roberts Lake, Doris North Project, 2013



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.

TMAC RESOURCES

Temperature and Dissolved Oxygen Profiles in Reference Lake D, Doris North Project, 2013

Figure A.2-5

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Annex A.2-1. Temperature and Dissolved Oxygen Profiles for AEMP Lakes, Doris North Project, 2013

Doris Lake South			
26-Apr-13			
Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen Saturation (%)
1.66	0.3	10.02	n/a
1.69	0.3	10.17	n/a
1.73	0.3	10.18	n/a
1.80	0.7	9.78	n/a
1.86	0.7	9.72	n/a
2.15	0.9	9.70	n/a
2.54	1.0	9.67	n/a
3.05	1.0	9.65	n/a
3.48	1.0	9.61	n/a
3.97	1.0	9.57	n/a
4.36	1.0	9.51	n/a
4.78	1.0	9.44	n/a
5.17	1.0	9.38	n/a
5.63	1.1	9.32	n/a
6.15	1.1	9.23	n/a
6.50	1.1	9.12	n/a
6.83	1.1	9.09	n/a
7.18	1.1	8.95	n/a
7.62	1.1	8.76	n/a
7.80	1.1	8.60	n/a
8.38	1.1	8.42	n/a
9.04	1.1	8.25	n/a
9.53	1.1	8.14	n/a
9.85	1.1	8.01	n/a

Doris Lake South			
19-Jul-13			
Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen Saturation (%)
0.0	10.4	11.93	106.1
0.5	10.1	11.9	105.5
1.0	10	11.89	105.3
1.5	9.9	11.89	105.1
2.0	9.9	11.87	104.9
2.5	9.8	11.86	104.6
3.0	9.7	11.86	104.3
3.5	9.7	11.84	104.2
4.0	9.6	11.8	103.7
4.5	9.6	11.74	103
5.0	9.5	11.62	101.6
5.5	9.2	11.56	100.4
6.0	9.2	11.53	100.2
6.5	9.2	11.49	99.9
7.0	9.2	11.47	99.7
7.5	9.2	11.46	99.6
8.0	9.1	11.47	99.5
8.5	9.1	11.46	99.4
9.0	9.1	11.44	99.2
9.5	9.1	11.33	98.3
10.0	9.1	11.08	96.3

Doris Lake South			
20-Aug-13			
Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen Saturation (%)
0.0	12.8	10.34	97.6
0.5	12.7	10.35	97.5
1.0	12.7	10.26	96.7
1.5	12.7	10.21	96.3
2.0	12.7	10.2	96.2
2.5	12.7	10.17	95.9
3.0	12.7	10.16	95.7
3.5	12.7	10.14	95.6
4.0	12.7	10.14	95.5
4.5	12.7	10.12	95.4
5.0	12.7	10.12	95.3
5.5	12.7	10.09	95.1
6.0	12.7	10.07	94.9
6.5	12.7	10.05	94.7
7.0	12.6	10.04	94.4
7.5	12.6	10.03	94.3
8.0	12.6	10.02	94.2
8.5	12.6	9.98	93.9
9.0	12.6	9.96	93.7
9.5	12.6	9.95	93.6
10.0	12.6	9.91	93.3

Doris Lake South			
20-Sep-13			
Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen Saturation (%)
0.0	4.9	13.89	108
0.5	4.9	13.8	108
1.0	4.9	13.78	107.6
1.5	4.9	13.76	107.4
2.0	4.9	13.77	107.5
2.5	4.9	13.74	107.3
3.0	4.9	13.72	107.2
3.5	4.9	13.72	107.1
4.0	4.9	13.7	107
4.5	4.9	13.7	107
5.0	4.9	13.69	107
5.5	4.9	13.68	106.8
6.0	4.9	13.66	106.7
6.5	4.9	13.66	106.6
7.0	4.9	13.64	106.5
7.5	4.9	13.62	106.3
8.0	4.9	13.6	106.3
8.5	4.9	13.59	106.2
9.0	4.9	13.6	106.2
9.5	4.9	13.59	106.1

Doris Lake North			
25-Apr-13			
Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen Saturation (%)
2.02	2.0	8.23	n/a
2.17	2.0	8.24	n/a
2.40	1.8	8.26	n/a
2.59	1.7	8.24	n/a
2.92	1.6	8.26	n/a
3.11	1.8	8.31	n/a
3.80	1.6	8.24	n/a
4.00	1.6	8.25	n/a
4.47	1.6	8.11	n/a
4.80	1.5	8.13	n/a
5.00	1.6	8.19	n/a
5.86	1.5	8.18	n/a
6.04	1.6	8.30	n/a
6.40	1.5	8.29	n/a
6.91	1.4	8.30	n/a
7.49	1.4	8.27	n/a
7.82	1.4	8.27	n/a
8.11	1.4	8.15	n/a
8.76	1.4	8.14	n/a
8.93	1.4	7.98	n/a
9.04	1.5	7.64	n/a
9.71	1.4	7.61	n/a
9.84	1.4	7.51	n/a
9.91	1.5	7.11	n/a
10.19	1.5	7.08	n/a
10.77	1.5	6.32	n/a
10.94	1.6	5.75	n/a
11.69	1.6	5.63	n/a
11.77	1.7	5.39	n/a
11.80	1.7	5.08	n/a
11.81	1.7	4.98	n/a
11.82	1.7	4.96	n/a
11.83	1.8	4.91	n/a
11.84	1.8	4.90	n/a
11.92	1.7	4.50	n/a
12.01	1.8	4.68	n/a
12.19	1.7	4.43	n/a
12.37	1.7	4.60	n/a
12.42	1.8	4.39	n/a
12.62	1.8	4.35	n/a

Doris Lake North			
17-Jul-13			
Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen Saturation (%)
0.0	8.7	11.91	101.9
0.5	8.7	11.87	102
1.0	8.7	11.87	102
1.5	8.7	11.85	101.8
2.0	8.7	11.85	101.9
2.5	8.7	11.85	101.8
3.0	8.7	11.86	101.8
3.5	8.7	11.83	101.6
4.0	8.7	11.82	101.6
4.5	8.7	11.81	101.4
5.0	8.7	11.80	101.4
5.5	8.7	11.82	101.2
6.0	8.6	11.80	101.2
6.5	8.6	11.80	101.1
7.0	8.7	11.77	101.1
7.5	8.7	11.78	101.1
8.0	8.6	11.79	101
8.5	8.6	11.79	100.9
9.0	8.6	11.78	100.9
9.5	8.6	11.77	100.8
10.0	8.6	11.76	100.8
11.0	8.6	11.72	100.7
12.0	8.7	11.70	100.5
13.0	8.6	11.71	100.4

Doris Lake North			
21-Aug-13			
Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen Saturation (%)
0.0	12.9	10.27	97.3
0.5	12.9	10.31	97.7
1.0	12.9	10.32	97.7
1.5	12.9	10.29	97.4
2.0	12.9	10.26	97.1
2.5	12.9	10.18	96.4
3.0	12.9	10.21	96.7
3.5	12.9	10.18	96.3
4.0	12.9	10.16	96.2
4.5	12.9	10.02	94.6
5.0	12.8	9.92	93.9
5.5	12.8	9.80	92.1
6.0	12.7	9.45	89.1
6.5	12.6	9.37	88.2
7.0	12.6	9.44	88.9
7.5	12.6	9.53	89.7
8.0	12.6	9.51	89.3
8.5	12.6	9.33	87.8
9.0	12.6	9.10	85.6
9.5	12.6	9.10	85.6
10.0	12.5	8.58	80.5
11.0	12.4	7.61	71.2
12.0	12.3	8.41	78.2

Doris Lake North			
20-Sep-13			
Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen Saturation (%)
0.0	4.7	13.99	108.7
0.5	4.8	13.94	108.6
1.0	4.8	13.92	108.5
1.5	4.8	13.90	108.3
2.0	4.8	13.90	108.3
2.5	4.8	13.90	108.2
3.0	4.8	13.88	108.1
3.5	4.8	13.86	107.9
4.0	4.8	13.84	107.8
4.5	4.8	13.83	107.7
5.0	4.8	13.81	107.6
5.5	4.8	13.78	107.3
6.0	4.8	13.75	107.2
6.5	4.8	13.75	107.1
7.0	4.8	13.74	107
7.5	4.8	13.73	107
8.0	4.8	13.72	106.9
8.5	4.8	13.72	106.8
9.0	4.8	13.70	106.8
9.5	4.8	13.69	106.6
10.0	4.8	13.68	106.6
11.0	4.8	13.66	106.4
12.0	4.8	13.60	105.9

Annex A.2-1. Temperature and Dissolved Oxygen Profiles for AEMP Lakes, Doris North Project, 2013

Reference Lake B			
28-Apr-13			
Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen Saturation (%)
1.95	0.3	10.55	n/a
2.45	0.6	10.53	n/a
3.08	1.1	10.53	n/a
3.64	1.5	10.62	n/a
4.35	1.8	10.25	n/a
4.96	2.0	9.76	n/a
5.49	2.2	9.31	n/a
5.97	2.3	8.76	n/a
6.56	2.4	8.06	n/a
7.04	2.5	7.52	n/a
7.58	2.6	7.06	n/a
8.05	2.8	6.64	n/a
8.66	3.0	6.14	n/a
9.04	3.1	5.55	n/a
9.49	3.3	4.99	n/a
9.80	3.3	4.25	n/a

Reference Lake B			
19-Jul-13			
Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen Saturation (%)
0.0	10.8	11.32	101.7
0.5	10.6	11.31	101.5
1.0	10.5	11.29	101.5
1.5	10.5	11.31	101.4
2.0	10.5	11.29	101.2
2.5	10.5	11.28	101.1
3.0	10.5	11.28	101.1
3.5	10.5	11.26	101
4.0	10.5	11.27	100.9
4.5	10.5	11.25	100.8
5.0	10.5	11.23	100.7
5.5	10.5	11.23	100.6
6.0	10.5	11.22	100.5
6.5	10.5	11.21	100.5
7.0	10.4	11.2	100.3
7.5	10.3	11.18	99.8
8.0	10.2	11.18	99.5
8.5	10.2	11.16	99.2
9.0	10.1	11.16	99.2

Reference Lake B			
18-Aug-13			
Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen Saturation (%)
0.0	13.3	10.42	99.8
0.5	13.4	10.4	99.6
1.0	13.5	10.38	99.6
1.5	13.5	10.37	99.5
2.0	13.5	10.37	99.5
2.5	13.5	10.36	99.4
3.0	13.5	10.35	99.4
3.5	13.5	10.35	99.3
4.0	13.5	10.34	99.2
4.5	13.4	10.33	99.1
5.0	13.3	10.38	99.2
5.5	13.2	10.39	99
6.0	13.1	10.38	98.8
6.5	12.8	10.4	98.3
7.0	12.6	10.34	97.3
7.5	12.5	10.36	97.2
8.0	12.5	10.37	97.3
8.5	12.5	10.37	97.3
9.0	12.5	10.36	97.3
9.5	12.5	10.36	97.2

Reference Lake B			
23-Sep-13			
Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen Saturation (%)
0.0	3	13.41	99.6
0.5	3	13.43	99.8
1.0	3	13.44	99.8
1.5	3	13.44	99.8
2.0	3	13.42	99.7
2.5	3	13.46	99.7
3.0	3	13.42	99.7
3.5	3	13.41	99.6
4.0	3	13.4	99.5
4.5	3	13.39	99.5
5.0	3	13.38	99.4
5.5	3	13.38	99.4
6.0	3	13.37	99.3
6.5	3	13.36	99.2
7.0	3	13.35	99.2
7.5	3	13.34	99.1
8.0	3	13.33	99
8.5	3	13.32	99
9.0	3	13.31	98.9
9.5	3	13.3	98.8
10.0	3	13.3	98.8
10.5	3	12.47	92.6

Little Roberts Lake			
27-Apr-13			
Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen Saturation (%)
1.90	0.0	9.97	68.4

Little Roberts Lake			
20-Jul-13			
Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen Saturation (%)
0.0	12.8	11.30	106.7
0.5	12.7	11.32	106.7
1.0	12.6	11.34	106.7
1.5	12.5	11.10	106.7

Little Roberts Lake			
21-Aug-13			
Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen Saturation (%)
0.0	10.1	11.14	98.9
0.5	10.1	11.14	98.9
1.0	10.1	11.12	98.7
1.5	10.1	11.11	98.7
2.0	10.1	11.19	99.6

Little Roberts Lake			
19-Sep-13			
Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen Saturation (%)
0.0	2.6	14.59	107.3
0.5	2.7	14.56	107.3
1.0	2.7	14.56	107.3
1.5	2.7	14.56	107.2
2.0	2.7	14.65	107.2

Reference Lake D			
28-Apr-13			
Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen Saturation (%)
2.48	0.3	2.96	n/a
2.63	0.2	2.93	n/a
2.63	0.2	2.91	n/a

Reference Lake D			
21-Jul-13			
Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen Saturation (%)
0.0	13.2	10.78	102.7
0.5	13.2	10.73	102.3
1.0	13.2	10.73	102.3
1.5	13.2	10.72	102.2
2.0	13.2	10.72	102.2
2.5	13.2	10.72	102.2

Reference Lake D			
18-Aug-13			
Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen Saturation (%)
0.0	12.2	10.79	100.4
0.5	12.0	10.87	100.9
1.0	12.0	10.89	100.8
1.5	11.8	11.00	101.6
2.0	11.7	11.70	102.3
2.5	11.7	11.11	102.5
3.0	11.6	11.3	104

Reference Lake D			
21-Sep-13			
Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen Saturation (%)
0.0	2.2	14.02	101.9
0.5	2.1	14.07	102
1.0	2.1	14.07	102
1.5	2.1	14.07	102
2.0	2.1	14.06	102
2.5	2.1	14.05	101.9
3.0	2.1	14.05	101.9
3.5	2.1	14.05	101.9

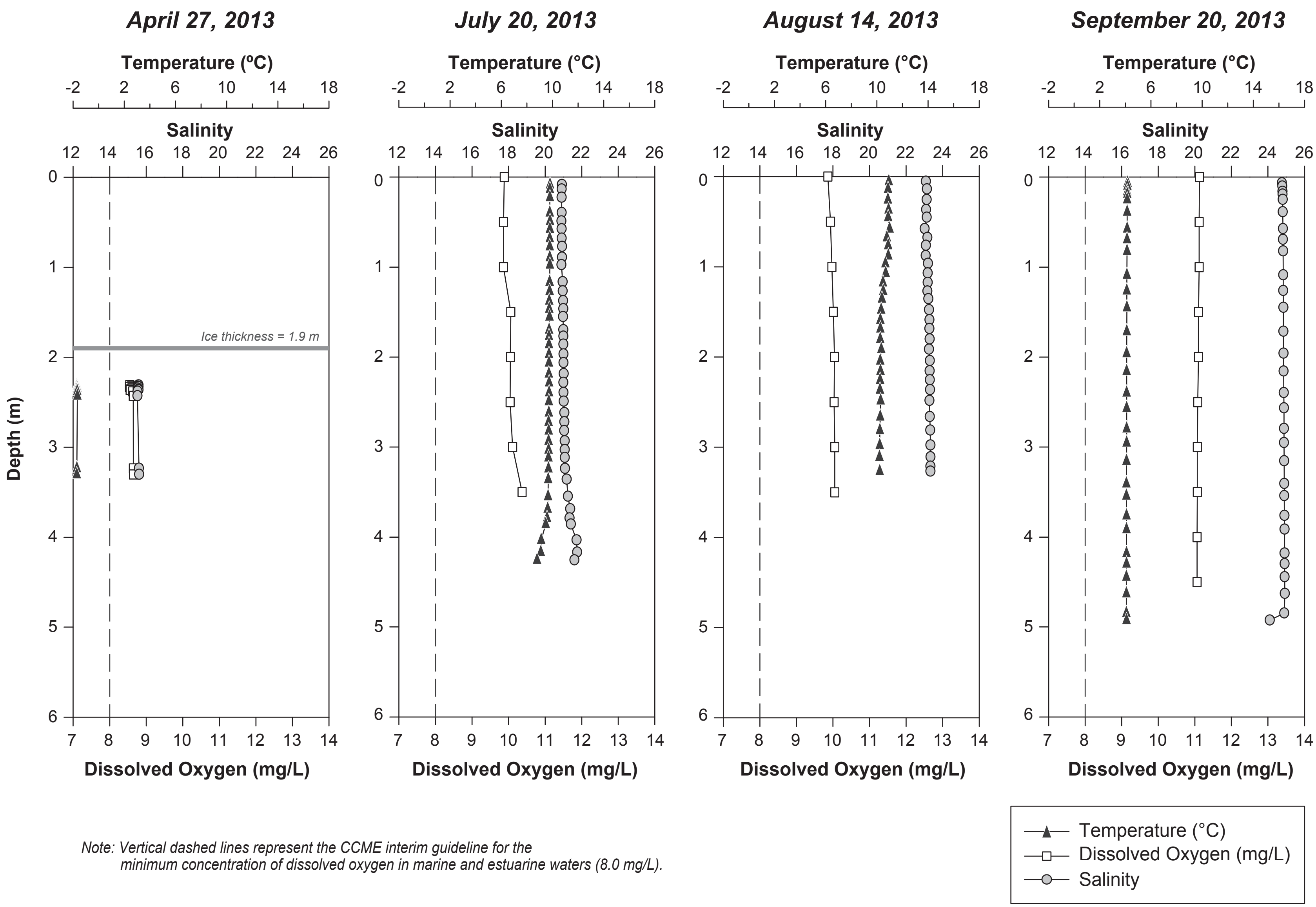
A.2.3 Marine Data

Marine Secchi depths and calculated euphotic zone depths (1% light level) are shown in Table A.2-3. Figures A.2-6 to A.2-8 show the temperature, dissolved oxygen, and salinity profiles collected at marine sites between April and September 2013; 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, 2013

Marine Site	Sampling Date	Secchi Depth (D_s) (m)	Euphotic Zone Depth 1% Light Level (m)
RBW	July 20, 2013	3.6	9.7*
	August 14, 2013	Bottom (4.5)	-
	September 20, 2013	Bottom (5.1)	-
RBE	July 20, 2013	Bottom (1.1)	-
	August 14, 2013	Bottom (0.65)	-
	September 21, 2013	Bottom (0.7)	-
REF-Marine 1	July 21, 2013	3.7	10.0*
	August 15, 2013	Bottom (8.0)	-
	September 28, 2013	Bottom (5.4)	-

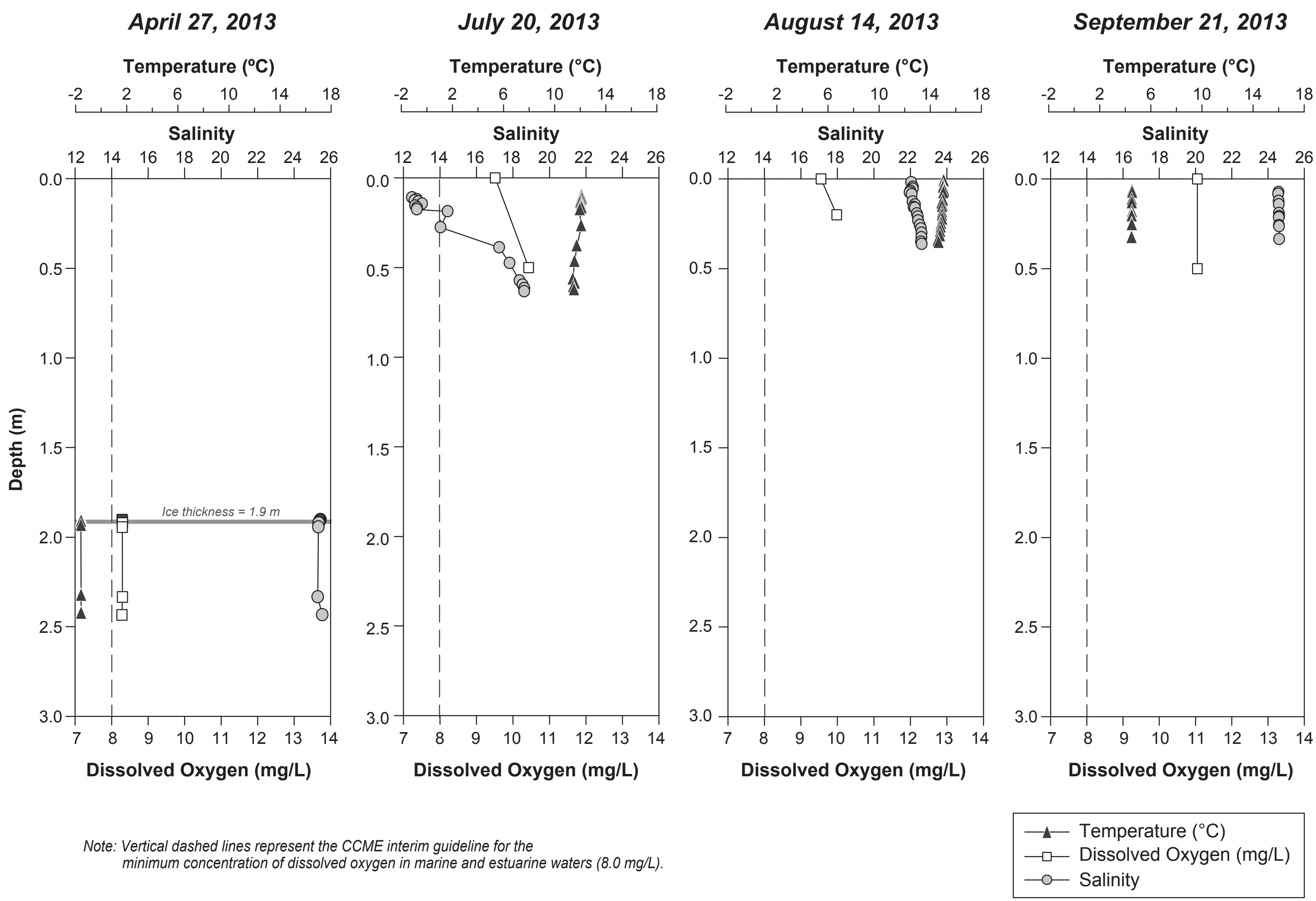
*Note: * indicates that the euphotic zone extended to the bottom of the water column.*



Note: 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 A.2-6

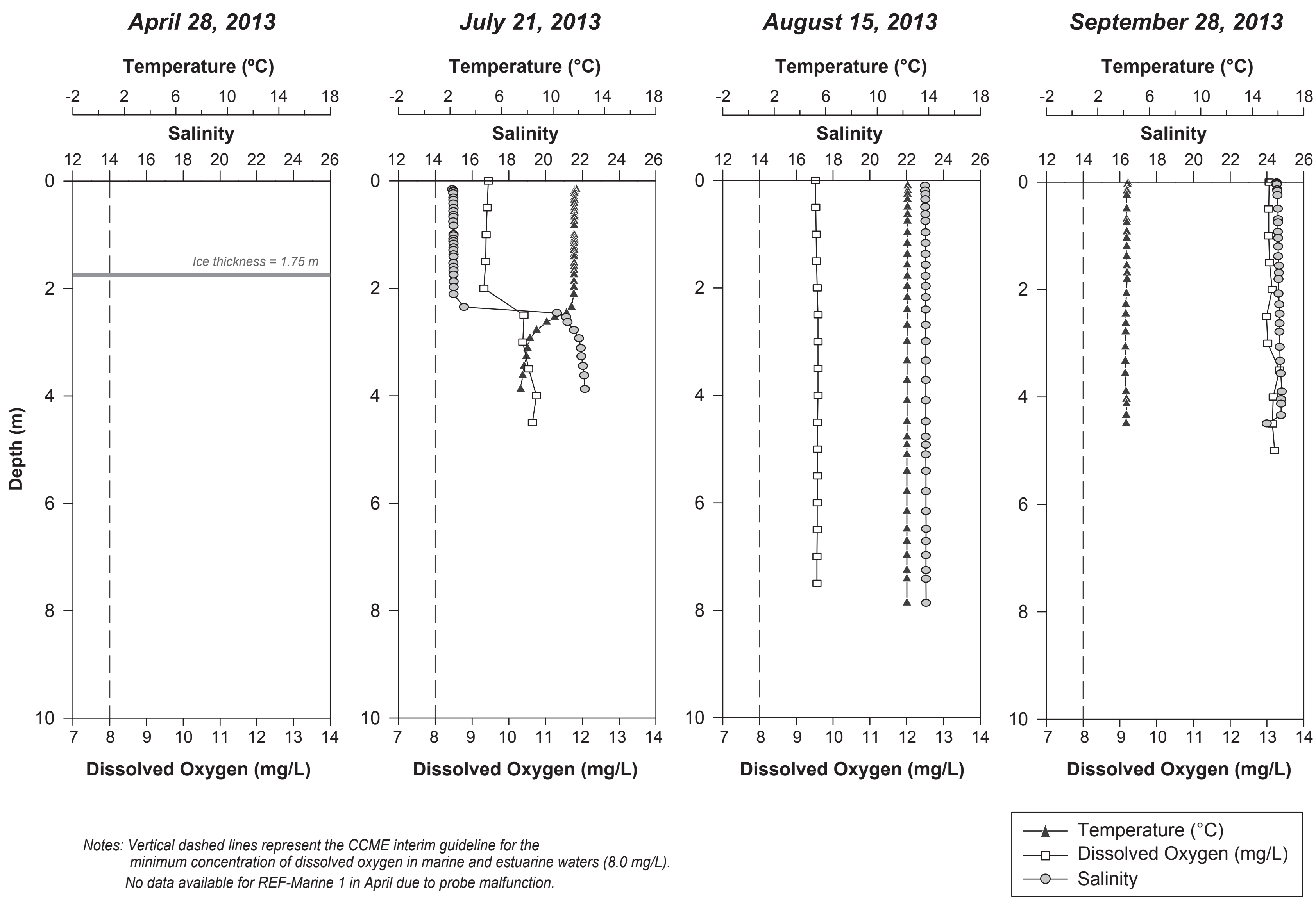
Temperature, Salinity, and Dissolved Oxygen Profiles at Marine Site RBW, Doris North Project, 2013



Note: 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 A.2-7

Temperature, Salinity, and Dissolved Oxygen Profiles at Marine Site RBE, Doris North Project, 2013



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 data available for REF-Marine 1 in April due to probe malfunction.

Figure A.2-8

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Temperature, Salinity, and Dissolved Oxygen Profiles at Marine Site REF-Marine 1, Doris North Project, 2013

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Annex A.2-2. Temperature and Salinity Profiles for AEMP Marine Sites, Doris North Project, 2013

RBW		
27-Apr-12		
Depth (m)	Temperature (°C)	Salinity
2.31	-1.7	15.6
2.32	-1.7	15.5
2.33	-1.7	15.6
2.34	-1.7	15.5
2.36	-1.7	15.6
2.36	-1.7	15.6
2.38	-1.7	15.5
2.43	-1.7	15.5
3.23	-1.7	15.6
3.30	-1.7	15.6

RBW		
20-Jul-13		
Depth (m)	Temperature (°C)	Salinity
0.08	9.8	20.9
0.13	9.8	20.9
0.23	9.8	20.9
0.39	9.8	20.9
0.49	9.8	20.9
0.58	9.8	20.9
0.68	9.8	20.9
0.77	9.8	20.9
0.89	9.8	20.9
0.97	9.8	20.9
1.16	9.8	21.0
1.27	9.8	21.0
1.37	9.7	21.0
1.46	9.7	21.0
1.55	9.8	21.0
1.70	9.7	21.0
1.77	9.7	21.0
1.86	9.7	21.0
1.97	9.7	21.0
2.06	9.7	21.0
2.19	9.7	21.0
2.28	9.7	21.0
2.39	9.7	21.0
2.49	9.7	21.0
2.62	9.7	21.0
2.72	9.7	21.0
2.82	9.7	21.0
2.93	9.7	21.1
3.03	9.7	21.1
3.12	9.7	21.1
3.24	9.7	21.1
3.36	9.7	21.2
3.55	9.7	21.3
3.69	9.6	21.4
3.79	9.6	21.3
3.86	9.5	21.4
4.03	9.1	21.7
4.17	9.1	21.8
4.26	8.8	21.6

RBW		
14-Aug-13		
Depth (m)	Temperature (°C)	Salinity
0.05	10.9	23.1
0.14	10.9	23.1
0.26	10.9	23.1
0.37	10.9	23.1
0.45	10.9	23.1
0.58	11.0	23.0
0.68	10.8	23.2
0.76	10.9	23.1
0.88	10.9	23.1
0.96	10.7	23.2
1.07	10.7	23.2
1.18	10.5	23.2
1.27	10.5	23.2
1.35	10.4	23.2
1.48	10.3	23.3
1.59	10.3	23.3
1.69	10.3	23.3
1.80	10.3	23.3
1.91	10.3	23.3
2.04	10.3	23.3
2.15	10.3	23.3
2.25	10.3	23.3
2.36	10.2	23.3
2.48	10.3	23.3
2.66	10.3	23.3
2.81	10.2	23.3
2.98	10.2	23.3
3.11	10.2	23.3
3.21	10.2	23.3
3.27	10.2	23.3

Annex A.2-2. Temperature and Salinity Profiles for AEMP Marine Sites, Doris North Project, 2013

RBW		
20-Sep-13		
Depth (m)	Temperature (°C)	Salinity
0.06	4.2	24.8
0.10	4.2	24.8
0.16	4.1	24.8
0.19	4.1	24.8
0.25	4.1	24.8
0.39	4.1	24.8
0.57	4.1	24.8
0.69	4.1	24.8
0.82	4.1	24.8
1.09	4.1	24.8
1.26	4.1	24.8
1.45	4.1	24.8
1.71	4.1	24.8
1.96	4.1	24.9
2.16	4.1	24.9
2.40	4.1	24.9
2.57	4.1	24.9
2.79	4.1	24.9
2.95	4.1	24.9
3.15	4.1	24.9
3.41	4.1	24.9
3.54	4.1	24.9
3.76	4.1	24.9
3.91	4.1	24.9
4.18	4.1	24.9
4.30	4.1	24.9
4.44	4.1	24.9
4.63	4.1	24.9
4.85	4.1	24.9
4.93	4.1	24.1

RBE		
27-Apr-12		
Depth (m)	Temperature (°C)	Salinity
1.90	-1.5	25.4
1.91	-1.5	25.4
1.91	-1.5	25.4
1.91	-1.5	25.4
1.92	-1.5	25.4
1.92	-1.5	25.3
1.92	-1.5	25.4
1.94	-1.5	25.3
2.33	-1.5	25.3
2.43	-1.5	25.5

RBE		
20-Jul-13		
Depth (m)	Temperature (°C)	Salinity
0.11	11.9	12.5
0.12	12.0	12.7
0.13	11.9	12.6
0.13	11.9	12.8
0.14	11.8	13.0
0.16	11.9	12.6
0.17	11.9	12.7
0.18	11.9	12.7
0.19	11.8	14.4
0.28	11.9	14.0
0.39	11.6	17.2
0.48	11.4	17.8
0.57	11.2	18.4
0.60	11.4	18.5
0.62	11.3	18.6
0.63	11.3	18.6

RBE		
14-Aug-13		
Depth (m)	Temperature (°C)	Salinity
0.02	14.9	22.0
0.05	14.8	22.1
0.06	14.8	22.1
0.07	14.9	22.0
0.08	14.9	22.0
0.08	14.9	22.1
0.13	14.8	22.1
0.14	14.7	22.2
0.16	14.8	22.2
0.16	14.8	22.2
0.19	14.8	22.4
0.21	14.8	22.4
0.23	14.8	22.4
0.26	14.7	22.5
0.28	14.6	22.6
0.30	14.6	22.6
0.33	14.6	22.6
0.35	14.4	22.6
0.36	14.5	22.6

RBE		
21-Sep-13		
Depth (m)	Temperature (°C)	Salinity
0.07	4.4	24.6
0.08	4.4	24.6
0.12	4.4	24.6
0.14	4.4	24.6
0.19	4.4	24.6
0.21	4.4	24.6
0.21	4.4	24.6
0.26	4.4	24.6
0.26	4.4	24.6
0.34	4.4	24.6

Annex A.2-2. Temperature and Salinity Profiles for AEMP Marine Sites, Doris North Project, 2013

REF-Marine 1		
28-Apr-13		
Depth (m)	Temperature (°C)	Salinity
n/a	n/a	n/a

Note: No data available, CTD malfunctioned.

REF-Marine 1		
21-Jul-13		
Depth (m)	Temperature (°C)	Salinity
0.16	11.8	14.9
0.18	11.7	15.0
0.19	11.7	15.0
0.23	11.7	15.0
0.31	11.7	15.0
0.35	11.7	15.0
0.42	11.7	15.0
0.50	11.7	15.0
0.56	11.7	15.0
0.64	11.7	15.0
0.67	11.7	15.0
0.76	11.7	15.0
0.83	11.6	15.0
0.99	11.6	15.0
1.02	11.7	15.0
1.08	11.7	15.0
1.12	11.7	15.0
1.17	11.6	15.0
1.24	11.6	15.0
1.29	11.6	15.0
1.37	11.6	15.0
1.41	11.6	15.0
1.53	11.6	15.0
1.60	11.6	15.0
1.67	11.6	15.0
1.75	11.6	15.0
1.87	11.6	15.0
1.98	11.6	15.0
2.11	11.6	15.0
2.35	11.4	15.6
2.46	11.0	20.6
2.54	10.1	21.1
2.63	9.5	21.2
2.78	8.7	21.5
2.93	8.2	21.8
3.11	8.0	21.9
3.27	7.9	21.9
3.45	7.8	22.0
3.62	7.6	22.1
3.88	7.5	22.1

REF-Marine 1		
15-Aug-13		
Depth (m)	Temperature (°C)	Salinity
0.10	12.4	23.0
0.19	12.4	23.0
0.25	12.4	23.0
0.35	12.4	23.0
0.49	12.4	23.0
0.63	12.4	23.0
0.75	12.3	23.0
0.97	12.3	23.0
1.16	12.3	23.0
1.37	12.3	23.0
1.57	12.3	23.0
1.78	12.3	23.0
1.97	12.3	23.0
2.17	12.3	23.0
2.40	12.3	23.0
2.69	12.3	23.0
2.99	12.3	23.0
3.35	12.3	23.0
3.72	12.3	23.0
4.09	12.3	23.0
4.49	12.3	23.0
4.77	12.3	23.0
4.92	12.3	23.0
5.10	12.3	23.0
5.41	12.3	23.1
5.79	12.3	23.1
6.16	12.3	23.1
6.49	12.3	23.1
6.72	12.3	23.1
6.98	12.3	23.1
7.26	12.3	23.1
7.42	12.3	23.1
7.87	12.3	23.1

REF-Marine 1		
28-Sep-13		
Depth (m)	Temperature (°C)	Salinity
0.01	4.3	24.5
0.01	4.3	24.5
0.02	4.4	24.5
0.03	4.4	24.5
0.04	4.3	24.5
0.14	4.3	24.6
0.16	4.3	24.6
0.24	4.3	24.6
0.50	4.2	24.6
0.69	4.2	24.6
0.75	4.2	24.6
0.93	4.3	24.6
1.04	4.2	24.6
1.20	4.2	24.6
1.38	4.2	24.6
1.56	4.3	24.7
1.69	4.3	24.7
1.81	4.3	24.6
2.08	4.2	24.6
2.28	4.2	24.7
2.45	4.2	24.7
2.63	4.2	24.7
2.79	4.2	24.7
3.07	4.1	24.7
3.33	4.1	24.7
3.56	4.1	24.7
3.90	4.2	24.8
4.04	4.2	24.8
4.13	4.2	24.8
4.34	4.2	24.8
4.49	4.2	24.0

Annex A.2-3. Dissolved Oxygen Profiles for AEMP Marine Sites, Doris North Project, 2013

RBW — 27-Apr-13

Depth (m)	Dissolved Oxygen (mg/L)	Dissolved Oxygen Saturation (%)
2.31	8.55	n/a
2.32	8.60	n/a
2.33	8.54	n/a
2.34	8.61	n/a
2.36	8.57	n/a
2.38	8.63	n/a
2.43	8.64	n/a
3.23	8.65	n/a
3.30	8.65	n/a

RBW — 20-Jul-13

Depth (m)	Dissolved Oxygen (mg/L)	Dissolved Oxygen Saturation (%)
0.0	9.88	103.6
0.5	9.86	102.7
1.0	9.86	102.6
1.5	10.06	103.3
2.0	10.05	103.0
2.5	10.04	103.2
3.0	10.11	102.9
3.5	10.37	103.5

RBW — 14-Aug-13

Depth (m)	Dissolved Oxygen (mg/L)	Dissolved Oxygen Saturation (%)
0.0	9.86	105.6
0.5	9.93	106.0
1.0	9.97	106.1
1.5	10.01	106.1
2.0	10.04	106.2
2.5	10.03	106.1
3.0	10.05	106.0
3.5	10.05	106.0

RBW — 20-Sep-13

Depth (m)	Dissolved Oxygen (mg/L)	Dissolved Oxygen Saturation (%)
0.0	11.13	102.1
0.5	11.12	102.0
1.0	11.12	102.0
1.5	11.10	101.9
2.0	11.10	101.8
2.5	11.08	101.7
3.0	11.07	101.5
3.5	11.07	101.5
4.0	11.06	101.4
4.5	11.06	101.4

RBE — 27-Apr-13

Depth (m)	Dissolved Oxygen (mg/L)	Dissolved Oxygen Saturation (%)
1.90	8.28	n/a
1.91	8.29	n/a
1.92	8.29	n/a
1.94	8.29	n/a
2.33	8.30	n/a
2.43	8.28	n/a

RBE — 20-Jul-13

Depth (m)	Dissolved Oxygen (mg/L)	Dissolved Oxygen Saturation (%)
0.0	9.51	104.8
0.5	10.43	114.6

RBE — 14-Aug-13

Depth (m)	Dissolved Oxygen (mg/L)	Dissolved Oxygen Saturation (%)
0.0	9.55	112.9
0.2	9.98	112.8

RBE — 21-Sep-13

Depth (m)	Dissolved Oxygen (mg/L)	Dissolved Oxygen Saturation (%)
0.0	11.05	101.1
0.5	11.05	101.1

REF-Marine 1 — 28-Apr-13

Depth (m)	Dissolved Oxygen (mg/L)	Dissolved Oxygen Saturation (%)
n/a	n/a	n/a

Note: No data available, CTD malfunctioned.

REF-Marine 1 — 21-Jul-13

Depth (m)	Dissolved Oxygen (mg/L)	Dissolved Oxygen Saturation (%)
0.0	9.44	102.9
0.5	9.41	102.5
1.0	9.38	102.2
1.5	9.37	102.0
2.0	9.32	101.6
2.5	10.41	105.0
3.0	10.38	103.5
3.5	10.54	104.4
4.0	10.75	105.0
4.5	10.64	103.0

REF-Marine 1 — 15-Aug-13

Depth (m)	Dissolved Oxygen (mg/L)	Dissolved Oxygen Saturation (%)
0.0	9.52	105.6
0.5	9.53	105.7
1.0	9.54	105.9
1.5	9.55	105.9
2.0	9.57	106.0
2.5	9.59	106.2
3.0	9.59	106.2
3.5	9.59	106.2
4.0	9.59	106.1
4.5	9.58	106.1
5.0	9.58	106.0
5.5	9.58	106.0
6.0	9.57	105.9
6.5	9.57	105.8
7.0	9.56	105.8
7.5	9.56	105.7

REF-Marine 1 — 28-Sep-13

Depth (m)	Dissolved Oxygen (mg/L)	Dissolved Oxygen Saturation (%)
0.0	13.06	99.1
0.5	13.05	99.0
1.0	13.05	99.1
1.5	13.07	99.2
2.0	13.14	99.7
2.5	12.99	98.6
3.0	13.02	98.7
3.5	13.34	101.9
4.0	13.17	100.2
4.5	13.15	100.0
5.0	13.21	100.5

A.3 2013 WATER QUALITY

The following sections present the water quality data collected between April and September 2013 from stream, lake, and marine sites, as well as the QA/QC water quality data. Only the variables that were subjected to an evaluation of effects (see main body of AEMP report) are shown graphically. All water quality variables were screened against CCME water quality guidelines for the protection of aquatic life (CCME 2013b). 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 2013. Figures A.3-1 to A.3-9 show monthly trends of select water quality variables. Annex A.3-1 presents the raw stream water quality data.

A.3.2 Lake Data

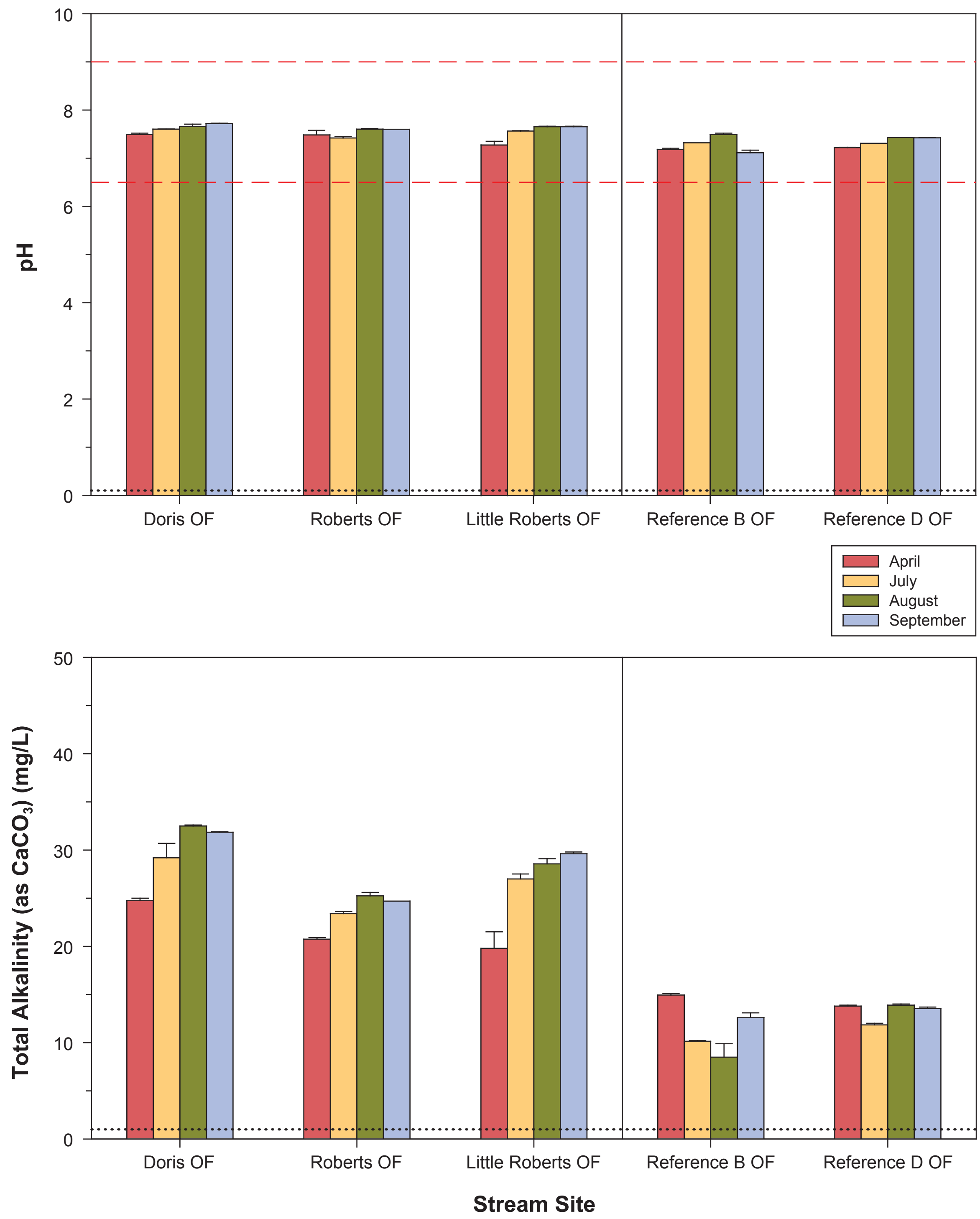
Lake water quality data were collected in April (under-ice sampling) and monthly from July to September 2013. Figures A.3-10 to A.3-18 show seasonal trends of select water quality variables. Annex A.3-2 presents the raw lake water quality data.

A.3.3 Marine Data

Marine water quality data were collected in April (under-ice sampling) and monthly from July to September 2013. Figures A.3-19 to A.3-27 show seasonal trends of select water quality variables. Annex A.3-3 presents the raw marine water quality data.

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

Annex A.3-4 presents the results of the QA/QC blank data (equipment, field, and travel blanks) collected to identify possible sources of contamination to water quality samples. There was no obvious contamination of water quality samples that can be attributed to sampling equipment, sample collection, or sample transportation.



Notes: Error bars represent the standard error of the mean of replicates.
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 A.3-1

pH and Total Alkalinity in Stream Sites, Doris North Project, 2013

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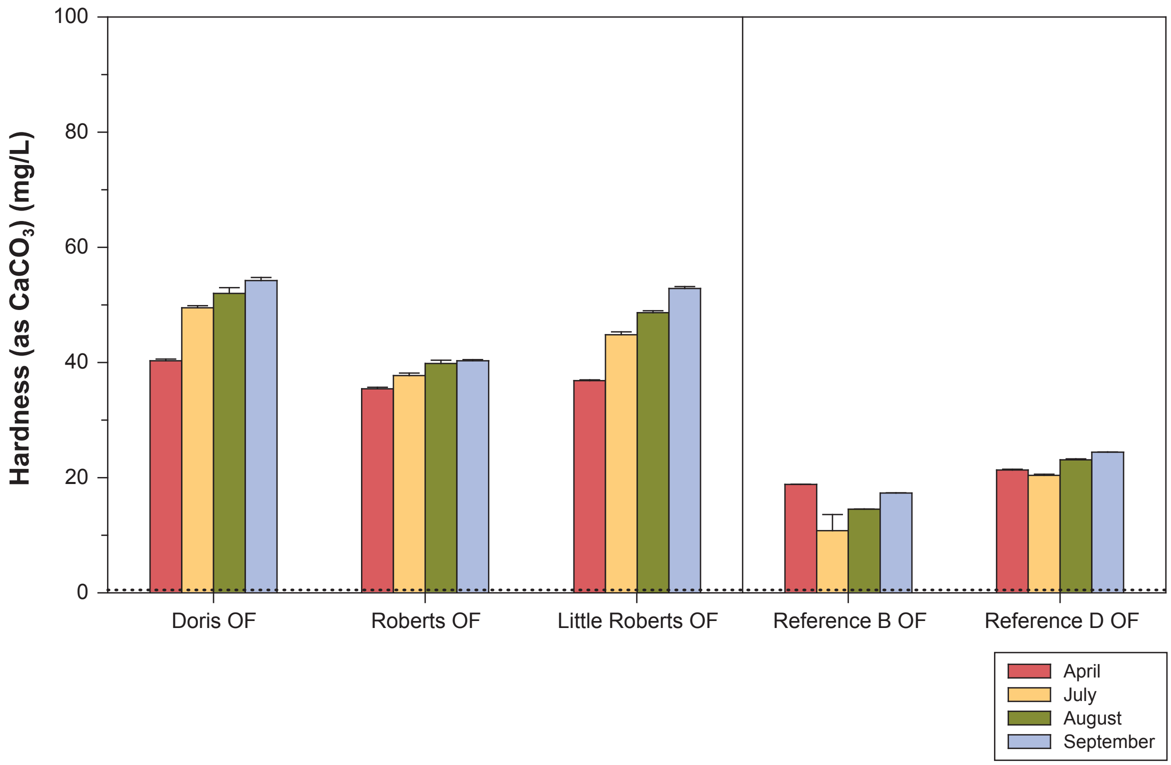

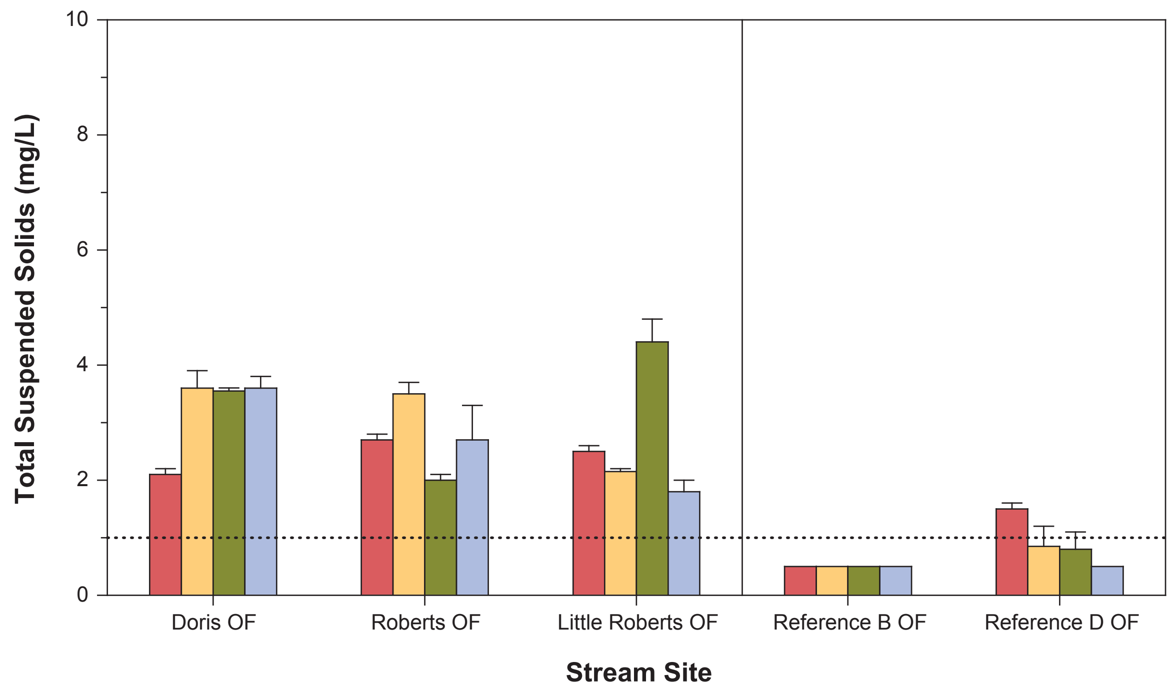

Notes: Error bars represent the standard error of the mean of replicates.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
The CCME freshwater guideline for total suspended solids is dependent upon background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

Figure A.3-2

Hardness and Total Suspended Solids in Stream Sites, Doris North Project, 2013

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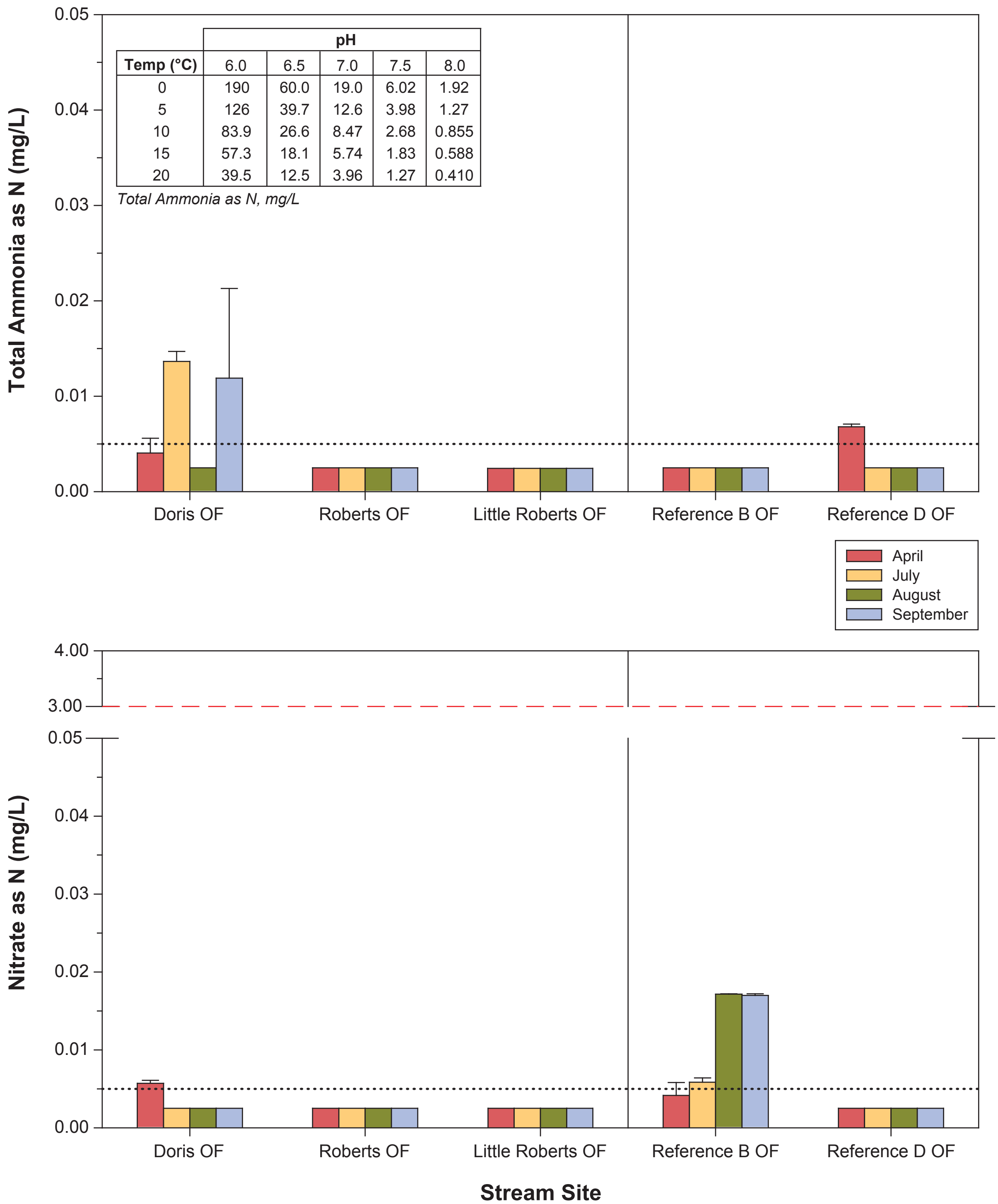

	pH				
Temp (°C)	6.0	6.5	7.0	7.5	8.0
0	190	60.0	19.0	6.02	1.92
5	126	39.7	12.6	3.98	1.27
10	83.9	26.6	8.47	2.68	0.855
15	57.3	18.1	5.74	1.83	0.588
20	39.5	12.5	3.96	1.27	0.410

Total Ammonia as N, mg/L

Notes: Error bars represent the standard error of the mean of replicates.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
Inset table shows the pH- and temperature-dependent CCME freshwater guideline for total ammonia.
Red dashed line represents the CCME freshwater guideline for nitrate as N (3.0 mg/L; long-term concentration).
Total ammonia and nitrate are required parameters for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

Figure A.3-3

Total Ammonia and Nitrate Concentrations in Stream Sites, Doris North Project, 2013

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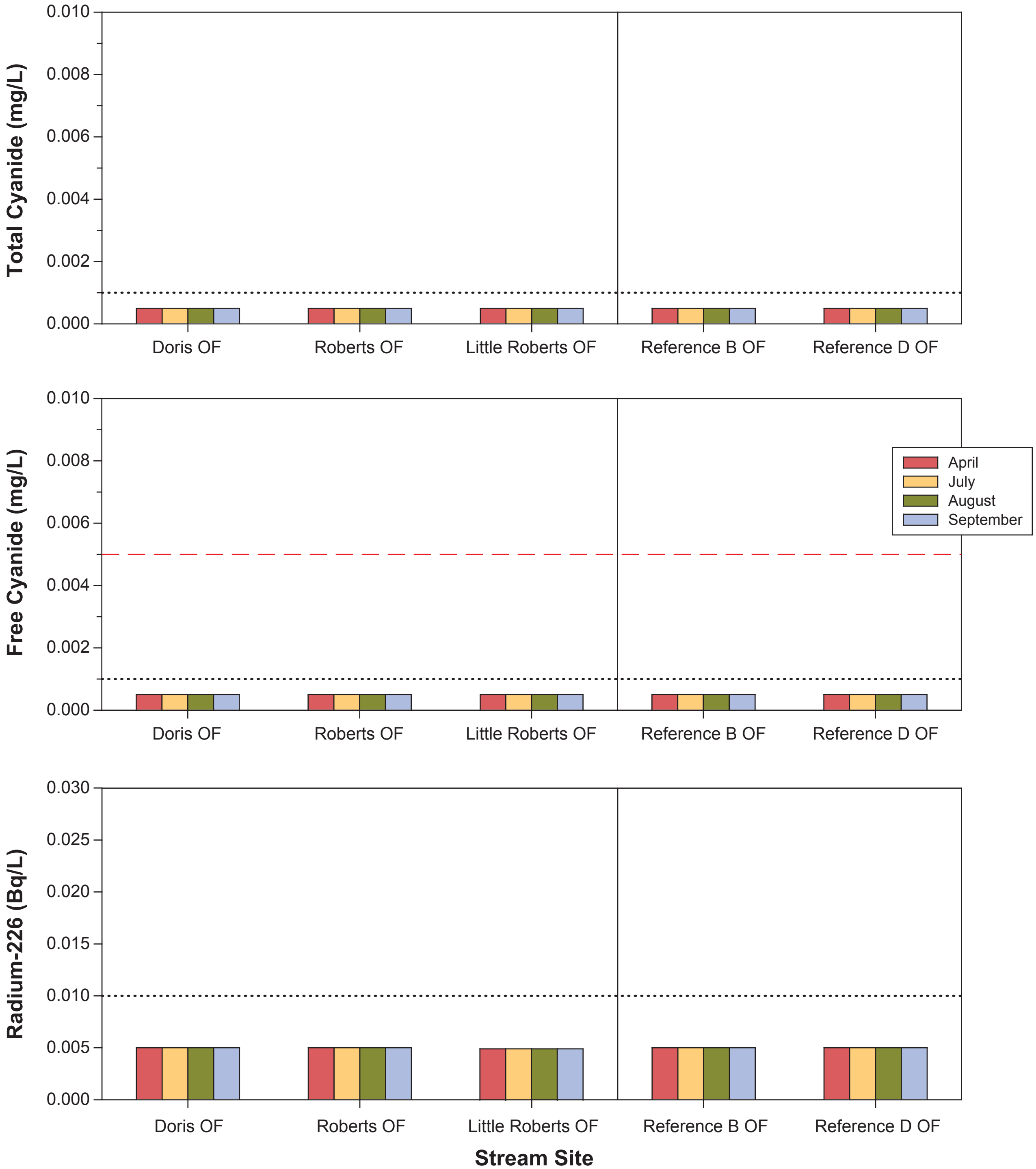

Notes: Error bars represent the standard error of the mean of replicates.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
All total cyanide, free cyanide, and radium-226 concentrations in stream samples were below the detection limit.
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.

Figure A.3-4

Total Cyanide, Free Cyanide, and Radium-226 Concentrations in Stream Sites, Doris North Project, 2013

TMAC RESOURCES

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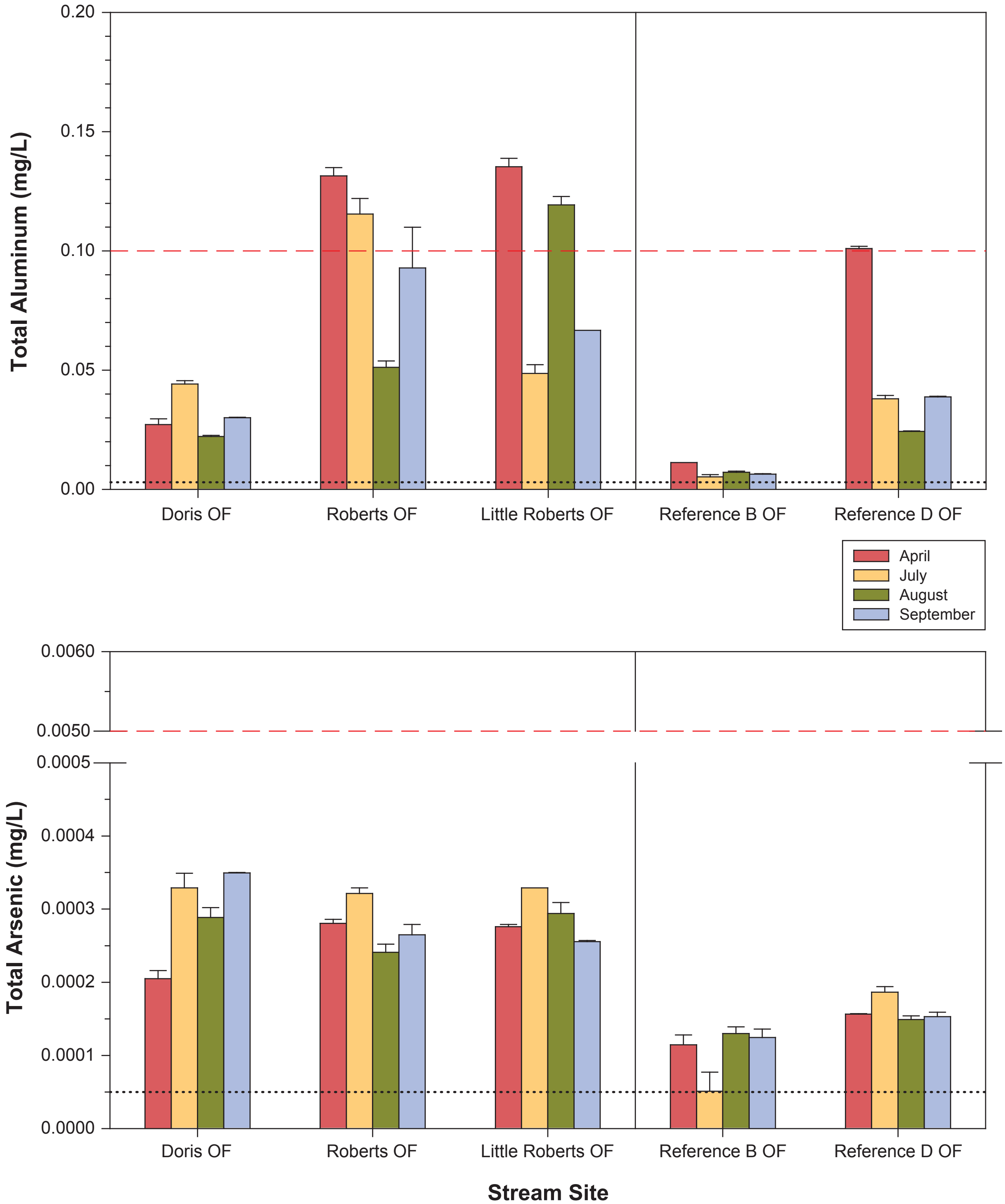

Notes: Error bars represent the standard error of the mean of replicates.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
Red dashed lines represent the pH-dependent CCME freshwater guideline for aluminum (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.
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.

Figure A.3-5

Total Aluminum and Total Arsenic Concentrations in Stream Sites, Doris North Project, 2013

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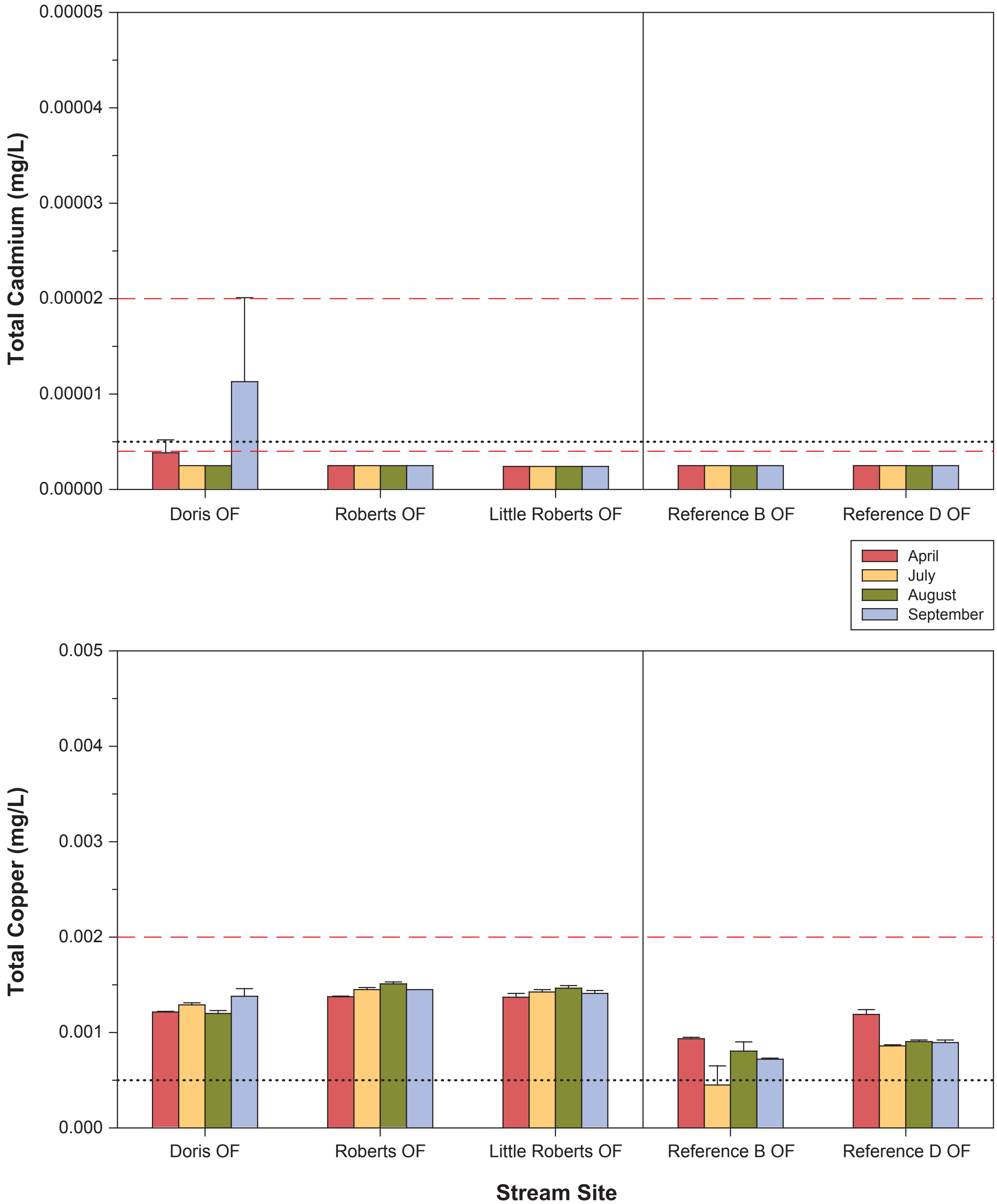

Notes: Error bars represent the standard error of the mean of replicates.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
The CCME freshwater guidelines for cadmium and copper are hardness dependent.
Red dashed lines represent the minimum and maximum CCME freshwater guidelines for cadmium (0.000004 and 0.000020 mg/L) and for copper (0.002 mg/L) based on the hardness (as $CaCO_3$) range in streams of 8.02 to 54.8 mg/L.
Mean total cadmium and total copper concentrations were always lower than applicable CCME guidelines.
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.

Figure A.3-6

Total Cadmium and Total Copper Concentrations in Stream Sites, Doris North Project, 2013

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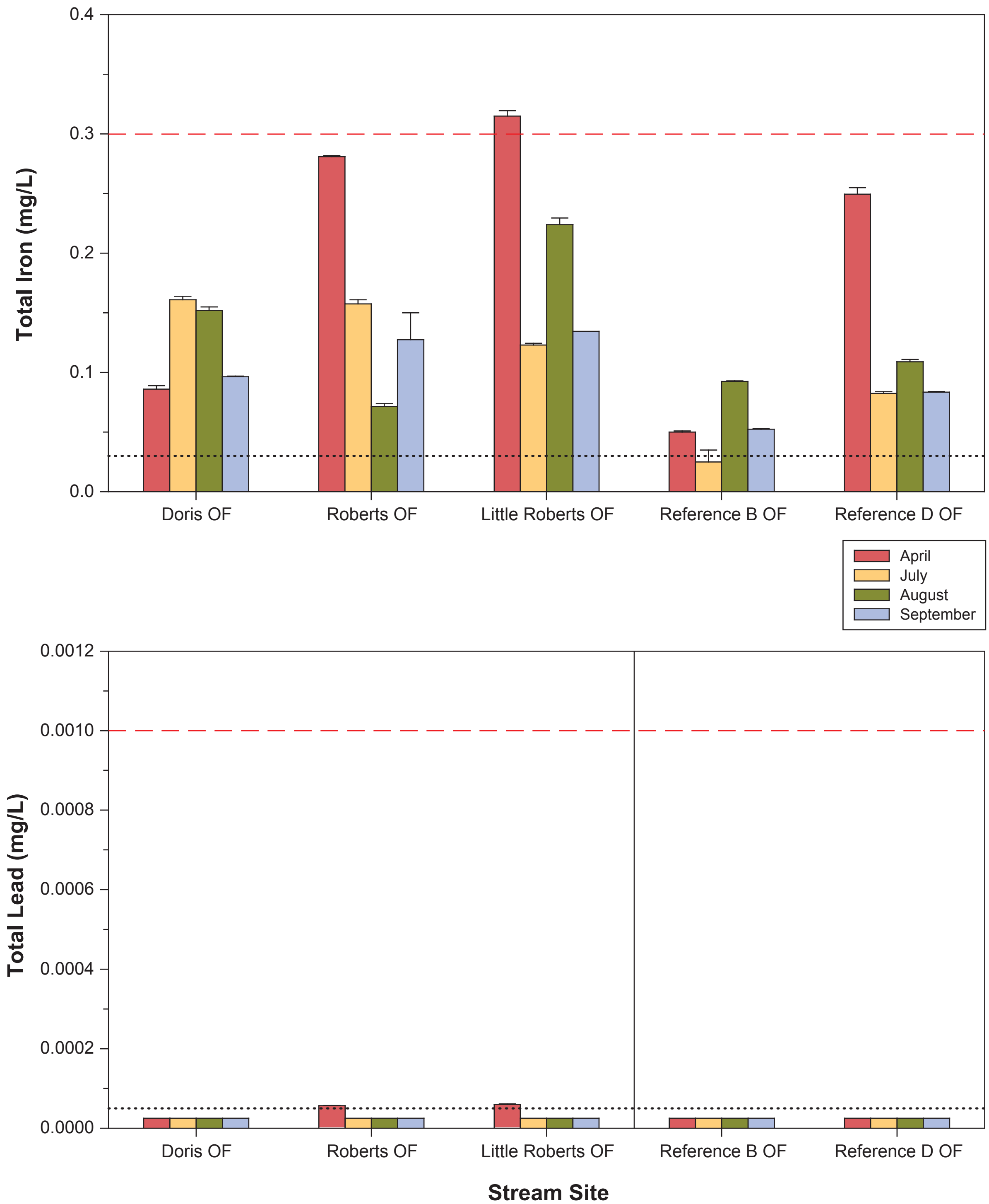

Notes: Error bars represent the standard error of the mean of replicates.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
The CCME freshwater guideline for lead is hardness dependent.
Red dashed lines represent the CCME freshwater guideline for iron (0.3 mg/L) and the CCME freshwater guideline for lead (0.001 mg/L) based on the hardness (as $CaCO_3$) range in streams of 8.02 to 54.8 mg/L.
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 A.3-7

Total Iron and Total Lead Concentrations in Stream Sites, Doris North Project, 2013

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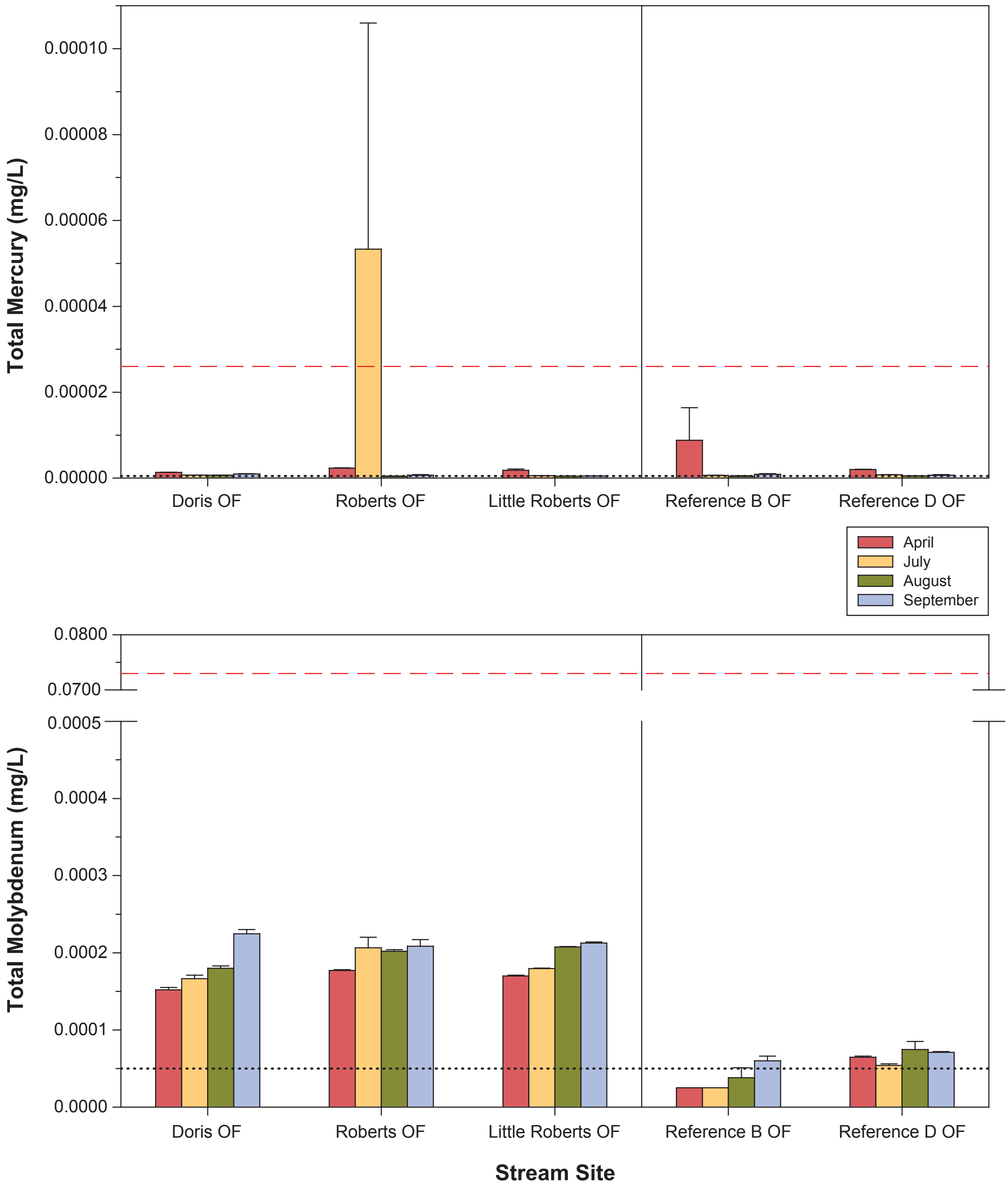

Notes: Error bars represent the standard error of the mean of replicates.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
Red dashed lines represent the CCME freshwater guidelines for inorganic mercury (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.

Figure A.3-8

Total Mercury and Total Molybdenum Concentrations in Stream Sites, Doris North Project, 2013

TMAC RESOURCES

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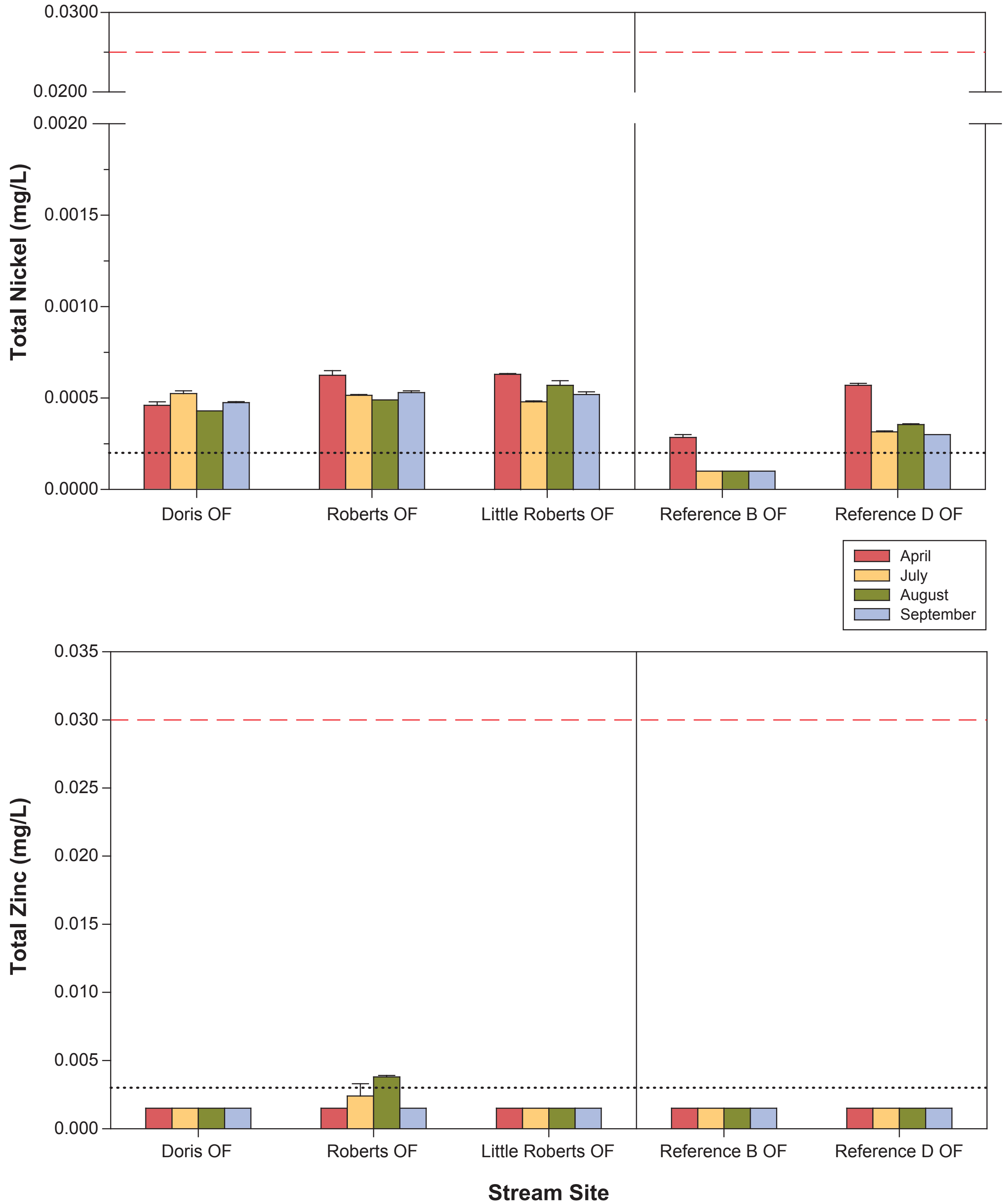


Notes: Error bars represent the standard error of the mean of replicates.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
The CCME guideline for nickel is hardness dependent.
Red dashed lines represent the CCME freshwater guideline for zinc (0.03 mg/L) and the CCME guideline for nickel (0.025 mg/L) based on the hardness (as CaCO3) range in streams of 8.02 to 54.8 mg/L.
Total nickel and total zinc are regulated as deleterious substances in effluents as per Schedule 4 of the MMER.

Figure A.3-9

Total Nickel and Total Zinc Concentrations in Stream Sites, Doris North Project, 2013

Annex A.3-1. Stream Water Quality Data, Doris North Project, 2013

Site ID:				Doris OF	Doris OF	Roberts OF	Roberts OF	Reference B OF
Replicate:				1	2	1	2	1
Date Sampled:		CCME guideline for the	Realized	12-Jun-13	12-Jun-13	13-Jun-13	13-Jun-13	13-Jun-13
ALS Sample ID:	Units	Protection of Aquatic life[a]	Detection Limit	L1317195-1	L1317195-2	L1317173-1	L1317173-2	L1317190-1
Physical Tests								
Conductivity	uS/cm		2.0	206	204	218	217	62.2
Hardness (as $CaCO_3$)	mg/L		0.50	40.0	40.6	35.2	35.7	18.8
pH	pH	6.5-9.0	0.10	7.47	7.52	7.58	7.39	7.16
Total Suspended Solids	mg/L	dependent on background levels	1.0	2.0	2.2	2.6	2.8	<1.0
Total Dissolved Solids	mg/L		10	88	111	114	112	39
Turbidity	NTU	dependent on background levels	0.10	1.81	1.88	2.60	3.00	0.62
Anions and Nutrients								
Alkalinity, Total (as $CaCO_3$)	mg/L		1.0 or 2.0	24.5	25.0	20.9	20.6	15.1
Ammonia, Total (as N)	mg/L	pH- and temperature-dependent	0.0050	0.0056	<0.0050	<0.0050	<0.0050	<0.0050
Bromide (Br)	mg/L		0.050	0.153	0.149	0.172	0.175	<0.050
Chloride (Cl)	mg/L	short-term: 640; long-term: 120	0.50	46.4	46.6	51.9	52.3	8.61
Fluoride (F)	mg/L	Inorganic fluorides: 0.12[b]	0.020	0.043	0.045	0.040	0.039	0.023
Nitrate (as N)	mg/L	short-term: 124; long-term: 3.0	0.0050	0.0061	0.0053	<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
Total Kjeldahl Nitrogen	mg/L		0.050	0.407	0.395	0.362	0.383	0.285
Total Nitrogen	mg/L		0.050	-	-	-	-	-
Orthophosphate-Dissolved (as P)	mg/L		0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Phosphorus (P)	mg/L	Trigger ranges from guidance framework[c]	0.0020	0.0158	0.0150	0.0204	0.0212	0.0055
Sulfate (SO_4)	mg/L		0.50	2.83	2.84	3.95	3.88	2.19
Cyanides								
Cyanide, Total	mg/L		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
Organic / Inorganic Carbon								
Dissolved Organic Carbon	mg/L		0.50	4.62	4.47	5.48	5.66	3.77
Total Organic Carbon	mg/L		0.50	4.79	4.82	5.73	5.56	3.92
Total Metals								
Aluminum (Al)	mg/L	0.005 if pH<6.5; 0.1 if pH≥6.5	0.0030	0.0296	0.0248	0.135	0.128	0.0113
Antimony (Sb)	mg/L		0.00001-0.00003	<0.000030	<0.000030	<0.000030	<0.000030	<0.000020
Arsenic (As)	mg/L	0.005	0.000050	0.000194	0.000216	0.000275	0.000286	0.000128
Barium (Ba)	mg/L		0.00010	0.00263	0.00260	0.00377	0.00400	0.00266
Beryllium (Be)	mg/L		0.0000050	<0.0000050	<0.0000050	0.0000078	0.0000071	<0.0000050
Bismuth (Bi)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Boron (B)	mg/L	short-term: 29; long-term: 1.5	0.0050	0.0234	0.0248	0.0297	0.0330	0.0153
Cadmium (Cd)	mg/L	equation[b,d]	0.0000050	<0.0000050	0.0000052	<0.0000050	<0.0000050	<0.0000050
Calcium (Ca)	mg/L		0.050	7.65	7.76	4.84	4.89	4.52
Cesium (Cs)	mg/L		0.0000050	<0.0000050	0.0000052	0.0000095	0.0000102	0.0000053
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
Cobalt (Co)	mg/L		0.000050	<0.000050	<0.000050	0.000094	0.000086	<0.000050
Copper (Cu)	mg/L	0.002-0.004[e]	0.00050	0.00122	0.00121	0.00137	0.00138	0.00092
Gallium (Ga)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Iron (Fe)	mg/L	0.3	0.030	0.089	0.083	0.282	0.280	0.049
Lead (Pb)	mg/L	0.001-0.007[f]	0.000050	<0.000050	<0.000050	0.000057	0.000056	<0.000050
Lithium (Li)	mg/L		0.00020	0.00294	0.00303	0.00250	0.00264	0.00068
Magnesium (Mg)	mg/L		0.10	5.08	5.15	5.60	5.71	1.83
Manganese (Mn)	mg/L		0.00020	0.0179	0.0170	0.0266	0.0266	0.00755
Mercury (Hg)	ug/L	Inorganic Hg: 0.026	0.00050	0.00136	0.00129	0.00240	0.00225	0.00123
Molybdenum (Mo)	mg/L	0.073[b]	0.000050	0.000155	0.000149	0.000178	0.000176	<0.000050
Nickel (Ni)	mg/L	0.025-0.150[g]	0.00020	0.00044	0.00048	0.00065	0.00060	0.00030
Phosphorus (P)	mg/L		0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium (K)	mg/L		2.0	<2.0	<2.0	2.4	2.5	<2.0
Rhenium (Re)	mg/L		0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Rubidium (Rb)	mg/L		0.000020	0.00121	0.00117	0.00141	0.00142	0.00112
Selenium (Se)	mg/L	0.001	0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Silicon (Si)	mg/L		0.050	1.04	1.04	0.907	0.918	0.232
Silver (Ag)	mg/L	0.0001	0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Sodium (Na)	mg/L		2.0	23.9	24.2	27.9	30.0	5.5
Strontium (Sr)	mg/L		0.000050	0.0357	0.0358	0.0315	0.0322	0.0219
Tellurium (Te)	mg/L		0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Thallium (Tl)	mg/L	0.0008	0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020
Thorium (Th)	mg/L		0.0000050	0.0000133	0.0000122	0.0000638	0.0000672	0.0000090
Tin (Sn)	mg/L		0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Titanium (Ti)	mg/L		0.00020	0.00104	0.00079	0.00526	0.00443	0.00035
Tungsten (W)	mg/L		0.000010	0.000011	<0.000010	<0.000010	<0.000010	<0.000010
Uranium (U)	mg/L	short-term: 0.033; long-term: 0.015	0.0000020	0.0000304	0.0000295	0.0000459	0.0000474	0.0000375
Vanadium (V)	mg/L		0.000050	0.000109	0.000107	0.000299	0.000282	<0.000050
Yttrium (Y)	mg/L		0.0000050	0.0000222	0.0000216	0.0000783	0.0000781	0.0000198
Zinc (Zn)	mg/L	0.03	0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030
Zirconium (Zr)	mg/L		0.000050	<0.000050	<0.000050	0.000081	0.000437	<0.000050
Radiochemistry								
Radium-226	Bq/L		0.010	<0.010	<0.010	<0.010	<0.010	<0.010

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, 2013.*

[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 and a maximum of 0.004 mg/L regardless of water hardness.*

[f] *Guideline is hardness-dependent at hardness as $CaCO_3$ >60 to 180 mg/L: lead guideline (mg/L) = $e^{\{1.273[\ln(hardness)]-4.705\}}$ / 1000. At hardness as $CaCO_3$ of ≤ 60mg/L, lead guideline is a minimum of 0.001 mg/L; at hardness as $CaCO_3$ of >180 mg/L, lead guideline is a maximum of 0.007 mg/L.*

[g] *Guideline is hardness-dependent at hardness as $CaCO_3$ >60 to 180 mg/L: nickel guideline (mg/L) = $e^{\{0.76[\ln(hardness)]+1.06\}}$ / 1000. At hardness as $CaCO_3$ of ≤ 60mg/L, nickel guideline is a minimum of 0.025 mg/L; at hardness as $CaCO_3$ of >180 mg/L, nickel guideline is a maximum of 0.150 mg/L.*

Annex A.3-1. Stream Water Quality Data, Doris North Project, 2013

Site ID:				Reference B OF	Little Roberts OF	Little Roberts OF	Reference D OF	Reference D OF
Replicate:				2	1	2	1	2
Date Sampled:		CCME guideline for the	Realized	13-Jun-13	12-Jun-13	12-Jun-13	13-Jun-13	13-Jun-13
ALS Sample ID:	Units	Protection of Aquatic life[a]	Detection Limit	L1317190-2	L1317195-3	L1317195-4	L1317190-3	L1317190-4
Physical Tests								
Conductivity	uS/cm		2.0	62.9	220	216	108	108
Hardness (as $CaCO_3$)	mg/L		0.50	18.9	37.1	36.8	21.2	21.5
pH	pH	6.5-9.0	0.10	7.21	7.38	7.22	7.21	7.23
Total Suspended Solids	mg/L	dependent on background levels	1.0	<1.0	2.6	2.4	1.6	1.4
Total Dissolved Solids	mg/L		10	40	125	116	55	57
Turbidity	NTU	dependent on background levels	0.10	0.46	3.30	3.32	2.02	1.99
Anions and Nutrients								
Alkalinity, Total (as $CaCO_3$)	mg/L		1.0 or 2.0	14.8	21.5	18.1	13.7	13.9
Ammonia, Total (as N)	mg/L	pH- and temperature-dependent	0.0050	<0.0050	<0.0050	<0.0050	0.0071	0.0065
Bromide (Br)	mg/L		0.050	<0.050	0.173	0.170	0.077	0.076
Chloride (Cl)	mg/L	short-term: 640; long-term: 120	0.50	8.98	52.7	51.7	22.9	23.0
Fluoride (F)	mg/L	Inorganic fluorides: 0.12[b]	0.020	0.024	0.040	0.039	0.035	0.035
Nitrate (as N)	mg/L	short-term: 124; long-term: 3.0	0.0050	0.0058	<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
Total Kjeldahl Nitrogen	mg/L		0.050	0.260	0.460	0.403	0.355	0.337
Total Nitrogen	mg/L		0.050	-	-	-	-	-
Orthophosphate-Dissolved (as P)	mg/L		0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Phosphorus (P)	mg/L	Trigger ranges from guidance framework[c]	0.0020	0.0062	0.0215	0.0213	0.0116	0.0123
Sulfate (SO_4)	mg/L		0.50	2.20	3.78	3.71	2.16	2.16
Cyanides								
Cyanide, Total	mg/L		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
Organic / Inorganic Carbon								
Dissolved Organic Carbon	mg/L		0.50	3.83	5.81	5.40	5.17	5.31
Total Organic Carbon	mg/L		0.50	3.84	6.14	5.89	5.28	5.23
Total Metals								
Aluminum (Al)	mg/L	0.005 if pH<6.5; 0.1 if pH≥6.5	0.0030	0.0113	0.139	0.132	0.100	0.102
Antimony (Sb)	mg/L		0.00001-0.00003	<0.000030	<0.000030	<0.000030	<0.000030	<0.000030
Arsenic (As)	mg/L	0.005	0.000050	0.000101	0.000273	0.000279	0.000156	0.000157
Barium (Ba)	mg/L		0.00010	0.00268	0.00404	0.00388	0.00297	0.00290
Beryllium (Be)	mg/L		0.0000050	<0.0000050	0.0000072	0.0000082	0.0000063	0.0000064
Bismuth (Bi)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Boron (B)	mg/L	short-term: 29; long-term: 1.5	0.0050	0.0114	0.0268	0.0250	0.0171	0.0209
Cadmium (Cd)	mg/L	equation[b,d]	0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Calcium (Ca)	mg/L		0.050	4.52	5.54	5.63	3.24	3.27
Cesium (Cs)	mg/L		0.0000050	0.0000055	0.0000116	0.0000116	0.0000091	0.0000091
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
Cobalt (Co)	mg/L		0.000050	<0.000050	0.000102	0.000095	0.000063	0.000062
Copper (Cu)	mg/L	0.002-0.004[e]	0.00050	0.00095	0.00141	0.00133	0.00114	0.00124
Gallium (Ga)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Iron (Fe)	mg/L	0.3	0.030	0.051	0.320	0.311	0.244	0.255
Lead (Pb)	mg/L	0.001-0.007[f]	0.000050	<0.000050	0.000059	0.000061	<0.000050	<0.000050
Lithium (Li)	mg/L		0.00020	0.00067	0.00274	0.00275	0.00158	0.00157
Magnesium (Mg)	mg/L		0.10	1.84	5.64	5.52	3.19	3.24
Manganese (Mn)	mg/L		0.00020	0.00724	0.0292	0.0278	0.00924	0.00945
Mercury (Hg)	ug/L	Inorganic Hg: 0.026	0.00050	0.0164	0.00159	0.00218	0.00195	0.00206
Molybdenum (Mo)	mg/L	0.073[b]	0.000050	<0.000050	0.000171	0.000169	0.000066	0.000063
Nickel (Ni)	mg/L	0.025-0.150[g]	0.00020	0.00027	0.00064	0.00063	0.00058	0.00056
Phosphorus (P)	mg/L		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
Rhenium (Re)	mg/L		0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Rubidium (Rb)	mg/L		0.000020	0.00108	0.00140	0.00139	0.00132	0.00127
Selenium (Se)	mg/L	0.001	0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Silicon (Si)	mg/L		0.050	0.236	1.13	1.12	0.467	0.472
Silver (Ag)	mg/L	0.0001	0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Sodium (Na)	mg/L		2.0	5.5	28.4	27.1	14.2	14.5
Strontium (Sr)	mg/L		0.000050	0.0218	0.0334	0.0331	0.0199	0.0199
Tellurium (Te)	mg/L		0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Thallium (Tl)	mg/L	0.0008	0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020
Thorium (Th)	mg/L		0.0000050	0.0000095	0.0000650	0.0000647	0.0000581	0.0000600
Tin (Sn)	mg/L		0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Titanium (Ti)	mg/L		0.00020	0.00036	0.00518	0.00492	0.00336	0.00384
Tungsten (W)	mg/L		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	0.0000360	0.0000419	0.0000429	0.0000532	0.0000539
Vanadium (V)	mg/L		0.000050	<0.000050	0.000308	0.000303	0.000212	0.000220
Yttrium (Y)	mg/L		0.0000050	0.0000186	0.0000777	0.0000750	0.0000675	0.0000666
Zinc (Zn)	mg/L	0.03	0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030
Zirconium (Zr)	mg/L		0.000050	<0.000050	0.000075	0.000074	0.000061	0.000061
Radiochemistry								
Radium-226	Bq/L		0.010	<0.010	<0.010	<0.010	<0.010	<0.010

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, 2013.*

[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 and a maximum of 0.004 mg/L regardless of water hardness.*

[f] *Guideline is hardness-dependent at hardness as* $CaCO_3$ *>60 to 180 mg/L: lead guideline (mg/L) =* $e^{\{1.273[\ln(hardness)]-4.705\}}$ */1000. At hardness as* $CaCO_3$ *of ≤ 60mg/L, lead guideline is a minimum of 0.001 mg/L; at hardness as* $CaCO_3$ *of >180 mg/L, lead guideline is a maximum of 0.007 mg/L.*

[g] *Guideline is hardness-dependent at hardness as* $CaCO_3$ *>60 to 180 mg/L: nickel guideline (mg/L) =* $e^{\{0.76[\ln(hardness)]+1.06\}}$ */1000. At hardness as* $CaCO_3$ *of ≤ 60mg/L, nickel guideline is a minimum of 0.025 mg/L; at hardness as* $CaCO_3$ *of >180 mg/L, nickel guideline is a maximum of 0.150 mg/L.*

Annex A.3-1. Stream Water Quality Data, Doris North Project, 2013

Site ID:				Doris OF	Doris OF	Roberts OF	Roberts OF	Reference B OF	Reference B OF
Replicate:				1	2	1	2	1	2
Date Sampled:		CCME guideline for the	Realized	17-Jul-13	17-Jul-13	18-Jul-13	18-Jul-13	19-Jul-13	19-Jul-13
ALS Sample ID:	Units	Protection of Aquatic life[a]	Detection Limit	L1335463-1	L1335463-2	L1335454-1	L1335454-2	L1336742-1	L1336742-2
Physical Tests									
Conductivity	uS/cm		2.0	268	257	242	240	49.0	48.9
Hardness (as $CaCO_3$)	mg/L		0.50	49.1	49.9	38.2	37.3	13.6	8.02
pH	pH	6.5-9.0	0.10	7.60	7.61	7.39	7.45	7.32	7.32
Total Suspended Solids	mg/L	dependent on background levels	1.0	3.9	3.3	3.7	3.3	<1.0	<1.0
Total Dissolved Solids	mg/L		10	127	152	148	147	34	35
Turbidity	NTU	dependent on background levels	0.10	3.58	5.78	1.53	1.63	0.31	0.71
Anions and Nutrients									
Alkalinity, Total (as $CaCO_3$)	mg/L		1.0 or 2.0	27.7	30.7	23.6	23.2	10.2	10.1
Ammonia, Total (as N)	mg/L	pH- and temperature-dependent	0.0050	0.0147	0.0126	<0.0050	<0.0050	<0.0050	<0.0050
Bromide (Br)	mg/L		0.050	0.182	0.201	0.220	0.209	<0.050	<0.050
Chloride (Cl)	mg/L	short-term: 640; long-term: 120	0.50	62.2	58.7	57.1	57.1	6.94	6.92
Fluoride (F)	mg/L	Inorganic fluorides: 0.12[b]	0.020	0.051	0.051	0.043	0.042	<0.020	<0.020
Nitrate (as N)	mg/L	short-term: 124; long-term: 3.0	0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0053	0.0064
Nitrite (as N)	mg/L	0.06	0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Total Kjeldahl Nitrogen	mg/L		0.050	0.531	0.539	0.302	0.310	0.176	0.183
Total Nitrogen	mg/L		0.050	-	-	-	-	0.181	0.190
Orthophosphate-Dissolved (as P)	mg/L		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	0.0248	0.0258	0.0175	0.0161	0.0038	0.0033
Sulfate (SO_4)	mg/L		0.50	2.81	2.64	4.25	4.25	1.68	1.68
Cyanides									
Cyanide, Total	mg/L		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
Organic / Inorganic Carbon									
Dissolved Organic Carbon	mg/L		0.50	5.42	5.56	4.79	4.63	2.71	2.68
Total Organic Carbon	mg/L		0.50	6.12	6.28	5.08	5.14	2.98	2.95
Total Metals									
Aluminum (Al)	mg/L	0.005 if pH<6.5; 0.1 if pH≥6.5	0.0030	0.0456	0.0429	0.109	0.122	0.0062	0.0044
Antimony (Sb)	mg/L		0.00001-0.00003	0.000018	0.000019	0.000019	0.000019	<0.000010	<0.000010
Arsenic (As)	mg/L	0.005	0.000050	0.000349	0.000309	0.000329	0.000314	0.000077	<0.000050
Barium (Ba)	mg/L		0.00010	0.00325	0.00337	0.00352	0.00333	0.00135	0.00081
Beryllium (Be)	mg/L		0.0000050	<0.0000050	<0.0000050	0.0000059	<0.0000050	<0.0000050	<0.0000050
Bismuth (Bi)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Boron (B)	mg/L	short-term: 29; long-term: 1.5	0.0050	0.0294	0.0288	0.0313	0.0306	0.0131	0.0097
Cadmium (Cd)	mg/L	equation[b,d]	0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Calcium (Ca)	mg/L		0.050	8.91	9.26	5.52	5.41	3.34	1.98
Cesium (Cs)	mg/L		0.0000050	<0.0000050	<0.0000050	0.0000082	0.0000078	<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
Cobalt (Co)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Copper (Cu)	mg/L	0.002-0.004[e]	0.00050	0.00127	0.00131	0.00143	0.00147	0.00065	<0.00050
Gallium (Ga)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Iron (Fe)	mg/L	0.3	0.030	0.158	0.164	0.161	0.154	0.035	<0.030
Lead (Pb)	mg/L	0.001-0.007[f]	0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Lithium (Li)	mg/L		0.00020	0.00404	0.00407	0.00280	0.00271	0.00047	0.00028
Magnesium (Mg)	mg/L		0.10	6.52	6.50	5.92	5.78	1.28	0.74
Manganese (Mn)	mg/L		0.00020	0.0233	0.0231	0.00889	0.00894	0.00146	0.00107
Mercury (Hg)	ug/L	Inorganic Hg: 0.026	0.00050	0.00068	0.00072	0.00064	0.106	0.00067	0.00058
Molybdenum (Mo)	mg/L	0.073[b]	0.000050	0.000162	0.000171	0.000220	0.000193	<0.000050	<0.000050
Nickel (Ni)	mg/L	0.025-0.150[g]	0.00020	0.00051	0.00054	0.00052	0.00051	<0.00020	<0.00020
Phosphorus (P)	mg/L		0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium (K)	mg/L		2.0	2.4	2.4	2.1	2.0	<2.0	<2.0
Rhenium (Re)	mg/L		0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Rubidium (Rb)	mg/L		0.000020	0.00166	0.00159	0.00159	0.00155	0.000812	0.000480
Selenium (Se)	mg/L	0.001	0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Silicon (Si)	mg/L		0.050	1.47	1.30	0.531	0.492	0.085	0.052
Silver (Ag)	mg/L	0.0001	0.0000050	<0.0000050	<0.0000050	<0.0000050	0.0000088	<0.0000050	<0.0000050
Sodium (Na)	mg/L		2.0	33.1	31.5	32.4	31.7	3.9	2.2
Strontium (Sr)	mg/L		0.000050	0.0431	0.0411	0.0332	0.0317	0.0155	0.00898
Tellurium (Te)	mg/L		0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Thallium (Tl)	mg/L	0.0008	0.0000020	<0.0000020	<0.0000020	0.0000027	<0.0000020	<0.0000020	<0.0000020
Thorium (Th)	mg/L		0.0000050	0.0000179	0.0000145	0.0000407	0.0000411	<0.0000050	<0.0000050
Tin (Sn)	mg/L		0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Titanium (Ti)	mg/L		0.00020	0.00162	0.00153	0.00414	0.00372	<0.00020	<0.00020
Tungsten (W)	mg/L		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	0.0000339	0.0000319	0.0000512	0.0000470	0.0000323	0.0000189
Vanadium (V)	mg/L		0.000050	0.000160	0.000165	0.000232	0.000224	<0.000050	<0.000050
Yttrium (Y)	mg/L		0.0000050	0.0000282	0.0000253	0.0000477	0.0000460	0.0000088	0.0000055
Zinc (Zn)	mg/L	0.03	0.0030	<0.0030	<0.0030	<0.0030	0.0033	<0.0030	<0.0030
Zirconium (Zr)	mg/L		0.000050	<0.000050	0.000079	<0.000050	<0.000050	<0.000050	<0.000050
Radiochemistry									
Radium-226	Bq/L		0.010	<0.010	<0.010	<0.010	<0.010	<0.01	<0.01

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, 2013.*

[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 and a maximum of 0.004 mg/L regardless of water hardness.*

[f] *Guideline is hardness-dependent at hardness as* $CaCO_3$ *>60 to 180 mg/L: lead guideline (mg/L) =* $e^{\{1.273[\ln(hardness)]-4.705\}}/1000$. *At hardness as* $CaCO_3$ *of ≤ 60mg/L, lead guideline is a minimum of 0.001 mg/L; at hardness as* $CaCO_3$ *of >180 mg/L, lead guideline is a maximum of 0.007 mg/L.*

[g] *Guideline is hardness-dependent at hardness as* $CaCO_3$ *>60 to 180 mg/L: nickel guideline (mg/L) =* $e^{\{0.76[\ln(hardness)]+1.06\}}/1000$. *At hardness as* $CaCO_3$ *of ≤ 60mg/L, nickel guideline is a minimum of 0.025 mg/L; at hardness as* $CaCO_3$ *of >180 mg/L, nickel guideline is a maximum of 0.150 mg/L.*

Annex A.3-1. Stream Water Quality Data, Doris North Project, 2013

Site ID:				Little Roberts OF	Little Roberts OF	Reference D OF	Reference D OF	Doris OF
Replicate:				1	2	1	2	1
Date Sampled:		CCME guideline for the	Realized	18-Jul-13	18-Jul-13	18-Jul-13	18-Jul-13	19-Aug-13
ALS Sample ID:	Units	Protection of Aquatic life[a]	Detection Limit	L1335463-3	L1335463-4	L1335454-3	L1335454-4	L1350568-13
Physical Tests								
Conductivity	uS/cm		2.0	253	253	114	114	272
Hardness (as $CaCO_3$)	mg/L		0.50	44.4	45.4	20.2	20.6	53.0
pH	pH	6.5-9.0	0.10	7.60	7.58	7.31	7.31	7.61
Total Suspended Solids	mg/L	dependent on background levels	1.0	2.1	2.2	<1.0	1.2	3.5
Total Dissolved Solids	mg/L		10	144	139	73	58	157
Turbidity	NTU	dependent on background levels	0.10	2.40	2.05	1.24	1.13	3.91
Anions and Nutrients								
Alkalinity, Total (as $CaCO_3$)	mg/L		1.0 or 2.0	27.5	26.5	12.0	11.7	32.6
Ammonia, Total (as N)	mg/L	pH- and temperature-dependent	0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Bromide (Br)	mg/L		0.050	0.223	0.179	0.080	0.090	0.203
Chloride (Cl)	mg/L	short-term: 640; long-term: 120	0.50	59.8	59.9	25.0	25.0	62.8
Fluoride (F)	mg/L	Inorganic fluorides: 0.12[b]	0.020	0.047	0.047	0.033	0.033	0.059
Nitrate (as N)	mg/L	short-term: 124; long-term: 3.0	0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Nitrite (as N)	mg/L	0.06	0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Total Kjeldahl Nitrogen	mg/L		0.050	0.376	0.435	0.228	0.251	0.509
Total Nitrogen	mg/L		0.050	-	-	-	-	-
Orthophosphate-Dissolved (as P)	mg/L		0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Phosphorus (P)	mg/L	Trigger ranges from guidance framework[c]	0.0020	0.0179	0.0174	0.0070	0.0065	0.0207
Sulfate (SO_4)	mg/L		0.50	3.64	3.64	2.21	2.21	2.96
Cyanides								
Cyanide, Total	mg/L		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
Organic / Inorganic Carbon								
Dissolved Organic Carbon	mg/L		0.50	5.24	5.19	3.84	3.86	5.45
Total Organic Carbon	mg/L		0.50	5.68	5.56	4.10	4.17	5.81
Total Metals								
Aluminum (Al)	mg/L	0.005 if pH<6.5; 0.1 if pH≥6.5	0.0030	0.0451	0.0525	0.0366	0.0394	0.0227
Antimony (Sb)	mg/L		0.00001-0.00003	0.000019	0.000019	0.000012	0.000013	0.000019
Arsenic (As)	mg/L	0.005	0.000050	0.000329	0.000329	0.000194	0.000179	0.000302
Barium (Ba)	mg/L		0.00010	0.00305	0.00305	0.00178	0.00191	0.00294
Beryllium (Be)	mg/L		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
Boron (B)	mg/L	short-term: 29; long-term: 1.5	0.0050	0.0291	0.0301	0.0176	0.0196	0.0262
Cadmium (Cd)	mg/L	equation[b,d]	0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Calcium (Ca)	mg/L		0.050	7.40	7.55	3.10	3.18	9.94
Cesium (Cs)	mg/L		0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Chromium (Cr)	mg/L	Cr(VI): 0.001; Cr(III): 0.0089[b]	0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Cobalt (Co)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.000051
Copper (Cu)	mg/L	0.002-0.004[e]	0.00050	0.00140	0.00145	0.00085	0.00087	0.00123
Gallium (Ga)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Iron (Fe)	mg/L	0.3	0.030	0.122	0.125	0.081	0.084	0.155
Lead (Pb)	mg/L	0.001-0.007[f]	0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Lithium (Li)	mg/L		0.00020	0.00333	0.00332	0.00141	0.00148	0.00368
Magnesium (Mg)	mg/L		0.10	6.30	6.46	3.03	3.08	6.83
Manganese (Mn)	mg/L		0.00020	0.00815	0.00829	0.00253	0.00287	0.0273
Mercury (Hg)	ug/L	Inorganic Hg: 0.026	0.00050	0.00065	0.00064	0.00084	0.00077	0.00068
Molybdenum (Mo)	mg/L	0.073[b]	0.000050	0.000179	0.000180	0.000052	0.000056	0.000183
Nickel (Ni)	mg/L	0.025-0.150[g]	0.00020	0.00049	0.00048	0.00032	0.00031	0.00043
Phosphorus (P)	mg/L		0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium (K)	mg/L		2.0	2.2	2.3	<2.0	<2.0	2.4
Rhenium (Re)	mg/L		0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Rubidium (Rb)	mg/L		0.000020	0.00154	0.00154	0.00112	0.00115	0.00138
Selenium (Se)	mg/L	0.001	0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Silicon (Si)	mg/L		0.050	0.791	0.822	0.185	0.186	1.20
Silver (Ag)	mg/L	0.0001	0.0000050	<0.0000050	<0.0000050	0.0000083	<0.0000050	<0.0000050
Sodium (Na)	mg/L		2.0	32.5	33.3	13.8	13.9	32.1
Strontium (Sr)	mg/L		0.000050	0.0386	0.0393	0.0190	0.0179	0.0531
Tellurium (Te)	mg/L		0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Thallium (Tl)	mg/L	0.0008	0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020
Thorium (Th)	mg/L		0.0000050	0.0000212	0.0000226	0.0000199	0.0000188	0.0000088
Tin (Sn)	mg/L		0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Titanium (Ti)	mg/L		0.00020	0.00172	0.00179	0.00105	0.00118	0.00080
Tungsten (W)	mg/L		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	0.0000370	0.0000381	0.0000306	0.0000318	0.0000333
Vanadium (V)	mg/L		0.000050	0.000150	0.000160	0.000085	0.000093	0.000110
Yttrium (Y)	mg/L		0.0000050	0.0000295	0.0000304	0.0000209	0.0000216	0.0000150
Zinc (Zn)	mg/L	0.03	0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030
Zirconium (Zr)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Radiochemistry								
Radium-226	Bq/L		0.010	<0.010	<0.010	<0.010	<0.010	<0.010

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, 2013.

[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 and a maximum of 0.004 mg/L regardless of water hardness.*

[f] Guideline is hardness-dependent at hardness as $CaCO_3$ >60 to 180 mg/L: lead guideline (mg/L) = $e^{\{1.273[ln(hardness)]-4.705\}}$ / 1000. At hardness as $CaCO_3$ of ≤ 60mg/L, lead guideline is a minimum of 0.001 mg/L; at hardness as $CaCO_3$ of >180 mg/L, lead guideline is a maximum of 0.007 mg/L.

[g] Guideline is hardness-dependent at hardness as $CaCO_3$ >60 to 180 mg/L: nickel guideline (mg/L) = $e^{\{0.76[ln(hardness)]+1.06\}}$ / 1000. At hardness as $CaCO_3$ of ≤ 60mg/L, nickel guideline is a minimum of 0.025 mg/L; at hardness as $CaCO_3$ of >180 mg/L, nickel guideline is a maximum of 0.150 mg/L.

Annex A.3-1. Stream Water Quality Data, Doris North Project, 2013

Site ID:				Doris OF	Roberts OF	Roberts OF	Reference B OF	Reference B OF
Replicate:				2	1	2	1	2
Date Sampled:		CCME guideline for the	Realized	19-Aug-13	16-Aug-13	16-Aug-13	22-Aug-13	22-Aug-13
ALS Sample ID:	Units	Protection of Aquatic life[a]	Detection Limit	L1350568-14	L1350568-1	L1350568-2	L1352799-8	L1352799-9
Physical Tests								
Conductivity	uS/cm		2.0	273	246	247	52.8	52.5
Hardness (as $CaCO_3$)	mg/L		0.50	51.0	40.4	39.3	14.5	14.6
pH	pH	6.5-9.0	0.10	7.71	7.62	7.59	7.52	7.47
Total Suspended Solids	mg/L	dependent on background levels	1.0	3.6	2.1	1.9	<1.0	<1.0
Total Dissolved Solids	mg/L		10	157	105	137	50	56
Turbidity	NTU	dependent on background levels	0.10	3.75	2.17	1.59	0.44	0.51
Anions and Nutrients								
Alkalinity, Total (as $CaCO_3$)	mg/L		1.0 or 2.0	32.4	25.6	24.9	7.1	9.9
Ammonia, Total (as N)	mg/L	pH- and temperature-dependent	0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Bromide (Br)	mg/L		0.050	0.206	0.202	0.203	<0.050	<0.050
Chloride (Cl)	mg/L	short-term: 640; long-term: 120	0.50	62.9	59.4	59.2	7.49	7.48
Fluoride (F)	mg/L	Inorganic fluorides: 0.12[b]	0.020	0.058	0.048	0.048	<0.020	<0.020
Nitrate (as N)	mg/L	short-term: 124; long-term: 3.0	0.0050	<0.0050	<0.0050	<0.0050	0.0171	0.0172
Nitrite (as N)	mg/L	0.06	0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Total Kjeldahl Nitrogen	mg/L		0.050	0.508	0.292	0.296	0.262	0.238
Total Nitrogen	mg/L		0.050	-	-	-	-	-
Orthophosphate-Dissolved (as P)	mg/L		0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Phosphorus (P)	mg/L	Trigger ranges from guidance framework[c]	0.0020	0.0189	0.0132	0.0115	0.0052	0.0052
Sulfate (SO_4)	mg/L		0.50	2.97	4.57	4.56	1.75	1.75
Cyanides								
Cyanide, Total	mg/L		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
Organic / Inorganic Carbon								
Dissolved Organic Carbon	mg/L		0.50	5.46	4.58	4.57	2.67	2.67
Total Organic Carbon	mg/L		0.50	5.94	4.86	4.81	2.82	2.88
Total Metals								
Aluminum (Al)	mg/L	0.005 if pH<6.5; 0.1 if pH≥6.5	0.0030	0.0218	0.0539	0.0486	0.0077	0.0068
Antimony (Sb)	mg/L		0.00001-0.00003	0.000020	0.000017	0.000018	0.000013	0.000012
Arsenic (As)	mg/L	0.005	0.000050	0.000275	0.000230	0.000252	0.000139	0.000121
Barium (Ba)	mg/L		0.00010	0.00286	0.00270	0.00257	0.00138	0.00132
Beryllium (Be)	mg/L		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
Boron (B)	mg/L	short-term: 29; long-term: 1.5	0.0050	0.0269	0.0291	0.0300	0.0091	0.0096
Cadmium (Cd)	mg/L	equation[b,d]	0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Calcium (Ca)	mg/L		0.050	9.51	5.81	5.71	3.50	3.53
Cesium (Cs)	mg/L		0.0000050	<0.0000050	0.0000050	<0.0000050	<0.0000050	<0.0000050
Chromium (Cr)	mg/L	Cr(VI): 0.001; Cr(III): 0.0089[b]	0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Cobalt (Co)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Copper (Cu)	mg/L	0.002-0.004[e]	0.00050	0.00117	0.00153	0.00149	0.00090	0.00071
Gallium (Ga)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Iron (Fe)	mg/L	0.3	0.030	0.149	0.074	0.069	0.093	0.092
Lead (Pb)	mg/L	0.001-0.007[f]	0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Lithium (Li)	mg/L		0.00020	0.00368	0.00241	0.00251	0.00045	0.00046
Magnesium (Mg)	mg/L		0.10	6.61	6.29	6.07	1.39	1.40
Manganese (Mn)	mg/L		0.00020	0.0265	0.00616	0.00626	0.00323	0.00227
Mercury (Hg)	ug/L	Inorganic Hg: 0.026	0.00050	0.00071	<0.00050	0.00051	0.00057	<0.00050
Molybdenum (Mo)	mg/L	0.073[b]	0.000050	0.000177	0.000204	0.000200	0.000051	<0.000050
Nickel (Ni)	mg/L	0.025-0.150[g]	0.00020	0.00043	0.00049	0.00049	<0.00020	<0.00020
Phosphorus (P)	mg/L		0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium (K)	mg/L		2.0	2.4	2.3	2.2	<2.0	<2.0
Rhenium (Re)	mg/L		0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Rubidium (Rb)	mg/L		0.000020	0.00139	0.00137	0.00130	0.000868	0.000851
Selenium (Se)	mg/L	0.001	0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Silicon (Si)	mg/L		0.050	1.15	0.317	0.285	0.109	0.110
Silver (Ag)	mg/L	0.0001	0.0000050	<0.0000050	<0.0000050	0.0000077	<0.0000050	<0.0000050
Sodium (Na)	mg/L		2.0	33.4	34.9	33.3	4.2	4.3
Strontium (Sr)	mg/L		0.000050	0.0513	0.0396	0.0394	0.0154	0.0157
Tellurium (Te)	mg/L		0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Thallium (Tl)	mg/L	0.0008	0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020
Thorium (Th)	mg/L		0.0000050	0.0000084	0.0000228	0.0000227	0.0000054	<0.0000050
Tin (Sn)	mg/L		0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Titanium (Ti)	mg/L		0.00020	0.00078	0.00208	0.00196	<0.00020	<0.00020
Tungsten (W)	mg/L		0.000010	<0.000010	<0.000010	<0.000010	0.000014	<0.000010
Uranium (U)	mg/L	short-term: 0.033; long-term: 0.015	0.0000020	0.0000317	0.0000485	0.0000490	0.0000345	0.0000333
Vanadium (V)	mg/L		0.000050	0.000113	0.000136	0.000141	<0.000050	<0.000050
Yttrium (Y)	mg/L		0.0000050	0.0000146	0.0000283	0.0000269	0.0000128	0.0000124
Zinc (Zn)	mg/L	0.03	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
Radiochemistry								
Radium-226	Bq/L		0.010	<0.010	<0.010	<0.010	<0.010	<0.010

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, 2013.*

[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 and a maximum of 0.004 mg/L regardless of water hardness.*

[f] *Guideline is hardness-dependent at hardness as* $CaCO_3$ *>60 to 180 mg/L: lead guideline (mg/L) =* $e^{\{1.273[\ln(hardness)]-4.705\}}$ */1000. At hardness as* $CaCO_3$ *of ≤ 60mg/L, lead guideline is a minimum of 0.001 mg/L; at hardness as* $CaCO_3$ *of >180 mg/L, lead guideline is a maximum of 0.007 mg/L.*

[g] *Guideline is hardness-dependent at hardness as* $CaCO_3$ *>60 to 180 mg/L: nickel guideline (mg/L) =* $e^{\{0.76[\ln(hardness)]+1.06\}}$ */1000. At hardness as* $CaCO_3$ *of ≤ 60mg/L, nickel guideline is a minimum of 0.025 mg/L; at hardness as* $CaCO_3$ *of >180 mg/L, nickel guideline is a maximum of 0.150 mg/L.*

Annex A.3-1. Stream Water Quality Data, Doris North Project, 2013

Site ID:				Little Roberts OF	Little Roberts OF	Reference D OF	Reference D OF	Doris OF
Replicate:				1	2	1	2	1
Date Sampled:		CCME guideline for the	Realized	17-Aug-13	17-Aug-13	17-Aug-13	17-Aug-13	18-Sep-13
ALS Sample ID:	Units	Protection of Aquatic life[a]	Detection Limit	L1350568-5	L1350568-6	L1350568-3	L1350568-4	L1366437-5
Physical Tests								
Conductivity	uS/cm		2.0	282	279	127	128	278
Hardness (as $CaCO_3$)	mg/L		0.50	49.1	48.4	22.9	23.3	54.8
pH	pH	6.5-9.0	0.10	7.67	7.69	7.43	7.43	7.71
Total Suspended Solids	mg/L	dependent on background levels	1.0	4.8	4.0	<1.0	1.1	3.4
Total Dissolved Solids	mg/L		10	142	157	69	69	139
Turbidity	NTU	dependent on background levels	0.10	4.08	4.18	0.83	0.89	6.68
Anions and Nutrients								
Alkalinity, Total (as $CaCO_3$)	mg/L		1.0 or 2.0	29.1	28.0	13.8	14.0	31.8
Ammonia, Total (as N)	mg/L	pH- and temperature-dependent	0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0213
Bromide (Br)	mg/L		0.050	0.223	0.224	0.092	0.090	0.252
Chloride (Cl)	mg/L	short-term: 640; long-term: 120	0.50	66.8	66.6	28.6	28.6	66.6
Fluoride (F)	mg/L	Inorganic fluorides: 0.12[b]	0.020	0.054	0.054	0.038	0.038	0.050
Nitrate (as N)	mg/L	short-term: 124; long-term: 3.0	0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Nitrite (as N)	mg/L	0.06	0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Total Kjeldahl Nitrogen	mg/L		0.050	0.391	0.410	0.242	0.257	0.478
Total Nitrogen	mg/L		0.050	-	-	-	-	-
Orthophosphate-Dissolved (as P)	mg/L		0.0010	<0.0010	0.0039	<0.0010	<0.0010	<0.0010
Phosphorus (P)	mg/L	Trigger ranges from guidance framework[c]	0.0020	0.0205	0.0190	0.0077	0.0089	0.0252
Sulfate (SO_4)	mg/L		0.50	4.42	4.37	2.38	2.38	3.23
Cyanides								
Cyanide, Total	mg/L		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
Organic / Inorganic Carbon								
Dissolved Organic Carbon	mg/L		0.50	5.18	5.13	3.93	4.05	4.95
Total Organic Carbon	mg/L		0.50	5.46	5.44	4.14	4.15	6.12
Total Metals								
Aluminum (Al)	mg/L	0.005 if pH<6.5; 0.1 if pH≥6.5	0.0030	0.123	0.116	0.0241	0.0246	0.0299
Antimony (Sb)	mg/L		0.00001-0.00003	0.000021	0.000020	0.000011	0.000013	0.000020
Arsenic (As)	mg/L	0.005	0.000050	0.000279	0.000309	0.000154	0.000144	0.000349
Barium (Ba)	mg/L		0.00010	0.00349	0.00347	0.00157	0.00162	0.00318
Beryllium (Be)	mg/L		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
Boron (B)	mg/L	short-term: 29; long-term: 1.5	0.0050	0.0289	0.0296	0.0167	0.0170	0.0307
Cadmium (Cd)	mg/L	equation[b,d]	0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	0.0000201
Calcium (Ca)	mg/L		0.050	8.08	8.07	3.42	3.47	10.0
Cesium (Cs)	mg/L		0.0000050	0.0000085	0.0000082	<0.0000050	<0.0000050	<0.0000050
Chromium (Cr)	mg/L	Cr(VI): 0.001; Cr(III): 0.0089[b]	0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Cobalt (Co)	mg/L		0.000050	0.000068	0.000069	<0.000050	<0.000050	<0.000050
Copper (Cu)	mg/L	0.002-0.004[e]	0.00050	0.00144	0.00149	0.00089	0.00092	0.00146
Gallium (Ga)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Iron (Fe)	mg/L	0.3	0.030	0.230	0.219	0.107	0.111	0.096
Lead (Pb)	mg/L	0.001-0.007[f]	0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Lithium (Li)	mg/L		0.00020	0.00332	0.00323	0.00150	0.00152	0.00406
Magnesium (Mg)	mg/L		0.10	7.03	6.86	3.50	3.56	7.23
Manganese (Mn)	mg/L		0.00020	0.0139	0.0139	0.00930	0.00931	0.0239
Mercury (Hg)	ug/L	Inorganic Hg: 0.026	0.00050	0.00052	0.00056	0.00053	0.00056	0.00087
Molybdenum (Mo)	mg/L	0.073[b]	0.000050	0.000207	0.000208	0.000085	0.000064	0.000219
Nickel (Ni)	mg/L	0.025-0.150[g]	0.00020	0.00060	0.00055	0.00036	0.00035	0.00048
Phosphorus (P)	mg/L		0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium (K)	mg/L		2.0	2.5	2.4	<2.0	<2.0	2.7
Rhenium (Re)	mg/L		0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Rubidium (Rb)	mg/L		0.000020	0.00157	0.00156	0.00105	0.00108	0.00166
Selenium (Se)	mg/L	0.001	0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Silicon (Si)	mg/L		0.050	0.883	0.843	0.178	0.180	1.43
Silver (Ag)	mg/L	0.0001	0.0000050	<0.0000050	<0.0000050	0.0000052	<0.0000050	<0.0000050
Sodium (Na)	mg/L		2.0	34.4	33.5	15.9	16.4	33.9
Strontium (Sr)	mg/L		0.000050	0.0508	0.0499	0.0232	0.0239	0.0512
Tellurium (Te)	mg/L		0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Thallium (Tl)	mg/L	0.0008	0.0000020	0.0000021	<0.0000020	<0.0000020	<0.0000020	<0.0000020
Thorium (Th)	mg/L		0.0000050	0.0000434	0.0000420	0.0000155	0.0000155	0.0000103
Tin (Sn)	mg/L		0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Titanium (Ti)	mg/L		0.00020	0.00492	0.00502	0.00065	0.00061	0.00080
Tungsten (W)	mg/L		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	0.0000429	0.0000423	0.0000375	0.0000393	0.0000378
Vanadium (V)	mg/L		0.000050	0.000298	0.000288	0.000077	0.000083	0.000137
Yttrium (Y)	mg/L		0.0000050	0.0000404	0.0000396	0.0000167	0.0000179	0.0000165
Zinc (Zn)	mg/L	0.03	0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030
Zirconium (Zr)	mg/L		0.000050	0.000053	0.000050	<0.000050	<0.000050	<0.000050
Radiochemistry								
Radium-226	Bq/L		0.010	<0.010	<0.010	<0.010	<0.010	<0.01

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, 2013.*

[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 and a maximum of 0.004 mg/L regardless of water hardness.*

[f] *Guideline is hardness-dependent at hardness as* $CaCO_3$ *>60 to 180 mg/L: lead guideline (mg/L) =* $e^{\{1.273[\ln(hardness)]-4.705\}}/1000$. *At hardness as* $CaCO_3$ *of ≤ 60mg/L, lead guideline is a minimum of 0.001 mg/L; at hardness as* $CaCO_3$ *of >180 mg/L, lead guideline is a maximum of 0.007 mg/L.*

[g] *Guideline is hardness-dependent at hardness as* $CaCO_3$ *>60 to 180 mg/L: nickel guideline (mg/L) =* $e^{\{0.76[\ln(hardness)]+1.06\}}/1000$. *At hardness as* $CaCO_3$ *of ≤ 60mg/L, nickel guideline is a minimum of 0.025 mg/L; at hardness as* $CaCO_3$ *of >180 mg/L, nickel guideline is a maximum of 0.150 mg/L.*

Annex A.3-1. Stream Water Quality Data, Doris North Project, 2013

Site ID:				Doris OF	Roberts OF	Roberts OF	Reference B OF	Reference B OF
Replicate:				2	1	2	1	2
Date Sampled:		CCME guideline for the	Realized	18-Sep-13	18-Sep-13	18-Sep-13	23-Sep-13	23-Sep-13
ALS Sample ID:	Units	Protection of Aquatic life[a]	Detection Limit	L1366437-6	L1366437-3	L1366437-4	L1367963-11	L1367963-12
Physical Tests								
Conductivity	uS/cm		2.0	280	247	246	58.1	58.2
Hardness (as $CaCO_3$)	mg/L		0.50	53.7	40.5	40.1	17.4	17.3
pH	pH	6.5-9.0	0.10	7.73	7.60	7.60	7.17	7.06
Total Suspended Solids	mg/L	dependent on background levels	1.0	3.8	3.3	2.1	<1.0	<1.0
Total Dissolved Solids	mg/L		10	163	99	126	38	42
Turbidity	NTU	dependent on background levels	0.10	5.60	2.70	2.05	1.22	0.63
Anions and Nutrients								
Alkalinity, Total (as $CaCO_3$)	mg/L		1.0 or 2.0	31.9	24.7	24.7	13.1	12.1
Ammonia, Total (as N)	mg/L	pH- and temperature-dependent	0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Bromide (Br)	mg/L		0.050	0.246	0.237	0.228	<0.050	<0.050
Chloride (Cl)	mg/L	short-term: 640; long-term: 120	0.50	66.6	59.8	59.9	8.32	8.31
Fluoride (F)	mg/L	Inorganic fluorides: 0.12[b]	0.020	0.051	0.043	0.043	<0.020	<0.020
Nitrate (as N)	mg/L	short-term: 124; long-term: 3.0	0.0050	<0.0050	<0.0050	<0.0050	0.0168	0.0172
Nitrite (as N)	mg/L	0.06	0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Total Kjeldahl Nitrogen	mg/L		0.050	0.492	0.297	0.276	0.233	0.245
Total Nitrogen	mg/L		0.050	-	-	-	-	-
Orthophosphate-Dissolved (as P)	mg/L		0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Phosphorus (P)	mg/L	Trigger ranges from guidance framework[c]	0.0020	0.0240	0.0151	0.0144	0.0045	0.0044
Sulfate (SO_4)	mg/L		0.50	3.18	4.57	4.59	2.23	2.24
Cyanides								
Cyanide, Total	mg/L		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
Organic / Inorganic Carbon								
Dissolved Organic Carbon	mg/L		0.50	4.79	4.25	4.35	2.82	3.35
Total Organic Carbon	mg/L		0.50	6.00	4.85	5.39	2.96	3.16
Total Metals								
Aluminum (Al)	mg/L	0.005 if pH<6.5; 0.1 if pH≥6.5	0.0030	0.0303	0.110	0.0758	0.0062	0.0066
Antimony (Sb)	mg/L		0.00001-0.00003	0.000020	0.000019	0.000021	0.000012	0.000013
Arsenic (As)	mg/L	0.005	0.000050	0.000350	0.000279	0.000251	0.000113	0.000136
Barium (Ba)	mg/L		0.00010	0.00305	0.00324	0.00303	0.00179	0.00164
Beryllium (Be)	mg/L		0.0000050	<0.0000050	0.0000057	<0.0000050	<0.0000050	<0.0000050
Bismuth (Bi)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Boron (B)	mg/L	short-term: 29; long-term: 1.5	0.0050	0.0309	0.0303	0.0307	0.0093	0.0092
Cadmium (Cd)	mg/L	equation[b,d]	0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Calcium (Ca)	mg/L		0.050	9.80	5.91	5.87	4.28	4.26
Cesium (Cs)	mg/L		0.0000050	<0.0000050	0.0000091	0.0000075	<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
Cobalt (Co)	mg/L		0.000050	<0.000050	0.000060	<0.000050	<0.000050	<0.000050
Copper (Cu)	mg/L	0.002-0.004[e]	0.00050	0.00130	0.00145	0.00145	0.00073	0.00071
Gallium (Ga)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Iron (Fe)	mg/L	0.3	0.030	0.097	0.150	0.105	0.053	0.052
Lead (Pb)	mg/L	0.001-0.007[f]	0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Lithium (Li)	mg/L		0.00020	0.00415	0.00265	0.00267	0.00059	0.00057
Magnesium (Mg)	mg/L		0.10	7.10	6.24	6.17	1.63	1.63
Manganese (Mn)	mg/L		0.00020	0.0237	0.00802	0.00603	0.00191	0.00185
Mercury (Hg)	ug/L	Inorganic Hg: 0.026	0.00050	0.00105	0.00056	0.00082	0.00071	0.00105
Molybdenum (Mo)	mg/L	0.073[b]	0.000050	0.000230	0.000200	0.000217	0.000054	0.000066
Nickel (Ni)	mg/L	0.025-0.150[g]	0.00020	0.00047	0.00054	0.00052	<0.00020	<0.00020
Phosphorus (P)	mg/L		0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium (K)	mg/L		2.0	2.7	2.3	2.3	<2.0	<2.0
Rhenium (Re)	mg/L		0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Rubidium (Rb)	mg/L		0.000020	0.00175	0.00153	0.00147	0.000893	0.000897
Selenium (Se)	mg/L	0.001	0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Silicon (Si)	mg/L		0.050	1.40	0.497	0.434	0.107	0.115
Silver (Ag)	mg/L	0.0001	0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Sodium (Na)	mg/L		2.0	34.4	32.9	32.2	4.4	4.4
Strontium (Sr)	mg/L		0.000050	0.0498	0.0367	0.0375	0.0191	0.0190
Tellurium (Te)	mg/L		0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Thallium (Tl)	mg/L	0.0008	0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020
Thorium (Th)	mg/L		0.0000050	0.0000106	0.0000365	0.0000275	0.0000073	0.0000065
Tin (Sn)	mg/L		0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Titanium (Ti)	mg/L		0.00020	0.00101	0.00494	0.00313	<0.00020	<0.00020
Tungsten (W)	mg/L		0.000010	0.000011	<0.000010	<0.000010	<0.000010	<0.000010
Uranium (U)	mg/L	short-term: 0.033; long-term: 0.015	0.0000020	0.0000385	0.0000482	0.0000457	0.0000462	0.0000481
Vanadium (V)	mg/L		0.000050	0.000140	0.000245	0.000195	<0.000050	0.000052
Yttrium (Y)	mg/L		0.0000050	0.0000167	0.0000431	0.0000359	0.0000135	0.0000140
Zinc (Zn)	mg/L	0.03	0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030
Zirconium (Zr)	mg/L		0.000050	<0.000050	0.000057	<0.000050	<0.000050	<0.000050
Radiochemistry								
Radium-226	Bq/L		0.010	<0.01	<0.01	<0.01	<0.01	<0.01

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, 2013.*

[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 and a maximum of 0.004 mg/L regardless of water hardness.*

[f] *Guideline is hardness-dependent at hardness as* $CaCO_3$ *>60 to 180 mg/L: lead guideline (mg/L) =* $e^{\{1.273[\ln(hardness)]-4.705\}}$ */ 1000. At hardness as* $CaCO_3$ *of ≤ 60mg/L, lead guideline is a minimum of 0.001 mg/L; at hardness as* $CaCO_3$ *of >180 mg/L, lead guideline is a maximum of 0.007 mg/L.*

[g] *Guideline is hardness-dependent at hardness as* $CaCO_3$ *>60 to 180 mg/L: nickel guideline (mg/L) =* $e^{\{0.76[\ln(hardness)]+1.06\}}$ */ 1000. At hardness as* $CaCO_3$ *of ≤ 60mg/L, nickel guideline is a minimum of 0.025 mg/L; at hardness as* $CaCO_3$ *of >180 mg/L, nickel guideline is a maximum of 0.150 mg/L.*

Annex A.3-1. Stream Water Quality Data, Doris North Project, 2013

Site ID:				Little Roberts OF	Little Roberts OF	Reference D OF	Reference D OF
Replicate:				1	2	1	2
Date Sampled:		CCME guideline for the	Realized	17-Sep-13	17-Sep-13	18-Sep-13	18-Sep-13
ALS Sample ID:	Units	Protection of Aquatic life[a]	Detection Limit	L1366437-1	L1366437-2	L1366437-7	L1366437-8
Physical Tests							
Conductivity	uS/cm		2.0	294	292	134	133
Hardness (as $CaCO_3$)	mg/L		0.50	52.6	53.3	24.4	24.5
pH	pH	6.5-9.0	0.10	7.69	7.67	7.43	7.42
Total Suspended Solids	mg/L	dependent on background levels	1.0	2.0	1.6	<1.0	<1.0
Total Dissolved Solids	mg/L		10	179	180	74	72
Turbidity	NTU	dependent on background levels	0.10	3.03	2.50	0.90	0.96
Anions and Nutrients							
Alkalinity, Total (as $CaCO_3$)	mg/L		1.0 or 2.0	29.8	29.4	13.7	13.4
Ammonia, Total (as N)	mg/L	pH- and temperature-dependent	0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Bromide (Br)	mg/L		0.050	0.261	0.253	0.102	0.095
Chloride (Cl)	mg/L	short-term: 640; long-term: 120	0.50	70.8	70.9	30.6	30.6
Fluoride (F)	mg/L	Inorganic fluorides: 0.12[b]	0.020	0.046	0.047	0.034	0.034
Nitrate (as N)	mg/L	short-term: 124; long-term: 3.0	0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Nitrite (as N)	mg/L	0.06	0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Total Kjeldahl Nitrogen	mg/L		0.050	0.389	0.364	0.221	0.258
Total Nitrogen	mg/L		0.050	-	-	-	-
Orthophosphate-Dissolved (as P)	mg/L		0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Phosphorus (P)	mg/L	Trigger ranges from guidance framework[c]	0.0020	0.0180	0.0179	0.0076	0.0091
Sulfate (SO_4)	mg/L		0.50	5.12	5.24	2.85	2.84
Cyanides							
Cyanide, Total	mg/L		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
Organic / Inorganic Carbon							
Dissolved Organic Carbon	mg/L		0.50	4.79	4.67	3.44	3.49
Total Organic Carbon	mg/L		0.50	5.42	5.36	3.77	3.77
Total Metals							
Aluminum (Al)	mg/L	0.005 if pH<6.5; 0.1 if pH≥6.5	0.0030	0.0669	0.0669	0.0386	0.0391
Antimony (Sb)	mg/L		0.00001-0.00003	0.000016	0.000018	0.000013	0.000013
Arsenic (As)	mg/L	0.005	0.000050	0.000257	0.000254	0.000147	0.000159
Barium (Ba)	mg/L		0.00010	0.00337	0.00341	0.00200	0.00187
Beryllium (Be)	mg/L		0.0000050	<0.0000050	0.0000052	<0.0000050	<0.0000050
Bismuth (Bi)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Boron (B)	mg/L	short-term: 29; long-term: 1.5	0.0050	0.0300	0.0306	0.0175	0.0192
Cadmium (Cd)	mg/L	equation[b,d]	0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Calcium (Ca)	mg/L		0.050	8.90	9.08	3.62	3.64
Cesium (Cs)	mg/L		0.0000050	0.0000056	0.0000054	<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
Cobalt (Co)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Copper (Cu)	mg/L	0.002-0.004[e]	0.00050	0.00138	0.00144	0.00092	0.00087
Gallium (Ga)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Iron (Fe)	mg/L	0.3	0.030	0.135	0.135	0.084	0.083
Lead (Pb)	mg/L	0.001-0.007[f]	0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Lithium (Li)	mg/L		0.00020	0.00361	0.00362	0.00158	0.00161
Magnesium (Mg)	mg/L		0.10	7.38	7.43	3.74	3.74
Manganese (Mn)	mg/L		0.00020	0.00726	0.00749	0.00331	0.00327
Mercury (Hg)	ug/L	Inorganic Hg: 0.026	0.00050	0.00058	0.00059	0.00083	0.00052
Molybdenum (Mo)	mg/L	0.073[b]	0.000050	0.000211	0.000214	0.000070	0.000072
Nickel (Ni)	mg/L	0.025-0.150[g]	0.00020	0.00051	0.00054	0.00030	0.00030
Phosphorus (P)	mg/L		0.30	<0.30	<0.30	<0.30	<0.30
Potassium (K)	mg/L		2.0	2.6	2.5	<2.0	<2.0
Rhenium (Re)	mg/L		0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Rubidium (Rb)	mg/L		0.000020	0.00165	0.00161	0.00114	0.00115
Selenium (Se)	mg/L	0.001	0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Silicon (Si)	mg/L		0.050	0.848	0.869	0.198	0.203
Silver (Ag)	mg/L	0.0001	0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Sodium (Na)	mg/L		2.0	37.0	36.1	16.5	16.5
Strontium (Sr)	mg/L		0.000050	0.0513	0.0509	0.0229	0.0232
Tellurium (Te)	mg/L		0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Thallium (Tl)	mg/L	0.0008	0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020
Thorium (Th)	mg/L		0.0000050	0.0000317	0.0000222	0.0000173	0.0000179
Tin (Sn)	mg/L		0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Titanium (Ti)	mg/L		0.00020	0.00254	0.00264	0.00115	0.00121
Tungsten (W)	mg/L		0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Uranium (U)	mg/L	short-term: 0.033; long-term: 0.015	0.0000020	0.0000416	0.0000407	0.0000358	0.0000342
Vanadium (V)	mg/L		0.000050	0.000181	0.000193	0.000099	0.000104
Yttrium (Y)	mg/L		0.0000050	0.0000410	0.0000310	0.0000196	0.0000202
Zinc (Zn)	mg/L	0.03	0.0030	<0.0030	<0.0030	<0.0030	<0.0030
Zirconium (Zr)	mg/L		0.000050	<0.000050	0.000050	<0.000050	<0.000050
Radiochemistry							
Radium-226	Bq/L		0.010	<0.01	<0.01	<0.01	<0.01

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, 2013.

[b] Interim guideline.

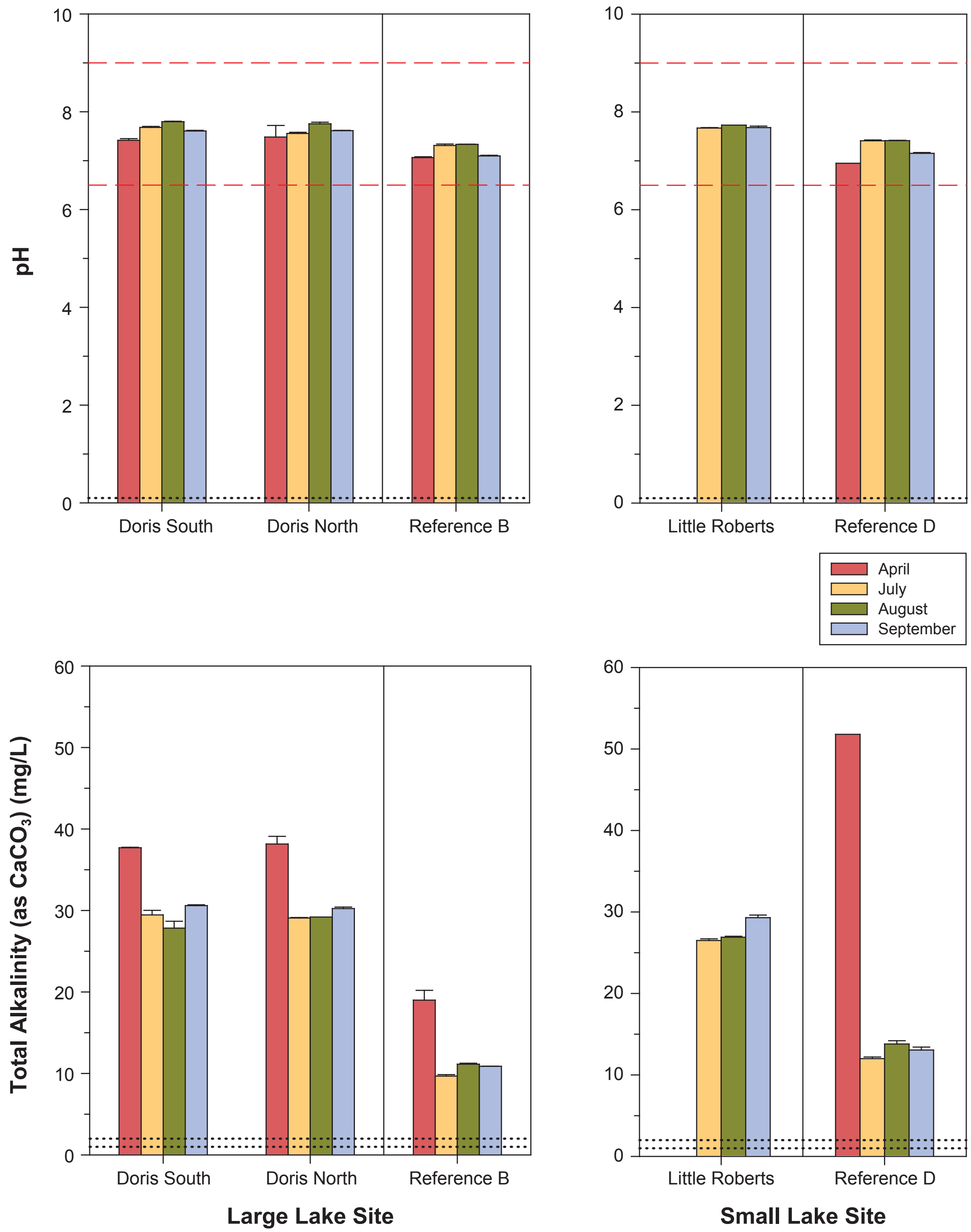
[c] Total phosphorus trigger ranges for lakes and rivers (mg/L): <0.004 = Ultra-oligotrophic; 0.004-0.01 = Oligotrophic; 0.01-0.02 = Mesotrophic; 0.02-0.035 = Meso-eutrophic; 0.035-0.1 = Eutrophic; >0.1 = Hyper-eutrophic.

[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 and a maximum of 0.004 mg/L regardless of water hardness.*

[f] Guideline is hardness-dependent at hardness as $CaCO_3$ *>60 to 180 mg/L: lead guideline (mg/L) =* $e^{\{1.273[\ln(hardness)]-4.705\}}$ */1000. At hardness as* $CaCO_3$ *of ≤ 60mg/L, lead guideline is a minimum of 0.001 mg/L; at hardness as* $CaCO_3$ *of >180 mg/L, lead guideline is a maximum of 0.007 mg/L.*

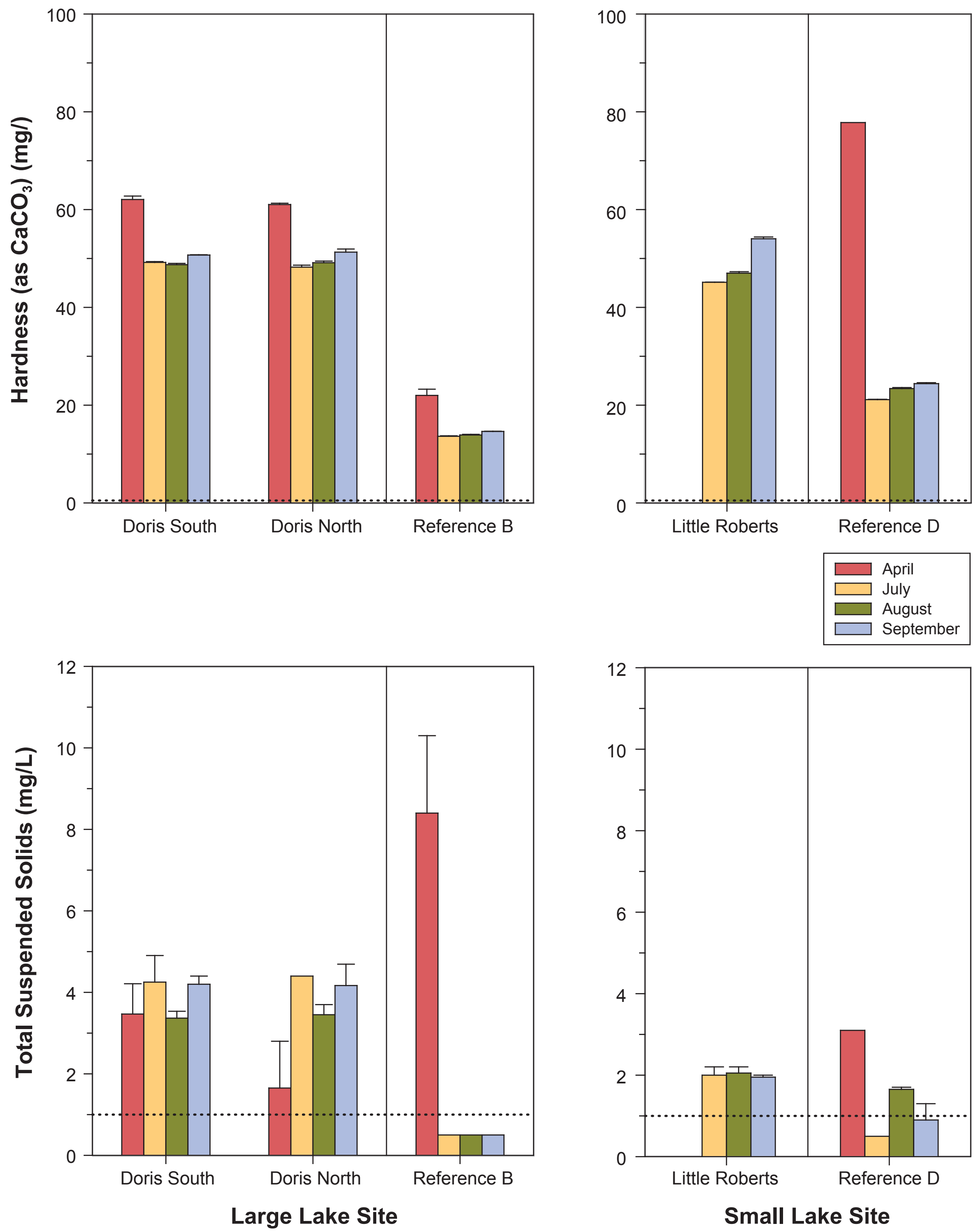
[g] Guideline is hardness-dependent at hardness as $CaCO_3$ *>60 to 180 mg/L: nickel guideline (mg/L) =* $e^{\{0.76[\ln(hardness)]+1.06\}}$ */1000. At hardness as* $CaCO_3$ *of ≤ 60mg/L, nickel guideline is a minimum of 0.025 mg/L; at hardness as* $CaCO_3$ *of >180 mg/L, nickel guideline is a maximum of 0.150 mg/L.*



Notes: Error bars represent the standard error of the mean of replicates.
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 A.3-10

pH and Total Alkalinity in Lake Sites, Doris North Project, 2013



Notes: Error bars represent the standard error of the mean of replicates.
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.
Total suspended solids are regulated as deleterious substances in effluents as per Schedule 4 of the MMER.

Figure A.3-11

Hardness and Total Suspended Solids in Lake Sites, Doris North Project, 2013

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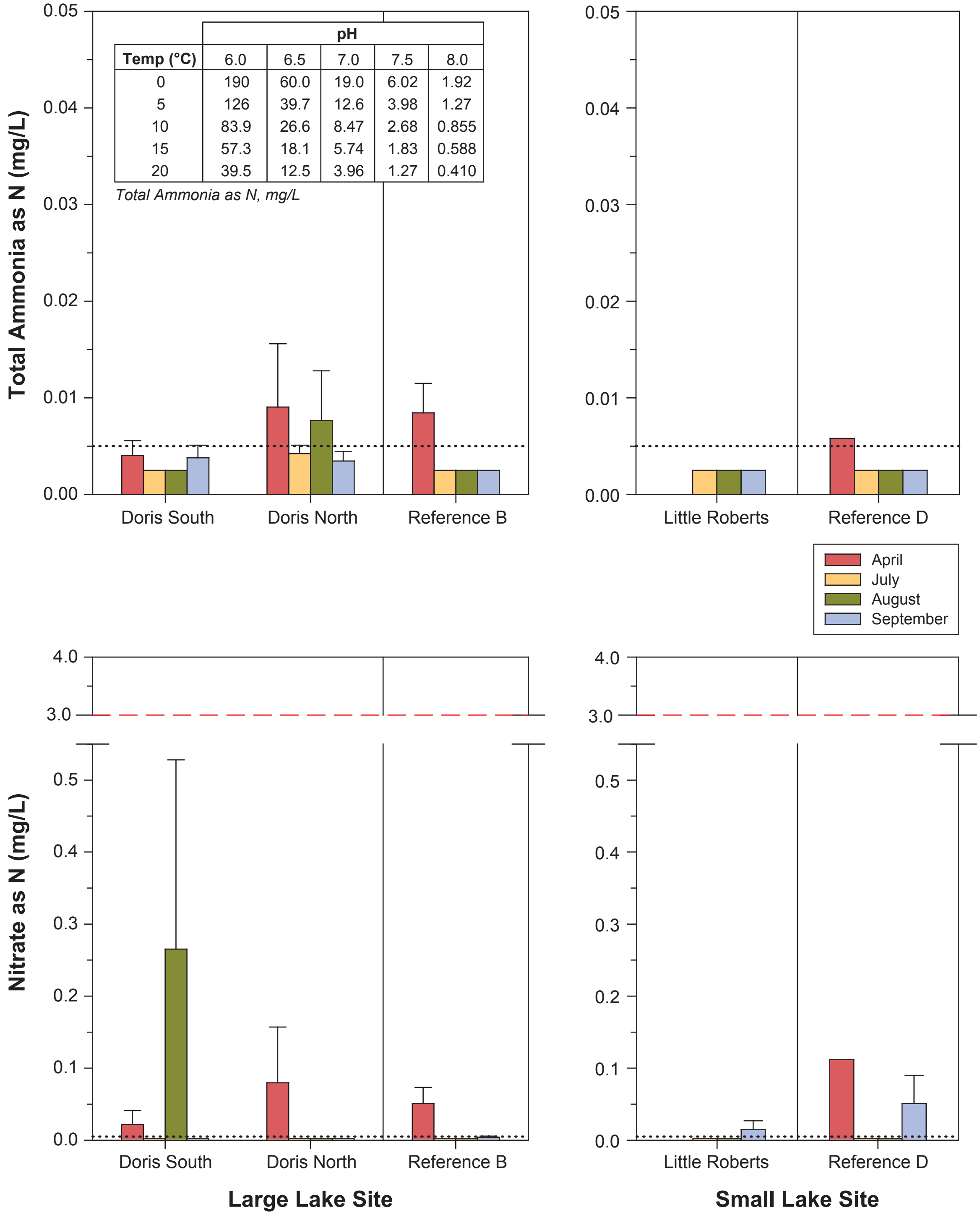


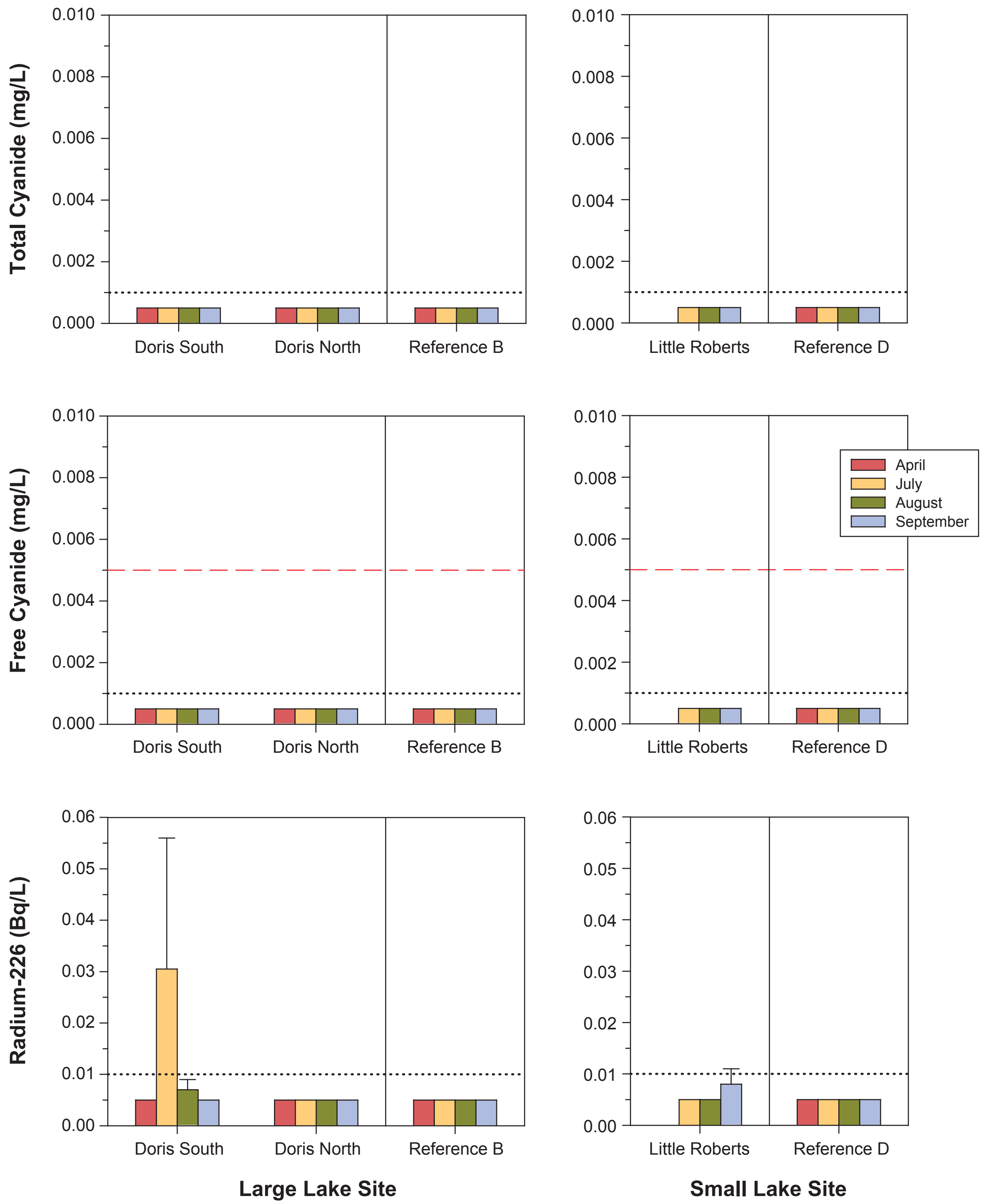
Temp (°C)	pH 6.0	6.5	7.0	7.5	8.0
0	190	60.0	19.0	6.02	1.92
5	126	39.7	12.6	3.98	1.27
10	83.9	26.6	8.47	2.68	0.855
15	57.3	18.1	5.74	1.83	0.588
20	39.5	12.5	3.96	1.27	0.410

Total Ammonia as N, mg/L

Notes: Error bars represent the standard error of the mean of replicates.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
Inset table shows the pH- and temperature-dependent CCME freshwater guideline for total ammonia.
Red dashed line represents the CCME freshwater guideline for nitrate as N (3.0 mg/L; long-term concentration).
Total ammonia and nitrate are required parameters for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

Figure A.3-12

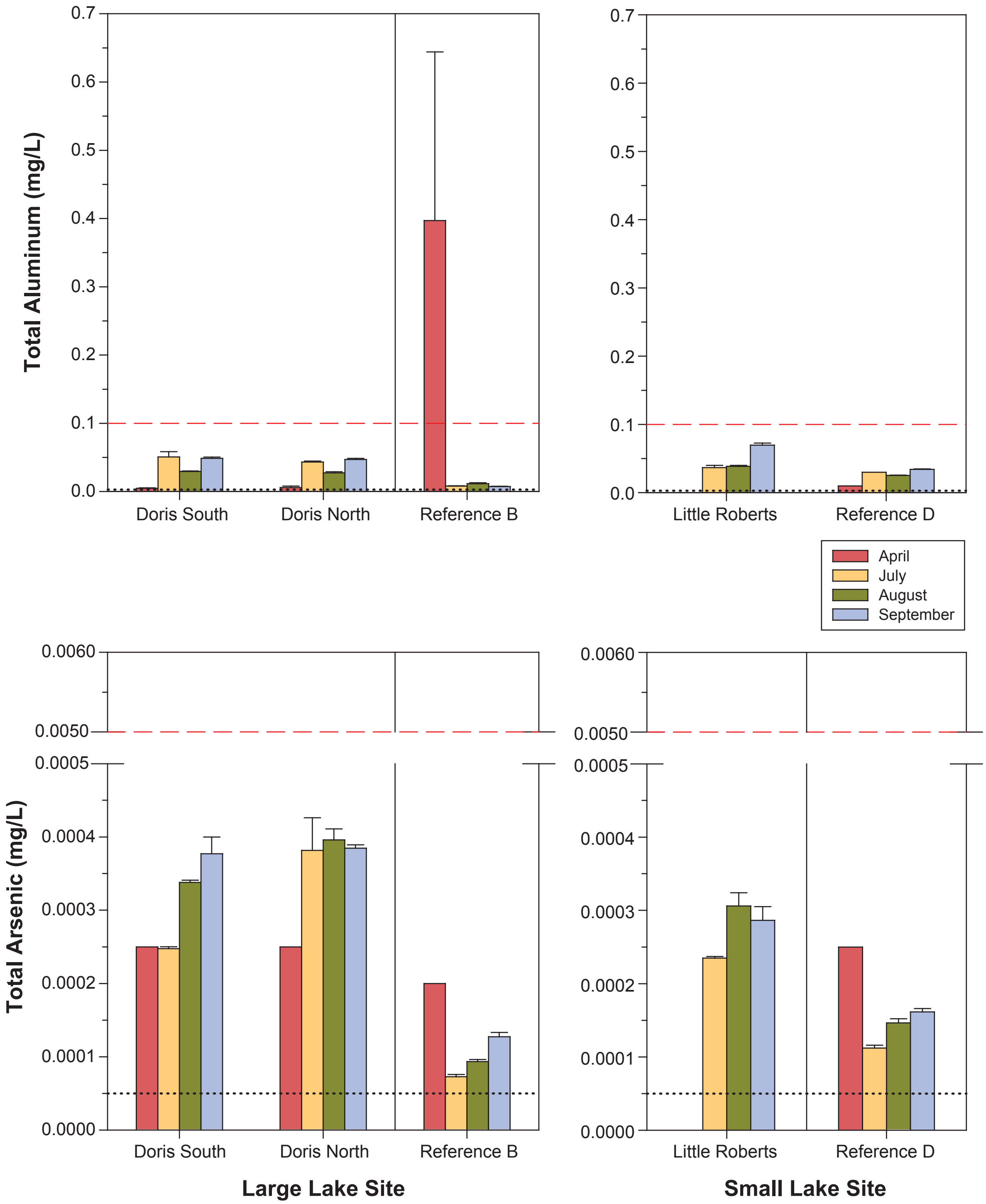
Total Ammonia and Nitrate Concentrations in Lake Sites, Doris North Project, 2013



Notes: Error bars represent the standard error of the mean of replicates.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
All total cyanide and free cyanide concentrations in lake samples were below the detection limit.
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.

Figure A.3-13

Total Cyanide, Free Cyanide and Radium-226 Concentrations in Lake Sites, Doris North Project, 2013



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

Figure A.3-14

Total Aluminum and Total Arsenic Concentrations in Lake Sites, Doris North Project, 2013

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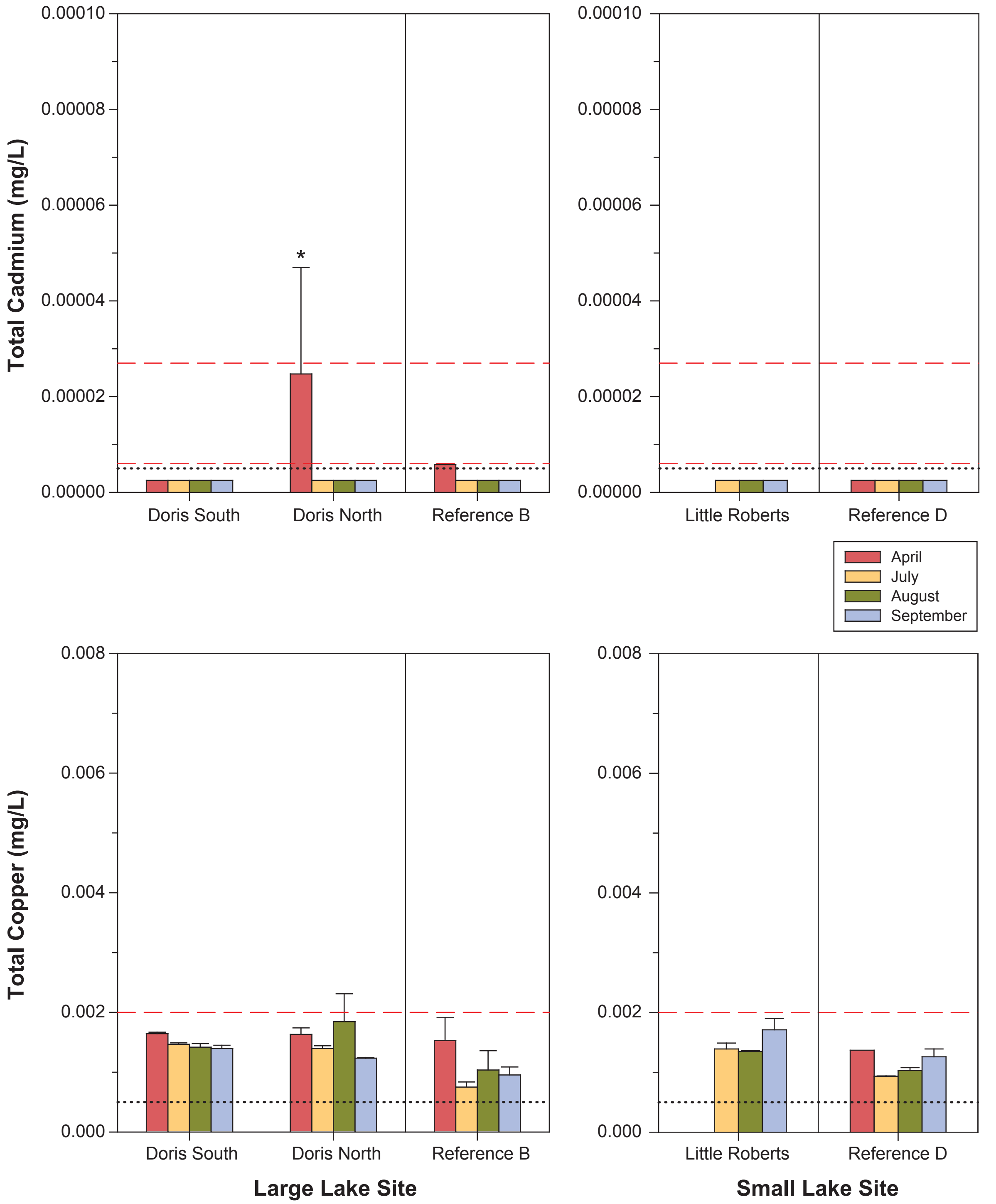

Notes: Error bars represent the standard error of the mean of replicates.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
The CCME freshwater guidelines for cadmium and copper are hardness dependent.
Red dashed lines represent the minimum and maximum CCME freshwater guidelines for cadmium (0.000006 and 0.000027 mg/L) and for copper (0.002 mg/L) based on the hardness (as $CaCO_3$) range in lakes of 13.4 to 77.8 mg/L.
* Indicates that mean concentration is higher than the applicable CCME guideline.
Total cadmium is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.
Total copper is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

Figure A.3-15

Total Cadmium and Total Copper Concentrations in Lake Sites, Doris North Project, 2013

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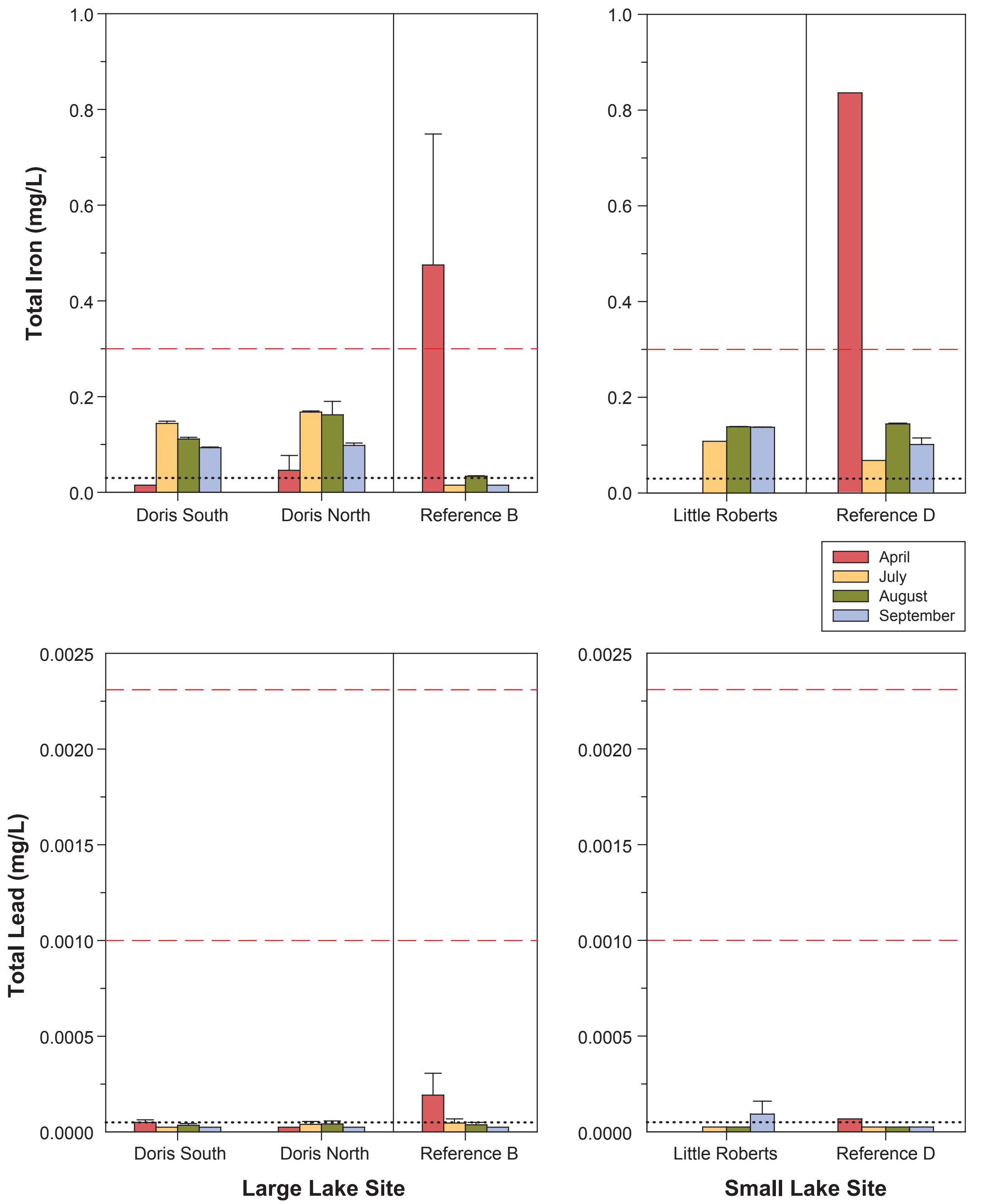
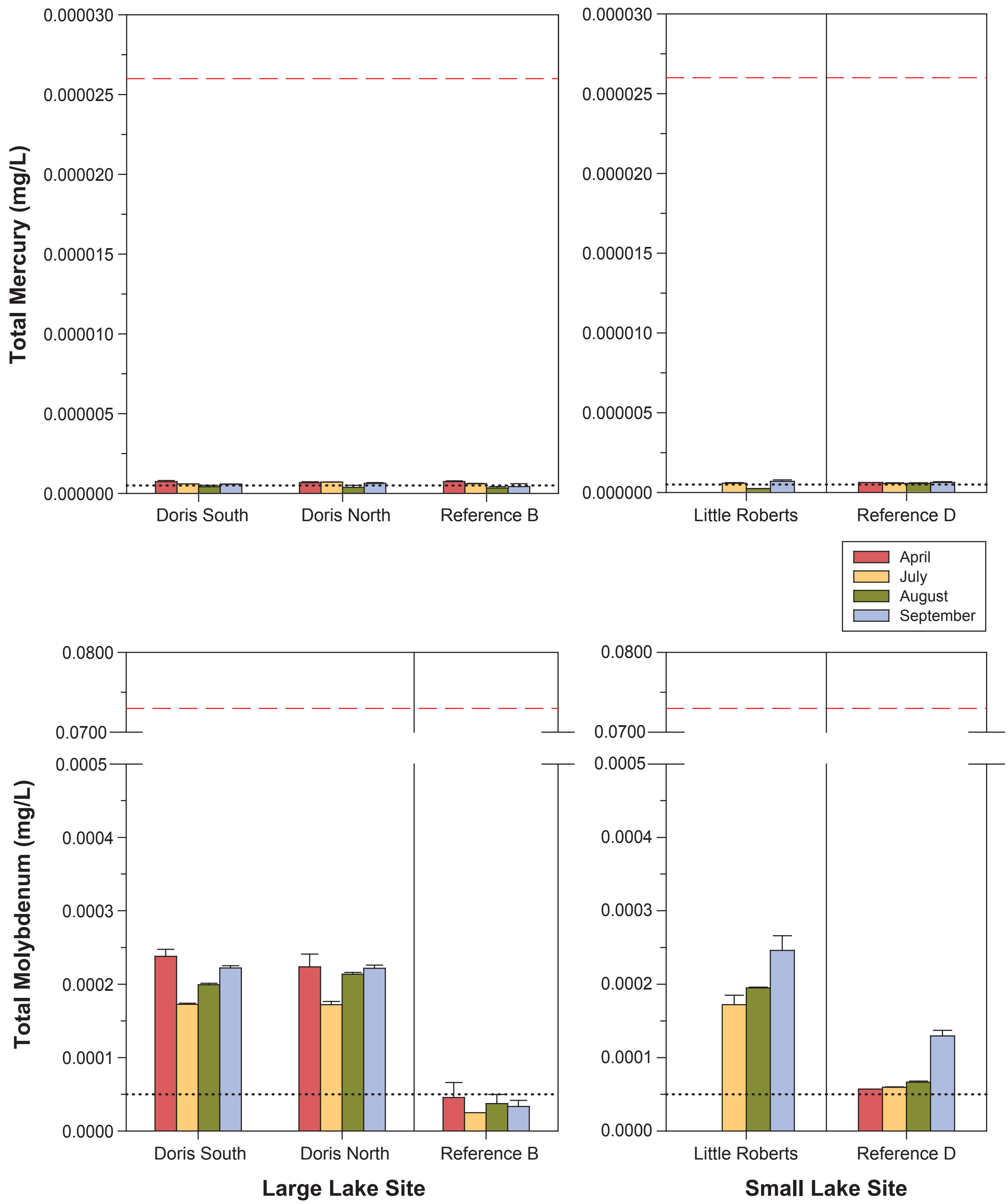


Notes: Error bars represent the standard error of the mean of replicates.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
The CCME freshwater guideline for lead is hardness dependent.
Red dashed lines represent the CCME freshwater guideline for iron (0.3 mg/L) and the minimum and maximum CCME freshwater guideline for lead (0.001 and 0.00231 mg/L) based on the hardness (as $CaCO_3$) range in lakes of 13.4 to 77.8 mg/L.
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 A.3-16

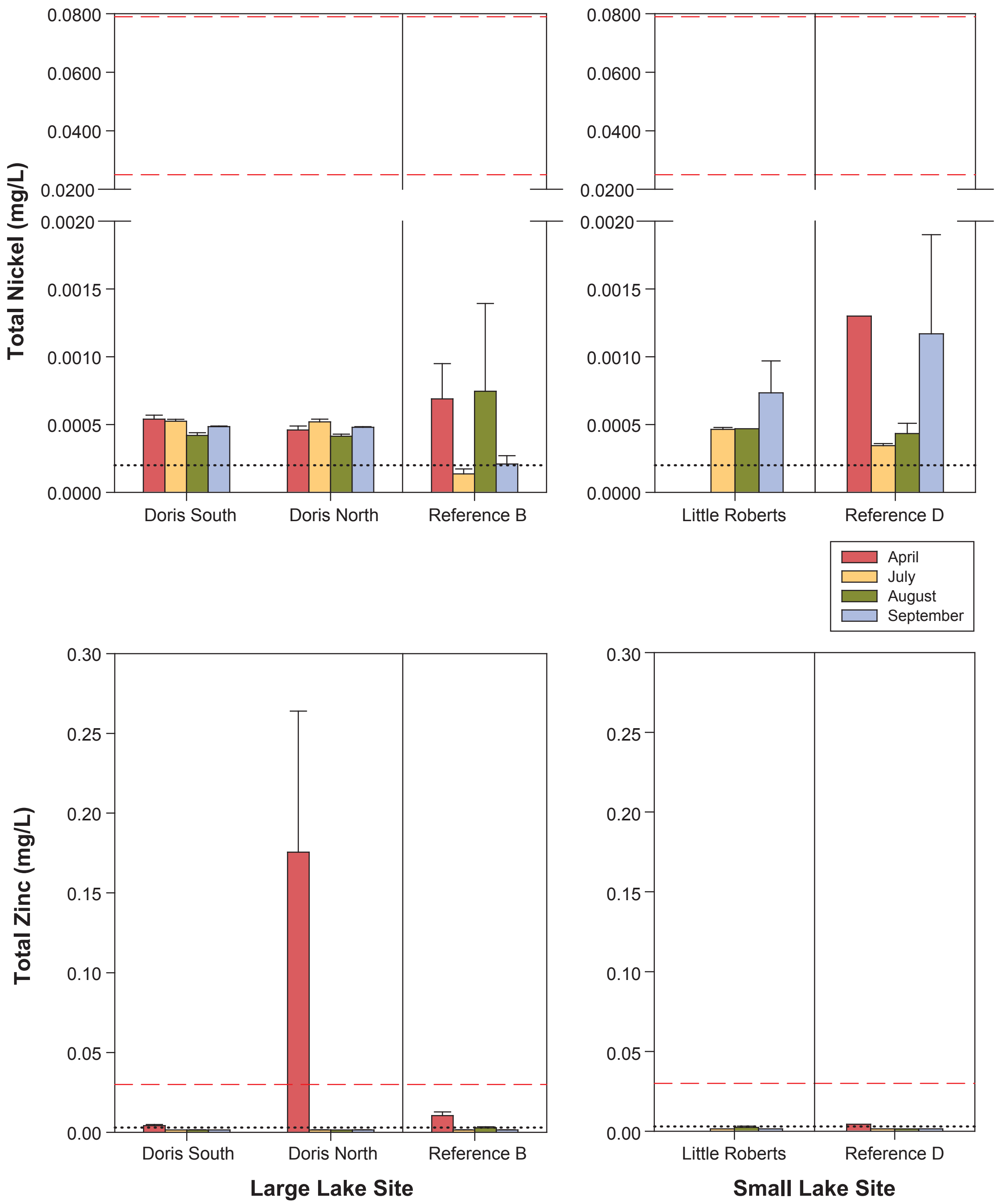
Total Iron and Total Lead Concentrations in Lake Sites, Doris North Project, 2013



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

Figure A.3-17

Total Mercury and Total Molybdenum Concentrations in Lake Sites, Doris North Project, 2013



Notes: Error bars represent the standard error of the mean of replicates.
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 CCME guideline for nickel (0.025 and 0.079 mg/L) based on the hardness (as CaCO3) range in lakes of 13.4 to 77.8 mg/L.
Total nickel and total zinc are regulated as deleterious substances in effluents as per Schedule 4 of the MMER.

Figure A.3-18

Total Nickel and Total Zinc Concentrations in Lake Sites, Doris North Project, 2013

Annex A.3-2. Lake Water Quality Data, Doris North Project, 2013

Site ID:				Doris South	Doris South	Doris South	Doris North	Doris North
Depth Zone:				Surface	Surface	Deep	Surface	Deep
Depth Sampled (m):				1 (below ice)	1 (below ice)	9.7	1 (below ice)	10.0
Replicate:				1	2	1	1	1
Date Sampled:		CCME guideline for the	Realized Detection	26-Apr-13	26-Apr-13	26-Apr-13	25-Apr-13	25-Apr-13
ALS Sample ID:	Units	Protection of Aquatic life[a]	Limit	L1296387-3	L1296387-5	L1296387-4	L1296387-1	L1296387-2
Physical Tests								
Conductivity	uS/cm		2.0	335	335	338	354	331
Hardness (as $CaCO_3$)	mg/L		0.50	62.1	63.3	60.8	60.8	61.3
pH	pH	6.5-9.0	0.10	7.47	7.43	7.35	7.72	7.25
Total Suspended Solids	mg/L	dependent on background levels	1.0	4.0	4.4	2.0	2.8	<1.0
Total Dissolved Solids	mg/L		10	196	191	197	202	194
Turbidity	NTU	dependent on background levels	0.10	5.51	5.18	3.07	4.05	1.18
Anions and Nutrients								
Alkalinity, Total (as $CaCO_3$)	mg/L		1.0 or 2.0	37.8	37.7	37.6	39.1	37.2
Ammonia, Total (as N)	mg/L	pH- and temperature-dependent	0.0050	<0.0050	<0.0050	0.0071	<0.0050	0.0156
Bromide (Br)	mg/L		0.050	0.281	0.285	0.269	0.274	0.267
Chloride (Cl)	mg/L	short-term: 640; long-term: 120	0.50	78.6	78.6	79.4	77.5	76.9
Fluoride (F)	mg/L	Inorganic fluorides: 0.12[b]	0.020	0.065	0.066	0.065	0.065	0.062
Nitrate (as N)	mg/L	short-term: 124; long-term: 3.0	0.0050	<0.0050	<0.0050	0.0606	<0.0050	0.157
Nitrite (as N)	mg/L	0.06	0.0010	<0.0010	<0.0010	<0.0010	0.0015	<0.0010
Total Kjeldahl Nitrogen	mg/L		0.050	0.82	0.690	0.539	0.654	0.432
Total Nitrogen	mg/L		0.050	-	-	-	-	-
Orthophosphate-Dissolved (as P)	mg/L		0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Phosphorus (P)	mg/L	Trigger ranges from guidance framework[c]	0.0020	0.0311	0.0304	0.0227	0.0274	0.0153
Sulfate (SO_4)	mg/L		0.50	3.55	3.53	3.54	3.46	3.32
Cyanides								
Cyanide, Total	mg/L		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
Organic / Inorganic Carbon								
Dissolved Organic Carbon	mg/L		0.50	7.04	7.03	7.02	6.86	6.62
Total Organic Carbon	mg/L		0.50	7.70	7.40	7.64	8.05	7.28
Total Metals								
Aluminum (Al)	mg/L	0.005 if pH<6.5; 0.1 if pH≥6.5	0.0030	0.0040	0.0046	0.0060	0.0041	0.0080
Antimony (Sb)	mg/L		0.000010-0.000040	<0.000040	<0.000040	<0.000030	<0.000030	<0.000030
Arsenic (As)	mg/L	0.005	0.000050-0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Barium (Ba)	mg/L		0.00010	0.00357	0.00361	0.00317	0.00306	0.00341
Beryllium (Be)	mg/L		0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Bismuth (Bi)	mg/L		0.000050 or 0.00010	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Boron (B)	mg/L	short-term: 29; long-term: 1.5	0.005-0.015	0.0321	0.0339	0.0312	0.0310	0.0315
Cadmium (Cd)	mg/L	equation[b,d]	0.0000050	<0.0000050	<0.0000050	<0.0000050	0.0000470	<0.0000050
Calcium (Ca)	mg/L		0.050	11.2	11.4	11.0	11.0	11.1
Cesium (Cs)	mg/L		0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Chromium (Cr)	mg/L	Cr(VI): 0.001; Cr(III): 0.0089[b]	0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Cobalt (Co)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Copper (Cu)	mg/L	0.002-0.004[e]	0.00050	0.00163	0.00169	0.00161	0.00174	0.00152
Gallium (Ga)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Iron (Fe)	mg/L	0.3	0.030	<0.030	<0.030	<0.030	<0.030	0.077
Lead (Pb)	mg/L	0.001-0.007[f]	0.000050	0.000052	0.000071	<0.000050	<0.000050	<0.000050
Lithium (Li)	mg/L		0.00020	0.00482	0.00495	0.00459	0.00471	0.00471
Magnesium (Mg)	mg/L		0.10	8.27	8.48	8.09	8.07	8.16
Manganese (Mn)	mg/L		0.00020	0.00483	0.00485	0.00844	0.00499	0.0194
Mercury (Hg)	ug/L	Inorganic Hg: 0.026	0.00050	0.00068	0.00067	0.00088	0.00073	0.00064
Molybdenum (Mo)	mg/L	0.073[b]	0.000050	0.000239	0.000254	0.000221	0.000241	0.000206
Nickel (Ni)	mg/L	0.025-0.150[g]	0.00020	0.00056	0.00058	0.00048	0.00049	0.00043
Phosphorus (P)	mg/L		0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium (K)	mg/L		2.0	2.9	3.0	2.9	2.9	2.9
Rhenium (Re)	mg/L		0.000005-0.00001	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Rubidium (Rb)	mg/L		0.000020	0.00177	0.00183	0.00172	0.00180	0.00177
Selenium (Se)	mg/L	0.001	0.0002-0.0004	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Silicon (Si)	mg/L		0.050	1.74	1.76	1.73	1.66	2.00
Silver (Ag)	mg/L	0.0001	0.000005-0.00003	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Sodium (Na)	mg/L		2.0	40.1	40.7	39.7	39.9	40.5
Strontium (Sr)	mg/L		0.00005-0.0001	0.0567	0.0577	0.0564	0.0563	0.0560
Tellurium (Te)	mg/L		0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Thallium (Tl)	mg/L	0.0008	0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020
Thorium (Th)	mg/L		0.0000050	0.0000055	0.0000061	<0.0000050	0.0000051	0.0000054
Tin (Sn)	mg/L		0.0002 or 0.0004	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Titanium (Ti)	mg/L		0.00020	<0.00020	<0.00020	0.00022	<0.00020	0.00021
Tungsten (W)	mg/L		0.000010	<0.000010	<0.000010	<0.000010	0.000011	<0.000010
Uranium (U)	mg/L	short-term: 0.033; long-term: 0.015	0.0000020	0.0000391	0.0000414	0.0000388	0.0000376	0.0000344
Vanadium (V)	mg/L		0.000050	0.000074	0.000076	0.000075	0.000072	0.000084
Yttrium (Y)	mg/L		0.0000050	0.0000158	0.0000166	0.0000173	0.0000157	0.0000185
Zinc (Zn)	mg/L	0.03	0.0030	0.0035	0.0034	0.0056	0.0871	0.264
Zirconium (Zr)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Radiochemistry								
Radium-226	Bq/L		0.010	<0.010	<0.010	<0.010	<0.010	<0.010

Notes:

** Sample collected from Little Roberts Lake in April was not included in report results because this sample was contaminated by sediment and is not considered representative of the water quality at this site. There was only 20 cm of water below the ice, and the sediments were disturbed by the augering process.*

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, 2013.*

[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 and a maximum of 0.004 mg/L regardless of water hardness.*

[f] *Guideline is hardness-dependent at hardness as* $CaCO_3$ *>60 to 180 mg/L: lead guideline (mg/L) =* $e^{\{1.273[\ln(hardness)]-4.705\}}$ */ 1000. At hardness as* $CaCO_3$ *of ≤ 60mg/L, lead guideline is a minimum of 0.001 mg/L; at hardness as* $CaCO_3$ *of >180 mg/L, lead guideline is a maximum of 0.007 mg/L.*

[g] *Guideline is hardness-dependent at hardness as* $CaCO_3$ *>60 to 180 mg/L: nickel guideline (mg/L) =* $e^{\{0.76[\ln(hardness)]+1.06\}}$ */ 1000. At hardness as* $CaCO_3$ *of ≤ 60mg/L, nickel guideline is a minimum of 0.025 mg/L; at hardness as* $CaCO_3$ *of >180 mg/L, nickel guideline is a maximum of 0.150 mg/L.*

Annex A.3-2. Lake Water Quality Data, Doris North Project, 2013

Site ID:				Reference B	Reference B	*Little Roberts	Reference D	Doris South
Depth Zone:				Surface	Deep	Surface	Surface	Surface
Depth Sampled (m):				1.0	8.0	0.0	1.0	1.0
Replicate:				1	1	1	1	1
Date Sampled:		CCME guideline for the	Realized Detection	28-Apr-13	28-Apr-13	27-Apr-13	28-Apr-13	19-Jul-13
ALS Sample ID:	Units	Protection of Aquatic life[a]	Limit	L1296387-14	L1296387-21	L1296387-7	L1296387-15	L1336742-3
Physical Tests								
Conductivity	uS/cm		2.0	73.9	82.7	2010	403	270
Hardness (as $CaCO_3$)	mg/L		0.50	23.3	20.7	393	77.8	49.4
pH	pH	6.5-9.0	0.10	7.08	7.05	7.06	6.95	7.66
Total Suspended Solids	mg/L	dependent on background levels	1.0	6.5	10.3	395	3.1	4.9
Total Dissolved Solids	mg/L		10	42	47	1210	230	161
Turbidity	NTU	dependent on background levels	0.10	1.31	1.89	159	3.06	5.45
Anions and Nutrients								
Alkalinity, Total (as $CaCO_3$)	mg/L		1.0 or 2.0	17.8	20.2	181	51.8	30.0
Ammonia, Total (as N)	mg/L	pH- and temperature-dependent	0.0050	0.0115	0.0054	0.115	0.0058	<0.0050
Bromide (Br)	mg/L		0.050	<0.050	<0.050	2.0	0.331	0.218
Chloride (Cl)	mg/L	short-term: 640; long-term: 120	0.50	10.5	10.1	552	89.4	62.9
Fluoride (F)	mg/L	Inorganic fluorides: 0.12[b]	0.020	0.026	0.024	<0.40	0.084	0.051
Nitrate (as N)	mg/L	short-term: 124; long-term: 3.0	0.0050	0.0286	0.0733	0.14	0.112	<0.0050
Nitrite (as N)	mg/L	0.06	0.0010	<0.0010	<0.0010	<0.020	<0.0010	<0.0010
Total Kjeldahl Nitrogen	mg/L		0.050	0.272	0.219	7.27	0.669	0.612
Total Nitrogen	mg/L		0.050	-	-	-	-	0.612
Orthophosphate-Dissolved (as P)	mg/L		0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Phosphorus (P)	mg/L	Trigger ranges from guidance framework[c]	0.0020	0.0085	0.0110	0.563	0.0372	0.0262
Sulfate (SO_4)	mg/L		0.50	2.72	2.67	19	5.48	2.71
Cyanides								
Cyanide, Total	mg/L		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
Organic / Inorganic Carbon								
Dissolved Organic Carbon	mg/L		0.50	3.56	3.55	26.3	10.2	5.37
Total Organic Carbon	mg/L		0.50	3.83	3.28	66.8	10.9	5.72
Total Metals								
Aluminum (Al)	mg/L	0.005 if pH<6.5; 0.1 if pH≥6.5	0.0030	0.644	0.150	13.2	0.0100	0.0584
Antimony (Sb)	mg/L		0.000010-0.000040	<0.000030	<0.000030	0.000100	<0.000040	0.000019
Arsenic (As)	mg/L	0.005	0.000050-0.00050	<0.00040	<0.00040	0.00339	<0.00050	0.000250
Barium (Ba)	mg/L		0.00010	0.00812	0.00414	0.128	0.00896	0.00355
Beryllium (Be)	mg/L		0.0000050	0.0000194	0.0000055	0.000424	<0.0000050	<0.0000050
Bismuth (Bi)	mg/L		0.000050 or 0.00010	<0.000050	<0.000050	<0.00010	<0.000050	<0.000050
Boron (B)	mg/L	short-term: 29; long-term: 1.5	0.005-0.015	<0.015	<0.015	0.155	0.0378	0.0265
Cadmium (Cd)	mg/L	equation[b,d]	0.0000050	0.0000056	0.0000060	0.000051	<0.0000050	<0.0000050
Calcium (Ca)	mg/L		0.050	5.30	4.95	59.0	12.1	9.15
Cesium (Cs)	mg/L		0.0000050	0.0000470	0.0000130	0.000858	<0.0000050	0.0000053
Chromium (Cr)	mg/L	Cr(VI): 0.001; Cr(III): 0.0089[b]	0.00050	0.00131	<0.00050	0.0289	<0.00050	<0.00050
Cobalt (Co)	mg/L		0.000050	0.000346	0.000166	0.00721	0.000183	0.000050
Copper (Cu)	mg/L	0.002-0.004[e]	0.00050	0.00191	0.00115	0.0180	0.00137	0.00149
Gallium (Ga)	mg/L		0.000050	0.000228	0.000051	0.00428	<0.000050	<0.000050
Iron (Fe)	mg/L	0.3	0.030	0.749	0.201	19.0	0.836	0.149
Lead (Pb)	mg/L	0.001-0.007[f]	0.000050	0.000306	0.000079	0.00415	0.000067	<0.000050
Lithium (Li)	mg/L		0.00020	0.00153	0.00083	0.0378	0.00432	0.00367
Magnesium (Mg)	mg/L		0.10	2.44	2.03	59.7	11.6	6.44
Manganese (Mn)	mg/L		0.00020	0.0163	0.0343	1.64	0.218	0.0188
Mercury (Hg)	ug/L	Inorganic Hg: 0.026	0.00050	0.00070	0.00079	0.0091	0.00063	0.00060
Molybdenum (Mo)	mg/L	0.073[b]	0.000050	0.000066	<0.000050	0.00074	0.000057	0.000174
Nickel (Ni)	mg/L	0.025-0.150[g]	0.00020	0.00095	0.00043	0.0177	0.00130	0.00054
Phosphorus (P)	mg/L		0.30	<0.30	<0.30	0.76	<0.30	<0.30
Potassium (K)	mg/L		2.0	<2.0	<2.0	17.2	3.6	2.4
Rhenium (Re)	mg/L		0.000005-0.00001	<0.0000050	<0.0000050	<0.000010	<0.0000050	<0.0000050
Rubidium (Rb)	mg/L		0.000020	0.00236	0.00133	0.0329	0.00309	0.00164
Selenium (Se)	mg/L	0.001	0.0002-0.0004	<0.00020	<0.00020	<0.00040	<0.00020	<0.00020
Silicon (Si)	mg/L		0.050	1.38	0.791	30.8	1.23	1.51
Silver (Ag)	mg/L	0.0001	0.000005-0.00003	<0.0000050	<0.0000050	<0.000030	<0.0000050	<0.0000050
Sodium (Na)	mg/L		2.0	6.0	5.2	267	47.0	33.4
Strontium (Sr)	mg/L		0.00005-0.0001	0.0268	0.0246	0.358	0.0731	0.0432
Tellurium (Te)	mg/L		0.000010	<0.000010	<0.000010	0.000035	0.000010	<0.000010
Thallium (Tl)	mg/L	0.0008	0.0000020	0.0000080	0.0000028	0.000118	<0.0000020	<0.0000020
Thorium (Th)	mg/L		0.0000050	0.000159	0.0000455	0.00350	0.0000241	0.0000225
Tin (Sn)	mg/L		0.0002 or 0.0004	<0.00020	<0.00020	<0.00040	<0.00020	<0.00020
Titanium (Ti)	mg/L		0.00020	0.0303	0.00748	0.721	0.00029	0.00249
Tungsten (W)	mg/L		0.000010	<0.000010	<0.000010	0.000122	<0.000010	<0.000010
Uranium (U)	mg/L	short-term: 0.033; long-term: 0.015	0.0000020	0.0000743	0.0000338	0.00109	0.0000413	0.0000344
Vanadium (V)	mg/L		0.000050	0.00147	0.000361	0.0334	0.000127	0.000174
Yttrium (Y)	mg/L		0.0000050	0.000227	0.0000700	0.00479	0.0000515	0.0000269
Zinc (Zn)	mg/L	0.03	0.0030	0.0081	0.0128	0.0549	0.0044	<0.0030
Zirconium (Zr)	mg/L		0.000050	<0.000050	<0.000050	0.00156	<0.000050	<0.000050
Radiochemistry								
Radium-226	Bq/L		0.010	<0.010	<0.010	0.013	<0.010	<0.01

Notes:

** Sample collected from Little Roberts Lake in April was not included in report results because this sample was contaminated by sediment and is not considered representative of the water quality at this site. There was only 20 cm of water below the ice, and the sediments were disturbed by the augering process.*

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, 2013.*

[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 and a maximum of 0.004 mg/L regardless of water hardness.*

[f] *Guideline is hardness-dependent at hardness as* $CaCO_3$ *>60 to 180 mg/L: lead guideline (mg/L) =* $e^{\{1.273[\ln(hardness)]-4.705\}}/1000$. *At hardness as* $CaCO_3$ *of ≤ 60mg/L, lead guideline is a minimum of 0.001 mg/L; at hardness as* $CaCO_3$ *of >180 mg/L, lead guideline is a maximum of 0.007 mg/L.*

[g] *Guideline is hardness-dependent at hardness as* $CaCO_3$ *>60 to 180 mg/L: nickel guideline (mg/L) =* $e^{\{0.76[\ln(hardness)]+1.06\}}/1000$. *At hardness as* $CaCO_3$ *of ≤ 60mg/L, nickel guideline is a minimum of 0.025 mg/L; at hardness as* $CaCO_3$ *of >180 mg/L, nickel guideline is a maximum of 0.150 mg/L.*

Annex A.3-2. Lake Water Quality Data, Doris North Project, 2013

Site ID:				Doris South	Doris North	Doris North	Doris North	Reference B
Depth Zone:				Deep	Surface	Surface	Deep	Surface
Depth Sampled (m):				9.0	1.0	1.0	12.0	1.0
Replicate:				1	1	2	1	1
Date Sampled:		CCME guideline for the	Realized Detection	19-Jul-13	17-Jul-13	17-Jul-13	17-Jul-13	19-Jul-13
ALS Sample ID:	Units	Protection of Aquatic life[a]	Limit	L1336742-4	L1335459-2	L1335459-4	L1335459-3	L1336785-1
Physical Tests								
Conductivity	uS/cm		2.0	271	264	268	267	47.8
Hardness (as $CaCO_3$)	mg/L		0.50	49.0	47.5	48.9	48.3	13.8
pH	pH	6.5-9.0	0.10	7.70	7.53	7.61	7.53	7.33
Total Suspended Solids	mg/L	dependent on background levels	1.0	3.6	4.4	4.4	4.4	<1.0
Total Dissolved Solids	mg/L		10	160	136	141	144	40
Turbidity	NTU	dependent on background levels	0.10	6.02	7.03	4.09	5.69	0.58
Anions and Nutrients								
Alkalinity, Total (as $CaCO_3$)	mg/L		1.0 or 2.0	28.9	29.2	29.0	29.0	9.8
Ammonia, Total (as N)	mg/L	pH- and temperature-dependent	0.0050	<0.0050	0.0052	0.0050	<0.0050	<0.0050
Bromide (Br)	mg/L		0.050	0.222	0.208	0.214	0.218	<0.050
Chloride (Cl)	mg/L	short-term: 640; long-term: 120	0.50	63.0	61.9	62.1	62.0	6.84
Fluoride (F)	mg/L	Inorganic fluorides: 0.12[b]	0.020	0.051	0.051	0.051	0.050	<0.020
Nitrate (as N)	mg/L	short-term: 124; long-term: 3.0	0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Nitrite (as N)	mg/L	0.06	0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Total Kjeldahl Nitrogen	mg/L		0.050	0.481	0.495	0.457	0.492	0.182
Total Nitrogen	mg/L		0.050	0.481	-	-	-	-
Orthophosphate-Dissolved (as P)	mg/L		0.0010	<0.0010	<0.0010	0.0092	<0.0010	<0.0010
Phosphorus (P)	mg/L	Trigger ranges from guidance framework[c]	0.0020	0.0247	0.0274	0.0284	0.0277	0.0037
Sulfate (SO_4)	mg/L		0.50	2.71	2.67	2.67	2.67	1.74
Cyanides								
Cyanide, Total	mg/L		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
Organic / Inorganic Carbon								
Dissolved Organic Carbon	mg/L		0.50	5.42	5.28	5.33	5.34	2.58
Total Organic Carbon	mg/L		0.50	5.91	5.93	5.90	5.73	3.24
Total Metals								
Aluminum (Al)	mg/L	0.005 if pH<6.5; 0.1 if pH≥6.5	0.0030	0.0431	0.0411	0.0458	0.0432	0.0089
Antimony (Sb)	mg/L		0.000010-0.000040	0.000019	0.000020	0.000022	0.000020	<0.000010
Arsenic (As)	mg/L	0.005	0.000050-0.00050	0.000245	0.000469	0.000354	0.000322	0.000069
Barium (Ba)	mg/L		0.00010	0.00337	0.00367	0.00338	0.00332	0.00174
Beryllium (Be)	mg/L		0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Bismuth (Bi)	mg/L		0.000050 or 0.00010	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Boron (B)	mg/L	short-term: 29; long-term: 1.5	0.005-0.015	0.0293	0.0289	0.0302	0.0285	0.0108
Cadmium (Cd)	mg/L	equation[b,d]	0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Calcium (Ca)	mg/L		0.050	9.04	8.58	8.80	8.69	3.29
Cesium (Cs)	mg/L		0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Chromium (Cr)	mg/L	Cr(VI): 0.001; Cr(III): 0.0089[b]	0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Cobalt (Co)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Copper (Cu)	mg/L	0.002-0.004[e]	0.00050	0.00144	0.00143	0.00145	0.00131	0.00092
Gallium (Ga)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Iron (Fe)	mg/L	0.3	0.030	0.139	0.163	0.171	0.169	<0.030
Lead (Pb)	mg/L	0.001-0.007[f]	0.000050	<0.000050	0.000069	<0.000050	<0.000050	0.000090
Lithium (Li)	mg/L		0.00020	0.00370	0.00398	0.00395	0.00406	0.00057
Magnesium (Mg)	mg/L		0.10	6.42	6.32	6.55	6.46	1.36
Manganese (Mn)	mg/L		0.00020	0.0210	0.0277	0.0283	0.0278	0.00169
Mercury (Hg)	ug/L	Inorganic Hg: 0.026	0.00050	0.00060	0.00071	0.00074	0.00070	0.00065
Molybdenum (Mo)	mg/L	0.073[b]	0.000050	0.000171	0.000164	0.000179	0.000173	<0.000050
Nickel (Ni)	mg/L	0.025-0.150[g]	0.00020	0.00051	0.00056	0.00051	0.00049	0.00021
Phosphorus (P)	mg/L		0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium (K)	mg/L		2.0	2.4	2.3	2.4	2.4	<2.0
Rhenium (Re)	mg/L		0.000005-0.00001	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Rubidium (Rb)	mg/L		0.000020	0.00163	0.00163	0.00165	0.00166	0.000832
Selenium (Se)	mg/L	0.001	0.0002-0.0004	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Silicon (Si)	mg/L		0.050	1.48	1.46	1.51	1.48	0.091
Silver (Ag)	mg/L	0.0001	0.000005-0.00003	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Sodium (Na)	mg/L		2.0	33.5	32.9	33.6	33.3	4.0
Strontium (Sr)	mg/L		0.00005-0.0001	0.0451	0.0418	0.0423	0.0429	0.0151
Tellurium (Te)	mg/L		0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Thallium (Tl)	mg/L	0.0008	0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	0.0000028
Thorium (Th)	mg/L		0.0000050	0.0000181	0.0000189	0.0000198	0.0000180	<0.0000050
Tin (Sn)	mg/L		0.0002 or 0.0004	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Titanium (Ti)	mg/L		0.00020	0.00130	0.00131	0.00156	0.00142	<0.00020
Tungsten (W)	mg/L		0.000010	<0.000010	<0.000010	0.000010	0.000011	<0.000010
Uranium (U)	mg/L	short-term: 0.033; long-term: 0.015	0.0000020	0.0000336	0.0000324	0.0000344	0.0000332	0.0000340
Vanadium (V)	mg/L		0.000050	0.000148	0.000147	0.000156	0.000151	<0.000050
Yttrium (Y)	mg/L		0.0000050	0.0000233	0.0000250	0.0000267	0.0000260	0.0000103
Zinc (Zn)	mg/L	0.03	0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030
Zirconium (Zr)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Radiochemistry								
Radium-226	Bq/L		0.010	0.056	<0.010	<0.010	<0.010	<0.01

Notes:

** Sample collected from Little Roberts Lake in April was not included in report results because this sample was contaminated by sediment and is not considered representative of the water quality at this site. There was only 20 cm of water below the ice, and the sediments were disturbed by the augering process.*

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, 2013.*

[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 and a maximum of 0.004 mg/L regardless of water hardness.*

[f] *Guideline is hardness-dependent at hardness as* $CaCO_3$ *>60 to 180 mg/L: lead guideline (mg/L) =* $e^{\{1.273[\ln(hardness)]-4.705\}}/1000$. *At hardness as* $CaCO_3$ *of ≤ 60mg/L, lead guideline is a minimum of 0.001 mg/L; at hardness as* $CaCO_3$ *of >180 mg/L, lead guideline is a maximum of 0.007 mg/L.*

[g] *Guideline is hardness-dependent at hardness as* $CaCO_3$ *>60 to 180 mg/L: nickel guideline (mg/L) =* $e^{\{0.76[\ln(hardness)]+1.06\}}/1000$. *At hardness as* $CaCO_3$ *of ≤ 60mg/L, nickel guideline is a minimum of 0.025 mg/L; at hardness as* $CaCO_3$ *of >180 mg/L, nickel guideline is a maximum of 0.150 mg/L.*

Annex A.3-2. Lake Water Quality Data, Doris North Project, 2013

Site ID:				Reference B	Reference B	Little Roberts	Little Roberts	Reference D
Depth Zone:				Deep	Deep	Surface	Surface	Surface
Depth Sampled (m):				8.0	8.0	0.5	0.5	1.0
Replicate:				1	2	1	2	1
Date Sampled:		CCME guideline for the	Realized Detection	19-Jul-13	19-Jul-13	20-Jul-13	20-Jul-13	21-Jul-13
ALS Sample ID:	Units	Protection of Aquatic life[a]	Limit	L1336785-2	L1336785-3	L1336779-1	L1336779-2	L1336779-3
Physical Tests								
Conductivity	uS/cm		2.0	47.3	47.2	259	258	113
Hardness (as $CaCO_3$)	mg/L		0.50	13.7	13.4	45.1	45.2	21.1
pH	pH	6.5-9.0	0.10	7.35	7.25	7.68	7.66	7.43
Total Suspended Solids	mg/L	dependent on background levels	1.0	<1.0	<1.0	1.8	2.2	<1.0
Total Dissolved Solids	mg/L		10	34	32	154	150	67
Turbidity	NTU	dependent on background levels	0.10	0.65	0.62	2.34	1.98	1.12
Anions and Nutrients								
Alkalinity, Total (as $CaCO_3$)	mg/L		1.0 or 2.0	9.9	9.3	26.3	26.7	12.2
Ammonia, Total (as N)	mg/L	pH- and temperature-dependent	0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Bromide (Br)	mg/L		0.050	<0.050	<0.050	0.199	0.197	0.073
Chloride (Cl)	mg/L	short-term: 640; long-term: 120	0.50	6.77	6.74	61.0	61.1	24.8
Fluoride (F)	mg/L	Inorganic fluorides: 0.12[b]	0.020	<0.020	<0.020	0.053	0.053	0.037
Nitrate (as N)	mg/L	short-term: 124; long-term: 3.0	0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Nitrite (as N)	mg/L	0.06	0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Total Kjeldahl Nitrogen	mg/L		0.050	0.211	0.209	0.383	0.384	0.243
Total Nitrogen	mg/L		0.050	-	-	0.383	0.384	0.243
Orthophosphate-Dissolved (as P)	mg/L		0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Phosphorus (P)	mg/L	Trigger ranges from guidance framework[c]	0.0020	0.0046	0.0035	0.0183	0.0167	0.0066
Sulfate (SO_4)	mg/L		0.50	1.74	1.73	3.62	3.59	2.19
Cyanides								
Cyanide, Total	mg/L		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
Organic / Inorganic Carbon								
Dissolved Organic Carbon	mg/L		0.50	2.69	2.82	5.75	5.76	4.21
Total Organic Carbon	mg/L		0.50	2.94	2.89	5.51	5.31	3.57
Total Metals								
Aluminum (Al)	mg/L	0.005 if pH<6.5; 0.1 if pH≥6.5	0.0030	0.0080	0.0074	0.0335	0.0399	0.0300
Antimony (Sb)	mg/L		0.000010-0.000040	<0.000010	<0.000010	0.000016	0.000018	0.000012
Arsenic (As)	mg/L	0.005	0.000050-0.00050	0.000070	0.000079	0.000233	0.000237	0.000116
Barium (Ba)	mg/L		0.00010	0.00154	0.00169	0.00305	0.00297	0.00186
Beryllium (Be)	mg/L		0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Bismuth (Bi)	mg/L		0.000050 or 0.00010	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Boron (B)	mg/L	short-term: 29; long-term: 1.5	0.005-0.015	0.0098	0.0112	0.0311	0.0293	0.0171
Cadmium (Cd)	mg/L	equation[b,d]	0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Calcium (Ca)	mg/L		0.050	3.28	3.21	7.88	7.87	3.34
Cesium (Cs)	mg/L		0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Chromium (Cr)	mg/L	Cr(VI): 0.001; Cr(III): 0.0089[b]	0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Cobalt (Co)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Copper (Cu)	mg/L	0.002-0.004[e]	0.00050	0.00067	0.00066	0.00129	0.00149	0.00094
Gallium (Ga)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Iron (Fe)	mg/L	0.3	0.030	<0.030	<0.030	0.108	0.108	0.068
Lead (Pb)	mg/L	0.001-0.007[f]	0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Lithium (Li)	mg/L		0.00020	0.00058	0.00056	0.00287	0.00320	0.00142
Magnesium (Mg)	mg/L		0.10	1.34	1.31	6.17	6.21	3.09
Manganese (Mn)	mg/L		0.00020	0.00175	0.00169	0.00863	0.00947	0.00360
Mercury (Hg)	ug/L	Inorganic Hg: 0.026	0.00050	0.00059	0.00060	0.00062	0.00054	0.00054
Molybdenum (Mo)	mg/L	0.073[b]	0.000050	<0.000050	<0.000050	0.000159	0.000185	0.000060
Nickel (Ni)	mg/L	0.025-0.150[g]	0.00020	<0.00020	<0.00020	0.00045	0.00048	0.00033
Phosphorus (P)	mg/L		0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium (K)	mg/L		2.0	<2.0	<2.0	2.2	2.2	<2.0
Rhenium (Re)	mg/L		0.000005-0.00001	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Rubidium (Rb)	mg/L		0.000020	0.000797	0.000798	0.00137	0.00150	0.00115
Selenium (Se)	mg/L	0.001	0.0002-0.0004	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Silicon (Si)	mg/L		0.050	0.090	0.088	0.834	0.839	0.173
Silver (Ag)	mg/L	0.0001	0.000005-0.00003	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Sodium (Na)	mg/L		2.0	3.9	3.9	32.0	32.2	13.6
Strontium (Sr)	mg/L		0.00005-0.0001	0.0148	0.0140	0.0388	0.0414	0.0205
Tellurium (Te)	mg/L		0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Thallium (Tl)	mg/L	0.0008	0.0000020	0.0000023	0.0000023	<0.0000020	<0.0000020	<0.0000020
Thorium (Th)	mg/L		0.0000050	0.0000054	<0.0000050	0.0000141	0.0000167	0.0000150
Tin (Sn)	mg/L		0.0002 or 0.0004	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Titanium (Ti)	mg/L		0.00020	<0.00020	<0.00020	0.00100	0.00119	0.00073
Tungsten (W)	mg/L		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	0.0000330	0.0000323	0.0000329	0.0000376	0.0000299
Vanadium (V)	mg/L		0.000050	<0.000050	<0.000050	0.000130	0.000147	0.000077
Yttrium (Y)	mg/L		0.0000050	0.0000100	0.0000100	0.0000238	0.0000267	0.0000202
Zinc (Zn)	mg/L	0.03	0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030
Zirconium (Zr)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Radiochemistry								
Radium-226	Bq/L		0.010	<0.01	<0.01	<0.01	<0.01	<0.01

Notes:

** Sample collected from Little Roberts Lake in April was not included in report results because this sample was contaminated by sediment and is not considered representative of the water quality at this site. There was only 20 cm of water below the ice, and the sediments were disturbed by the augering process.*

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, 2013.*

[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 and a maximum of 0.004 mg/L regardless of water hardness.*

[f] *Guideline is hardness-dependent at hardness as $CaCO_3$ >60 to 180 mg/L: lead guideline (mg/L) = $e^{\{1.273[\ln(hardness)]-4.705\}}$ / 1000. At hardness as $CaCO_3$ of ≤ 60mg/L, lead guideline is a minimum of 0.001 mg/L; at hardness as $CaCO_3$ of >180 mg/L, lead guideline is a maximum of 0.007 mg/L.*

[g] *Guideline is hardness-dependent at hardness as $CaCO_3$ >60 to 180 mg/L: nickel guideline (mg/L) = $e^{\{0.76[\ln(hardness)]+1.06\}}$ / 1000. At hardness as $CaCO_3$ of ≤ 60mg/L, nickel guideline is a minimum of 0.025 mg/L; at hardness as $CaCO_3$ of >180 mg/L, nickel guideline is a maximum of 0.150 mg/L.*

Annex A.3-2. Lake Water Quality Data, Doris North Project, 2013

Site ID:				Reference D	Doris South	Doris South	Doris South	Doris North
Depth Zone:				Surface	Surface	Surface	Deep	Surface
Depth Sampled (m):				1.0	1.0	1.0	9.5	1.0
Replicate:				2	1	2	1	1
Date Sampled:		CCME guideline for the	Realized Detection	21-Jul-13	20-Aug-13	20-Aug-13	20-Aug-13	20-Aug-13
ALS Sample ID:	Units	Protection of Aquatic life[a]	Limit	L1336779-4	L1352799-1	L1352799-3	L1352799-2	L1352799-4
Physical Tests								
Conductivity	uS/cm		2.0	113	272	271	270	270
Hardness (as $CaCO_3$)	mg/L		0.50	21.2	48.6	49.3	48.3	48.8
pH	pH	6.5-9.0	0.10	7.39	7.78	7.79	7.82	7.79
Total Suspended Solids	mg/L	dependent on background levels	1.0	<1.0	3.7	3.2	3.2	3.2
Total Dissolved Solids	mg/L		10	62	180	169	172	176
Turbidity	NTU	dependent on background levels	0.10	1.14	4.52	4.45	4.51	4.74
Anions and Nutrients								
Alkalinity, Total (as $CaCO_3$)	mg/L		1.0 or 2.0	11.8	26.2	28.9	28.4	29.2
Ammonia, Total (as N)	mg/L	pH- and temperature-dependent	0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Bromide (Br)	mg/L		0.050	0.073	0.227	0.214	0.217	0.215
Chloride (Cl)	mg/L	short-term: 640; long-term: 120	0.50	24.6	63.9	63.8	63.9	63.8
Fluoride (F)	mg/L	Inorganic fluorides: 0.12[b]	0.020	0.036	0.048	0.049	0.048	0.049
Nitrate (as N)	mg/L	short-term: 124; long-term: 3.0	0.0050	<0.0050	0.791	<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
Total Kjeldahl Nitrogen	mg/L		0.050	0.230	0.507	0.626	0.546	0.627
Total Nitrogen	mg/L		0.050	0.230	-	-	-	-
Orthophosphate-Dissolved (as P)	mg/L		0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Phosphorus (P)	mg/L	Trigger ranges from guidance framework[c]	0.0020	0.0065	0.0249	0.0226	0.0243	0.0236
Sulfate (SO_4)	mg/L		0.50	2.16	2.70	2.68	2.67	2.66
Cyanides								
Cyanide, Total	mg/L		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
Organic / Inorganic Carbon								
Dissolved Organic Carbon	mg/L		0.50	4.17	5.00	5.08	5.05	5.07
Total Organic Carbon	mg/L		0.50	3.48	5.60	5.55	5.59	5.85
Total Metals								
Aluminum (Al)	mg/L	0.005 if pH<6.5; 0.1 if pH≥6.5	0.0030	0.0300	0.0303	0.0279	0.0303	0.0256
Antimony (Sb)	mg/L		0.000010-0.000040	0.000013	0.000019	0.000022	0.000019	0.000023
Arsenic (As)	mg/L	0.005	0.000050-0.00050	0.000108	0.000335	0.000344	0.000335	0.000381
Barium (Ba)	mg/L		0.00010	0.00183	0.00298	0.00289	0.00285	0.00298
Beryllium (Be)	mg/L		0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Bismuth (Bi)	mg/L		0.000050 or 0.00010	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Boron (B)	mg/L	short-term: 29; long-term: 1.5	0.005-0.015	0.0162	0.0272	0.0269	0.0276	0.0283
Cadmium (Cd)	mg/L	equation[b,d]	0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Calcium (Ca)	mg/L		0.050	3.36	8.86	8.98	8.81	8.96
Cesium (Cs)	mg/L		0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Chromium (Cr)	mg/L	Cr(VI): 0.001; Cr(III): 0.0089[b]	0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Cobalt (Co)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	0.000052	<0.000050
Copper (Cu)	mg/L	0.002-0.004[e]	0.00050	0.00093	0.00144	0.00151	0.00130	0.00138
Gallium (Ga)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Iron (Fe)	mg/L	0.3	0.030	0.068	0.111	0.105	0.118	0.134
Lead (Pb)	mg/L	0.001-0.007[f]	0.000050	<0.000050	0.000053	<0.000050	<0.000050	<0.000050
Lithium (Li)	mg/L		0.00020	0.00144	0.00351	0.00342	0.00357	0.00346
Magnesium (Mg)	mg/L		0.10	3.12	6.42	6.52	6.39	6.42
Manganese (Mn)	mg/L		0.00020	0.00372	0.0381	0.0359	0.0421	0.0488
Mercury (Hg)	ug/L	Inorganic Hg: 0.026	0.00050	0.00061	0.00053	<0.00050	0.00050	<0.00050
Molybdenum (Mo)	mg/L	0.073[b]	0.000050	0.000059	0.000202	0.000196	0.000200	0.000216
Nickel (Ni)	mg/L	0.025-0.150[g]	0.00020	0.00036	0.00041	0.00046	0.00039	0.00040
Phosphorus (P)	mg/L		0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium (K)	mg/L		2.0	<2.0	2.4	2.4	2.4	2.3
Rhenium (Re)	mg/L		0.000005-0.00001	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Rubidium (Rb)	mg/L		0.000020	0.00116	0.00162	0.00154	0.00161	0.00158
Selenium (Se)	mg/L	0.001	0.0002-0.0004	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Silicon (Si)	mg/L		0.050	0.165	1.38	1.39	1.38	1.39
Silver (Ag)	mg/L	0.0001	0.000005-0.00003	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Sodium (Na)	mg/L		2.0	13.7	32.6	33.3	32.4	32.5
Strontium (Sr)	mg/L		0.00005-0.0001	0.0203	0.0468	0.0444	0.0450	0.0452
Tellurium (Te)	mg/L		0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Thallium (Tl)	mg/L	0.0008	0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020
Thorium (Th)	mg/L		0.0000050	0.0000153	0.0000101	0.0000093	0.0000104	0.0000085
Tin (Sn)	mg/L		0.0002 or 0.0004	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Titanium (Ti)	mg/L		0.00020	0.00067	0.00096	0.00087	0.00105	0.00094
Tungsten (W)	mg/L		0.000010	<0.000010	0.000012	0.000011	0.000012	0.000013
Uranium (U)	mg/L	short-term: 0.033; long-term: 0.015	0.0000020	0.0000303	0.0000338	0.0000326	0.0000350	0.0000346
Vanadium (V)	mg/L		0.000050	0.000082	0.000137	0.000119	0.000146	0.000144
Yttrium (Y)	mg/L		0.0000050	0.0000202	0.0000154	0.0000139	0.0000159	0.0000151
Zinc (Zn)	mg/L	0.03	0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030
Zirconium (Zr)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Radiochemistry								
Radium-226	Bq/L		0.010	<0.01	<0.010	<0.010	0.011	<0.010

Notes:

** Sample collected from Little Roberts Lake in April was not included in report results because this sample was contaminated by sediment and is not considered representative of the water quality at this site. There was only 20 cm of water below the ice, and the sediments were disturbed by the augering process.*

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, 2013.

[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 and a maximum of 0.004 mg/L regardless of water hardness.*

[f] Guideline is hardness-dependent at hardness as $CaCO_3$ >60 to 180 mg/L: lead guideline (mg/L) = $e^{\{1.273[\ln(hardness)]-4.705\}}/1000$. *At hardness as $CaCO_3$ of ≤ 60mg/L, lead guideline is a minimum of 0.001 mg/L; at hardness as $CaCO_3$ of >180 mg/L, lead guideline is a maximum of 0.007 mg/L.*

[g] Guideline is hardness-dependent at hardness as $CaCO_3$ >60 to 180 mg/L: nickel guideline (mg/L) = $e^{\{0.76[\ln(hardness)]+1.06\}}/1000$. *At hardness as $CaCO_3$ of ≤ 60mg/L, nickel guideline is a minimum of 0.025 mg/L; at hardness as $CaCO_3$ of >180 mg/L, nickel guideline is a maximum of 0.150 mg/L.*

Annex A.3-2. Lake Water Quality Data, Doris North Project, 2013

Site ID:				Doris North	Reference B	Reference B	Reference B	Little Roberts
Depth Zone:				Deep	Surface	Deep	Deep	Surface
Depth Sampled (m):				12.5	1.0	8.0	8.0	0.5
Replicate:				1	1	1	2	1
Date Sampled:		CCME guideline for the	Realized Detection	20-Aug-13	18-Aug-13	18-Aug-13	18-Aug-13	21-Aug-13
ALS Sample ID:	Units	Protection of Aquatic life[a]	Limit	L1352799-5	L1350568-9	L1350568-10	L1350568-11	L1352799-6
Physical Tests								
Conductivity	uS/cm		2.0	271	48.6	48.9	49.1	278
Hardness (as $CaCO_3$)	mg/L		0.50	49.5	13.6	14.0	14.1	47.3
pH	pH	6.5-9.0	0.10	7.72	7.33	7.34	7.33	7.73
Total Suspended Solids	mg/L	dependent on background levels	1.0	3.7	<1.0	<1.0	<1.0	2.2
Total Dissolved Solids	mg/L		10	170	29	26	28	183
Turbidity	NTU	dependent on background levels	0.10	5.22	0.41	0.62	0.68	2.61
Anions and Nutrients								
Alkalinity, Total (as $CaCO_3$)	mg/L		1.0 or 2.0	29.2	11.3	10.9	11.2	26.8
Ammonia, Total (as N)	mg/L	pH- and temperature-dependent	0.0050	0.0128	<0.0050	<0.0050	<0.0050	<0.0050
Bromide (Br)	mg/L		0.050	0.219	<0.050	<0.050	<0.050	0.221
Chloride (Cl)	mg/L	short-term: 640; long-term: 120	0.50	63.8	7.11	7.03	7.05	65.9
Fluoride (F)	mg/L	Inorganic fluorides: 0.12[b]	0.020	0.049	0.021	0.021	0.021	0.046
Nitrate (as N)	mg/L	short-term: 124; long-term: 3.0	0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Nitrite (as N)	mg/L	0.06	0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Total Kjeldahl Nitrogen	mg/L		0.050	0.510	0.198	0.182	0.172	0.407
Total Nitrogen	mg/L		0.050	-	-	-	-	-
Orthophosphate-Dissolved (as P)	mg/L		0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Phosphorus (P)	mg/L	Trigger ranges from guidance framework[c]	0.0020	0.0268	0.0035	0.0044	0.0046	0.0173
Sulfate (SO_4)	mg/L		0.50	2.64	1.74	1.75	1.75	4.10
Cyanides								
Cyanide, Total	mg/L		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
Organic / Inorganic Carbon								
Dissolved Organic Carbon	mg/L		0.50	5.00	2.59	2.54	2.56	4.89
Total Organic Carbon	mg/L		0.50	5.52	2.80	2.93	2.76	5.75
Total Metals								
Aluminum (Al)	mg/L	0.005 if pH<6.5; 0.1 if pH≥6.5	0.0030	0.0291	0.0142	0.0109	0.0095	0.0399
Antimony (Sb)	mg/L		0.000010-0.000040	0.000020	<0.000010	<0.000010	<0.000010	0.000019
Arsenic (As)	mg/L	0.005	0.000050-0.00050	0.000411	0.000094	0.000098	0.000088	0.000324
Barium (Ba)	mg/L		0.00010	0.00302	0.00143	0.00146	0.00145	0.00267
Beryllium (Be)	mg/L		0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Bismuth (Bi)	mg/L		0.000050 or 0.00010	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Boron (B)	mg/L	short-term: 29; long-term: 1.5	0.005-0.015	0.0285	0.0093	0.0092	0.0088	0.0283
Cadmium (Cd)	mg/L	equation[b,d]	0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Calcium (Ca)	mg/L		0.050	9.07	3.25	3.34	3.38	7.93
Cesium (Cs)	mg/L		0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Chromium (Cr)	mg/L	Cr(VI): 0.001; Cr(III): 0.0089[b]	0.00050	<0.00050	0.00282	<0.00050	<0.00050	<0.00050
Cobalt (Co)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Copper (Cu)	mg/L	0.002-0.004[e]	0.00050	0.00231	0.00168	0.00070	0.00073	0.00136
Gallium (Ga)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Iron (Fe)	mg/L	0.3	0.030	0.190	0.036	0.033	0.032	0.139
Lead (Pb)	mg/L	0.001-0.007[f]	0.000050	0.000057	0.000062	<0.000050	<0.000050	<0.000050
Lithium (Li)	mg/L		0.00020	0.00350	0.00064	0.00065	0.00062	0.00300
Magnesium (Mg)	mg/L		0.10	6.51	1.34	1.37	1.38	6.68
Manganese (Mn)	mg/L		0.00020	0.0730	0.00209	0.00190	0.00184	0.0113
Mercury (Hg)	ug/L	Inorganic Hg: 0.026	0.00050	0.00051	<0.00050	<0.00050	0.00052	<0.00050
Molybdenum (Mo)	mg/L	0.073[b]	0.000050	0.000211	0.000062	<0.000050	<0.000050	0.000196
Nickel (Ni)	mg/L	0.025-0.150[g]	0.00020	0.00043	0.00204	<0.00020	<0.00020	0.00047
Phosphorus (P)	mg/L		0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium (K)	mg/L		2.0	2.4	<2.0	<2.0	<2.0	2.3
Rhenium (Re)	mg/L		0.000005-0.00001	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Rubidium (Rb)	mg/L		0.000020	0.00161	0.000725	0.000747	0.000746	0.00151
Selenium (Se)	mg/L	0.001	0.0002-0.0004	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Silicon (Si)	mg/L		0.050	1.45	0.107	0.116	0.114	0.618
Silver (Ag)	mg/L	0.0001	0.000005-0.00003	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Sodium (Na)	mg/L		2.0	33.0	4.1	4.1	4.1	35.0
Strontium (Sr)	mg/L		0.00005-0.0001	0.0447	0.0165	0.0170	0.0174	0.0444
Tellurium (Te)	mg/L		0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Thallium (Tl)	mg/L	0.0008	0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020
Thorium (Th)	mg/L		0.0000050	0.0000100	<0.0000050	<0.0000050	<0.0000050	0.0000181
Tin (Sn)	mg/L		0.0002 or 0.0004	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Titanium (Ti)	mg/L		0.00020	0.00110	<0.00020	0.00023	<0.00020	0.00135
Tungsten (W)	mg/L		0.000010	0.000017	<0.000010	<0.000010	<0.000010	<0.000010
Uranium (U)	mg/L	short-term: 0.033; long-term: 0.015	0.0000020	0.0000336	0.0000332	0.0000332	0.0000343	0.0000340
Vanadium (V)	mg/L		0.000050	0.000148	<0.000050	<0.000050	<0.000050	0.000137
Yttrium (Y)	mg/L		0.0000050	0.0000168	0.0000085	0.0000072	0.0000074	0.0000236
Zinc (Zn)	mg/L	0.03	0.0030	<0.0030	0.0030	0.0038	<0.0030	<0.0030
Zirconium (Zr)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Radiochemistry								
Radium-226	Bq/L		0.010	<0.010	<0.010	<0.010	<0.010	<0.010

Notes:

** Sample collected from Little Roberts Lake in April was not included in report results because this sample was contaminated by sediment and is not considered representative of the water quality at this site. There was only 20 cm of water below the ice, and the sediments were disturbed by the augering process.*

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, 2013.*

[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 and a maximum of 0.004 mg/L regardless of water hardness.*

[f] *Guideline is hardness-dependent at hardness as* $CaCO_3$ *>60 to 180 mg/L: lead guideline (mg/L) =* $e^{\{1.273[\ln(hardness)]-4.705\}} / 1000$. *At hardness as* $CaCO_3$ *of ≤ 60mg/L, lead guideline is a minimum of 0.001 mg/L; at hardness as* $CaCO_3$ *of >180 mg/L, lead guideline is a maximum of 0.007 mg/L.*

[g] *Guideline is hardness-dependent at hardness as* $CaCO_3$ *>60 to 180 mg/L: nickel guideline (mg/L) =* $e^{\{0.76[\ln(hardness)]+1.06\}} / 1000$. *At hardness as* $CaCO_3$ *of ≤ 60mg/L, nickel guideline is a minimum of 0.025 mg/L; at hardness as* $CaCO_3$ *of >180 mg/L, nickel guideline is a maximum of 0.150 mg/L.*

Annex A.3-2. Lake Water Quality Data, Doris North Project, 2013

Site ID:				Little Roberts	Reference D	Reference D	Doris South	Doris South
Depth Zone:				Surface	Surface	Surface	Surface	Deep
Depth Sampled (m):				0.5	1.0	1.0	1.0	8.0
Replicate:				1	1	2	1	1
Date Sampled:		CCME guideline for the	Realized Detection	21-Aug-13	18-Aug-13	18-Aug-13	20-Sep-13	20-Sep-13
ALS Sample ID:	Units	Protection of Aquatic life[a]	Limit	L1352799-7	L1350568-7	L1350568-8	L1367963-1	L1367963-2
Physical Tests								
Conductivity	uS/cm		2.0	277	129	129	270	271
Hardness (as $CaCO_3$)	mg/L		0.50	46.7	23.6	23.2	50.6	50.8
pH	pH	6.5-9.0	0.10	7.73	7.42	7.41	7.60	7.62
Total Suspended Solids	mg/L	dependent on background levels	1.0	1.9	1.7	1.6	4.0	4.4
Total Dissolved Solids	mg/L		10	182	70	62	169	172
Turbidity	NTU	dependent on background levels	0.10	2.33	0.94	0.98	6.22	8.44
Anions and Nutrients								
Alkalinity, Total (as $CaCO_3$)	mg/L		1.0 or 2.0	27.0	13.4	14.2	30.7	30.5
Ammonia, Total (as N)	mg/L	pH- and temperature-dependent	0.0050	<0.0050	<0.0050	<0.0050	0.0051	<0.0050
Bromide (Br)	mg/L		0.050	0.210	0.091	0.090	0.236	0.225
Chloride (Cl)	mg/L	short-term: 640; long-term: 120	0.50	66.0	28.9	28.9	64.6	64.6
Fluoride (F)	mg/L	Inorganic fluorides: 0.12[b]	0.020	0.046	0.037	0.037	0.051	0.051
Nitrate (as N)	mg/L	short-term: 124; long-term: 3.0	0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Nitrite (as N)	mg/L	0.06	0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Total Kjeldahl Nitrogen	mg/L		0.050	0.396	0.248	0.246	0.683	0.457
Total Nitrogen	mg/L		0.050	-	-	-	-	-
Orthophosphate-Dissolved (as P)	mg/L		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	0.0087	0.0079	0.0266	0.0259
Sulfate (SO_4)	mg/L		0.50	4.10	2.44	2.43	2.71	2.71
Cyanides								
Cyanide, Total	mg/L		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
Organic / Inorganic Carbon								
Dissolved Organic Carbon	mg/L		0.50	4.87	3.90	4.00	4.96	5.10
Total Organic Carbon	mg/L		0.50	5.34	4.00	4.29	6.81	6.10
Total Metals								
Aluminum (Al)	mg/L	0.005 if pH<6.5; 0.1 if pH≥6.5	0.0030	0.0375	0.0258	0.0248	0.0506	0.0466
Antimony (Sb)	mg/L		0.000010-0.000040	0.000019	0.000015	0.000012	0.000019	0.000020
Arsenic (As)	mg/L	0.005	0.000050-0.00050	0.000288	0.000141	0.000152	0.000400	0.000354
Barium (Ba)	mg/L		0.00010	0.00267	0.00177	0.00173	0.00330	0.00321
Beryllium (Be)	mg/L		0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Bismuth (Bi)	mg/L		0.000050 or 0.00010	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Boron (B)	mg/L	short-term: 29; long-term: 1.5	0.005-0.015	0.0291	0.0172	0.0161	0.0285	0.0313
Cadmium (Cd)	mg/L	equation[b,d]	0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Calcium (Ca)	mg/L		0.050	7.85	3.50	3.44	9.20	9.19
Cesium (Cs)	mg/L		0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Chromium (Cr)	mg/L	Cr(VI): 0.001; Cr(III): 0.0089[b]	0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Cobalt (Co)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Copper (Cu)	mg/L	0.002-0.004[e]	0.00050	0.00134	0.00108	0.00098	0.00134	0.00145
Gallium (Ga)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Iron (Fe)	mg/L	0.3	0.030	0.138	0.143	0.146	0.095	0.092
Lead (Pb)	mg/L	0.001-0.007[f]	0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Lithium (Li)	mg/L		0.00020	0.00302	0.00154	0.00156	0.00408	0.00397
Magnesium (Mg)	mg/L		0.10	6.58	3.60	3.55	6.71	6.76
Manganese (Mn)	mg/L		0.00020	0.0111	0.00945	0.00930	0.0270	0.0269
Mercury (Hg)	ug/L	Inorganic Hg: 0.026	0.00050	<0.00050	0.00053	0.00061	0.00059	0.00058
Molybdenum (Mo)	mg/L	0.073[b]	0.000050	0.000194	0.000065	0.000068	0.000225	0.000219
Nickel (Ni)	mg/L	0.025-0.150[g]	0.00020	0.00047	0.00051	0.00036	0.00049	0.00048
Phosphorus (P)	mg/L		0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium (K)	mg/L		2.0	2.3	<2.0	<2.0	2.5	2.4
Rhenium (Re)	mg/L		0.000005-0.00001	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Rubidium (Rb)	mg/L		0.000020	0.00149	0.00107	0.00106	0.00173	0.00168
Selenium (Se)	mg/L	0.001	0.0002-0.0004	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Silicon (Si)	mg/L		0.050	0.618	0.200	0.192	1.40	1.42
Silver (Ag)	mg/L	0.0001	0.000005-0.00003	<0.0000050	<0.0000050	0.0000061	<0.0000050	<0.0000050
Sodium (Na)	mg/L		2.0	34.7	16.7	16.8	33.0	33.0
Strontium (Sr)	mg/L		0.00005-0.0001	0.0443	0.0245	0.0240	0.0471	0.0469
Tellurium (Te)	mg/L		0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Thallium (Tl)	mg/L	0.0008	0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020
Thorium (Th)	mg/L		0.0000050	0.0000185	0.0000161	0.0000146	0.0000141	0.0000142
Tin (Sn)	mg/L		0.0002 or 0.0004	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Titanium (Ti)	mg/L		0.00020	0.00127	0.00065	0.00059	0.00174	0.00156
Tungsten (W)	mg/L		0.000010	<0.000010	<0.000010	<0.000010	0.000013	0.000012
Uranium (U)	mg/L	short-term: 0.033; long-term: 0.015	0.0000020	0.0000333	0.0000286	0.0000269	0.0000351	0.0000358
Vanadium (V)	mg/L		0.000050	0.000135	0.000075	0.000078	0.000182	0.000176
Yttrium (Y)	mg/L		0.0000050	0.0000239	0.0000179	0.0000174	0.0000195	0.0000185
Zinc (Zn)	mg/L	0.03	0.0030	0.0032	<0.0030	<0.0030	<0.0030	<0.0030
Zirconium (Zr)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	0.000169	0.000061
Radiochemistry								
Radium-226	Bq/L		0.010	<0.010	<0.010	<0.010	<0.01	<0.01

Notes:

** Sample collected from Little Roberts Lake in April was not included in report results because this sample was contaminated by sediment and is not considered representative of the water quality at this site. There was only 20 cm of water below the ice, and the sediments were disturbed by the augering process.*

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, 2013.*

[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 and a maximum of 0.004 mg/L regardless of water hardness.*

[f] *Guideline is hardness-dependent at hardness as* $CaCO_3$ *>60 to 180 mg/L: lead guideline (mg/L) =* $e^{\{1.273[\ln(hardness)]-4.705\}}/1000$. *At hardness as* $CaCO_3$ *of ≤ 60mg/L, lead guideline is a minimum of 0.001 mg/L; at hardness as* $CaCO_3$ *of >180 mg/L, lead guideline is a maximum of 0.007 mg/L.*

[g] *Guideline is hardness-dependent at hardness as* $CaCO_3$ *>60 to 180 mg/L: nickel guideline (mg/L) =* $e^{\{0.76[\ln(hardness)]+1.06\}}/1000$. *At hardness as* $CaCO_3$ *of ≤ 60mg/L, nickel guideline is a minimum of 0.025 mg/L; at hardness as* $CaCO_3$ *of >180 mg/L, nickel guideline is a maximum of 0.150 mg/L.*

Annex A.3-2. Lake Water Quality Data, Doris North Project, 2013

Site ID:				Doris North	Doris North	Doris North	Reference B	Reference B
Depth Zone:				Surface	Deep	Deep	Surface	Surface
Depth Sampled (m):				1.0	11.0	11.0	1.0	1.0
Replicate:				1	1	2	1	2
Date Sampled:		CCME guideline for the	Realized Detection	20-Sep-13	20-Sep-13	20-Sep-13	23-Sep-13	23-Sep-13
ALS Sample ID:	Units	Protection of Aquatic life[a]	Limit	L1367963-4	L1367963-5	L1367963-6	L1367963-13	L1367963-15
Physical Tests								
Conductivity	uS/cm		2.0	269	270	272	49.6	49.4
Hardness (as $CaCO_3$)	mg/L		0.50	50.0	51.9	52.0	14.7	14.7
pH	pH	6.5-9.0	0.10	7.60	7.62	7.62	7.08	7.13
Total Suspended Solids	mg/L	dependent on background levels	1.0	4.3	3.2	5.0	<1.0	<1.0
Total Dissolved Solids	mg/L		10	138	169	170	38	35
Turbidity	NTU	dependent on background levels	0.10	6.43	5.75	5.28	1.66	0.83
Anions and Nutrients								
Alkalinity, Total (as $CaCO_3$)	mg/L		1.0 or 2.0	29.9	30.4	30.4	10.8	10.9
Ammonia, Total (as N)	mg/L	pH- and temperature-dependent	0.0050	<0.0050	0.0054	<0.0050	<0.0050	<0.0050
Bromide (Br)	mg/L		0.050	0.222	0.223	0.218	<0.050	<0.050
Chloride (Cl)	mg/L	short-term: 640; long-term: 120	0.50	64.6	64.7	64.7	7.17	7.11
Fluoride (F)	mg/L	Inorganic fluorides: 0.12[b]	0.020	0.050	0.051	0.051	<0.020	<0.020
Nitrate (as N)	mg/L	short-term: 124; long-term: 3.0	0.0050	<0.0050	<0.0050	<0.0050	0.0073	<0.0050
Nitrite (as N)	mg/L	0.06	0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Total Kjeldahl Nitrogen	mg/L		0.050	0.580	0.578	0.481	0.216	0.212
Total Nitrogen	mg/L		0.050	-	-	-	-	-
Orthophosphate-Dissolved (as P)	mg/L		0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Phosphorus (P)	mg/L	Trigger ranges from guidance framework[c]	0.0020	0.0267	0.0280	0.0270	0.0037	0.0040
Sulfate (SO_4)	mg/L		0.50	2.72	2.72	2.72	1.77	1.76
Cyanides								
Cyanide, Total	mg/L		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
Organic / Inorganic Carbon								
Dissolved Organic Carbon	mg/L		0.50	4.93	5.24	5.31	2.69	2.40
Total Organic Carbon	mg/L		0.50	5.79	6.22	6.64	2.67	2.80
Total Metals								
Aluminum (Al)	mg/L	0.005 if pH<6.5; 0.1 if pH≥6.5	0.0030	0.0451	0.0505	0.0454	0.0082	0.0071
Antimony (Sb)	mg/L		0.000010-0.000040	0.000020	0.000020	0.000021	0.000014	0.000012
Arsenic (As)	mg/L	0.005	0.000050-0.00050	0.000391	0.000376	0.000387	0.000135	0.000131
Barium (Ba)	mg/L		0.00010	0.00323	0.00343	0.00312	0.00144	0.00142
Beryllium (Be)	mg/L		0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Bismuth (Bi)	mg/L		0.000050 or 0.00010	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Boron (B)	mg/L	short-term: 29; long-term: 1.5	0.005-0.015	0.0292	0.0311	0.0307	0.0115	0.0089
Cadmium (Cd)	mg/L	equation[b,d]	0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Calcium (Ca)	mg/L		0.050	9.08	9.47	9.47	3.51	3.53
Cesium (Cs)	mg/L		0.0000050	<0.0000050	0.0000050	<0.0000050	<0.0000050	<0.0000050
Chromium (Cr)	mg/L	Cr(VI): 0.001; Cr(III): 0.0089[b]	0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Cobalt (Co)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Copper (Cu)	mg/L	0.002-0.004[e]	0.00050	0.00124	0.00125	0.00121	0.00118	0.00096
Gallium (Ga)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Iron (Fe)	mg/L	0.3	0.030	0.088	0.104	0.102	<0.030	<0.030
Lead (Pb)	mg/L	0.001-0.007[f]	0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Lithium (Li)	mg/L		0.00020	0.00398	0.00394	0.00391	0.00054	0.00054
Magnesium (Mg)	mg/L		0.10	6.63	6.86	6.88	1.44	1.42
Manganese (Mn)	mg/L		0.00020	0.0271	0.0282	0.0271	0.00110	0.00101
Mercury (Hg)	ug/L	Inorganic Hg: 0.026	0.00050	0.00055	0.00071	0.00065	<0.00050	0.00080
Molybdenum (Mo)	mg/L	0.073[b]	0.000050	0.000230	0.000220	0.000215	<0.000050	<0.000050
Nickel (Ni)	mg/L	0.025-0.150[g]	0.00020	0.00047	0.00049	0.00048	0.00031	<0.00020
Phosphorus (P)	mg/L		0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium (K)	mg/L		2.0	2.4	2.5	2.4	<2.0	<2.0
Rhenium (Re)	mg/L		0.000005-0.00001	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Rubidium (Rb)	mg/L		0.000020	0.00170	0.00169	0.00165	0.000792	0.000791
Selenium (Se)	mg/L	0.001	0.0002-0.0004	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Silicon (Si)	mg/L		0.050	1.38	1.46	1.44	0.087	0.085
Silver (Ag)	mg/L	0.0001	0.000005-0.00003	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Sodium (Na)	mg/L		2.0	32.2	33.1	32.9	4.0	3.9
Strontium (Sr)	mg/L		0.00005-0.0001	0.0469	0.0476	0.0466	0.0166	0.0164
Tellurium (Te)	mg/L		0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Thallium (Tl)	mg/L	0.0008	0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020
Thorium (Th)	mg/L		0.0000050	0.0000134	0.0000144	0.0000132	<0.0000050	<0.0000050
Tin (Sn)	mg/L		0.0002 or 0.0004	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Titanium (Ti)	mg/L		0.00020	0.00164	0.00181	0.00174	0.00021	<0.00020
Tungsten (W)	mg/L		0.000010	0.000012	0.000012	0.000012	<0.000010	<0.000010
Uranium (U)	mg/L	short-term: 0.033; long-term: 0.015	0.0000020	0.0000357	0.0000360	0.0000354	0.0000297	0.0000295
Vanadium (V)	mg/L		0.000050	0.000165	0.000185	0.000173	<0.000050	<0.000050
Yttrium (Y)	mg/L		0.0000050	0.0000180	0.0000200	0.0000183	0.0000070	0.0000069
Zinc (Zn)	mg/L	0.03	0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030
Zirconium (Zr)	mg/L		0.000050	<0.000050	<0.000050	0.000074	<0.000050	<0.000050
Radiochemistry								
Radium-226	Bq/L		0.010	<0.01	<0.01	<0.01	<0.01	<0.01

Notes:

** Sample collected from Little Roberts Lake in April was not included in report results because this sample was contaminated by sediment and is not considered representative of the water quality at this site. There was only 20 cm of water below the ice, and the sediments were disturbed by the augering process.*

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, 2013.*

[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 and a maximum of 0.004 mg/L regardless of water hardness.*

[f] *Guideline is hardness-dependent at hardness as* $CaCO_3$ *>60 to 180 mg/L: lead guideline (mg/L) =* $e^{\{1.273[\ln(hardness)]-4.705\}}/1000$. *At hardness as* $CaCO_3$ *of ≤ 60mg/L, lead guideline is a minimum of 0.001 mg/L; at hardness as* $CaCO_3$ *of >180 mg/L, lead guideline is a maximum of 0.007 mg/L.*

[g] *Guideline is hardness-dependent at hardness as* $CaCO_3$ *>60 to 180 mg/L: nickel guideline (mg/L) =* $e^{\{0.76[\ln(hardness)]+1.06\}}/1000$. *At hardness as* $CaCO_3$ *of ≤ 60mg/L, nickel guideline is a minimum of 0.025 mg/L; at hardness as* $CaCO_3$ *of >180 mg/L, nickel guideline is a maximum of 0.150 mg/L.*

Annex A.3-2. Lake Water Quality Data, Doris North Project, 2013

Site ID:				Reference B	Little Roberts	Little Roberts	Reference D	Reference D
Depth Zone:				Deep	Surface	Surface	Surface	Surface
Depth Sampled (m):				9.0	0.5	0.5	1.0	1.0
Replicate:				1	1	2	1	2
Date Sampled:		CCME guideline for the	Realized Detection	23-Sep-13	19-Sep-13	19-Sep-13	21-Sep-13	21-Sep-13
ALS Sample ID:	Units	Protection of Aquatic life[a]	Limit	L1367963-14	L1366437-10	L1366437-11	L1367963-8	L1367963-9
Physical Tests								
Conductivity	uS/cm		2.0	49.2	293	297	130	130
Hardness (as $CaCO_3$)	mg/L		0.50	14.5	53.7	54.4	24.6	24.2
pH	pH	6.5-9.0	0.10	7.08	7.65	7.71	7.14	7.17
Total Suspended Solids	mg/L	dependent on background levels	1.0	<1.0	2.0	1.9	1.3	<1.0
Total Dissolved Solids	mg/L		10	38	167	167	81	81
Turbidity	NTU	dependent on background levels	0.10	3.95	3.30	2.85	0.93	1.03
Anions and Nutrients								
Alkalinity, Total (as $CaCO_3$)	mg/L		1.0 or 2.0	10.9	29.0	29.6	12.7	13.4
Ammonia, Total (as N)	mg/L	pH- and temperature-dependent	0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Bromide (Br)	mg/L		0.050	<0.050	0.271	0.269	0.086	0.096
Chloride (Cl)	mg/L	short-term: 640; long-term: 120	0.50	7.09	70.5	70.6	29.4	29.4
Fluoride (F)	mg/L	Inorganic fluorides: 0.12[b]	0.020	<0.020	0.047	0.047	0.033	0.033
Nitrate (as N)	mg/L	short-term: 124; long-term: 3.0	0.0050	<0.0050	0.0270	<0.0050	0.0900	0.0116
Nitrite (as N)	mg/L	0.06	0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Total Kjeldahl Nitrogen	mg/L		0.050	0.207	0.401	0.424	0.284	0.287
Total Nitrogen	mg/L		0.050	-	-	-	-	-
Orthophosphate-Dissolved (as P)	mg/L		0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Phosphorus (P)	mg/L	Trigger ranges from guidance framework[c]	0.0020	0.0039	0.0179	0.0179	0.0065	0.0063
Sulfate (SO_4)	mg/L		0.50	1.76	4.99	5.01	2.67	2.66
Cyanides								
Cyanide, Total	mg/L		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
Organic / Inorganic Carbon								
Dissolved Organic Carbon	mg/L		0.50	2.42	4.76	4.62	3.68	3.53
Total Organic Carbon	mg/L		0.50	2.49	5.27	5.14	3.75	3.64
Total Metals								
Aluminum (Al)	mg/L	0.005 if pH<6.5; 0.1 if pH≥6.5	0.0030	0.0070	0.0727	0.0666	0.0349	0.0336
Antimony (Sb)	mg/L		0.000010-0.000040	0.000011	0.000020	0.000021	0.000015	0.000016
Arsenic (As)	mg/L	0.005	0.000050-0.00050	0.000116	0.000268	0.000305	0.000166	0.000157
Barium (Ba)	mg/L		0.00010	0.00146	0.00361	0.00352	0.00195	0.00193
Beryllium (Be)	mg/L		0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Bismuth (Bi)	mg/L		0.000050 or 0.00010	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Boron (B)	mg/L	short-term: 29; long-term: 1.5	0.005-0.015	0.0087	0.0310	0.0330	0.0175	0.0185
Cadmium (Cd)	mg/L	equation[b,d]	0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Calcium (Ca)	mg/L		0.050	3.49	9.05	9.28	3.70	3.67
Cesium (Cs)	mg/L		0.0000050	<0.0000050	0.0000061	0.0000060	<0.0000050	<0.0000050
Chromium (Cr)	mg/L	Cr(VI): 0.001; Cr(III): 0.0089[b]	0.00050	<0.00050	0.00062	<0.00050	0.00330	<0.00050
Cobalt (Co)	mg/L		0.000050	<0.000050	0.000052	<0.000050	<0.000050	<0.000050
Copper (Cu)	mg/L	0.002-0.004[e]	0.00050	0.00072	0.00190	0.00152	0.00139	0.00113
Gallium (Ga)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Iron (Fe)	mg/L	0.3	0.030	<0.030	0.138	0.137	0.115	0.088
Lead (Pb)	mg/L	0.001-0.007[f]	0.000050	<0.000050	0.000160	<0.000050	<0.000050	<0.000050
Lithium (Li)	mg/L		0.00020	0.00053	0.00367	0.00382	0.00155	0.00158
Magnesium (Mg)	mg/L		0.10	1.40	7.55	7.59	3.72	3.66
Manganese (Mn)	mg/L		0.00020	0.00101	0.00711	0.00728	0.00352	0.00321
Mercury (Hg)	ug/L	Inorganic Hg: 0.026	0.00050	<0.00050	0.00079	0.00062	0.00058	0.00068
Molybdenum (Mo)	mg/L	0.073[b]	0.000050	0.000050	0.000226	0.000266	0.000137	0.000122
Nickel (Ni)	mg/L	0.025-0.150[g]	0.00020	0.00022	0.00097	0.00050	0.00190	0.00044
Phosphorus (P)	mg/L		0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium (K)	mg/L		2.0	<2.0	2.6	2.6	<2.0	<2.0
Rhenium (Re)	mg/L		0.000005-0.00001	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Rubidium (Rb)	mg/L		0.000020	0.000789	0.00163	0.00165	0.00114	0.00112
Selenium (Se)	mg/L	0.001	0.0002-0.0004	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Silicon (Si)	mg/L		0.050	0.084	0.859	0.853	0.188	0.178
Silver (Ag)	mg/L	0.0001	0.000005-0.00003	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Sodium (Na)	mg/L		2.0	3.9	37.4	35.4	15.7	15.4
Strontium (Sr)	mg/L		0.00005-0.0001	0.0163	0.0520	0.0524	0.0225	0.0223
Tellurium (Te)	mg/L		0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Thallium (Tl)	mg/L	0.0008	0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020
Thorium (Th)	mg/L		0.0000050	<0.0000050	0.0000232	0.0000272	0.0000136	0.0000149
Tin (Sn)	mg/L		0.0002 or 0.0004	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Titanium (Ti)	mg/L		0.00020	<0.00020	0.00235	0.00228	0.00081	0.00092
Tungsten (W)	mg/L		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	0.0000285	0.0000397	0.0000392	0.0000304	0.0000308
Vanadium (V)	mg/L		0.000050	<0.000050	0.000187	0.000176	0.000094	0.000087
Yttrium (Y)	mg/L		0.0000050	0.0000074	0.0000320	0.0000695	0.0000183	0.0000185
Zinc (Zn)	mg/L	0.03	0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030
Zirconium (Zr)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Radiochemistry								
Radium-226	Bq/L		0.010	<0.01	<0.01	0.011	<0.01	<0.01

Notes:

** Sample collected from Little Roberts Lake in April was not included in report results because this sample was contaminated by sediment and is not considered representative of the water quality at this site. There was only 20 cm of water below the ice, and the sediments were disturbed by the augering process.*

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, 2013.*

[b] *Interim guideline.*

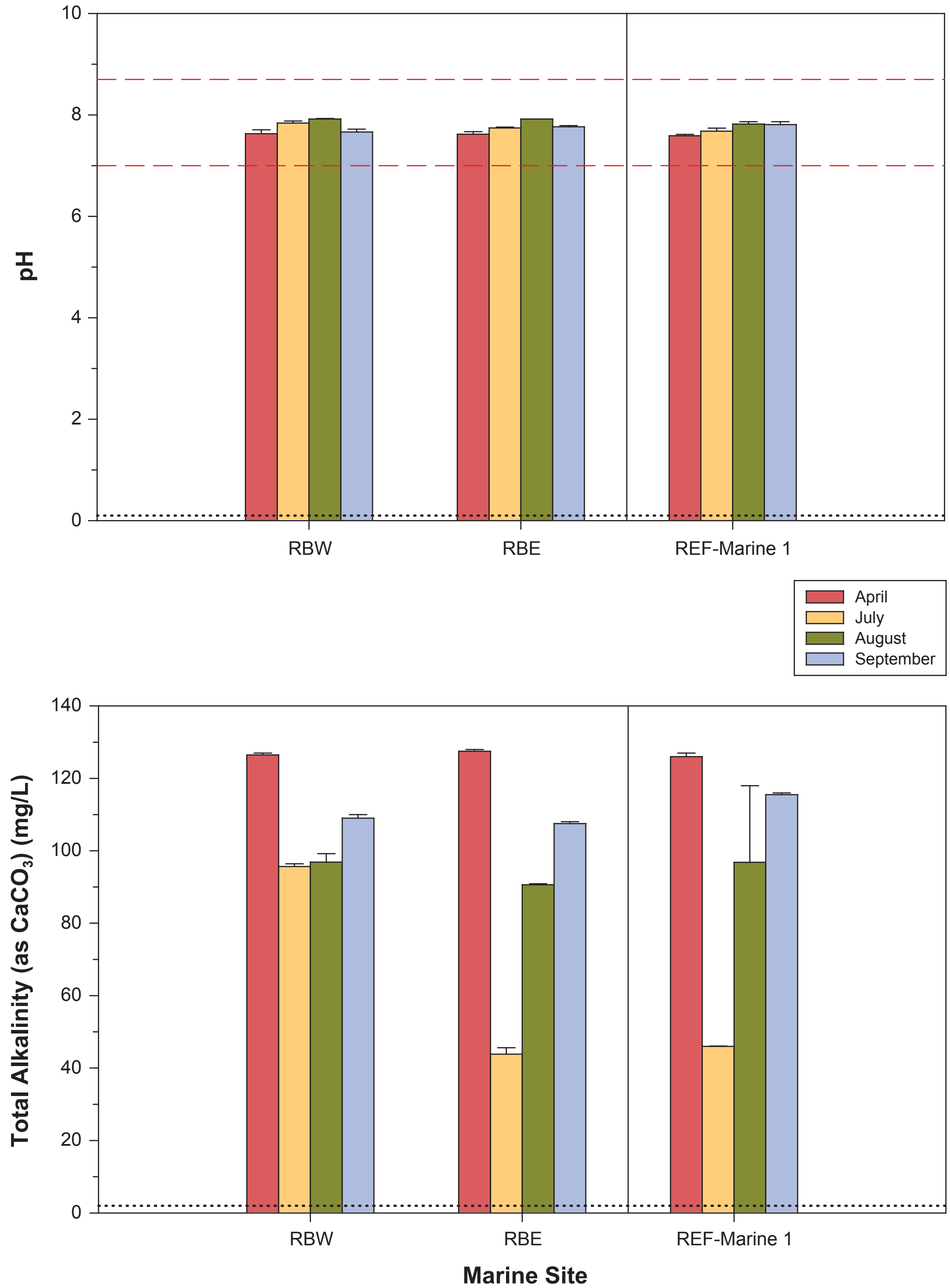
[c] *Total phosphorus trigger ranges for lakes and rivers (mg/L): <0.004 = Ultra-oligotrophic; 0.004-0.01 = Oligotrophic; 0.01-0.02 = Mesotrophic; 0.02-0.035 = Meso-eutrophic; 0.035-0.1 = Eutrophic; >0.1 = Hyper-eutrophic.*

[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 and a maximum of 0.004 mg/L regardless of water hardness.*

[f] *Guideline is hardness-dependent at hardness as* $CaCO_3$ *>60 to 180 mg/L: lead guideline (mg/L) =* $e^{\{1.273[\ln(hardness)]-4.705\}}/1000$. *At hardness as* $CaCO_3$ *of ≤ 60mg/L, lead guideline is a minimum of 0.001 mg/L; at hardness as* $CaCO_3$ *of >180 mg/L, lead guideline is a maximum of 0.007 mg/L.*

[g] *Guideline is hardness-dependent at hardness as* $CaCO_3$ *>60 to 180 mg/L: nickel guideline (mg/L) =* $e^{\{0.76[\ln(hardness)]+1.06\}}/1000$. *At hardness as* $CaCO_3$ *of ≤ 60mg/L, nickel guideline is a minimum of 0.025 mg/L; at hardness as* $CaCO_3$ *of >180 mg/L, nickel guideline is a maximum of 0.150 mg/L.*



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

Figure A.3-19

pH and Total Alkalinity in Marine Sites, Doris North Project, 2013

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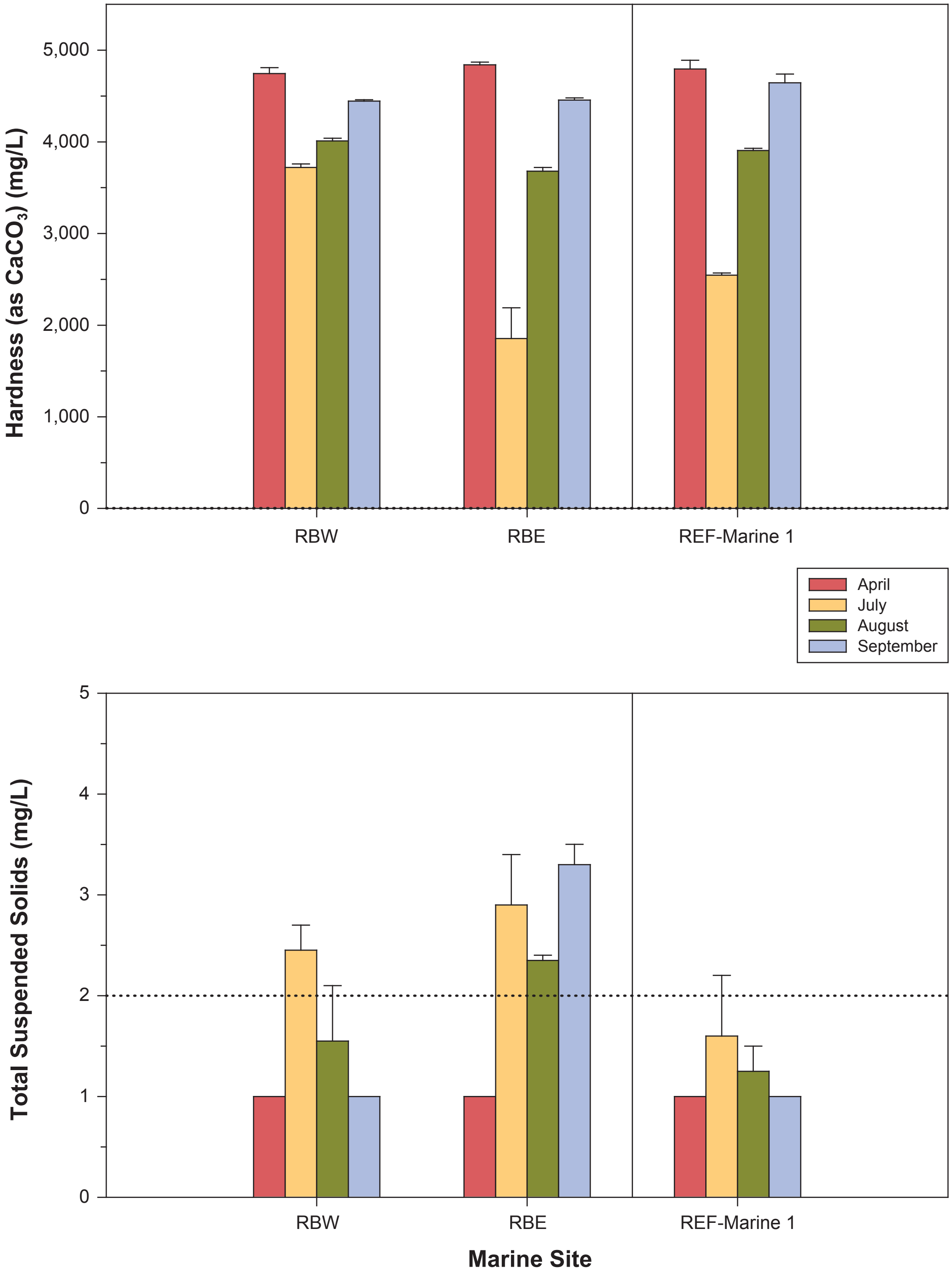
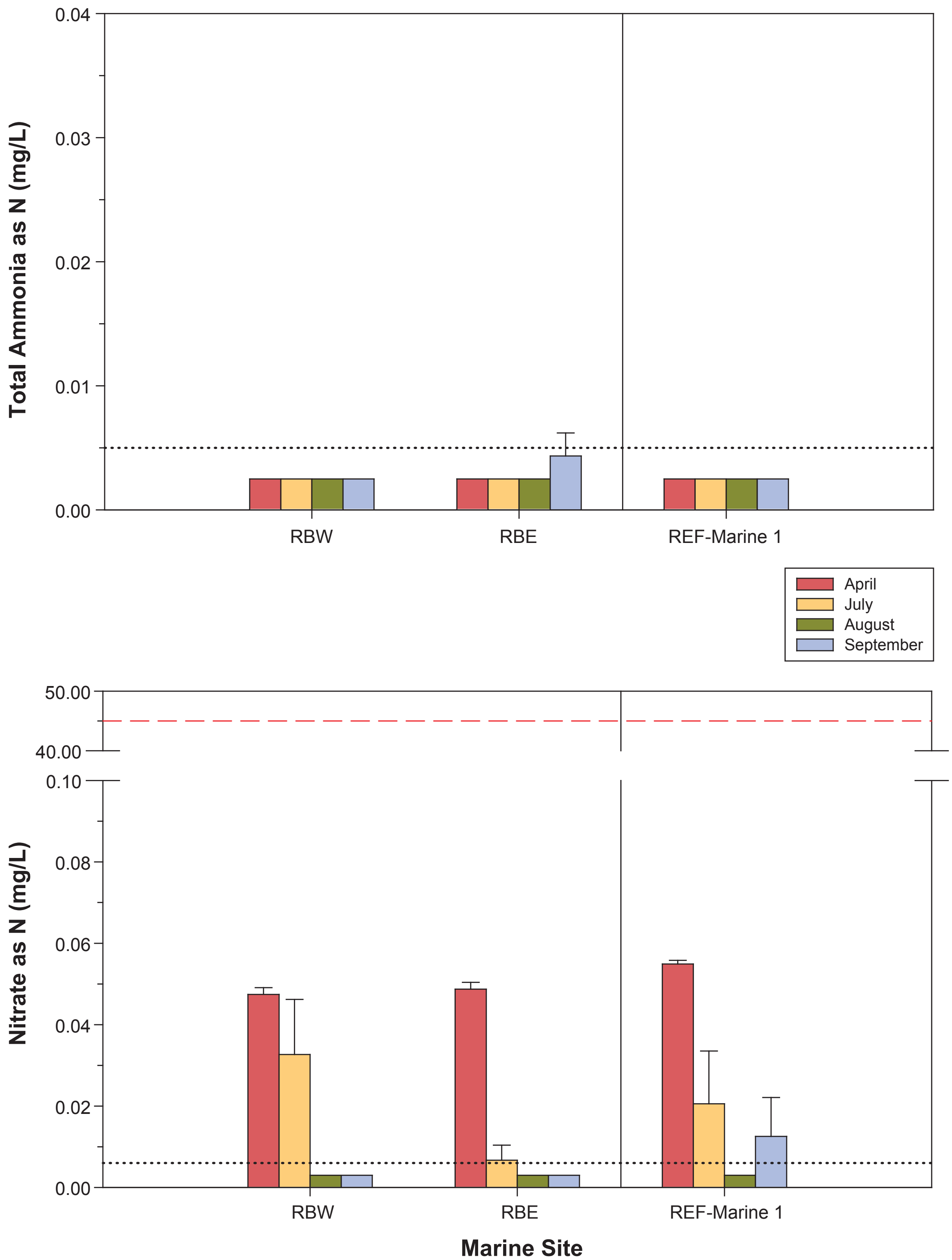


Notes: Error bars represent the standard error of the mean of replicates.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
The CCME marine guideline for total suspended solids is dependent upon background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

Figure A.3-20

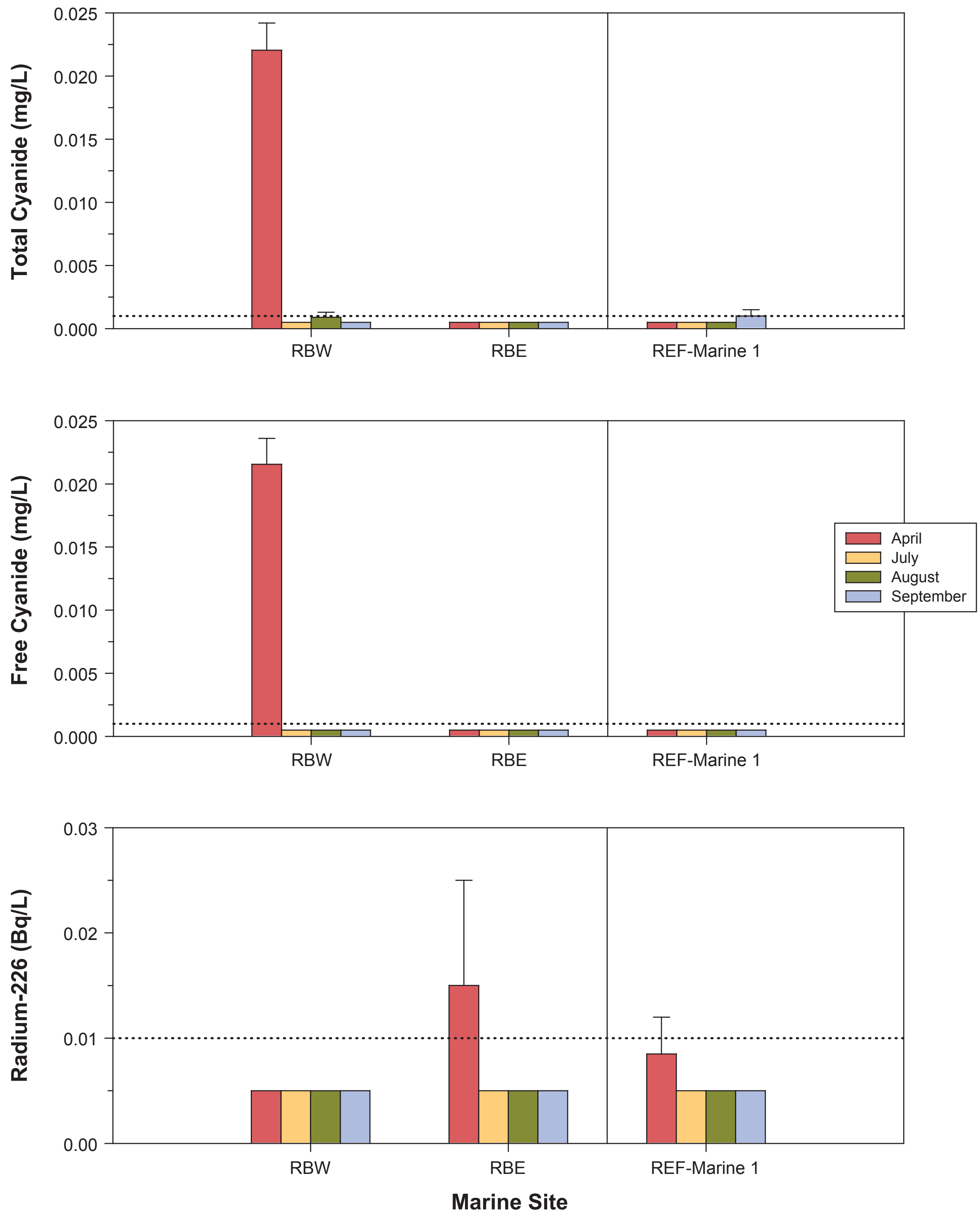
Hardness and Total Suspended Solids in Marine Sites, Doris North Project, 2013



Notes: Error bars represent the standard error of the mean of replicates.
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 nitrate as N (45 mg/L; long-term concentration).
Total ammonia and nitrate are required parameters for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

Figure A.3-21

Total Ammonia and Nitrate Concentrations in Marine Sites, Doris North Project, 2013



Notes: Error bars represent the standard error of the mean of replicates.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
Total cyanide and radium-226 are regulated as deleterious substances in effluents as per Schedule 4 of the MMER.

Figure A.3-22

Total Cyanide, Free Cyanide, and Radium-226 Concentrations in Marine Sites, Doris North Project, 2013

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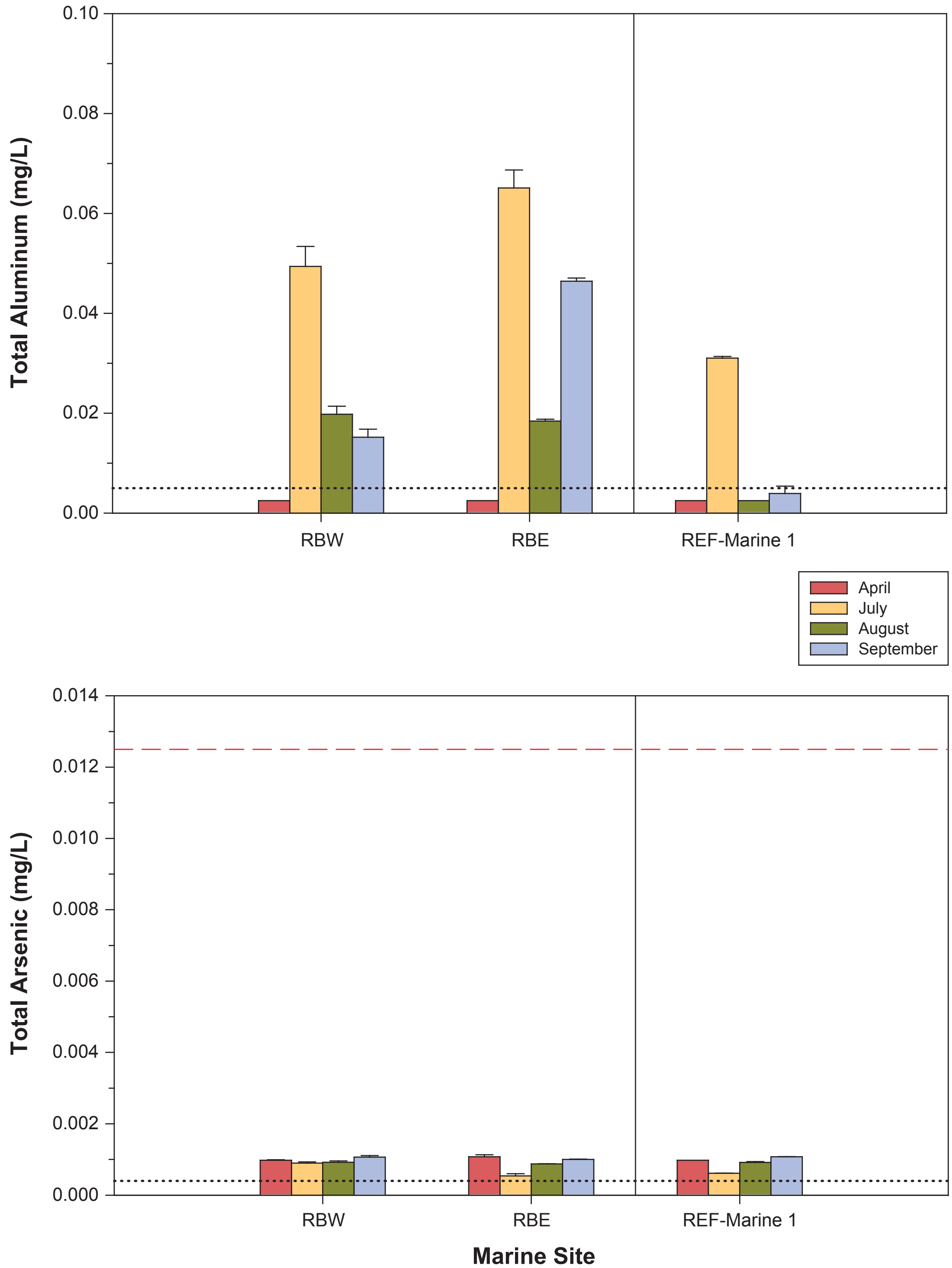


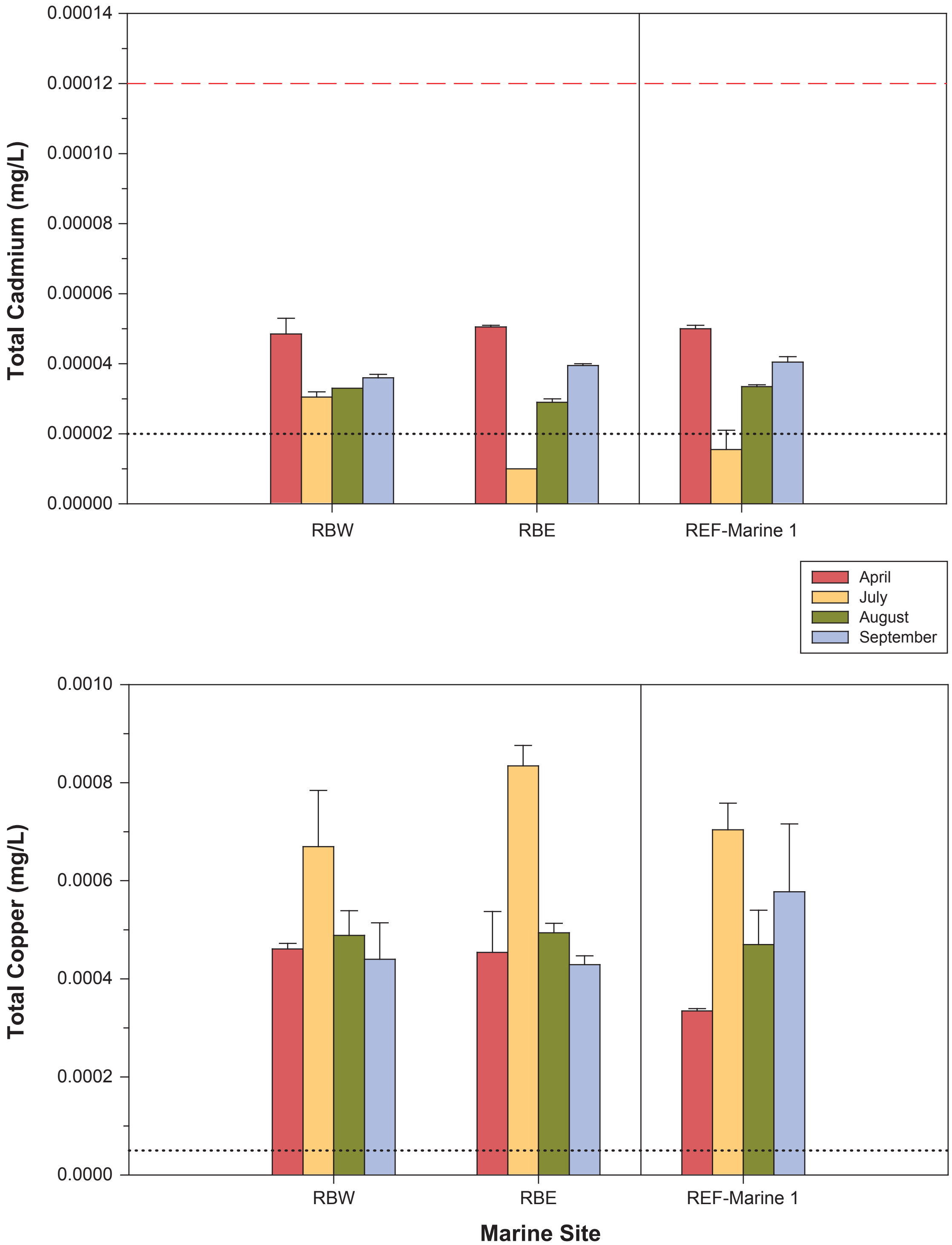
Notes: Error bars represent the standard error of the mean of replicates.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
Red dashed line represents the interim CCME marine guideline for arsenic (0.0125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

Figure A.3-23

Total Aluminum and Total Arsenic Concentrations in Marine Sites, Doris North Project, 2013

TMAC RESOURCES

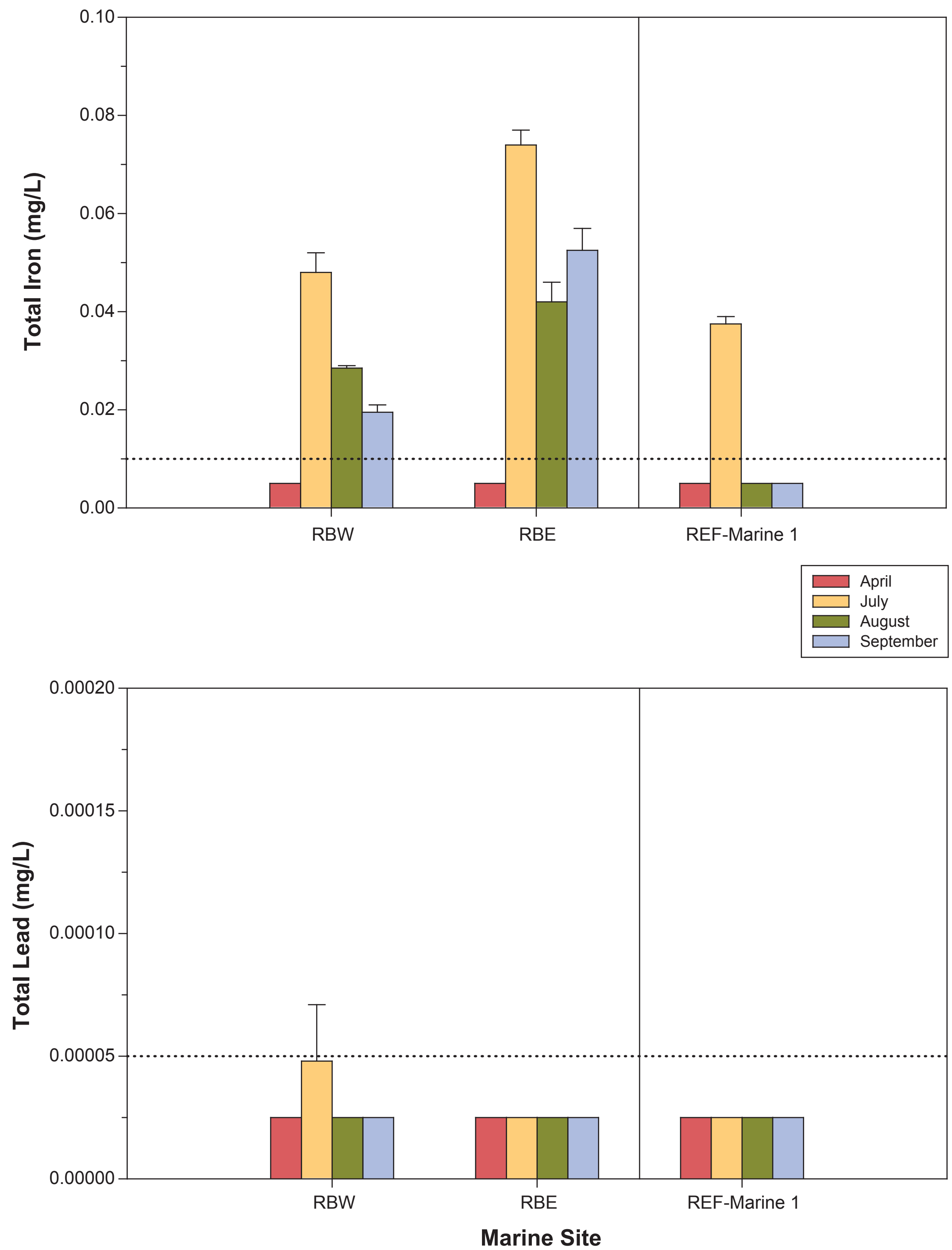
Rescan an ERM company



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

Figure A.3-24

Total Cadmium and Total Copper Concentrations in Marine Sites, Doris North Project, 2013



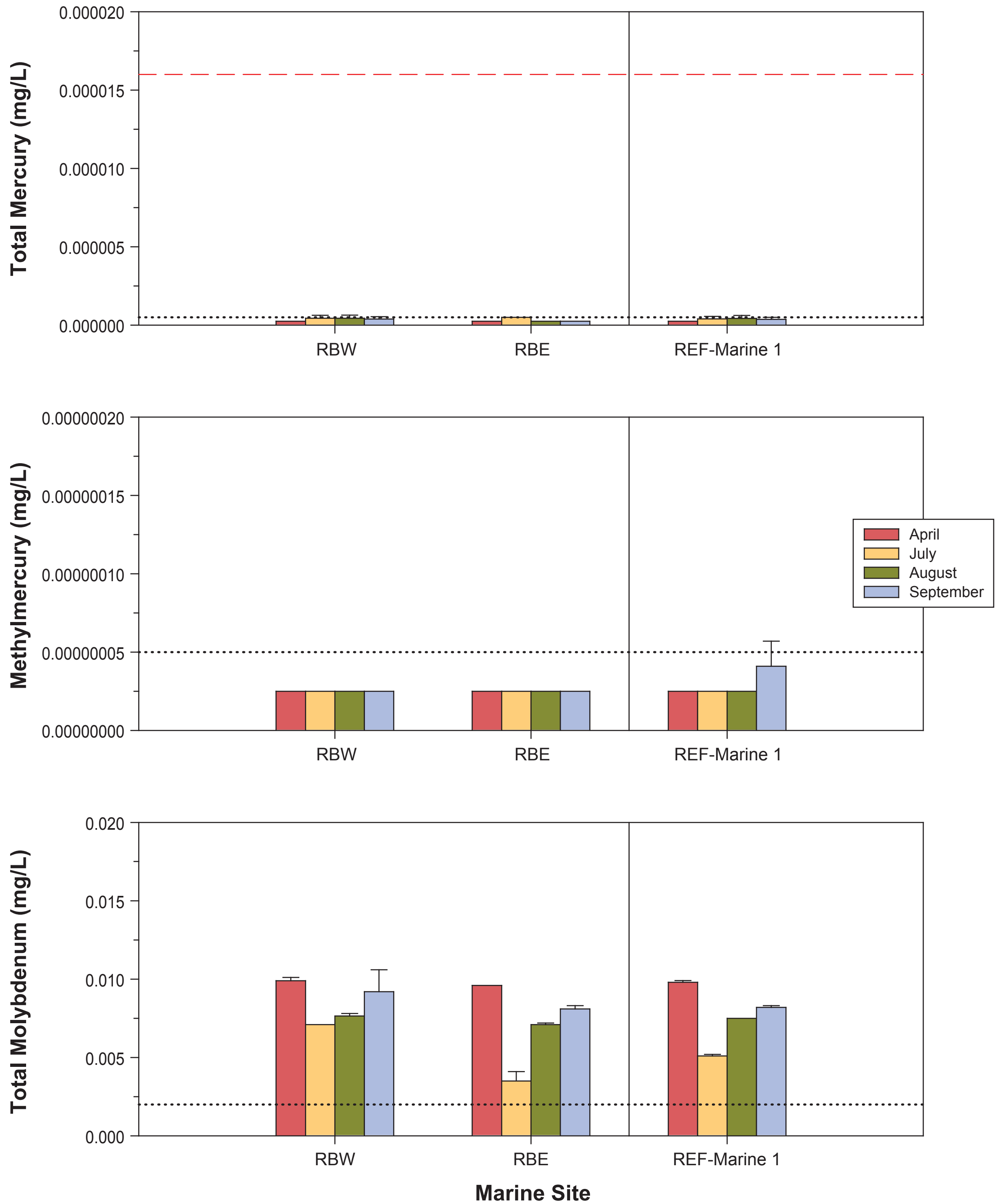
Notes: Error bars represent the standard error of the mean of replicates.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
Total iron is a required parameter for effluent characterization as per Schedule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

Figure A.3-25

Total Iron and Total Lead Concentrations in Marine Sites, Doris North Project, 2013

TMAC RESOURCES

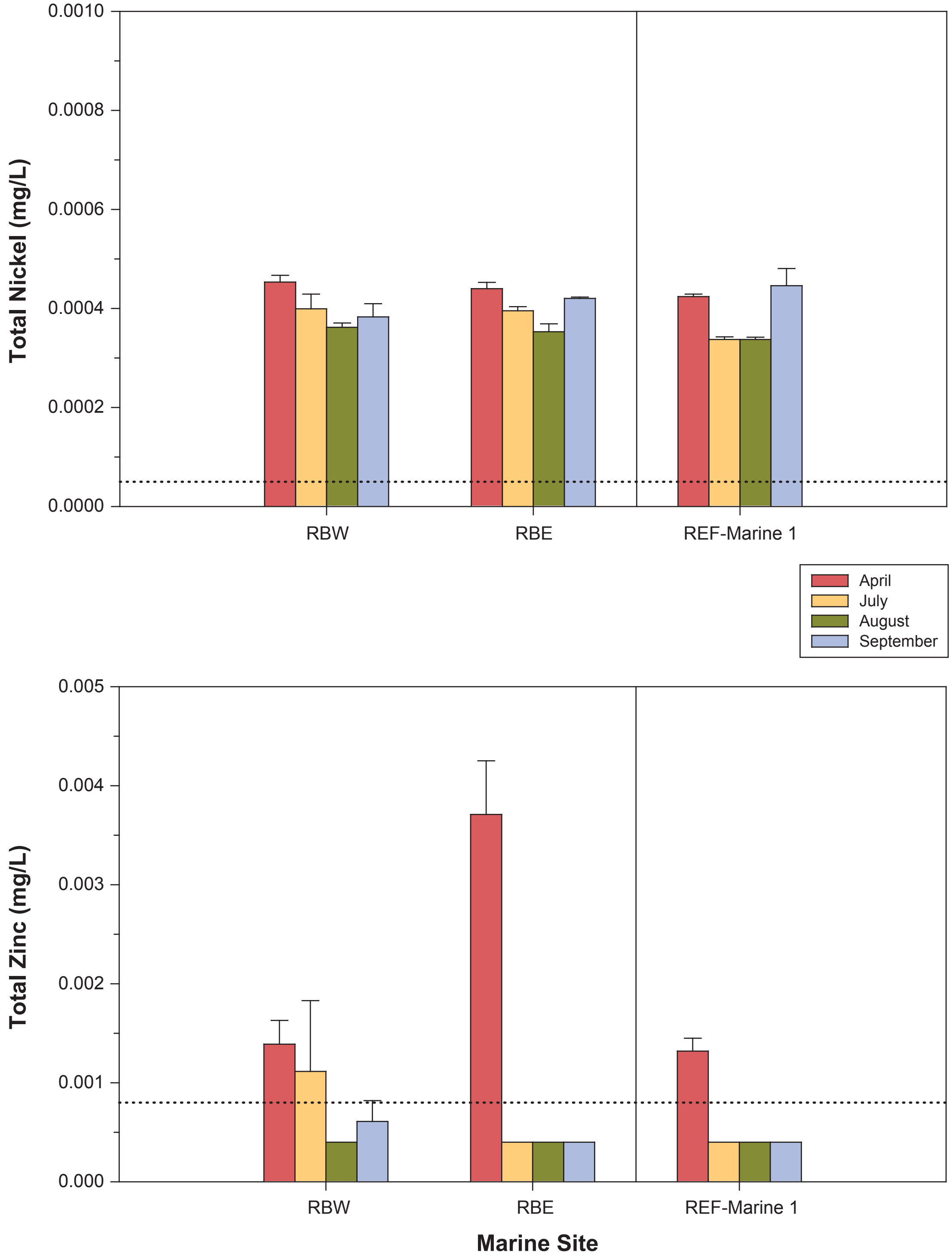
Rescan an ERM company



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

Figure A.3-26

Total Mercury, Methylmercury, and Total Molybdenum Concentrations in Marine Sites, Doris North Project, 2013



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

Figure A.3-27

Total Nickel and Total Zinc Concentrations in Marine Sites, Doris North Project, 2013

Annex A.3-3. Marine Water Quality Data, Doris North Project, 2013

Site ID:				RBW	RBW	RBE	RBE	REF-Marine 1	REF-Marine 1
Depth Zone:				Surface	Surface	Surface	Surface	Surface	Surface
Depth Sampled (m):				1.0	1.0	1.0	1.0	1.0	1.0
Replicate:				1	2	1	2	1	2
Date Sampled:		CCME guideline for the	Realized	27-Apr-13	27-Apr-13	27-Apr-13	27-Apr-13	28-Apr-13	28-Apr-13
ALS Sample ID:	Units	Protection of Aquatic life[a]	Detection Limit	L1296387-9	L1296387-11	L1296387-8	L1296387-10	L1296387-16	L1296387-19
Physical Tests									
Hardness (as $CaCO_3$)	mg/L		4.3	4680	4810	4870	4810	4700	4890
pH	pH	7.0-8.7	0.10	7.55	7.71	7.57	7.67	7.56	7.62
Salinity	psu	<10% fluctuation[b]	1.0	26.9	27.9	26.7	27.7	27.5	28.0
Total Suspended Solids	mg/L	dependent on background levels	2.0 or 3.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Total Dissolved Solids	mg/L		80	27700	28900	29600	29000	30100	30100
Turbidity	NTU	dependent on background levels	0.10	0.30	0.31	0.33	0.37	0.29	0.46
Anions and Nutrients									
Alkalinity, Total (as $CaCO_3$)	mg/L		2.0	127	126	127	128	127	125
Ammonia, Total (as N)	mg/L		0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Bromide (Br)	mg/L		5.0	52.2	52.9	50.5	52.3	54.2	53.3
Chloride (Cl)	mg/L		50	15700	15600	15400	15700	16100	15500
Fluoride (F)	mg/L		0.75	1.30	1.20	1.20	1.22	1.21	1.25
Nitrate and Nitrite (as N)	mg/L		0.0060	0.0457	0.0491	0.0470	0.0504	0.0540	0.0558
Nitrate (as N)	mg/L	short-term: 339; long-term: 45	0.0060	0.0457	0.0491	0.0470	0.0504	0.0540	0.0558
Nitrite (as N)	mg/L		0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Total Kjeldahl Nitrogen	mg/L		0.050	0.096	0.106	0.113	0.110	0.084	0.076
Orthophosphate-Dissolved (as P)	mg/L		0.0010	0.0384	0.0381	0.0371	0.0403	0.0378	0.0389
Phosphorus (P)	mg/L		0.0020	0.0403	0.0410	0.0437	0.0447	0.0426	0.0405
Sulfate (SO_4)	mg/L		50	2200	2180	2150	2210	2260	2190
Cyanides									
Cyanide, Total	mg/L		0.0010	0.0199	0.0242	<0.0010	<0.0010	<0.0010	<0.0010
Cyanide, Free	mg/L		0.0010	0.0195	0.0236	<0.0010	<0.0010	<0.0010	<0.0010
Organic / Inorganic Carbon									
Dissolved Organic Carbon			0.50	1.52	1.90	1.45	2.15	1.85	1.37
Total Organic Carbon	mg/L		0.50	1.26	1.80	1.41	2.10	1.60	1.41
Total Metals									
Aluminum (Al)	mg/L		0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Antimony (Sb)	mg/L		0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Arsenic (As)	mg/L	0.0125[b]	0.00040	0.00097	0.00099	0.00113	0.00102	0.00098	0.00098
Barium (Ba)	mg/L		0.0010	0.0129	0.0128	0.0126	0.0124	0.0125	0.0126
Beryllium (Be)	mg/L		0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Bismuth (Bi)	mg/L		0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Boron (B)	mg/L		0.10	4.24	4.29	4.21	4.20	4.21	4.18
Cadmium (Cd)	mg/L	0.00012	0.000020	0.000044	0.000053	0.000050	0.000051	0.000051	0.000049
Calcium (Ca)	mg/L		0.50	315	324	320	321	316	317
Cesium (Cs)	mg/L		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]	0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Cobalt (Co)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Copper (Cu)	mg/L		0.000050	0.000450	0.000472	0.000537	0.000371	0.000330	0.000339
Gallium (Ga)	mg/L		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
Lead (Pb)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Lithium (Li)	mg/L		0.020	0.150	0.155	0.152	0.150	0.151	0.150
Magnesium (Mg)	mg/L		1.0	946	970	988	973	949	996
Manganese (Mn)	mg/L		0.000050	0.000906	0.000946	0.000962	0.000938	0.00119	0.00113
Mercury (Hg)	ug/L	Inorganic Hg: 0.016[b]	0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Molybdenum (Mo)	mg/L		0.0020	0.0097	0.0101	0.0096	0.0096	0.0099	0.0097
Nickel (Ni)	mg/L		0.000050	0.000467	0.000440	0.000453	0.000427	0.000429	0.000419
Phosphorus (P)	mg/L		1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Potassium (K)	mg/L		20	306	318	317	312	310	322
Rhenium (Re)	mg/L		0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Rubidium (Rb)	mg/L		0.0050	0.0969	0.101	0.0967	0.0955	0.0981	0.0971
Selenium (Se)	mg/L		0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Silicon (Si)	mg/L		0.50	<0.50	0.53	0.52	<0.50	0.54	0.56
Silver (Ag)	mg/L		0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Sodium (Na)	mg/L		20	8630	8960	8890	8810	8690	8990
Strontium (Sr)	mg/L		0.050	5.81	6.04	6.03	5.90	5.88	6.14
Tellurium (Te)	mg/L		0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Thallium (Tl)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Thorium (Th)	mg/L		0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Tin (Sn)	mg/L		0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Titanium (Ti)	mg/L		0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Tungsten (W)	mg/L		0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Uranium (U)	mg/L		0.000050	0.00259	0.00266	0.00256	0.00256	0.00259	0.00257
Vanadium (V)	mg/L		0.00050	0.00068	0.00079	0.00075	0.00082	0.00070	0.00073
Yttrium (Y)	mg/L		0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Zinc (Zn)	mg/L		0.00080	0.00115	0.00163	0.00425	0.00317	0.00119	0.00145
Zirconium (Zr)	mg/L		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
Radiochemistry									
Radium-226	Bq/L		0.010	<0.010	<0.010	<0.010	0.025	0.012	<0.010

Notes:

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

[a] *Canadian water quality guidelines for the protection of marine aquatic life, Canadian Council of Ministers of the Environment, 2013.*

[b] *Interim guideline.*

Annex A.3-3. Marine Water Quality Data, Doris North Project, 2013

Site ID:				RBW	RBW	RBE	RBE	REF-Marine 1	REF-Marine 1
Depth Zone:				Surface	Surface	Surface	Surface	Surface	Surface
Depth Sampled (m):				0.5	0.5	0.5	0.5	0.5	0.5
Replicate:				1	2	1	2	1	2
Date Sampled:		CCME guideline for the	Realized	20-Jul-13	20-Jul-13	20-Jul-13	20-Jul-13	21-Jul-13	21-Jul-13
ALS Sample ID:	Units	Protection of Aquatic life[a]	Detection Limit	L1336762-3	L1336762-4	L1336762-1	L1336762-2	L1336704-1	L1336704-2
Physical Tests									
Hardness (as $CaCO_3$)	mg/L		4.3	3760	3680	1520	2190	2520	2570
pH	pH	7.0-8.7	0.10	7.80	7.88	7.73	7.76	7.62	7.74
Salinity	psu	<10% fluctuation[b]	1.0	21.3	21.1	9.3	12.0	14.9	15.0
Total Suspended Solids	mg/L	dependent on background levels	2.0 or 3.0	2.7	2.2	3.4	2.4	<2.0	2.2
Total Dissolved Solids	mg/L		80	23900	22800	10700	12400	16100	17100
Turbidity	NTU	dependent on background levels	0.10	1.69	1.46	3.08	2.60	1.05	1.06
Anions and Nutrients									
Alkalinity, Total (as $CaCO_3$)	mg/L		2.0	94.9	96.4	42.1	45.6	45.9	46.1
Ammonia, Total (as N)	mg/L		0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Bromide (Br)	mg/L		5.0	40.4	37.1	15.5	19.5	33.4	28.7
Chloride (Cl)	mg/L		50	11700	10900	4600	5580	8460	8390
Fluoride (F)	mg/L		0.75	0.95	0.93	<0.75	0.76	<0.75	0.83
Nitrate and Nitrite (as N)	mg/L		0.0060	0.0462	0.0191	0.0104	<0.0060	0.0335	0.0076
Nitrate (as N)	mg/L	short-term: 339; long-term: 45	0.0060	0.0462	0.0191	0.0104	<0.0060	0.0335	0.0076
Nitrite (as N)	mg/L		0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Total Kjeldahl Nitrogen	mg/L		0.050	0.132	0.521	0.252	0.240	0.160	0.182
Orthophosphate-Dissolved (as P)	mg/L		0.0010	0.0181	0.0181	0.0030	0.0062	0.0129	0.0126
Phosphorus (P)	mg/L		0.0020	0.0238	0.0234	0.0172	0.0185	0.0186	0.0169
Sulfate (SO_4)	mg/L		50	1640	1540	634	775	1160	1150
Cyanides									
Cyanide, Total	mg/L		0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Cyanide, Free	mg/L		0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Organic / Inorganic Carbon									
Dissolved Organic Carbon			0.50	1.49	1.43	3.66	3.20	2.20	1.92
Total Organic Carbon	mg/L		0.50	1.58	1.55	4.59	3.71	2.09	2.07
Total Metals									
Aluminum (Al)	mg/L		0.0050	0.0534	0.0454	0.0615	0.0687	0.0307	0.0314
Antimony (Sb)	mg/L		0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Arsenic (As)	mg/L	0.0125[b]	0.00040	0.00093	0.00087	0.00048	0.00060	0.00062	0.00061
Barium (Ba)	mg/L		0.0010	0.0089	0.0087	0.0054	0.0066	0.0068	0.0070
Beryllium (Be)	mg/L		0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Bismuth (Bi)	mg/L		0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Boron (B)	mg/L		0.10	2.97	3.02	1.28	1.76	2.11	2.18
Cadmium (Cd)	mg/L	0.00012	0.000020	0.000032	0.000029	<0.000020	<0.000020	0.000021	<0.000020
Calcium (Ca)	mg/L		0.50	244	242	100	143	164	168
Cesium (Cs)	mg/L		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]	0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Cobalt (Co)	mg/L		0.000050	0.000057	<0.000050	0.000059	0.000066	<0.000050	<0.000050
Copper (Cu)	mg/L		0.000050	0.000784	0.000555	0.000876	0.000793	0.000650	0.000758
Gallium (Ga)	mg/L		0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Iron (Fe)	mg/L		0.010	0.052	0.044	0.077	0.071	0.039	0.036
Lead (Pb)	mg/L		0.000050	0.000071	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Lithium (Li)	mg/L		0.020	0.121	0.123	0.048	0.071	0.084	0.088
Magnesium (Mg)	mg/L		1.0	764	748	308	446	512	522
Manganese (Mn)	mg/L		0.000050	0.00340	0.00307	0.00692	0.00610	0.00191	0.00186
Mercury (Hg)	ug/L	Inorganic Hg: 0.016[b]	0.00050	<0.00050	0.00063	0.00050	0.00050	0.00056	<0.00050
Molybdenum (Mo)	mg/L		0.0020	0.0071	0.0071	0.0029	0.0041	0.0050	0.0052
Nickel (Ni)	mg/L		0.000050	0.000429	0.000370	0.000404	0.000387	0.000343	0.000332
Phosphorus (P)	mg/L		1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Potassium (K)	mg/L		20	232	231	94	136	155	158
Rhenium (Re)	mg/L		0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Rubidium (Rb)	mg/L		0.0050	0.0737	0.0751	0.0296	0.0422	0.0519	0.0527
Selenium (Se)	mg/L		0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Silicon (Si)	mg/L		0.50	<0.50	<0.50	0.64	0.51	<0.50	<0.50
Silver (Ag)	mg/L		0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Sodium (Na)	mg/L		20	6480	6460	2580	3760	4290	4360
Strontium (Sr)	mg/L		0.050	4.49	4.50	1.82	2.64	2.99	3.04
Tellurium (Te)	mg/L		0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Thallium (Tl)	mg/L		0.000050	<0.000050	<0.000050	0.000053	0.000055	<0.000050	<0.000050
Thorium (Th)	mg/L		0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Tin (Sn)	mg/L		0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Titanium (Ti)	mg/L		0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Tungsten (W)	mg/L		0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Uranium (U)	mg/L		0.000050	0.00206	0.00204	0.000806	0.00118	0.00145	0.00144
Vanadium (V)	mg/L		0.00050	0.00070	0.00075	<0.00050	0.00058	0.00054	0.00057
Yttrium (Y)	mg/L		0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Zinc (Zn)	mg/L		0.00080	0.00183	<0.00080	<0.00080	<0.00080	<0.00080	<0.00080
Zirconium (Zr)	mg/L		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
Radiochemistry									
Radium-226	Bq/L		0.010	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Notes:

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

[a] *Canadian water quality guidelines for the protection of marine aquatic life, Canadian Council of Ministers of the Environment, 2013.*

[b] *Interim guideline.*

Annex A.3-3. Marine Water Quality Data, Doris North Project, 2013

Site ID:				RBW	RBW	RBE	RBE	REF-Marine 1	REF-Marine 1
Depth Zone:				**Surface**	**Surface**	**Surface**	**Surface**	**Surface**	**Surface**
Depth Sampled (m):				**1.0**	**1.0**	**0.1**	**0.1**	**1.0**	**1.0**
Replicate:				**1**	**2**	**1**	**2**	**1**	**2**
Date Sampled:		**CCME guideline for the**	**Realized**	**14-Aug-13**	**14-Aug-13**	**14-Aug-13**	**14-Aug-13**	**15-Aug-13**	**15-Aug-13**
ALS Sample ID:	**Units**	**Protection of Aquatic life[a]**	**Detection Limit**	**L1349159-1**	**L1349159-2**	**L1349159-3**	**L1349159-4**	**L1349159-7**	**L1349159-8**
Physical Tests									
Hardness (as $CaCO_3$)	mg/L		4.3	4040	3980	3640	3720	3880	3930
pH	pH	7.0-8.7	0.10	7.91	7.93	7.92	7.92	7.77	7.87
Salinity	psu	<10% fluctuation[b]	1.0	23.3	23.5	21.6	21.9	23.0	23.2
Total Suspended Solids	mg/L	dependent on background levels	2.0 or 3.0	2.1	<2.0	2.4	2.3	<3.0	<2.0
Total Dissolved Solids	mg/L		80	25800	26700	24400	24100	25300	25200
Turbidity	NTU	dependent on background levels	0.10	0.68	0.77	1.12	0.89	0.29	0.22
Anions and Nutrients									
Alkalinity, Total (as $CaCO_3$)	mg/L		2.0	99.2	94.5	90.3	90.9	75.6	118
Ammonia, Total (as N)	mg/L		0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Bromide (Br)	mg/L		5.0	45.7	45.8	42.3	42.9	36.7	46.6
Chloride (Cl)	mg/L		50	13000	13200	12100	12300	10500	13000
Fluoride (F)	mg/L		0.75	1.06	1.19	0.97	0.87	1.06	0.95
Nitrate and Nitrite (as N)	mg/L		0.0060	<0.0060	<0.0060	<0.0060	<0.0060	<0.0060	<0.0060
Nitrate (as N)	mg/L	short-term: 339; long-term: 45	0.0060	<0.0060	<0.0060	<0.0060	<0.0060	<0.0060	<0.0060
Nitrite (as N)	mg/L		0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Total Kjeldahl Nitrogen	mg/L		0.050	0.102	0.087	0.153	0.150	0.096	0.090
Orthophosphate-Dissolved (as P)	mg/L		0.0010	0.0331	0.0229	0.0196	0.0204	0.0222	0.0232
Phosphorus (P)	mg/L		0.0020	0.0292	0.0297	0.0298	0.0293	0.0287	0.0280
Sulfate (SO_4)	mg/L		50	1840	1870	1710	1740	1480	1830
Cyanides									
Cyanide, Total	mg/L		0.0010	0.0013	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Cyanide, Free	mg/L		0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Organic / Inorganic Carbon									
Dissolved Organic Carbon			0.50	0.87	0.90	1.29	1.16	1.21	1.13
Total Organic Carbon	mg/L		0.50	1.08	1.06	1.45	1.41	1.30	1.24
Total Metals									
Aluminum (Al)	mg/L		0.0050	0.0214	0.0182	0.0188	0.0181	<0.0050	<0.0050
Antimony (Sb)	mg/L		0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Arsenic (As)	mg/L	0.0125[b]	0.00040	0.00088	0.00096	0.00087	0.00088	0.00089	0.00094
Barium (Ba)	mg/L		0.0010	0.0093	0.0093	0.0083	0.0082	0.0082	0.0084
Beryllium (Be)	mg/L		0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Bismuth (Bi)	mg/L		0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Boron (B)	mg/L		0.10	3.12	3.39	3.12	3.10	3.29	3.32
Cadmium (Cd)	mg/L	0.00012	0.000020	0.000033	0.000033	0.000028	0.000030	0.000033	0.000034
Calcium (Ca)	mg/L		0.50	263	256	238	245	255	260
Cesium (Cs)	mg/L		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]	0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Cobalt (Co)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Copper (Cu)	mg/L		0.000050	0.000438	0.000539	0.000513	0.000475	0.000540	0.000400
Gallium (Ga)	mg/L		0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Iron (Fe)	mg/L		0.010	0.029	0.028	0.046	0.038	<0.010	<0.010
Lead (Pb)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Lithium (Li)	mg/L		0.020	0.125	0.116	0.106	0.104	0.112	0.111
Magnesium (Mg)	mg/L		1.0	822	811	738	756	789	796
Manganese (Mn)	mg/L		0.000050	0.00193	0.00198	0.00328	0.00317	0.00169	0.00177
Mercury (Hg)	ug/L	Inorganic Hg: 0.016[b]	0.00050	<0.00050	0.00064	<0.00050	<0.00050	0.00062	<0.00050
Molybdenum (Mo)	mg/L		0.0020	0.0075	0.0078	0.0070	0.0072	0.0075	0.0075
Nickel (Ni)	mg/L		0.000050	0.000353	0.000371	0.000337	0.000369	0.000333	0.000342
Phosphorus (P)	mg/L		1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Potassium (K)	mg/L		20	259	251	233	239	249	255
Rhenium (Re)	mg/L		0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Rubidium (Rb)	mg/L		0.0050	0.0795	0.0797	0.0734	0.0720	0.0767	0.0780
Selenium (Se)	mg/L		0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Silicon (Si)	mg/L		0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Silver (Ag)	mg/L		0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Sodium (Na)	mg/L		20	7170	6960	6430	6560	6920	7100
Strontium (Sr)	mg/L		0.050	4.75	4.62	4.30	4.40	4.59	4.70
Tellurium (Te)	mg/L		0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Thallium (Tl)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Thorium (Th)	mg/L		0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Tin (Sn)	mg/L		0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Titanium (Ti)	mg/L		0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Tungsten (W)	mg/L		0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Uranium (U)	mg/L		0.000050	0.00196	0.00205	0.00180	0.00187	0.00195	0.00195
Vanadium (V)	mg/L		0.00050	0.00069	0.00076	0.00061	0.00065	0.00067	0.00060
Yttrium (Y)	mg/L		0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Zinc (Zn)	mg/L		0.00080	<0.00080	<0.00080	<0.00080	<0.00080	<0.00080	<0.00080
Zirconium (Zr)	mg/L		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
Radiochemistry									
Radium-226	Bq/L		0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010

Notes:

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

[a] *Canadian water quality guidelines for the protection of marine aquatic life, Canadian Council of Ministers of the Environment, 2013.*

[b] *Interim guideline.*

Annex A.3-3. Marine Water Quality Data, Doris North Project, 2013

Site ID:				RBW	RBW	RBE	RBE	REF-Marine 1	REF-Marine 1
Depth Zone:				Surface	Surface	Surface	Surface	Surface	Surface
Depth Sampled (m):				1.0	1.0	0.5	0.5	1.0	1.0
Replicate:				1	2	1	2	1	2
Date Sampled:		CCME guideline for the	Realized	20-Sep-13	20-Sep-13	21-Sep-13	21-Sep-13	28-Sep-13	28-Sep-13
ALS Sample ID:	Units	Protection of Aquatic life[a]	Detection Limit	L1367952-1	L1367952-2	L1367952-3	L1367952-4	L1371437-1	L1371437-2
Physical Tests									
Hardness (as $CaCO_3$)	mg/L		4.3	4430	4460	4430	4480	4550	4740
pH	pH	7.0-8.7	0.10	7.61	7.72	7.75	7.79	7.75	7.87
Salinity	psu	<10% fluctuation[b]	1.0	24.3	24.0	24.0	24.2	24.7	24.9
Total Suspended Solids	mg/L	dependent on background levels	2.0 or 3.0	<2.0	<2.0	3.1	3.5	<2.0	<2.0
Total Dissolved Solids	mg/L		80	24500	26000	25000	24700	26700	26000
Turbidity	NTU	dependent on background levels	0.10	0.48	0.48	1.50	1.38	0.88	0.37
Anions and Nutrients									
Alkalinity, Total (as $CaCO_3$)	mg/L		2.0	110	108	107	108	115	116
Ammonia, Total (as N)	mg/L		0.0050	<0.0050	<0.0050	<0.0050	0.0062	<0.0050	<0.0050
Bromide (Br)	mg/L		5.0	52.7	50.7	51.1	49.3	47.8	48.4
Chloride (Cl)	mg/L		50	14600	14500	14600	14400	13600	13700
Fluoride (F)	mg/L		0.75	0.85	0.84	1.01	0.92	0.99	1.01
Nitrate and Nitrite (as N)	mg/L		0.0060	<0.0060	<0.0060	<0.0060	<0.0060	0.0221	<0.0060
Nitrate (as N)	mg/L	short-term: 339; long-term: 45	0.0060	<0.0060	<0.0060	<0.0060	<0.0060	0.0221	<0.0060
Nitrite (as N)	mg/L		0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Total Kjeldahl Nitrogen	mg/L		0.050	0.112	0.120	0.114	0.114	0.103	0.119
Orthophosphate-Dissolved (as P)	mg/L		0.0010	0.0227	0.0237	0.0229	0.0233	0.0263	0.0275
Phosphorus (P)	mg/L		0.0020	0.0291	0.0290	0.0315	0.0312	0.0312	0.0302
Sulfate (SO_4)	mg/L		50	2040	2020	2030	2000	1920	1940
Cyanides									
Cyanide, Total	mg/L		0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.0015	<0.0010
Cyanide, Free	mg/L		0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Organic / Inorganic Carbon									
Dissolved Organic Carbon			0.50	0.88	1.29	1.13	1.12	1.15	1.08
Total Organic Carbon	mg/L		0.50	1.36	1.50	1.43	1.39	1.31	1.30
Total Metals									
Aluminum (Al)	mg/L		0.0050	0.0168	0.0136	0.0458	0.0471	0.0054	<0.0050
Antimony (Sb)	mg/L		0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Arsenic (As)	mg/L	0.0125[b]	0.00040	0.00111	0.00102	0.00101	0.00099	0.00107	0.00108
Barium (Ba)	mg/L		0.0010	0.0094	0.0092	0.0101	0.0095	0.0095	0.0095
Beryllium (Be)	mg/L		0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Bismuth (Bi)	mg/L		0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Boron (B)	mg/L		0.10	3.21	3.11	3.25	3.09	3.18	3.27
Cadmium (Cd)	mg/L	0.00012	0.000020	0.000037	0.000035	0.000039	0.000040	0.000042	0.000039
Calcium (Ca)	mg/L		0.50	298	297	293	298	298	314
Cesium (Cs)	mg/L		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]	0.00050	0.00059	<0.00050	0.00107	0.0317	<0.00050	<0.00050
Cobalt (Co)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	0.000052	<0.000050	<0.000050
Copper (Cu)	mg/L		0.000050	0.000514	0.000366	0.000447	0.000411	0.000716	0.000439
Gallium (Ga)	mg/L		0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Iron (Fe)	mg/L		0.010	0.021	0.018	0.057	0.048	<0.010	<0.010
Lead (Pb)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Lithium (Li)	mg/L		0.020	0.137	0.127	0.133	0.126	0.133	0.137
Magnesium (Mg)	mg/L		1.0	896	902	898	907	925	961
Manganese (Mn)	mg/L		0.000050	0.00215	0.00191	0.00251	0.00246	0.00188	0.00193
Mercury (Hg)	ug/L	Inorganic Hg: 0.016[b]	0.00050	0.00054	<0.00050	<0.00050	<0.00050	<0.00050	0.00050
Molybdenum (Mo)	mg/L		0.0020	0.0106	0.0078	0.0083	0.0079	0.0081	0.0083
Nickel (Ni)	mg/L		0.000050	0.000410	0.000356	0.000418	0.000423	0.000481	0.000411
Phosphorus (P)	mg/L		1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Potassium (K)	mg/L		20	273	273	271	276	274	287
Rhenium (Re)	mg/L		0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Rubidium (Rb)	mg/L		0.0050	0.0900	0.0821	0.0846	0.0796	0.0886	0.0903
Selenium (Se)	mg/L		0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.00076	0.00082
Silicon (Si)	mg/L		0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Silver (Ag)	mg/L		0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Sodium (Na)	mg/L		20	7700	7720	7650	7780	7490	7820
Strontium (Sr)	mg/L		0.050	5.18	5.22	5.16	5.27	5.33	5.60
Tellurium (Te)	mg/L		0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Thallium (Tl)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Thorium (Th)	mg/L		0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Tin (Sn)	mg/L		0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Titanium (Ti)	mg/L		0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Tungsten (W)	mg/L		0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Uranium (U)	mg/L		0.000050	0.00226	0.00232	0.00239	0.00229	0.00228	0.00228
Vanadium (V)	mg/L		0.00050	0.00111	0.00075	0.00097	0.00081	0.00068	0.00067
Yttrium (Y)	mg/L		0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Zinc (Zn)	mg/L		0.00080	0.00082	<0.00080	<0.00080	<0.00080	<0.00080	<0.00080
Zirconium (Zr)	mg/L		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	0.000057	<0.000050
Radiochemistry									
Radium-226	Bq/L		0.010	<0.01	<0.01	<0.01	<0.01	<0.010	<0.010

Notes:

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

[a] Canadian water quality guidelines for the protection of marine aquatic life, Canadian Council of Ministers of the Environment, 2013.

[b] Interim guideline.

Annex A.3-4. QA/QC Blank Data for Water Quality Sampling, Doris North Project, 2013

Blank Type			Equipment Blank (Freshwater)	Field Blank (Freshwater)	Travel Blank (Freshwater)	Equipment Blank (Marine)	Field Blank (Marine)	Travel Blank (Marine)	Field Blank (Freshwater)
Date Sampled:			24-Apr-13	27-Apr-13	27-Apr-13	28-Apr-13	28-Apr-13	28-Apr-13	13-Jun-13
ALS Sample ID:	Units	Realized Detection Limit	L1296387-6	L1296387-12	L1296387-13	L1296387-22	L1296387-17	L1296387-18	L1317173-3
Physical Tests									
Conductivity	µS/cm	2.0	<2.0	<2.0	<2.0	-	-	-	<2.0
Hardness (as $CaCO_3$)	mg/L	0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
pH	pH	0.10	**5.89**	**6.04**	**5.85**	**5.79**	**6.48**	**6.19**	**5.94**
Salinity	PSU	1	-	-	-	<1.0	<1.0	<1.0	-
Total Suspended Solids	mg/L	1.0-3.0	<1.0	<1.0	<1.0	<2.0	<2.0	<2.0	<1.0
Total Dissolved Solids	mg/L	10	<10	<10	<10	<10	<10	<10	<10
Turbidity	NTU	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	1.0-2.0	<1.0	<1.0	<1.0	<2.0	<2.0	<2.0	**1.2**
Ammonia, Total (as N)	mg/L	0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	**0.0088**	<0.0050
Bromide (Br)	mg/L	0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Chloride (Cl)	mg/L	0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Fluoride (F)	mg/L	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	-	-	-
Nitrate (as N)	mg/L	0.005-0.006	<0.0050	<0.0050	<0.0050	<0.0060	<0.0050	<0.0050	<0.0050
Nitrite (as N)	mg/L	0.001-0.002	<0.0010	<0.0010	<0.0010	<0.0020	<0.0010	<0.0010	<0.0010
Total Kjeldahl Nitrogen	mg/L	0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Total Nitrogen	mg/L	0.050	-	-	-	-	-	-	-
Orthophosphate-Dissolved (as P)	mg/L	0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Phosphorus (P)	mg/L	0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Sulfate (SO_4)	mg/L	0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Cyanides									
Cyanide, Total	mg/L	0.0010	<0.0010	<0.0010	<0.0010	**0.0034**	**0.0013**	<0.0010	<0.0010
Cyanide, Free	mg/L	0.0010	<0.0010	<0.0010	<0.0010	**0.0034**	**0.0014**	<0.0010	<0.0010
Organic / Inorganic Carbon									
Dissolved Organic Carbon	mg/L	0.50	<0.50	<0.50	-	<0.50	<0.50	-	<0.50
Total Organic Carbon	mg/L	0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Total Metals									
Aluminum (Al)	mg/L	0.003-0.005	<0.0030	<0.0030	<0.0030	<0.0050	<0.0050	<0.0050	<0.0030
Antimony (Sb)	mg/L	0.00001-0.0005	<0.000010	<0.000010	<0.000010	<0.00050	<0.00050	<0.00050	<0.000010
Arsenic (As)	mg/L	0.00005-0.0004	<0.000050	<0.000050	<0.000050	<0.00040	<0.00040	<0.00040	<0.000050
Barium (Ba)	mg/L	0.0001-0.001	**0.00017**	<0.00010	<0.00010	<0.0010	<0.0010	<0.0010	<0.00010
Beryllium (Be)	mg/L	0.000005-0.0005	<0.0000050	<0.0000050	<0.0000050	<0.00050	<0.00050	<0.00050	<0.0000050
Bismuth (Bi)	mg/L	0.00005-0.0005	<0.000050	<0.000050	<0.000050	<0.00050	<0.00050	<0.00050	<0.000050
Boron (B)	mg/L	0.005-0.1	<0.0050	<0.0050	<0.0050	<0.10	<0.10	<0.10	<0.0050
Cadmium (Cd)	mg/L	0.000005-0.00002	<0.0000050	<0.0000050	<0.0000050	<0.000020	<0.000020	<0.000020	<0.0000050
Calcium (Ca)	mg/L	0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Cesium (Cs)	mg/L	0.000005-0.0005	<0.0000050	<0.0000050	<0.0000050	<0.00050	<0.00050	<0.00050	<0.0000050
Chromium (Cr)	mg/L	0.000500	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Cobalt (Co)	mg/L	0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Copper (Cu)	mg/L	0.00005-0.0005	<0.00050	<0.00050	<0.00050	<0.000050	<0.000050	<0.000050	<0.00050
Gallium (Ga)	mg/L	0.00005-0.0005	<0.000050	<0.000050	<0.000050	<0.00050	<0.00050	<0.00050	<0.000050
Iron (Fe)	mg/L	0.01-0.03	<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
Lithium (Li)	mg/L	0.0002-0.02	<0.00020	<0.00020	<0.00020	<0.020	<0.020	<0.020	<0.00020
Magnesium (Mg)	mg/L	0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Manganese (Mn)	mg/L	0.00005-0.0002	<0.00020	<0.00020	<0.00020	<0.000050	<0.000050	<0.000050	<0.00020
Mercury (Hg)	ug/L	0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Molybdenum (Mo)	mg/L	0.00005-0.002	<0.000050	<0.000050	<0.000050	<0.0020	<0.0020	<0.0020	<0.000050
Nickel (Ni)	mg/L	0.00005-0.0002	<0.00020	<0.00020	<0.00020	<0.000050	<0.000050	<0.000050	<0.00020
Phosphorus (P)	mg/L	0.3-1.0	<0.30	<0.30	<0.30	<1.0	<1.0	<1.0	<0.30
Potassium (K)	mg/L	2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Rhenium (Re)	mg/L	0.000005-0.0005	<0.0000050	<0.0000050	<0.0000050	<0.00050	<0.00050	<0.00050	<0.0000050
Rubidium (Rb)	mg/L	0.00002-0.005	<0.000020	<0.000020	<0.000020	<0.0050	<0.0050	<0.0050	<0.000020
Selenium (Se)	mg/L	0.0002-0.0005	<0.00020	<0.00020	<0.00020	<0.00050	<0.00050	<0.00050	<0.00020
Silicon (Si)	mg/L	0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Silver (Ag)	mg/L	0.000005-0.0001	<0.0000050	<0.0000050	<0.0000050	<0.00010	<0.00010	<0.00010	<0.0000050
Sodium (Na)	mg/L	2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Strontium (Sr)	mg/L	0.00005-0.005	<0.000050	<0.000050	<0.000050	<0.0050	<0.0050	<0.0050	<0.000050
Tellurium (Te)	mg/L	0.00001-0.0005	<0.000010	<0.000010	<0.000010	<0.00050	<0.00050	<0.00050	<0.000010
Thallium (Tl)	mg/L	0.000002-0.00005	<0.0000020	<0.0000020	<0.0000020	<0.000050	<0.000050	<0.000050	<0.0000020
Thorium (Th)	mg/L	0.000005-0.0005	<0.0000050	<0.0000050	<0.0000050	<0.00050	<0.00050	<0.00050	<0.0000050
Tin (Sn)	mg/L	0.00020-0.001	<0.00020	<0.00020	<0.00020	<0.0010	<0.0010	<0.0010	<0.00020
Titanium (Ti)	mg/L	0.0002-0.005	<0.00020	<0.00020	<0.00020	<0.0050	<0.0050	<0.0050	<0.00020
Tungsten (W)	mg/L	0.00001-0.001	<0.000010	<0.000010	<0.000010	<0.0010	<0.0010	<0.0010	<0.000010
Uranium (U)	mg/L	0.000002-0.00005	<0.0000020	<0.0000020	<0.0000020	<0.000050	<0.000050	<0.000050	<0.0000020
Vanadium (V)	mg/L	0.00005-0.0005	<0.000050	<0.000050	<0.000050	<0.00050	<0.00050	<0.00050	<0.000050
Yttrium (Y)	mg/L	0.000005-0.0005	<0.0000050	<0.0000050	<0.0000050	<0.00050	<0.00050	<0.00050	<0.0000050
Zinc (Zn)	mg/L	0.0008-0.003	**0.0270**	<0.0030	<0.0030	**0.0117**	<0.00080	<0.00080	<0.0030
Zirconium (Zr)	mg/L	0.00005-0.0005	<0.000050	<0.000050	<0.000050	<0.00050	<0.00050	<0.00050	<0.000050
Speciated Metals									
Methyl Mercury		0.00005	-	-	-	<0.000050	<0.000050	<0.000050	-
Radiochemistry									
Radium-226	Bq/L	0.010	<0.010	-	-	<0.010	-	-	-

Note:

Bold values represent concentrations that are higher than analytical detection limits.

Annex A.3-4. QA/QC Blank Data for Water Quality Sampling, Doris North Project, 2013

Blank Type			Travel Blank (Freshwater)	Equipment Blank (Freshwater)	Field Blank (Freshwater)	Travel Blank (Freshwater)	Equipment Blank (Marine)	Field Blank (Marine)	Equipment Blank (Freshwater)
Date Sampled:			**12-Jun-13**	**17-Jul-13**	**20-Jul-13**	**19-Jul-13**	**19-Jul-13**	**21-Jul-13**	**13-Aug-13**
ALS Sample ID:	**Units**	**Realized Detection Limit**	**L1317195-5**	**L1335459-1**	**L1336779-5**	**L1336785-4**	**L1336704-3**	**L1336704-4**	**L1352799-11**
Physical Tests									
Conductivity	µS/cm	2.0	<2.0	<2.0	<2.0	<2.0	-	-	<2.0
Hardness (as $CaCO_3$)	mg/L	0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
pH	pH	0.10	**5.79**	**5.72**	**5.81**	**5.80**	**5.90**	**5.67**	**5.91**
Salinity	PSU	1	-	-	-	-	<1.0	<1.0	-
Total Suspended Solids	mg/L	1.0-3.0	<1.0	<1.0	<1.0	<1.0	<2.0	<2.0	<1.0
Total Dissolved Solids	mg/L	10	<10	<10	<10	<10	<10	<10	<10
Turbidity	NTU	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	1.0-2.0	**1.1**	<1.0	<1.0	<1.0	<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
Bromide (Br)	mg/L	0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Chloride (Cl)	mg/L	0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Fluoride (F)	mg/L	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	-
Nitrate (as N)	mg/L	0.005-0.006	<0.0050	**0.0099**	<0.0050	<0.0050	<0.0060	<0.0060	<0.0050
Nitrite (as N)	mg/L	0.001-0.002	<0.0010	<0.0010	<0.0010	<0.0010	<0.0020	<0.0020	<0.0010
Total Kjeldahl Nitrogen	mg/L	0.050	<0.050	<0.050	<0.050	<0.050	<0.050	**0.077**	<0.050
Total Nitrogen	mg/L	0.050	-	-	<0.050	-	-	-	-
Orthophosphate-Dissolved (as P)	mg/L	0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Phosphorus (P)	mg/L	0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Sulfate (SO_4)	mg/L	0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Cyanides									
Cyanide, Total	mg/L	0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Cyanide, Free	mg/L	0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Organic / Inorganic Carbon									
Dissolved Organic Carbon	mg/L	0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Total Organic Carbon	mg/L	0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Total Metals									
Aluminum (Al)	mg/L	0.003-0.005	<0.0030	**0.0165**	<0.0030	<0.0030	<0.0050	<0.0050	**0.0050**
Antimony (Sb)	mg/L	0.00001-0.0005	<0.000010	<0.000010	<0.000010	<0.000010	<0.00050	<0.00050	<0.000010
Arsenic (As)	mg/L	0.00005-0.0004	<0.000050	<0.000050	<0.000050	<0.000050	<0.00040	<0.00040	<0.000050
Barium (Ba)	mg/L	0.0001-0.001	<0.00010	**0.00031**	<0.00010	<0.00010	<0.0010	<0.0010	<0.00010
Beryllium (Be)	mg/L	0.000005-0.0005	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.00050	<0.00050	<0.0000050
Bismuth (Bi)	mg/L	0.00005-0.0005	<0.000050	<0.000050	<0.000050	<0.000050	<0.00050	<0.00050	<0.000050
Boron (B)	mg/L	0.005-0.1	<0.0050	<0.0050	<0.0050	<0.0050	<0.10	<0.10	<0.0050
Cadmium (Cd)	mg/L	0.000005-0.00002	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.000020	<0.000020	<0.0000050
Calcium (Ca)	mg/L	0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Cesium (Cs)	mg/L	0.000005-0.0005	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.00050	<0.00050	<0.0000050
Chromium (Cr)	mg/L	0.000500	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Cobalt (Co)	mg/L	0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Copper (Cu)	mg/L	0.00005-0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.000050	<0.000050	<0.00050
Gallium (Ga)	mg/L	0.00005-0.0005	<0.000050	<0.000050	<0.000050	<0.000050	<0.00050	<0.00050	<0.000050
Iron (Fe)	mg/L	0.01-0.03	<0.030	<0.030	<0.030	<0.030	<0.010	<0.010	<0.030
Lead (Pb)	mg/L	0.000050	<0.000050	**0.000135**	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Lithium (Li)	mg/L	0.0002-0.02	<0.00020	<0.00020	<0.00020	<0.00020	<0.020	<0.020	<0.00020
Magnesium (Mg)	mg/L	0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Manganese (Mn)	mg/L	0.00005-0.0002	<0.00020	<0.00020	<0.00020	<0.00020	<0.000050	<0.000050	<0.00020
Mercury (Hg)	ug/L	0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Molybdenum (Mo)	mg/L	0.00005-0.002	<0.000050	<0.000050	<0.000050	<0.000050	<0.0020	<0.0020	<0.000050
Nickel (Ni)	mg/L	0.00005-0.0002	<0.00020	<0.00020	<0.00020	<0.00020	<0.000050	<0.000050	<0.00020
Phosphorus (P)	mg/L	0.3-1.0	<0.30	<0.30	<0.30	<0.30	<1.0	<1.0	<0.30
Potassium (K)	mg/L	2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Rhenium (Re)	mg/L	0.000005-0.0005	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.00050	<0.00050	<0.0000050
Rubidium (Rb)	mg/L	0.00002-0.005	<0.000020	<0.000020	<0.000020	<0.000020	<0.0050	<0.0050	<0.000020
Selenium (Se)	mg/L	0.0002-0.0005	<0.00020	<0.00020	<0.00020	<0.00020	<0.00050	<0.00050	<0.00020
Silicon (Si)	mg/L	0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Silver (Ag)	mg/L	0.000005-0.0001	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.00010	<0.00010	<0.0000050
Sodium (Na)	mg/L	2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Strontium (Sr)	mg/L	0.00005-0.005	<0.000050	<0.000050	<0.000050	<0.000050	<0.0050	<0.0050	<0.000050
Tellurium (Te)	mg/L	0.00001-0.0005	<0.000010	<0.000010	<0.000010	<0.000010	<0.00050	<0.00050	<0.000010
Thallium (Tl)	mg/L	0.000002-0.00005	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.000050	<0.000050	<0.0000020
Thorium (Th)	mg/L	0.000005-0.0005	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.00050	<0.00050	<0.0000050
Tin (Sn)	mg/L	0.00020-0.001	<0.00020	<0.00020	<0.00020	<0.00020	<0.0010	<0.0010	<0.00020
Titanium (Ti)	mg/L	0.0002-0.005	<0.00020	<0.00020	<0.00020	<0.00020	<0.0050	<0.0050	<0.00020
Tungsten (W)	mg/L	0.00001-0.001	<0.000010	<0.000010	<0.000010	<0.000010	<0.0010	<0.0010	<0.000010
Uranium (U)	mg/L	0.000002-0.00005	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.000050	<0.000050	<0.0000020
Vanadium (V)	mg/L	0.00005-0.0005	<0.000050	<0.000050	<0.000050	<0.000050	<0.00050	<0.00050	<0.000050
Yttrium (Y)	mg/L	0.000005-0.0005	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.00050	<0.00050	<0.0000050
Zinc (Zn)	mg/L	0.0008-0.003	<0.0030	<0.0030	<0.0030	<0.0030	<0.00080	<0.00080	<0.0030
Zirconium (Zr)	mg/L	0.00005-0.0005	<0.000050	<0.000050	<0.000050	<0.000050	<0.00050	<0.00050	<0.000050
Speciated Metals									
Methyl Mercury		0.00005	-	-	-	-	<0.000050	<0.000050	-
Radiochemistry									
Radium-226	Bq/L	0.010	-	<0.010	<0.01	<0.01	<0.01	<0.01	<0.010

Note:

Bold values represent concentrations that are higher than analytical detection limits.

Annex A.3-4. QA/QC Blank Data for Water Quality Sampling, Doris North Project, 2013

Blank Type Date Sampled: ALS Sample ID:	Units	Realized Detection Limit	Field Blank (Freshwater) 19-Aug-13 L1350568-12	Travel Blank (Freshwater) 22-Aug-13 L1352799-10	Equipment Blank (Marine) 13-Aug-13 L1352799-12	Field Blank (Marine) 15-Aug-13 L1349159-6	Travel Blank (Marine) 14-Aug-13 L1349159-5	Equipment Blank (Freshwater) 19-Sep-13 L1366437-9	Field Blank (Freshwater) 20-Sep-13 L1367963-3
Physical Tests									
Conductivity	µS/cm	2.0	<2.0	<2.0	-	-	-	<2.0	<2.0
Hardness (as $CaCO_3$)	mg/L	0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
pH	pH	0.10	**5.79**	**5.69**	**5.66**	**6.10**	**6.14**	**5.87**	**5.85**
Salinity	PSU	1	-	-	<1.0	<1.0	<1.0	-	-
Total Suspended Solids	mg/L	1.0-3.0	<1.0	<1.0	<2.0	<2.0	<3.0	<1.0	<1.0
Total Dissolved Solids	mg/L	10	<10	<10	<10	<10	<10	<10	<10
Turbidity	NTU	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	1.0-2.0	<1.0	<2.0	<1.0	<2.0	<2.0	<1.0	**1.4**
Ammonia, Total (as N)	mg/L	0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Bromide (Br)	mg/L	0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Chloride (Cl)	mg/L	0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Fluoride (F)	mg/L	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	-	-
Nitrate (as N)	mg/L	0.005-0.006	<0.0050	<0.0050	<0.0060	<0.0060	<0.0060	**0.0124**	<0.0050
Nitrite (as N)	mg/L	0.001-0.002	<0.0010	<0.0010	<0.0020	<0.0020	<0.0020	<0.0010	<0.0010
Total Kjeldahl Nitrogen	mg/L	0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Total Nitrogen	mg/L	0.050	-	-	-	-	-	-	-
Orthophosphate-Dissolved (as P)	mg/L	0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Phosphorus (P)	mg/L	0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Sulfate (SO_4)	mg/L	0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Cyanides									
Cyanide, Total	mg/L	0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Cyanide, Free	mg/L	0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Organic / Inorganic Carbon									
Dissolved Organic Carbon	mg/L	0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Total Organic Carbon	mg/L	0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Total Metals									
Aluminum (Al)	mg/L	0.003-0.005	<0.0030	<0.0030	<0.0050	<0.0050	<0.0050	<0.0030	<0.0030
Antimony (Sb)	mg/L	0.00001-0.0005	<0.000010	<0.000010	<0.00050	<0.00050	<0.00050	<0.000010	<0.000010
Arsenic (As)	mg/L	0.00005-0.0004	<0.000050	<0.000050	<0.00040	<0.00040	<0.00040	<0.000050	<0.000050
Barium (Ba)	mg/L	0.0001-0.001	<0.00010	<0.00010	<0.0010	<0.0010	<0.0010	<0.00010	<0.00010
Beryllium (Be)	mg/L	0.000005-0.0005	<0.0000050	<0.0000050	<0.00050	<0.00050	<0.00050	<0.0000050	<0.0000050
Bismuth (Bi)	mg/L	0.00005-0.0005	<0.000050	<0.000050	<0.00050	<0.00050	<0.00050	<0.000050	<0.000050
Boron (B)	mg/L	0.005-0.1	<0.0050	<0.0050	<0.10	<0.10	<0.10	<0.0050	<0.0050
Cadmium (Cd)	mg/L	0.000005-0.00002	<0.0000050	<0.0000050	<0.000020	<0.000020	<0.000020	<0.0000050	<0.0000050
Calcium (Ca)	mg/L	0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Cesium (Cs)	mg/L	0.000005-0.0005	<0.0000050	<0.0000050	<0.00050	<0.00050	<0.00050	<0.0000050	<0.0000050
Chromium (Cr)	mg/L	0.000500	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Cobalt (Co)	mg/L	0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Copper (Cu)	mg/L	0.00005-0.0005	<0.00050	<0.00050	**0.000096**	<0.000050	<0.000050	<0.00050	<0.00050
Gallium (Ga)	mg/L	0.00005-0.0005	<0.000050	<0.000050	<0.00050	<0.00050	<0.00050	<0.000050	<0.000050
Iron (Fe)	mg/L	0.01-0.03	<0.030	<0.030	<0.010	<0.010	<0.010	<0.030	<0.030
Lead (Pb)	mg/L	0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	**0.000104**	<0.000050
Lithium (Li)	mg/L	0.0002-0.02	<0.00020	<0.00020	<0.020	<0.020	<0.020	<0.00020	<0.00020
Magnesium (Mg)	mg/L	0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Manganese (Mn)	mg/L	0.00005-0.0002	<0.00020	<0.00020	<0.000050	<0.000050	<0.000050	<0.00020	<0.00020
Mercury (Hg)	ug/L	0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Molybdenum (Mo)	mg/L	0.00005-0.002	<0.000050	<0.000050	<0.0020	<0.0020	<0.0020	<0.000050	<0.000050
Nickel (Ni)	mg/L	0.00005-0.0002	<0.00020	<0.00020	<0.000050	<0.000050	<0.000050	<0.00020	<0.00020
Phosphorus (P)	mg/L	0.3-1.0	<0.30	<0.30	<1.0	<1.0	<1.0	<0.30	<0.30
Potassium (K)	mg/L	2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Rhenium (Re)	mg/L	0.000005-0.0005	<0.0000050	<0.0000050	<0.00050	<0.00050	<0.00050	<0.0000050	<0.0000050
Rubidium (Rb)	mg/L	0.00002-0.005	<0.000020	<0.000020	<0.0050	<0.0050	<0.0050	<0.000020	<0.000020
Selenium (Se)	mg/L	0.0002-0.0005	<0.00020	<0.00020	<0.00050	<0.00050	<0.00050	<0.00020	<0.00020
Silicon (Si)	mg/L	0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Silver (Ag)	mg/L	0.000005-0.0001	<0.0000050	<0.0000050	<0.00010	<0.00010	<0.00010	<0.0000050	<0.0000050
Sodium (Na)	mg/L	2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Strontium (Sr)	mg/L	0.00005-0.005	<0.000050	<0.000050	<0.0050	<0.0050	<0.0050	<0.000050	<0.000050
Tellurium (Te)	mg/L	0.00001-0.0005	<0.000010	<0.000010	<0.00050	<0.00050	<0.00050	<0.000010	<0.000010
Thallium (Tl)	mg/L	0.000002-0.00005	<0.0000020	<0.0000020	<0.000050	<0.000050	<0.000050	<0.0000020	<0.0000020
Thorium (Th)	mg/L	0.000005-0.0005	<0.0000050	<0.0000050	<0.00050	<0.00050	<0.00050	<0.0000050	<0.0000050
Tin (Sn)	mg/L	0.00020-0.001	<0.00020	<0.00020	<0.0010	<0.0010	<0.0010	<0.00020	<0.00020
Titanium (Ti)	mg/L	0.0002-0.005	<0.00020	<0.00020	<0.0050	<0.0050	<0.0050	<0.00020	<0.00020
Tungsten (W)	mg/L	0.00001-0.001	<0.000010	<0.000010	<0.0010	<0.0010	<0.0010	<0.000010	<0.000010
Uranium (U)	mg/L	0.000002-0.00005	<0.0000020	<0.0000020	<0.000050	<0.000050	<0.000050	<0.0000020	<0.0000020
Vanadium (V)	mg/L	0.00005-0.0005	<0.000050	<0.000050	<0.00050	<0.00050	<0.00050	<0.000050	<0.000050
Yttrium (Y)	mg/L	0.000005-0.0005	<0.0000050	<0.0000050	<0.00050	<0.00050	<0.00050	<0.0000050	<0.0000050
Zinc (Zn)	mg/L	0.0008-0.003	<0.0030	<0.0030	<0.00080	<0.00080	<0.00080	<0.0030	<0.0030
Zirconium (Zr)	mg/L	0.00005-0.0005	<0.000050	<0.000050	<0.00050	<0.00050	<0.00050	<0.000050	<0.000050
Speciated Metals									
Methyl Mercury		0.00005	-	-	<0.000050	<0.000050	<0.000050	-	-
Radiochemistry									
Radium-226	Bq/L	0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.01	<0.01

Note:

Bold values represent concentrations that are higher than analytical detection limits.

Annex A.3-4. QA/QC Blank Data for Water Quality Sampling, Doris North Project, 2013

Blank Type			Travel Blank (Freshwater)	Equipment Blank (Marine)	Field Blank (Marine)	Travel Blank (Marine)
Date Sampled:			21-Sep-13	21-Sep-13	21-Sep-13	28-Sep-13
ALS Sample ID:	Units	Realized Detection Limit	L1367963-7	L1367963-10	L1367952-5	L1371437-3
Physical Tests						
Conductivity	µS/cm	2.0	<2.0	<2.0	-	-
Hardness (as $CaCO_3$)	mg/L	0.50	<0.50	<0.50	<0.50	<0.50
pH	pH	0.10	**5.81**	**5.92**	**6.11**	**5.45**
Salinity	PSU	1	-	-	<1.0	<1.0
Total Suspended Solids	mg/L	1.0-3.0	<1.0	<1.0	<2.0	<2.0
Total Dissolved Solids	mg/L	10	<10	<10	<10	<10
Turbidity	NTU	0.10	<0.10	<0.10	<0.10	<0.10
Anions and Nutrients						
Alkalinity, Total (as $CaCO_3$)	mg/L	1.0-2.0	<1.0	**1.3**	<2.0	<2.0
Ammonia, Total (as N)	mg/L	0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Bromide (Br)	mg/L	0.050	<0.050	<0.050	<0.050	<0.050
Chloride (Cl)	mg/L	0.50	<0.50	<0.50	<0.50	<0.50
Fluoride (F)	mg/L	0.020	<0.020	<0.020	<0.020	<0.020
Nitrate and Nitrite (as N)	mg/L	0.006	-	-	<0.0060	<0.0060
Nitrate (as N)	mg/L	0.005-0.006	<0.0050	0.0096	<0.0060	<0.0060
Nitrite (as N)	mg/L	0.001-0.002	<0.0010	<0.0010	<0.0020	<0.0020
Total Kjeldahl Nitrogen	mg/L	0.050	<0.050	<0.050	<0.050	<0.050
Total Nitrogen	mg/L	0.050	-	-	-	-
Orthophosphate-Dissolved (as P)	mg/L	0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Phosphorus (P)	mg/L	0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Sulfate (SO_4)	mg/L	0.50	<0.50	<0.50	<0.50	<0.50
Cyanides						
Cyanide, Total	mg/L	0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Cyanide, Free	mg/L	0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Organic / Inorganic Carbon						
Dissolved Organic Carbon	mg/L	0.50	<0.50	<0.50	**0.54**	<0.50
Total Organic Carbon	mg/L	0.50	<0.50	<0.50	<0.50	0.50
Total Metals						
Aluminum (Al)	mg/L	0.003-0.005	<0.0030	<0.0030	<0.0050	<0.0050
Antimony (Sb)	mg/L	0.00001-0.0005	<0.000010	<0.000010	<0.00050	<0.00050
Arsenic (As)	mg/L	0.00005-0.0004	<0.000050	<0.000050	<0.00040	<0.00040
Barium (Ba)	mg/L	0.0001-0.001	<0.00010	<0.00010	<0.0010	<0.0010
Beryllium (Be)	mg/L	0.000005-0.0005	<0.0000050	<0.0000050	<0.00050	<0.00050
Bismuth (Bi)	mg/L	0.00005-0.0005	<0.000050	<0.000050	<0.00050	<0.00050
Boron (B)	mg/L	0.005-0.1	<0.0050	<0.0050	<0.10	<0.10
Cadmium (Cd)	mg/L	0.000005-0.00002	<0.0000050	<0.0000050	<0.000020	<0.000020
Calcium (Ca)	mg/L	0.050	<0.050	<0.050	<0.050	<0.050
Cesium (Cs)	mg/L	0.000005-0.0005	<0.0000050	<0.0000050	<0.00050	<0.00050
Chromium (Cr)	mg/L	0.000500	<0.00050	<0.00050	<0.00050	<0.00050
Cobalt (Co)	mg/L	0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Copper (Cu)	mg/L	0.00005-0.0005	<0.00050	<0.00050	<0.000050	<0.000050
Gallium (Ga)	mg/L	0.00005-0.0005	<0.000050	<0.000050	<0.00050	<0.00050
Iron (Fe)	mg/L	0.01-0.03	<0.030	<0.030	<0.010	<0.010
Lead (Pb)	mg/L	0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Lithium (Li)	mg/L	0.0002-0.02	<0.00020	<0.00020	<0.020	<0.020
Magnesium (Mg)	mg/L	0.10	<0.10	<0.10	<0.10	<0.10
Manganese (Mn)	mg/L	0.00005-0.0002	<0.00020	<0.00020	<0.000050	<0.000050
Mercury (Hg)	ug/L	0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Molybdenum (Mo)	mg/L	0.00005-0.002	<0.000050	<0.000050	<0.0020	<0.0020
Nickel (Ni)	mg/L	0.00005-0.0002	<0.00020	<0.00020	<0.000050	<0.000050
Phosphorus (P)	mg/L	0.3-1.0	<0.30	<0.30	<1.0	<1.0
Potassium (K)	mg/L	2.0	<2.0	<2.0	<2.0	<2.0
Rhenium (Re)	mg/L	0.000005-0.0005	<0.0000050	<0.0000050	<0.00050	<0.00050
Rubidium (Rb)	mg/L	0.00002-0.005	<0.000020	<0.000020	<0.0050	<0.0050
Selenium (Se)	mg/L	0.0002-0.0005	<0.00020	<0.00020	<0.00050	<0.00050
Silicon (Si)	mg/L	0.050	<0.050	<0.050	<0.050	<0.050
Silver (Ag)	mg/L	0.000005-0.0001	<0.0000050	<0.0000050	<0.00010	<0.00010
Sodium (Na)	mg/L	2.0	<2.0	<2.0	<2.0	<2.0
Strontium (Sr)	mg/L	0.00005-0.005	<0.000050	<0.000050	<0.0050	<0.0050
Tellurium (Te)	mg/L	0.00001-0.0005	<0.000010	<0.000010	<0.00050	<0.00050
Thallium (Tl)	mg/L	0.000002-0.00005	<0.0000020	<0.0000020	<0.000050	<0.000050
Thorium (Th)	mg/L	0.000005-0.0005	<0.0000050	<0.0000050	<0.00050	<0.00050
Tin (Sn)	mg/L	0.00020-0.001	<0.00020	<0.00020	<0.0010	<0.0010
Titanium (Ti)	mg/L	0.0002-0.005	<0.00020	<0.00020	<0.0050	<0.0050
Tungsten (W)	mg/L	0.00001-0.001	<0.000010	<0.000010	<0.0010	<0.0010
Uranium (U)	mg/L	0.000002-0.00005	<0.0000020	<0.0000020	<0.000050	<0.000050
Vanadium (V)	mg/L	0.00005-0.0005	<0.000050	<0.000050	<0.00050	<0.00050
Yttrium (Y)	mg/L	0.000005-0.0005	<0.0000050	<0.0000050	<0.00050	<0.00050
Zinc (Zn)	mg/L	0.0008-0.003	<0.0030	<0.0030	<0.00080	<0.00080
Zirconium (Zr)	mg/L	0.00005-0.0005	<0.000050	<0.000050	<0.00050	<0.00050
Speciated Metals						
Methyl Mercury		0.00005	-	<0.000050	<0.000050	<0.000050
Radiochemistry						
Radium-226	Bq/L	0.010	<0.01	<0.01	<0.01	<0.010

Note:

Bold values represent concentrations that are higher than analytical detection limits.

A.4 2013 SEDIMENT QUALITY

The following sections present the sediment quality data collected in August 2013 from stream, lake, and marine sites. Only the variables that were subjected to an evaluation of effects (see main body of AEMP report) are shown graphically. All sediment quality variables were screened against CCME sediment quality guidelines for the protection of aquatic life (CCME 2013a). 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 2013a). CCME guidelines are included in all graphs and annexes.

A.4.1 Stream Data

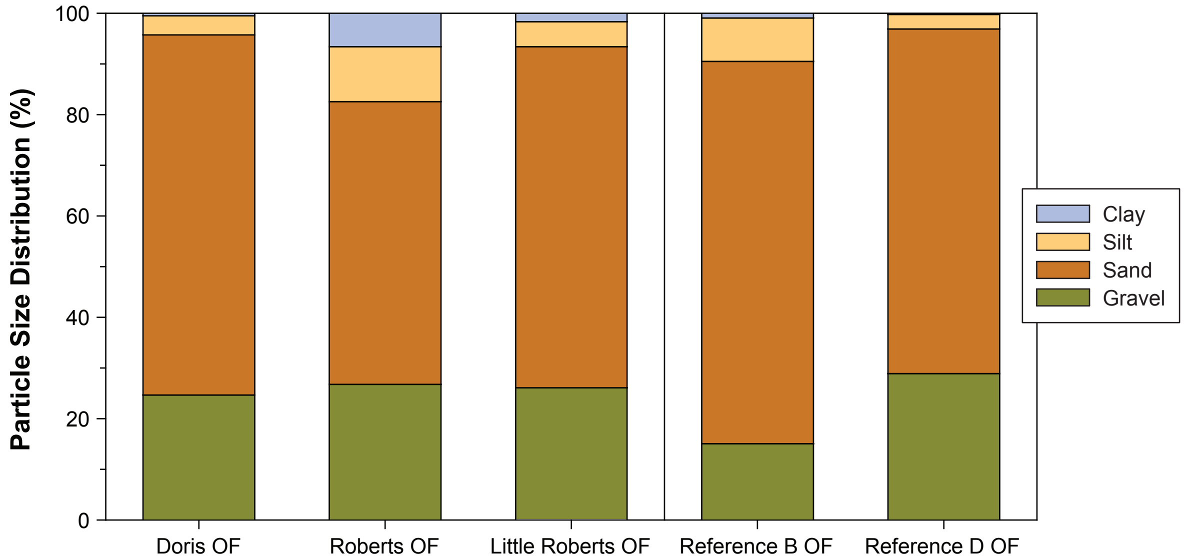
Figures A.4-1 to A.4-5 show select sediment quality variable concentrations in the AEMP streams. Annex A.4-1 presents the raw stream sediment quality data.

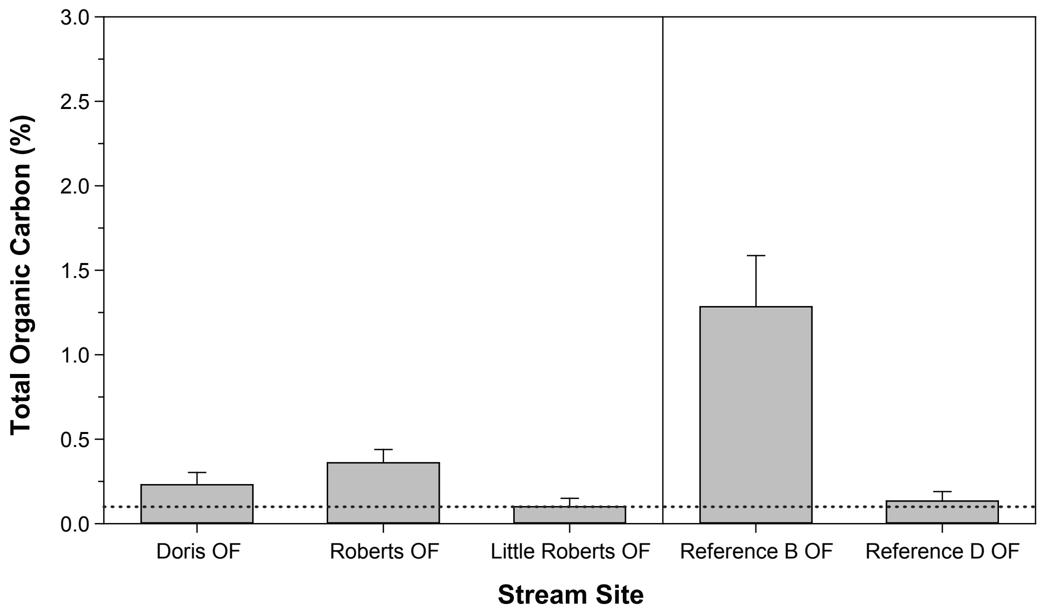
A.4.2 Lake Data

Figures A.4-6 to A.4-10 show select sediment quality variable concentrations in the surveyed lakes. 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 variable concentrations in the AEMP marine sites. Annex A.4-3 presents the raw marine sediment quality data.





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

Particle Size Distribution and Total Organic Carbon Concentration in Stream Sediments, Doris North Project, August 2013

Figure A.4-1

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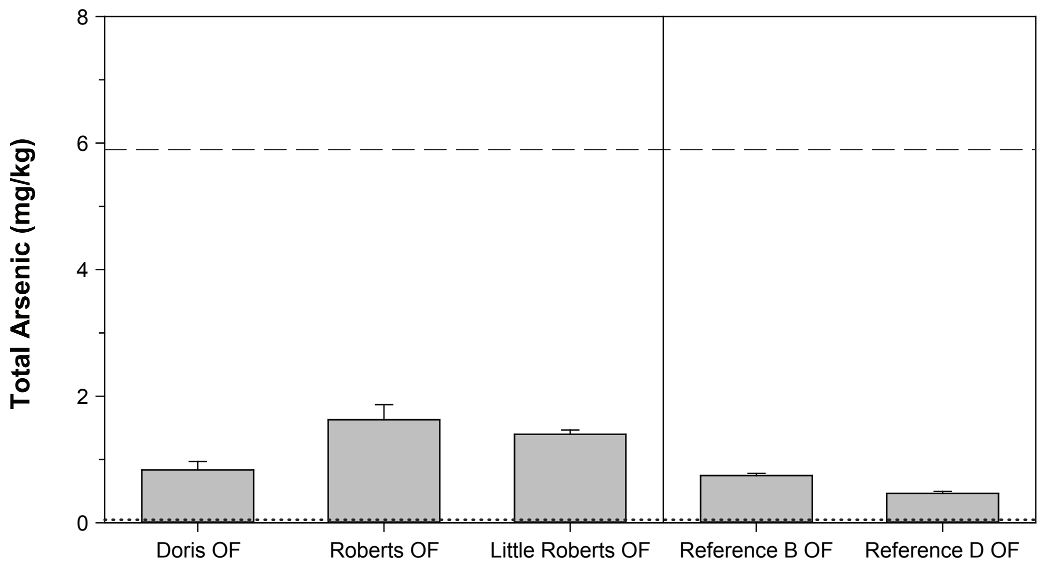
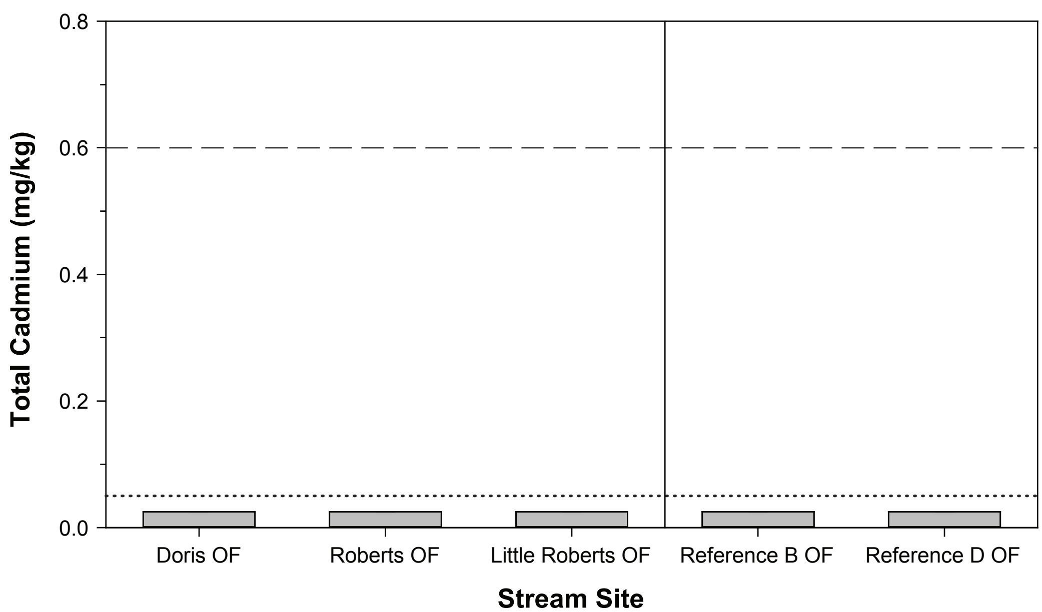
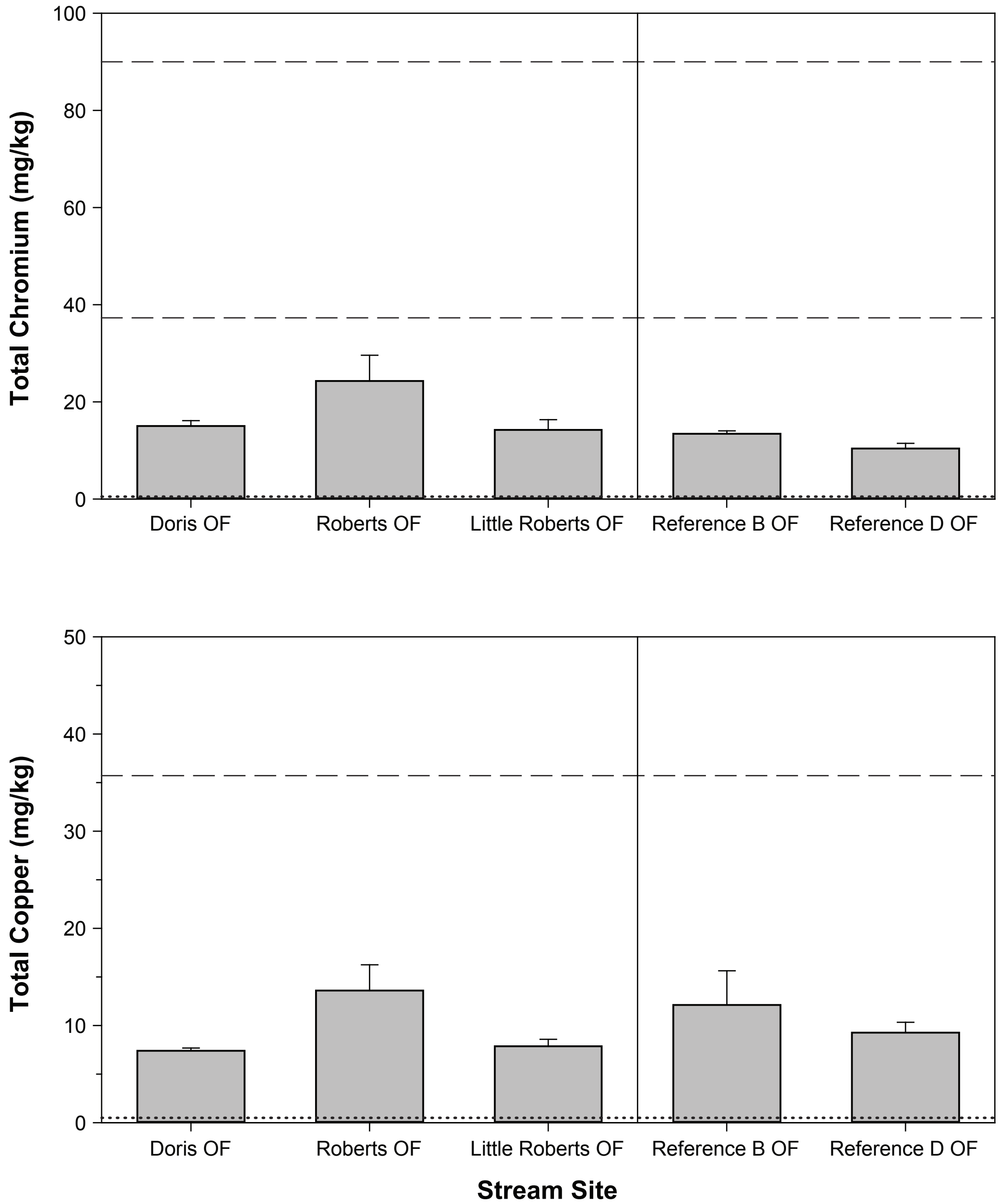




Notes: Error bars represent the standard error of the mean of replicates.
Black dotted lines represent analytical detection limits; values below the detection limit are plotted at half the detection limit.
Black dashed lines represent the CCME freshwater interim sediment quality guidelines (ISQGs) for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

Total Arsenic and Total Cadmium Concentrations in Stream Sediments, Doris North Project, August 2013

Figure A.4-2



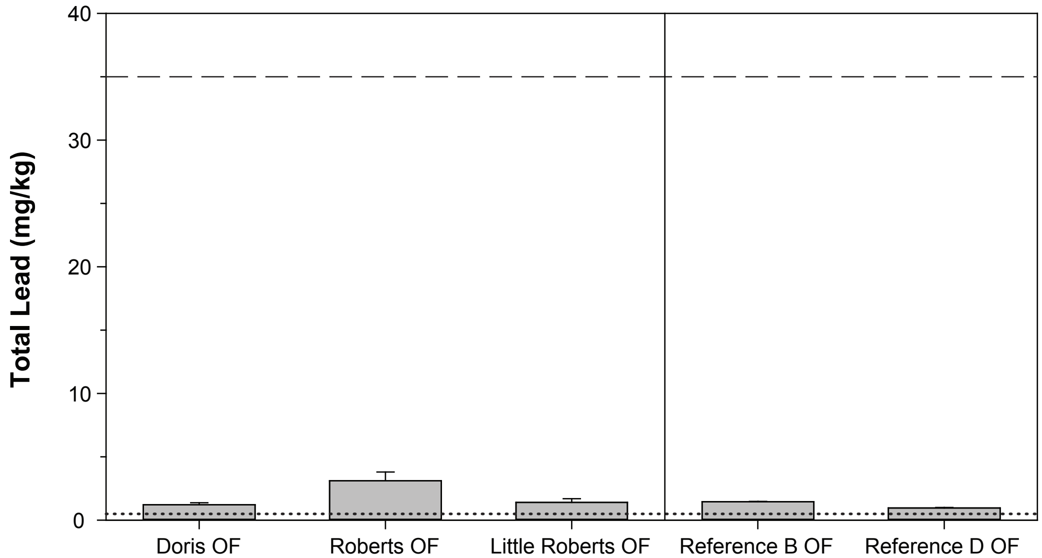
Notes: Error bars represent the standard error of the mean of replicates.
Black dotted lines represent analytical detection limits; values below the detection limit are plotted at half the detection limit.
Black dashed lines represent the CCME freshwater interim sediment quality guidelines (ISQGs) for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

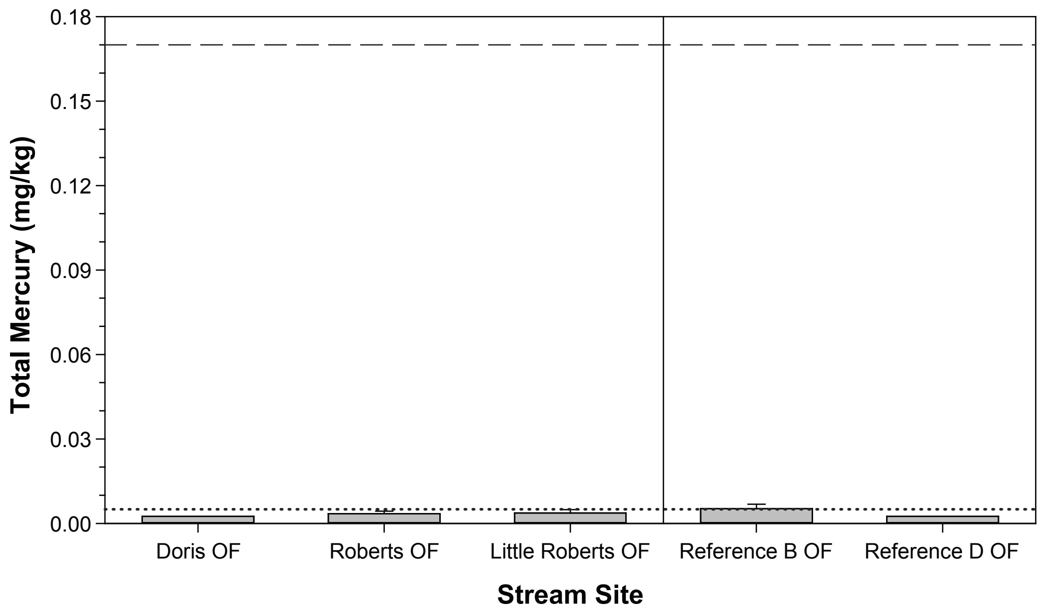
Figure A.4-3

Total Chromium and Total Copper Concentrations in Stream Sediments, Doris North Project, August 2013

TMAC RESOURCES

Rescan an ERM company

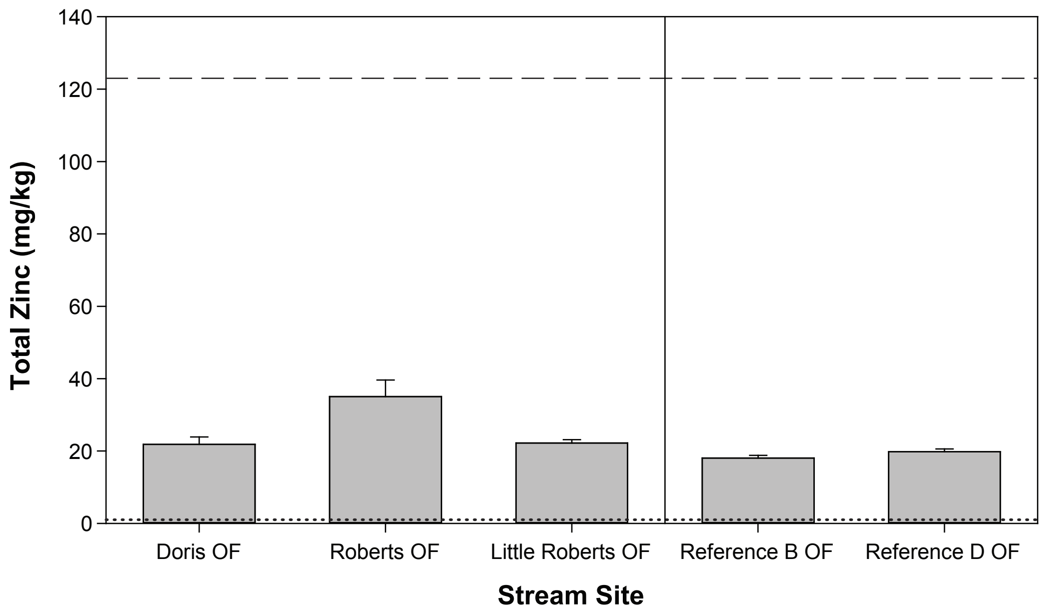




Notes: Error bars represent the standard error of the mean of replicates.
Black dotted lines represent analytical detection limits; values below the detection limit are plotted at half the detection limit.
Black dashed lines represent the CCME freshwater interim sediment quality guidelines (ISQGs) for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

Figure A.4-4

Total Lead and Total Mercury Concentrations in Stream Sediments, Doris North Project, August 2013



Notes: Error bars represent the standard error of the mean of replicates.
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 A.4-5

Total Zinc
Concentrations in Stream Sediments,
Doris North Project, August 2013

Annex A.4-1. Stream Sediment Quality Data, Doris North Project, 2013

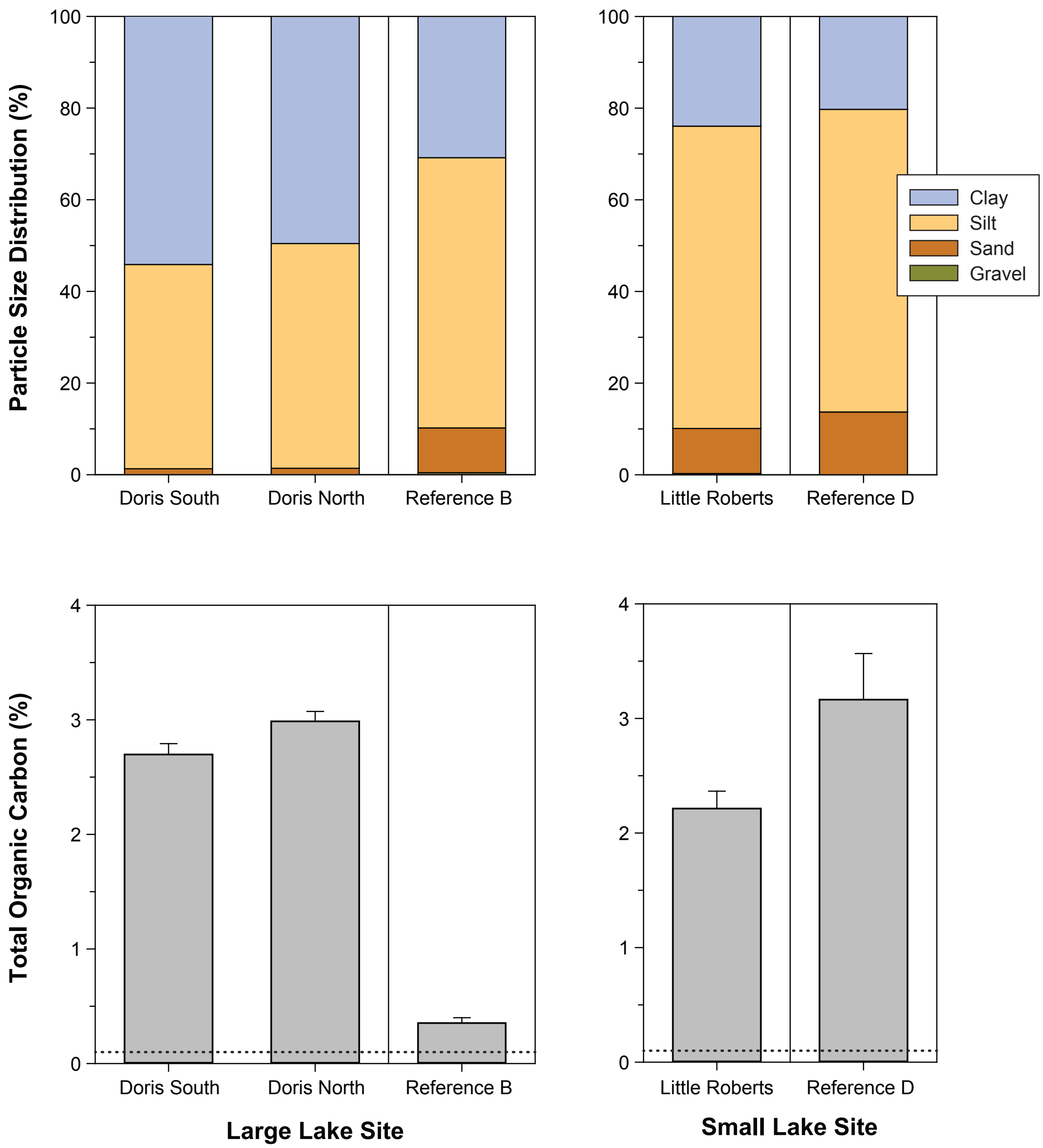
Site ID:		CCME Guidelines for the Protection of Aquatic Life[a]		Realized Detection Limit	Doris OF	Doris OF	Doris OF	Roberts OF	Roberts OF	Roberts OF	Little Roberts OF	Little Roberts OF	Little Roberts OF	Reference B OF	Reference B OF	Reference B OF	Reference D OF	Reference D OF	Reference D OF
Replicate:					1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Date Sampled:					19-Aug-13	19-Aug-13	19-Aug-13	16-Aug-13	16-Aug-13	16-Aug-13	17-Aug-13	17-Aug-13	17-Aug-13	22-Aug-13	22-Aug-13	22-Aug-13	17-Aug-13	17-Aug-13	17-Aug-13
ALS Sample ID:	Unit	ISQG[b]	PEL[c]		L1350578-13	L1350578-14	L1350578-15	L1350578-1	L1350578-2	L1350578-3	L1350578-7	L1350578-8	L1350578-9	L1352797-13	L1352797-14	L1352797-15	L1350578-4	L1350578-5	L1350578-6
Physical Tests																			
Moisture	%			0.25	22.7	20.9	28.5	23.4	26.2	23.0	15.4	18.3	22.2	43.6	34.0	33.0	18.9	20.8	27.6
pH	pH			0.10	7.03	7.01	6.90	6.97	7.12	6.85	7.21	7.46	7.28	5.60	5.90	5.88	6.91	6.95	6.57
Particle Size																			
% Gravel (>2 mm)	%			0.10	30.0	25.4	18.6	24.3	33.5	22.5	36.1	26.5	15.7	6.03	18.7	20.5	37.8	26.8	22.1
% Sand (2.0 mm - 0.063 mm)	%			0.10	66.7	71.6	74.9	66.7	37.2	63.5	52.9	71.3	77.7	79.0	74.7	72.6	60.6	72.1	71.3
% Silt (0.063 mm - 4 µm)	%			0.10	2.85	2.81	5.72	7.10	17.1	8.34	7.28	1.85	5.74	13.9	5.75	6.07	1.44	0.97	6.26
% Clay (<4 µm)	%			0.10	0.44	0.21	0.82	1.92	12.2	5.68	3.68	0.42	0.93	1.11	0.85	0.89	0.14	<0.10	0.38
Texture	-			-	Sand	Sand	Sand	Sand	Sandy loam	Loamy sand	Loamy sand	Sand	Sand	Sand	Sand	Sand	Sand	Sand	Sand
Anions & Nutrients																			
Total Nitrogen	%			0.020	0.036	0.027	0.044	0.043	0.050	0.029	0.021	0.022	0.037	0.112	0.070	0.063	0.026	<0.020	0.032
Organic / Inorganic Carbon																			
Total Organic Carbon	%			0.10	0.22	0.11	0.36	0.35	0.50	0.23	<0.10	<0.10	0.20	1.89	0.99	0.97	0.11	<0.10	0.24
Plant Available Nutrients																			
Available Ammonium-N	mg/kg			1.0-1.6	3.4	2.2	2.9	3.9	6.7	3.8	1.9	1.7	3.4	6.6	3.8	4.3	1.8	1.3	4.1
Available Nitrate-N	mg/kg			1.0-4.0	<1.0	<1.0	<1.0	<1.0	<4.0	<4.0	<1.0	<1.0	<1.0	<4.0	<1.0	<1.0	<1.0	<1.0	<1.0
Available Nitrite-N	mg/kg			0.40-0.80	<0.40	<0.40	<0.40	<0.40	<0.80	<0.80	<0.40	<0.40	<0.40	<0.80	<0.40	<0.40	<0.40	<0.40	<0.40
Available Phosphate-P	mg/kg			2.0	3.8	3.7	6.3	5.9	3.4	3.8	2.3	2.6	2.5	<2.0	2.4	2.0	<2.0	<2.0	3.3
Metals																			
Aluminum (Al)	mg/kg			50	5280	5840	6470	6280	12100	10500	6880	5300	5180	4720	5130	5650	6410	5980	5410
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	0.743	0.667	1.10	1.24	2.06	1.59	1.53	1.37	1.30	0.720	0.709	0.817	0.486	0.399	0.508
Barium (Ba)	mg/kg			0.50	12.4	12.8	23.0	27.1	69.1	50.6	28.3	17.3	17.0	12.1	12.0	13.0	11.8	12.3	13.9
Beryllium (Be)	mg/kg			0.20	<0.20	<0.20	<0.20	<0.20	0.31	0.27	<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	1770	1910	2450	2250	4100	3550	2510	1820	1730	1940	2170	2050	2610	2020	2030
Chromium (Cr)	mg/kg	37.3	90	0.50	16.0	12.8	16.3	14.1	32.1	26.7	18.4	12.8	11.5	12.6	13.1	14.6	12.0	8.37	10.9
Cobalt (Co)	mg/kg			0.10	4.38	4.48	5.10	4.71	8.05	7.31	5.37	4.64	4.42	2.98	3.38	3.85	4.83	4.68	4.29
Copper (Cu)	mg/kg	35.7	197	0.50	7.35	6.91	7.90	8.36	17.0	15.4	9.21	6.77	7.59	9.94	19.0	7.38	11.4	8.00	8.36
Iron (Fe)	mg/kg			50	10900	11400	13300	11400	19400	17400	12300	10700	9750	7160	8910	10100	12200	10900	9870
Lead (Pb)	mg/kg	35	91.3	0.50	0.95	1.17	1.53	1.83	4.16	3.36	1.99	1.04	1.17	1.52	1.45	1.41	0.98	0.87	1.03
Lithium (Li)	mg/kg			5.0	11.0	10.0	10.9	13.1	22.4	19.7	14.3	11.1	10.8	8.0	8.5	9.5	14.6	13.8	12.9
Magnesium (Mg)	mg/kg			20	4240	3910	4430	4370	7970	7340	5030	4030	4030	2870	3100	3760	4900	4900	3950
Manganese (Mn)	mg/kg			1.0	165	160	163	158	257	219	214	191	252	83.1	99.9	114	222	175	124
Mercury (Hg)	mg/kg	0.17	0.486	0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0053	<0.0050	0.0061	<0.0050	<0.0050	0.0054	0.0079	<0.0050	<0.0050	<0.0050
Molybdenum (Mo)	mg/kg			0.50	0.87	<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	9.25	8.39	10.1	8.67	17.3	15.7	11.3	9.49	8.33	7.87	7.96	9.65	9.58	8.05	7.84
Phosphorus (P)	mg/kg			50	346	283	353	289	425	452	283	286	276	268	305	327	361	365	304
Potassium (K)	mg/kg			100	600	590	880	1190	3040	2430	1260	720	720	310	390	410	540	560	610
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	<100	150	220	270	640	500	250	140	140	130	120	110	200	120	170
Strontium (Sr)	mg/kg			0.50	7.07	9.71	11.1	12.1	23.2	18.9	13.0	8.53	8.18	9.50	9.53	9.32	12.2	8.67	10.3
Sulphur (S)	mg/kg			500	<500	<500	<500	<500	900	<500	600	<500	<500	800	600	600	<500	<500	600
Thallium (Tl)	mg/kg			0.050	<0.050	<0.050	<0.050	0.051	0.121	0.096	0.067	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<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	295	379	428	466	947	820	532	363	320	458	462	511	417	278	399
Uranium (U)	mg/kg			0.050	0.397	0.302	0.359	0.482	0.894	0.813	0.685	0.346	0.307	0.673	0.524	0.560	0.505	0.439	0.408
Vanadium (V)	mg/kg			0.20	19.3	23.4	26.0	23.1	43.9	39.7	24.9	24.9	21.6	17.0	20.2	20.8	31.2	19.1	24.3
Zinc (Zn)	mg/kg	123	315	1.0	19.4	20.1	25.9	26.0	40.9	38.3	24.1	21.1	21.3	16.6	18.3	19.2	20.9	20.1	18.5

Notes:

[a] Canadian sediment quality guidelines for the protection of freshwater aquatic life, Canadian Council of Ministers of the Environment, 2013

[b] ISQG = Interim Sediment Quality Guideline

[c] PEL = Probable Effects Level



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

Particle Size Distribution and Total Organic Carbon Concentration in Lake Sediments, Doris North Project, August 2013

Figure A.4-6

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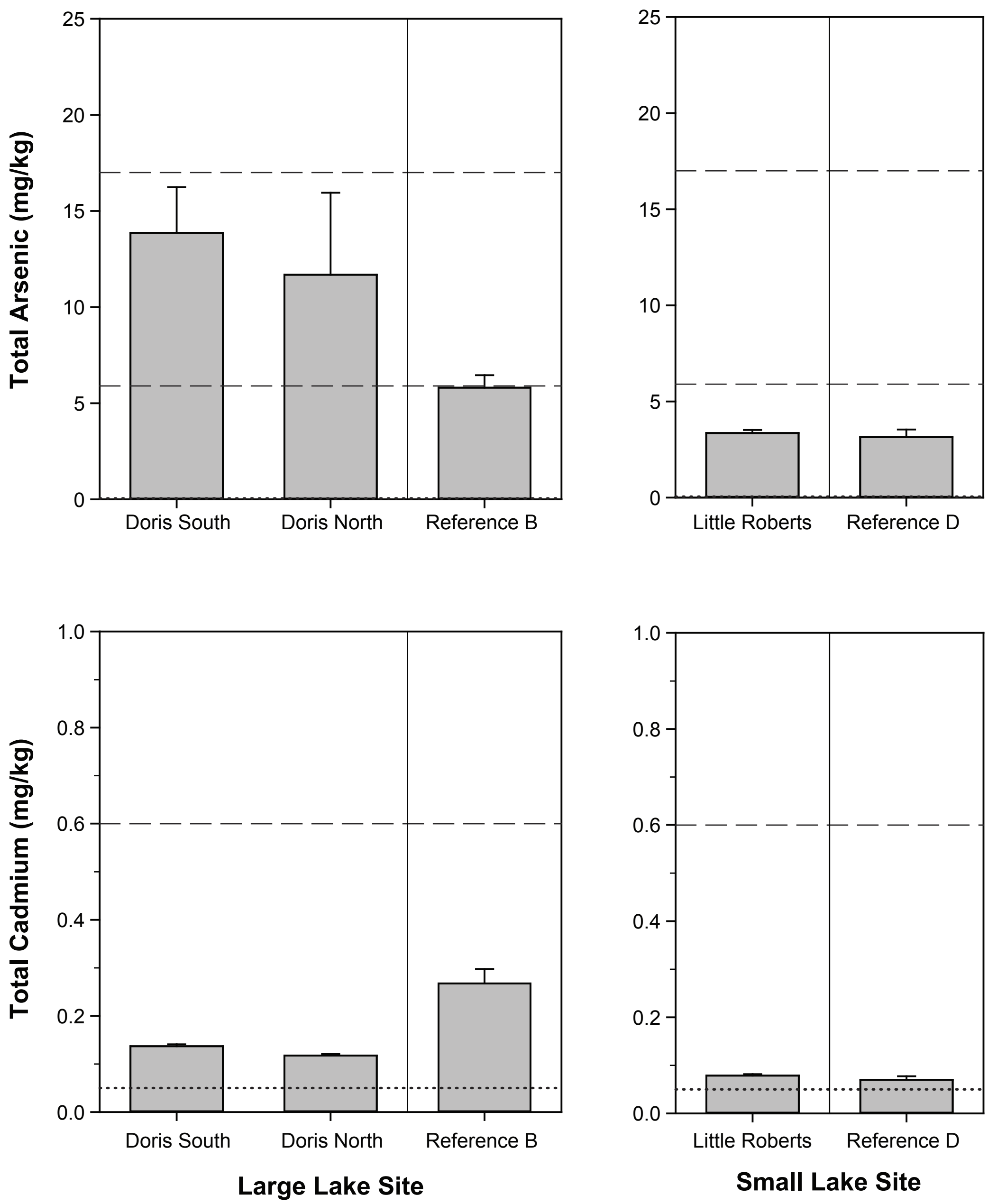
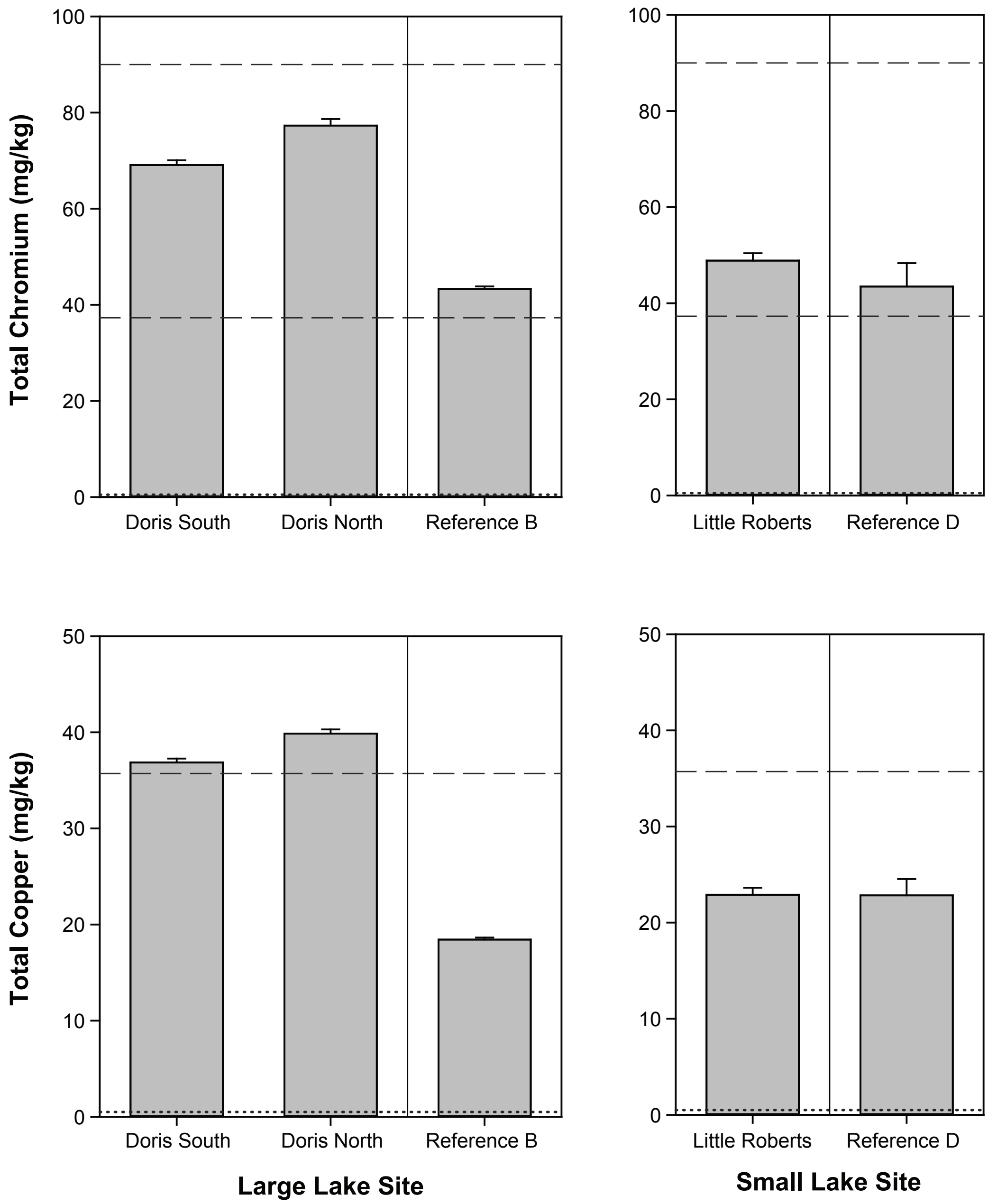


Notes: Error bars represent the standard error of the mean of replicates.
Black dotted lines represent analytical detection limits; values below the detection limit are plotted at half the detection limit.
Black dashed lines represent the CCME freshwater interim sediment quality guidelines (ISQGs) for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

Figure A.4-7

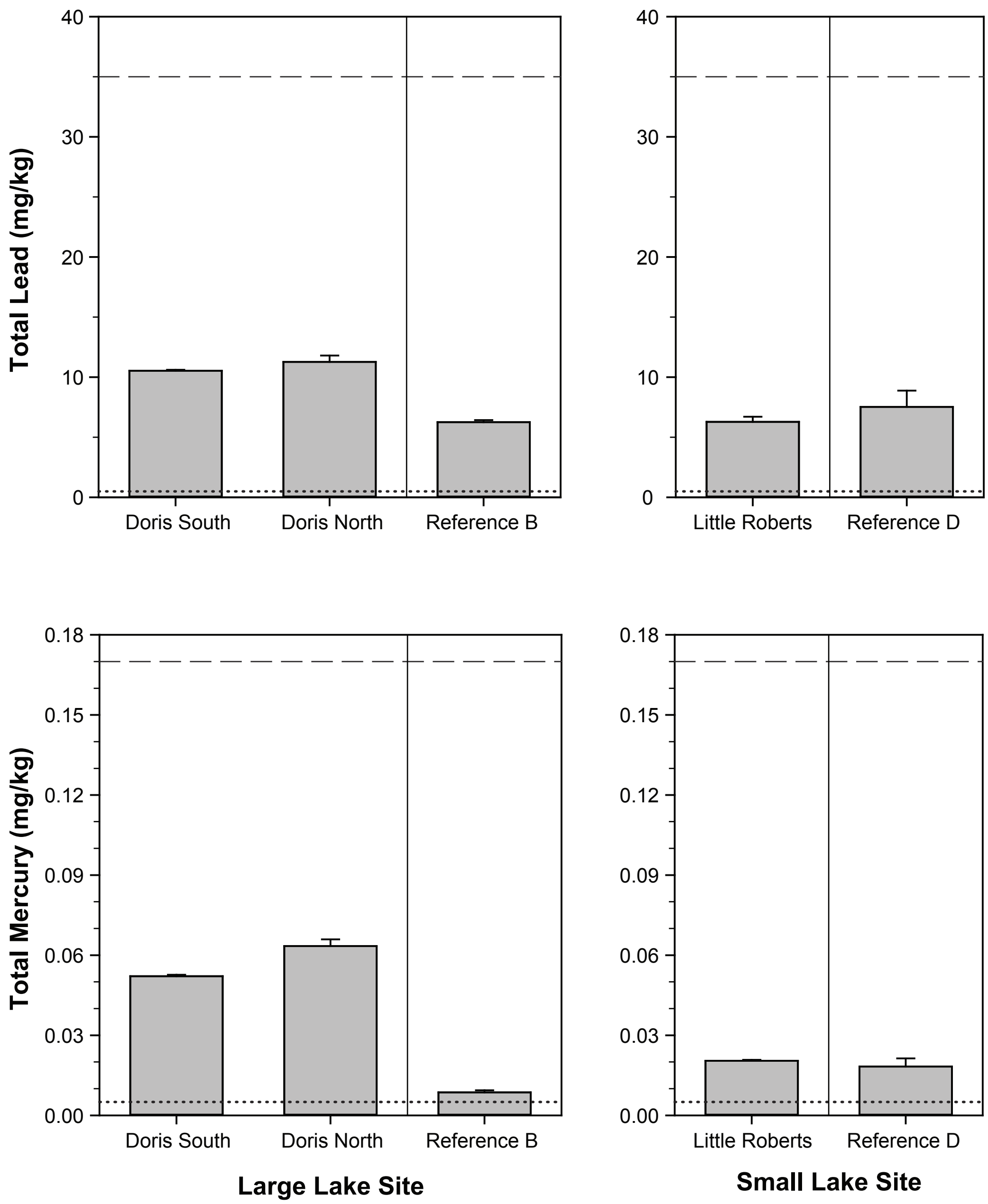
Total Arsenic and Total Cadmium Concentrations in Lake Sediments, Doris North Project, August 2013



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

Total Chromium and Total Copper Concentrations in Lake Sediments, Doris North Project, August 2013

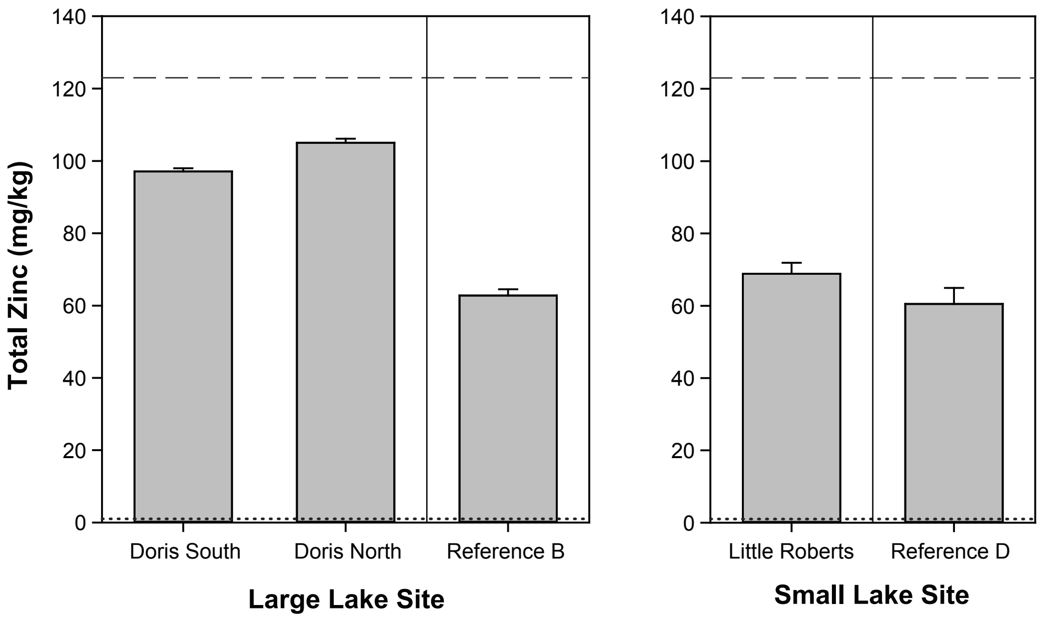
Figure A.4-8



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

Figure A.4-9

Total Lead and Total Mercury Concentrations in Lake Sediments, Doris North Project, August 2013



Notes: Error bars represent the standard error of the mean of replicates.
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 A.4-10

Total Zinc
Concentrations in Lake Sediments,
Doris North Project, August 2013

Annex A.4-2. Lake Sediment Quality Data, Doris North Project, 2013

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
Date Sampled:					20-Aug-13	20-Aug-13	20-Aug-13	21-Aug-13	21-Aug-13	21-Aug-13
Replicate:					1	2	3	1	2	3
Depth Sampled:					10.0	10.0	10.0	13.5	13.5	13.5
ALS Sample ID:	Unit	ISQG[b]	PEL[c]		L1352797-4	L1352797-5	L1352797-6	L1352797-10	L1352797-11	L1352797-12
Physical Tests										
Moisture	%			0.25	74.1	74.2	71.9	75.0	74.9	75.7
pH	pH			0.10	5.77	5.65	5.70	5.49	5.86	5.75
Particle Size										
% Gravel (>2 mm)	%			0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
% Sand (2.0 mm - 0.063 mm)	%			0.10	1.32	1.51	1.00	1.88	1.03	1.16
% Silt (0.063 mm - 4 µm)	%			0.10	45.2	45.3	43.2	62.7	41.7	42.7
% Clay (<4 µm)	%			0.10	53.5	53.2	55.8	35.4	57.3	56.1
Texture	-			-	Silty clay	Silty clay	Silty clay	Silty clay loam	Silty clay	Silty clay
Anions and Nutrients										
Total Nitrogen	%			0.020	0.324	0.324	0.299	0.369	0.346	0.362
Organic / Inorganic Carbon										
Total Organic Carbon	%			0.10	2.70	2.86	2.53	3.11	2.82	3.03
Plant Available Nutrients										
Available Ammonium-N	mg/kg			1.6-2.4	3.8	3.4	30.3	42.0	44.1	4.8
Available Nitrate-N	mg/kg			4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0
Available Nitrite-N	mg/kg			0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80
Available Phosphate-P	mg/kg			2.0-4.0	2.5	2.3	2.4	6.5	2.6	2.7
Metals										
Aluminum (Al)	mg/kg			50	25400	25400	24100	26900	28700	28000
Antimony (Sb)	mg/kg			0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.13
Arsenic (As)	mg/kg	5.9	17	0.050	18.5	10.6	12.5	19.7	5.17	10.2
Barium (Ba)	mg/kg			0.50	182	171	171	172	163	162
Beryllium (Be)	mg/kg			0.20	0.80	0.86	0.81	0.90	0.89	0.89
Bismuth (Bi)	mg/kg			0.20	0.25	0.25	0.25	0.26	0.25	0.26
Cadmium (Cd)	mg/kg	0.6	3.5	0.050	0.144	0.131	0.136	0.115	0.115	0.123
Calcium (Ca)	mg/kg			50	5870	5890	5380	5990	5940	6300
Chromium (Cr)	mg/kg	37.3	90	0.50	69.6	70.5	67.2	74.8	79.6	77.5
Cobalt (Co)	mg/kg			0.10	15.5	16.1	15.2	15.8	15.6	15.3
Copper (Cu)	mg/kg	35.7	197	0.50	37.4	37.1	36.1	39.2	39.7	40.7
Iron (Fe)	mg/kg			50	58100	52200	52500	61600	43000	51400
Lead (Pb)	mg/kg	35	91.3	0.50	10.7	10.5	10.4	12.0	10.2	11.6
Lithium (Li)	mg/kg			5.0	39.6	40.6	39.3	42.2	44.4	44.4
Magnesium (Mg)	mg/kg			20	14100	14200	13700	14800	16300	15600
Manganese (Mn)	mg/kg			1.0	2170	1820	1820	1280	545	642
Mercury (Hg)	mg/kg	0.17	0.486	0.0050	0.0529	0.0510	0.0524	0.0645	0.0586	0.0671
Molybdenum (Mo)	mg/kg			0.50	2.33	1.41	1.80	1.52	1.35	1.26
Nickel (Ni)	mg/kg			0.50	46.2	47.0	45.4	47.5	48.2	48.4
Phosphorus (P)	mg/kg			50	1370	1030	1150	1570	975	1340
Potassium (K)	mg/kg			100	6120	6110	5650	6390	6870	6650
Selenium (Se)	mg/kg			0.20	0.43	0.39	0.39	0.43	0.35	0.38
Silver (Ag)	mg/kg			0.10	0.10	0.11	<0.10	0.24	0.23	0.24
Sodium (Na)	mg/kg			100	1540	1520	1380	1630	1530	1590
Strontium (Sr)	mg/kg			0.50	41.5	40.9	37.7	44.0	41.3	44.4
Sulphur (S)	mg/kg			500	1400	1600	1400	1400	1400	1400
Thallium (Tl)	mg/kg			0.050	0.286	0.292	0.279	0.287	0.292	0.303
Tin (Sn)	mg/kg			2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Titanium (Ti)	mg/kg			1.0	1520	1550	1330	1590	1740	1690
Uranium (U)	mg/kg			0.050	2.58	2.47	2.49	2.61	2.26	2.51
Vanadium (V)	mg/kg			0.20	80.6	79.0	76.7	87.0	82.5	86.5
Zinc (Zn)	mg/kg	123	315	1.0	97.6	98.3	95.3	103	107	105

Site ID:		CCME Guidelines for the Protection of Aquatic Life[a]		Realized Detection Limit	Reference Lake B	Reference Lake B	Reference Lake B	Little Roberts Lake	Little Roberts Lake
Date Sampled:					18-Aug-13	18-Aug-13	18-Aug-13	21-Aug-13	21-Aug-13
Replicate:					1	2	3	1	2
Depth Sampled:					10.2	10.2	10.2	2.2	2.2
ALS Sample ID:	Unit	ISQG[b]	PEL[c]		L1350578-10	L1350578-11	L1350578-12	L1352797-7	L1352797-8
Physical Tests									
Moisture	%			0.25	43.5	47.8	41.5	61.2	65.5
pH	pH			0.10	5.70	5.54	5.70	5.91	6.36
Particle Size									
% Gravel (>2 mm)	%			0.10	0.35	0.11	0.92	<0.10	0.74
% Sand (2.0 mm - 0.063 mm)	%			0.10	11.3	8.92	9.09	11.9	9.44
% Silt (0.063 mm - 4 µm)	%			0.10	57.2	60.8	58.9	64.8	66.0
% Clay (<4 µm)	%			0.10	31.2	30.2	31.1	23.3	23.9
Texture	-			-	Silty clay loam	Silt loam / Silty clay loam	Silty clay loam	Silt loam	Silt loam
Anions and Nutrients									
Total Nitrogen	%			0.020	0.060	0.066	0.052	0.224	0.290
Organic / Inorganic Carbon									
Total Organic Carbon	%			0.10	0.36	0.43	0.27	1.91	2.36
Plant Available Nutrients									
Available Ammonium-N	mg/kg			1.6-2.4	6.9	8.4	6.3	10.5	16.5
Available Nitrate-N	mg/kg			4.0	<4.0	<4.0	<4.0	<4.0	<4.0
Available Nitrite-N	mg/kg			0.80	<0.80	<0.80	<0.80	<0.80	<0.80
Available Phosphate-P	mg/kg			2.0-4.0	<2.0	<2.0	2.8	6.7	5.1
Metals									
Aluminum (Al)	mg/kg			50	15100	15700	15700	17600	16900
Antimony (Sb)	mg/kg			0.10	0.18	0.21	0.22	<0.10	<0.10
Arsenic (As)	mg/kg	5.9	17	0.050	5.01	5.32	7.10	3.31	3.12
Barium (Ba)	mg/kg			0.50	87.0	85.8	88.6	96.9	93.7
Beryllium (Be)	mg/kg			0.20	0.53	0.48	0.56	0.52	0.47
Bismuth (Bi)	mg/kg			0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Cadmium (Cd)	mg/kg	0.6	3.5	0.050	0.217	0.320	0.266	0.076	0.076
Calcium (Ca)	mg/kg			50	3880	3880	4180	5850	5430
Chromium (Cr)	mg/kg	37.3	90	0.50	42.8	42.8	44.4	51.8	48.2
Cobalt (Co)	mg/kg			0.10	16.7	15.8	18.5	10.8	9.98
Copper (Cu)	mg/kg	35.7	197	0.50	18.1	18.8	18.4	23.0	21.6
Iron (Fe)	mg/kg			50	27800	26800	25400	24700	24400
Lead (Pb)	mg/kg	35	91.3	0.50	6.05	6.12	6.60	7.13	5.87
Lithium (Li)	mg/kg			5.0	27.6	26.5	28.6	28.0	27.6
Magnesium (Mg)	mg/kg			20	8270	8080	8350	11100	10800
Manganese (Mn)	mg/kg			1.0	237	233	238	345	342
Mercury (Hg)	mg/kg	0.17	0.486	0.0050	0.0089	0.0098	0.0072	0.0209	0.0198
Molybdenum (Mo)	mg/kg			0.50	2.02	1.96	2.26	1.17	1.06
Nickel (Ni)	mg/kg			0.50	25.7	25.2	27.7	26.8	25.8
Phosphorus (P)	mg/kg			50	616	620	667	786	760
Potassium (K)	mg/kg			100	3650	3670	3810	4260	4210
Selenium (Se)	mg/kg			0.20	0.38	0.41	0.49	0.22	<0.20
Silver (Ag)	mg/kg			0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Sodium (Na)	mg/kg			100	470	450	470	960	890
Strontium (Sr)	mg/kg			0.50	26.6	26.4	27.8	34.0	31.0
Sulphur (S)	mg/kg			500	1900	2800	3500	1200	1200
Thallium (Tl)	mg/kg			0.050	0.241	0.271	0.282	0.203	0.178
Tin (Sn)	mg/kg			2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Titanium (Ti)	mg/kg			1.0	996	1010	1040	1330	1320
Uranium (U)	mg/kg			0.050	1.70	1.75	1.83	1.46	1.44
Vanadium (V)	mg/kg			0.20	47.5	46.6	48.9	58.1	54.2
Zinc (Zn)	mg/kg	123	315	1.0	59.7	63.1	65.6	65.9	74.9

Notes:

Shaded cells indicate values that exceed CCME guidelines.

[a] *Canadian sediment quality guidelines for the protection of freshwater aquatic life, Canadian Council of Ministers of the Environment, 2013*

[b] *ISQG = Interim Sediment Quality Guideline*

[c] *PEL = Probable Effects Level*

Annex A.4-2. Lake Sediment Quality Data, Doris North Project, 2013

Site ID:		CCME Guidelines for the Protection of Aquatic Life[a]		Realized Detection Limit	Little Roberts Lake	Reference Lake D	Reference Lake D	Reference Lake D
Date Sampled:					21-Aug-13	20-Aug-13	20-Aug-13	20-Aug-13
Replicate:					3	1	2	3
Depth Sampled:					2.2	1.3	1.3	1.3
ALS Sample ID:	Unit	ISQG[b]	PEL[c]		L1352797-9	L1352797-1	L1352797-2	L1352797-3
Physical Tests								
Moisture	%			0.25	62.9	60.1	51.4	62.7
pH	pH			0.10	5.85	5.66	6.23	5.78
Particle Size								
% Gravel (>2 mm)	%			0.10	<0.10	<0.10	<0.10	<0.10
% Sand (2.0 mm - 0.063 mm)	%			0.10	8.20	9.39	16.8	14.8
% Silt (0.063 mm - 4 µm)	%			0.10	67.1	77.3	48.9	71.9
% Clay (<4 µm)	%			0.10	24.7	13.3	34.3	13.3
Texture	-			-	Silt loam	Silt	Silty clay loam	Silt loam
Anions and Nutrients								
Total Nitrogen	%			0.020	0.255	0.281	0.276	0.349
Organic / Inorganic Carbon								
Total Organic Carbon	%			0.10	2.37	2.81	2.71	3.97
Plant Available Nutrients								
Available Ammonium-N	mg/kg			1.6-2.4	19.0	15.7	5.4	17.8
Available Nitrate-N	mg/kg			4.0	<4.0	<4.0	<4.0	<4.0
Available Nitrite-N	mg/kg			0.80	<0.80	<0.80	<0.80	<0.80
Available Phosphate-P	mg/kg			2.0-4.0	<2.0	5.7	3.4	12.6
Metals								
Aluminum (Al)	mg/kg			50	16300	13900	20200	14500
Antimony (Sb)	mg/kg			0.10	<0.10	0.11	0.10	<0.10
Arsenic (As)	mg/kg	5.9	17	0.050	3.66	3.13	3.84	2.46
Barium (Ba)	mg/kg			0.50	95.1	97.3	112	80.3
Beryllium (Be)	mg/kg			0.20	0.48	0.43	0.63	0.45
Bismuth (Bi)	mg/kg			0.20	<0.20	<0.20	<0.20	<0.20
Cadmium (Cd)	mg/kg	0.6	3.5	0.050	0.084	0.084	0.060	0.066
Calcium (Ca)	mg/kg			50	5090	4870	5540	4950
Chromium (Cr)	mg/kg	37.3	90	0.50	46.6	38.2	53.2	39.0
Cobalt (Co)	mg/kg			0.10	10.4	7.96	11.5	8.01
Copper (Cu)	mg/kg	35.7	197	0.50	24.1	20.8	26.2	21.5
Iron (Fe)	mg/kg			50	24700	19500	29500	20500
Lead (Pb)	mg/kg	35	91.3	0.50	5.85	10.1	6.99	5.50
Lithium (Li)	mg/kg			5.0	27.1	23.0	34.1	23.4
Magnesium (Mg)	mg/kg			20	10500	8050	12500	8550
Manganese (Mn)	mg/kg			1.0	301	252	315	257
Mercury (Hg)	mg/kg	0.17	0.486	0.0050	0.0206	0.0232	0.0127	0.0189
Molybdenum (Mo)	mg/kg			0.50	1.31	0.89	1.12	0.84
Nickel (Ni)	mg/kg			0.50	25.9	20.8	29.7	22.8
Phosphorus (P)	mg/kg			50	678	662	716	745
Potassium (K)	mg/kg			100	4080	3320	5490	3500
Selenium (Se)	mg/kg			0.20	0.23	<0.20	0.21	0.20
Silver (Ag)	mg/kg			0.10	<0.10	<0.10	<0.10	<0.10
Sodium (Na)	mg/kg			100	870	590	1390	660
Strontium (Sr)	mg/kg			0.50	28.8	27.0	33.3	28.7
Sulphur (S)	mg/kg			500	1900	1500	1200	1300
Thallium (Tl)	mg/kg			0.050	0.184	0.152	0.219	0.159
Tin (Sn)	mg/kg			2.0	<2.0	<2.0	<2.0	<2.0
Titanium (Ti)	mg/kg			1.0	1210	1160	1510	1140
Uranium (U)	mg/kg			0.050	1.48	1.88	2.05	1.99
Vanadium (V)	mg/kg			0.20	53.0	45.7	63.1	47.0
Zinc (Zn)	mg/kg	123	315	1.0	65.7	61.7	67.5	52.3

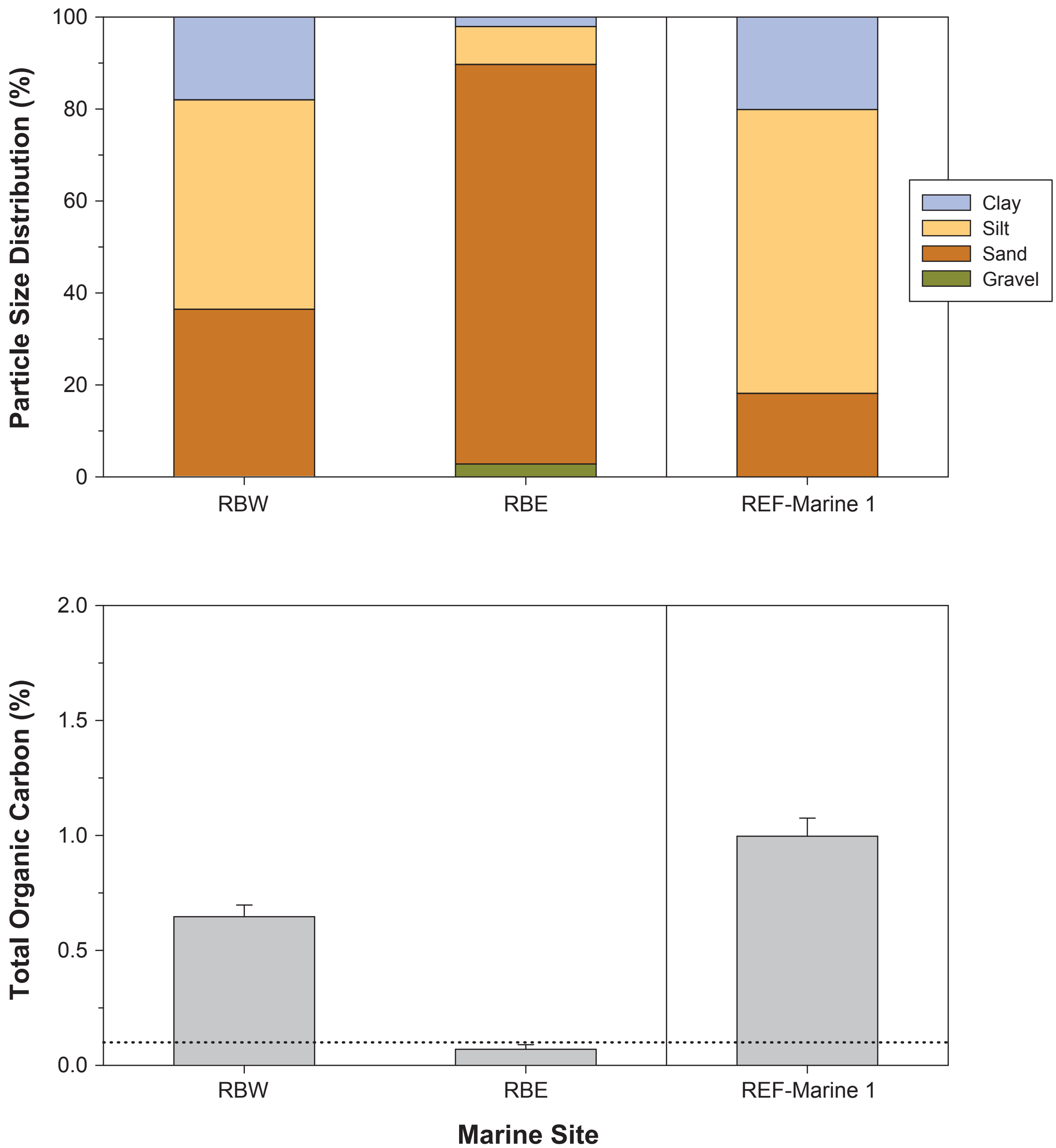
Notes:

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, 2013*

[b] *ISQG = Interim Sediment Quality Guideline*

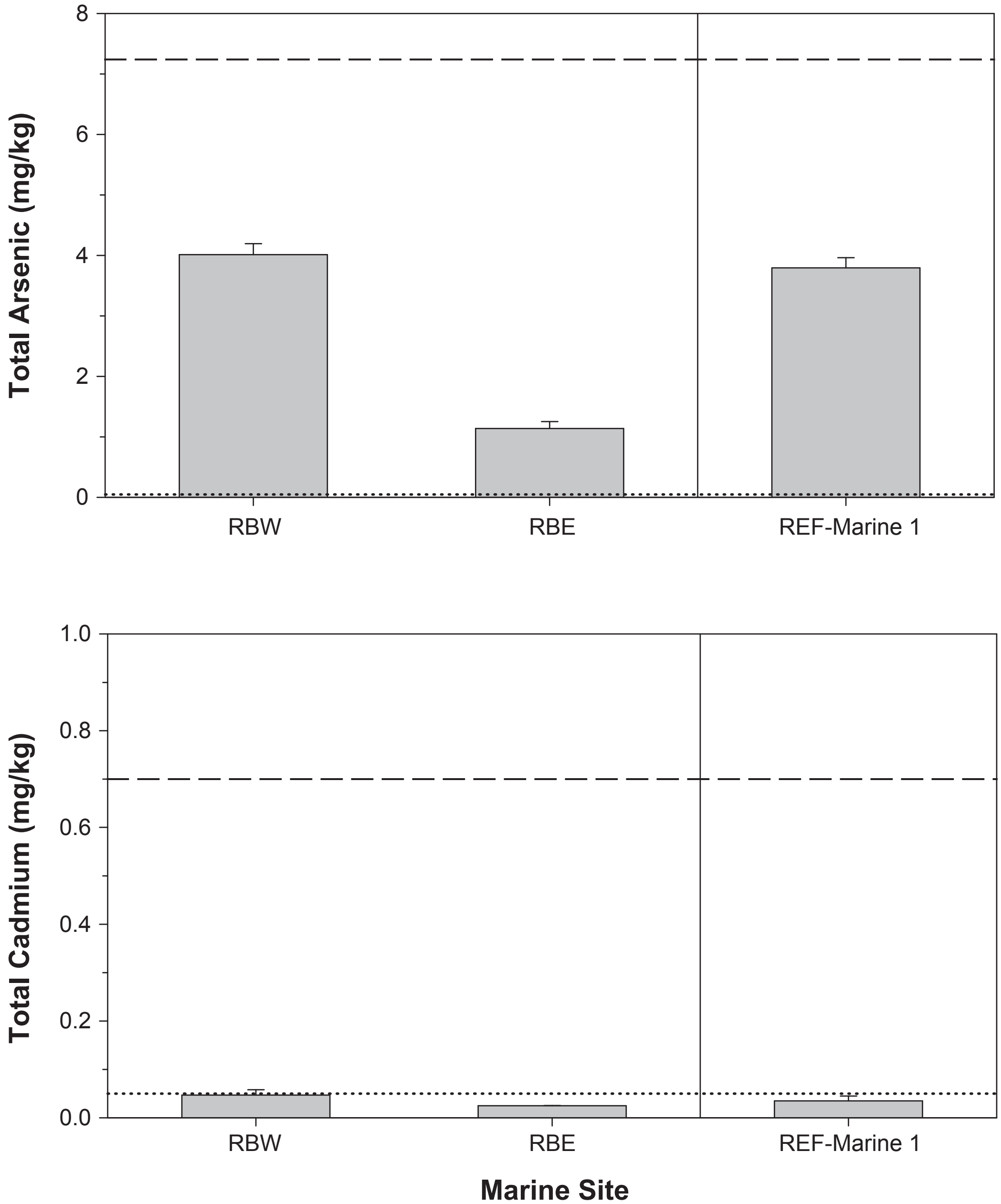
[c] *PEL = Probable Effects Level*



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

Particle Size Distribution and Total Organic Carbon Concentration in Marine Sediments, Doris North Project, August 2013

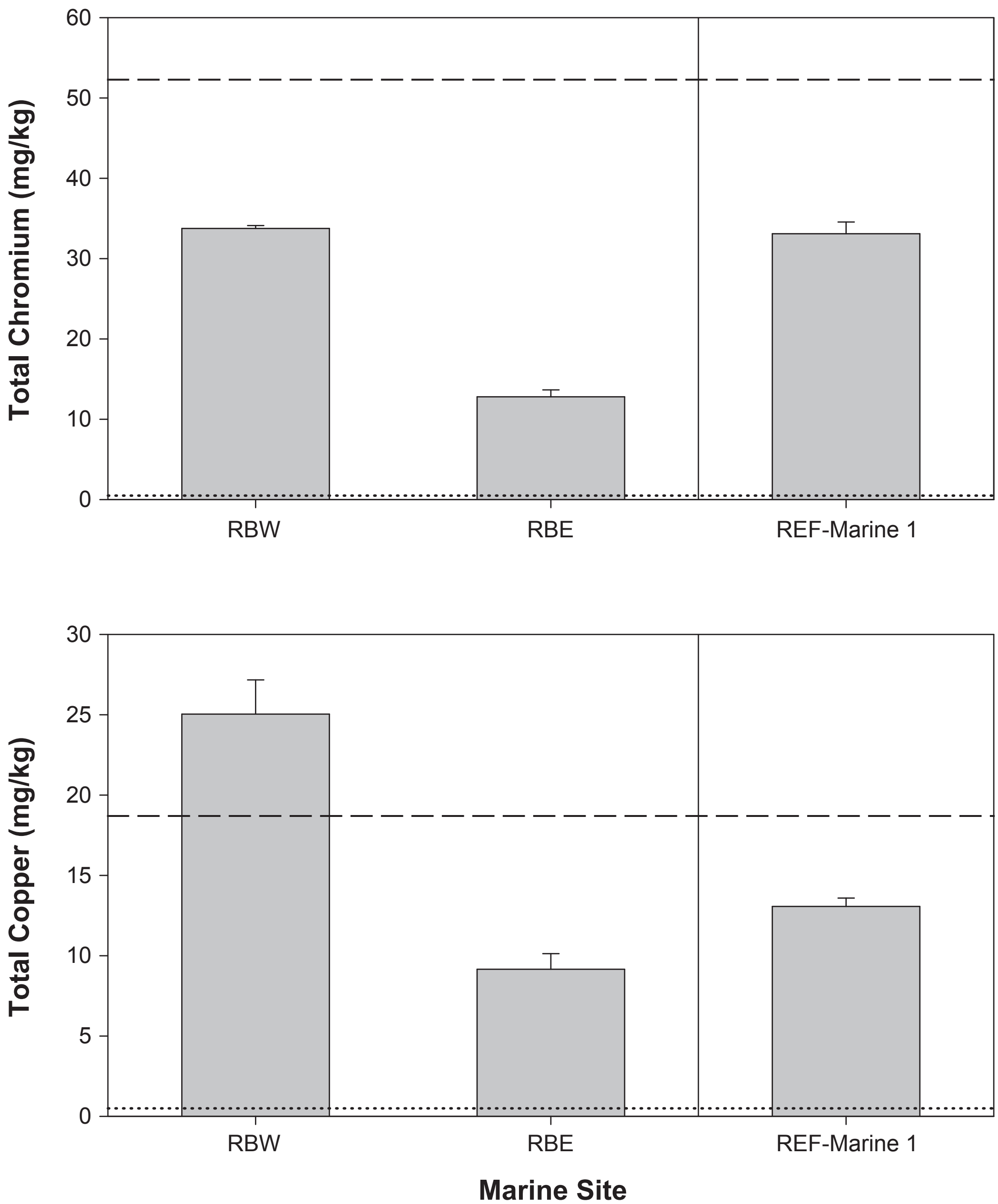
Figure A.4-11



Notes: Error bars represent the standard error of the mean of replicates.
Black dotted line represents the analytical detection limit; 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.

Figure A.4-12

Total Arsenic and Total Cadmium Concentrations in Marine Sediments, Doris North Project, August 2013



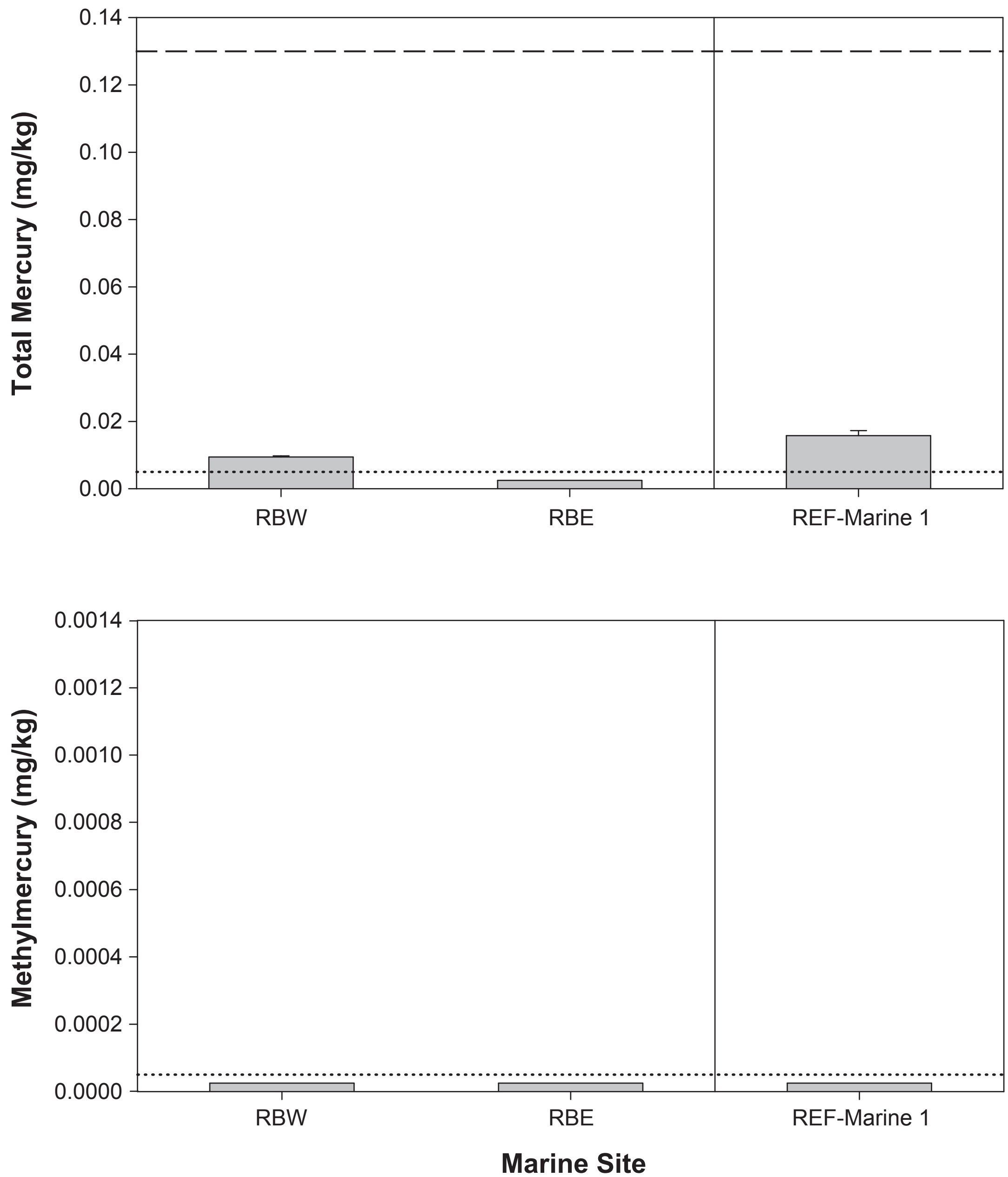
Notes: Error bars represent the standard error of the mean of replicates.
Black dotted line represents the analytical detection limit; values below the detection limit are plotted at half the detection limit.
Black dashed lines represent the CCME marine and estuarine interim sediment quality guidelines (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.

Figure A.4-13

Total Chromium and Total Copper Concentrations in Marine Sediments, Doris North Project, August 2013

MAC RESOURCES

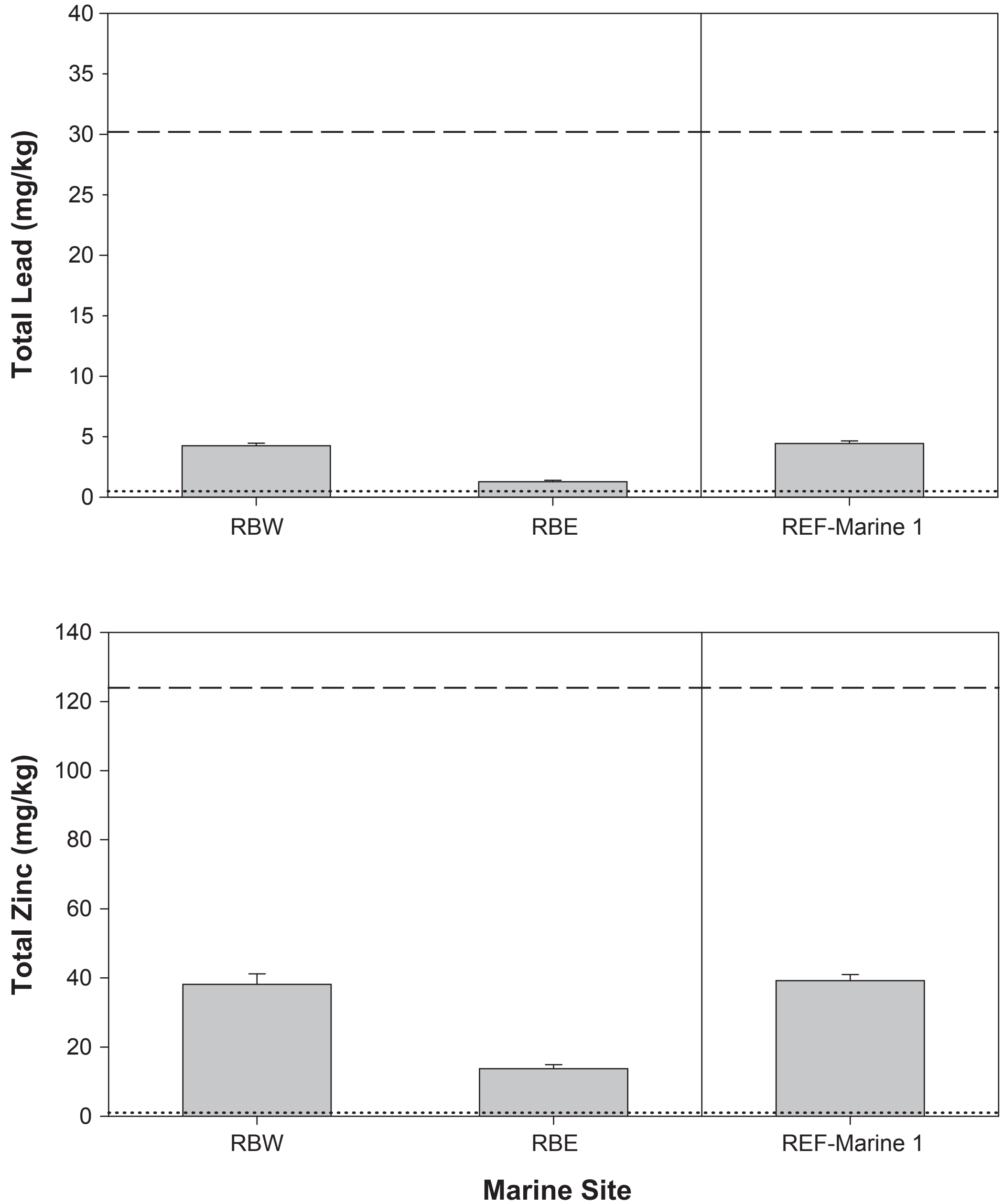
Rescan an ERM company



Notes: Error bars represent the standard error of the mean of replicates.
Black dotted line represents the analytical detection limit; 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 total mercury (0.13 mg/kg); the probable effects level (PEL) for total mercury (0.7 mg/kg) is not shown.

Figure A.4-14

Total Mercury and Methylmercury Concentrations in Marine Sediments, Doris North Project, August 2013



Notes: Error bars represent the standard error of the mean of replicates.
Black dotted line represents the analytical detection limit; 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 zinc (124 mg/kg); probable effects levels (PELs) for lead (112 mg/kg) and zinc (271 mg/kg) are not shown.

Figure A.4-15

Total Lead and Total Zinc Concentrations in Marine Sediments, Doris North Project, August 2013

Annex A.4-3. Marine Sediment Quality Data, Doris North Project, 2013

Site ID:		CCME Guidelines for the Protection of Aquatic Life[a]		Realized Detection Limit	RBW	RBW	RBW	RBE	RBE	RBE	REF- Marine 1	REF- Marine 1	REF- Marine 1
Date Sampled:					14-Aug-13	14-Aug-13	14-Aug-13	14-Aug-13	16-Aug-13	16-Aug-13	15-Aug-13	15-Aug-13	15-Aug-13
Replicate:					1	2	3	1	2	3	1	2	3
Depth Sampled:					4.5	4.5	4.5	0.5	0.5	0.5	6.0	6.0	6.0
ALS Sample ID:	Unit	ISQG[b]	PEL[c]		L1349164-1	L1349164-2	L1349164-3	L1349164-4	L1350575-1	L1350575-2	L1349164-5	L1349164-6	L1349164-7
Physical Tests													
Moisture	%			0.25	37.1	42.8	36.5	24.5	23.0	23.3	41.7	51.0	47.1
pH	pH			0.10	8.00	7.81	8.13	7.70	7.42	7.74	7.41	7.85	8.22
Particle Size													
% Gravel (>2 mm)	%			0.10	<0.10	<0.10	<0.10	0.41	4.43	3.60	<0.10	<0.10	<0.10
% Sand (2.0 mm - 0.063 mm)	%			0.10	37.0	32.7	39.6	79.1	89.8	91.8	17.0	17.2	20.2
% Silt (0.063 mm - 4 μm)	%			0.10	47.0	46.1	43.5	16.7	4.40	3.62	61.7	61.4	62.1
% Clay (<4 μm)	%			0.10	16.0	21.2	16.9	3.84	1.36	0.97	21.4	21.4	17.8
Texture	-			-	Loam	Loam	Loam	Loamy sand	Sand	Sand	Silt loam	Silt loam	Silt loam
Anions and Nutrients													
Total Nitrogen	%			0.020	0.059	0.078	0.062	<0.020	<0.020	<0.020	0.089	0.131	0.115
Organic / Inorganic Carbon													
Total Organic Carbon	%			0.10	0.55	0.72	0.67	0.11	<0.10	<0.10	0.95	1.15	0.89
Plant Available Nutrients													
Available Ammonium-N	mg/kg			1.0-1.6	8.8	17.5	10.7	2.1	<1.0	<1.0	5.4	11.5	21.3
Available Nitrate-N	mg/kg			1.0-4.0	<4.0	<4.0	<4.0	<1.0	<1.0	<1.0	<4.0	<4.0	<4.0
Available Nitrite-N	mg/kg			0.40-0.80	<0.80	<0.80	<0.80	<0.40	<0.40	<0.40	<0.80	<0.80	<0.80
Available Phosphate-P	mg/kg			2.0	12.6	15.4	11.2	7.1	5.1	6.1	28.0	23.8	28.9
Metals													
Aluminum (Al)	mg/kg			50	10500	10900	10500	5040	3920	3580	12300	12800	10900
Antimony (Sb)	mg/kg			0.10	<0.10	0.15	<0.10	<0.10	<0.10	<0.10	0.14	0.15	0.11
Arsenic (As)	mg/kg	7.24	41.6	0.050	4.32	4.03	3.69	1.36	1.09	0.966	3.63	4.13	3.63
Barium (Ba)	mg/kg			0.50	46.1	50.3	40.3	16.9	10.4	10.6	56.5	60.9	49.8
Beryllium (Be)	mg/kg			0.20	0.28	0.31	0.26	<0.20	<0.20	<0.20	0.37	0.38	0.33
Bismuth (Bi)	mg/kg			0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Cadmium (Cd)	mg/kg	0.7	4.2	0.050	<0.050	0.058	0.058	<0.050	<0.050	<0.050	<0.050	0.055	<0.050
Calcium (Ca)	mg/kg			50	5850	4460	10300	2020	1810	1960	5200	5420	8120
Chromium (Cr)	mg/kg	52.3	160	0.50	33.3	34.5	33.5	14.4	12.6	11.4	34.1	35.0	30.2
Cobalt (Co)	mg/kg			0.10	7.64	7.54	8.28	3.99	3.58	3.62	6.60	6.86	5.85
Copper (Cu)	mg/kg	18.7	108	0.50	23.2	22.6	29.3	11.0	8.78	7.68	12.5	14.1	12.6
Iron (Fe)	mg/kg			50	19000	19000	19200	9440	8910	8800	17800	18400	16200
Lead (Pb)	mg/kg	30.2	112	0.50	3.95	4.67	4.17	1.52	1.19	1.14	4.53	4.77	4.04
Lithium (Li)	mg/kg			5.0	16.6	19.6	17.3	9.5	7.3	7.0	22.4	23.4	19.4
Magnesium (Mg)	mg/kg			20	8610	9070	8840	4080	3100	2930	9090	9770	8220
Manganese (Mn)	mg/kg			1.0	206	194	229	93.9	79.5	78.8	201	205	181
Mercury (Hg)	mg/kg	0.13	0.7	0.0050	0.0095	0.0100	0.0088	<0.0050	<0.0050	<0.0050	0.0136	0.0186	0.0152
Molybdenum (Mo)	mg/kg			0.50	0.61	0.82	0.79	<0.50	<0.50	<0.50	0.67	0.92	0.85
Nickel (Ni)	mg/kg			0.50	17.1	17.6	17.8	8.79	6.74	6.65	16.1	17.2	14.6
Phosphorus (P)	mg/kg			50	610	619	523	258	249	291	840	805	832
Potassium (K)	mg/kg			100	2820	3160	2460	1090	700	630	3720	4020	3390
Selenium (Se)	mg/kg			0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	0.24	0.34	0.26
Silver (Ag)	mg/kg			0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Sodium (Na)	mg/kg			100	5100	5870	4100	2220	2330	2340	6350	8580	6210
Strontium (Sr)	mg/kg			0.50	28.9	25.9	34.6	11.9	9.84	9.29	34.2	39.3	56.6
Sulphur (S)	mg/kg			500	1700	2200	1800	1300	600	1600	1500	2400	1600
Thallium (Tl)	mg/kg			0.050	0.111	0.122	0.106	<0.050	<0.050	<0.050	0.130	0.144	0.118
Tin (Sn)	mg/kg			2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Titanium (Ti)	mg/kg			1.0	788	752	772	407	338	338	980	987	873
Uranium (U)	mg/kg			0.050	0.754	0.804	0.714	0.397	0.337	0.330	1.17	1.27	1.06
Vanadium (V)	mg/kg			0.20	42.8	43.3	44.0	21.3	20.8	21.1	43.9	45.4	39.3
Zinc (Zn)	mg/kg	124	271	1.0	35.5	44.2	34.8	16.1	12.8	12.3	39.6	42.1	36.0
Speciated Metals													
Methyl mercury	mg/kg			0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050

Notes:

Shaded cells indicate values that exceed CCME guidelines.

[a] *Canadian sediment quality guidelines for the protection of marine aquatic life, Canadian Council of Ministers of the Environment, 2013.*

[b] *ISQG = Interim Sediment Quality Guideline*

[c] *PEL = Probable Effects Level*

A.5 2013 PRIMARY PRODUCERS

The following sections present the periphyton and phytoplankton biomass (as chlorophyll *a*) data collected between April and September 2013 from stream, lake, and marine sites.

A.5.1 Stream Data

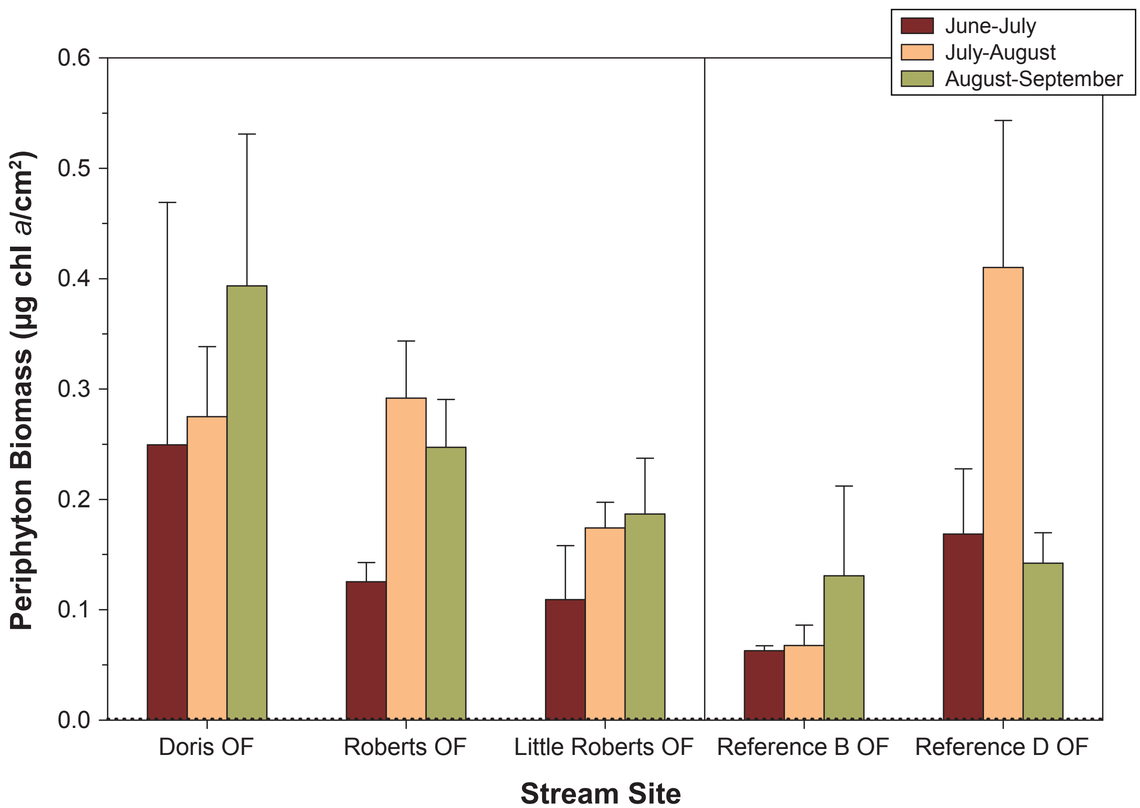
Stream periphyton sampling plates were installed three times in AEMP streams (in June, July, and August), and were retrieved after approximately one month (in July, August, and September, respectively). Figure A.5-1 shows the periphyton biomass levels measured in streams. Annex A.5-1 presents the raw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

A.5.2 Lake Data

Lake phytoplankton samples were collected in April (under-ice sampling) and monthly from July to September 2013. 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 2013. 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.

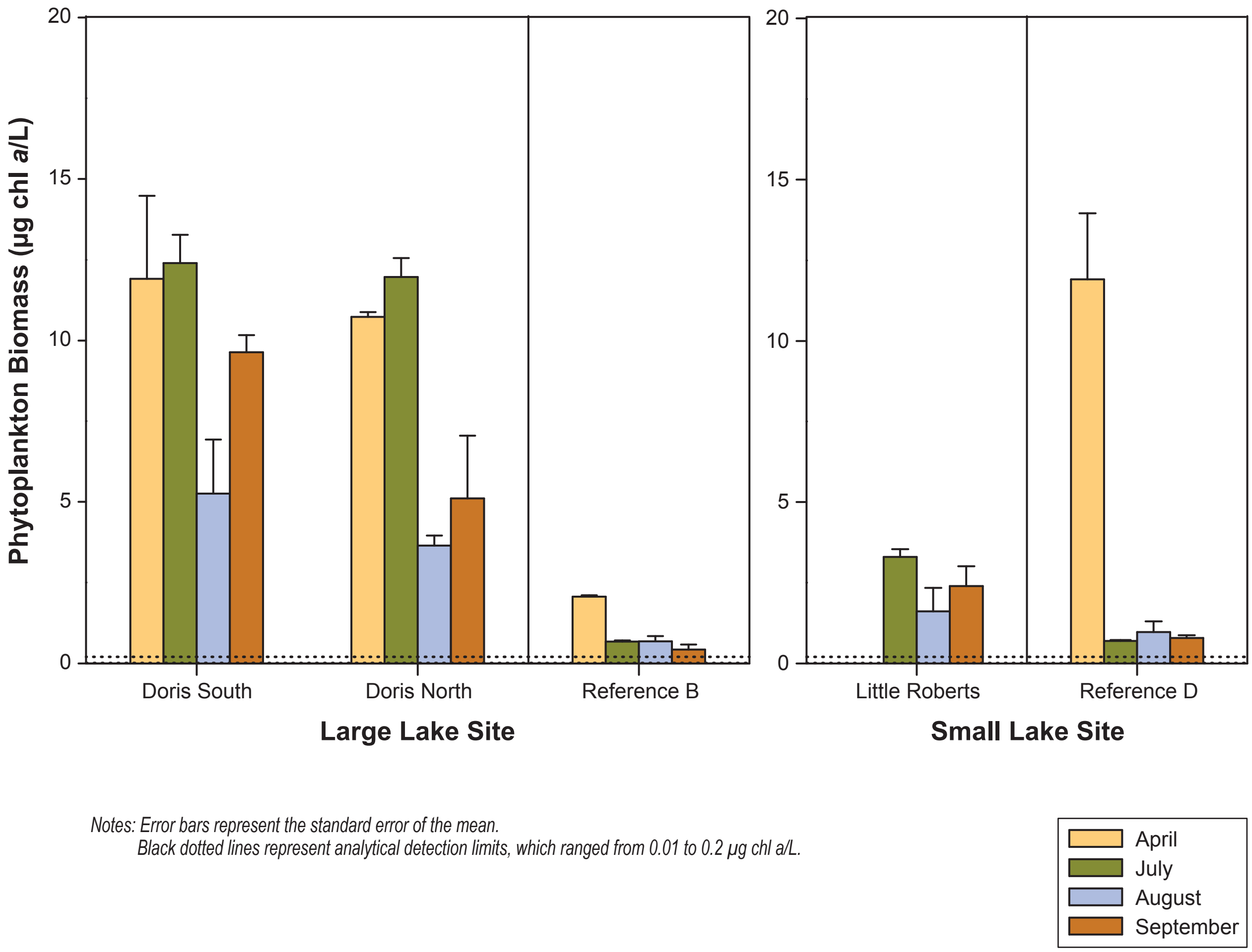
Figure A.5-1

Periphyton Biomass (as Chlorophyll *a*) in Stream Sites, Doris North Project, 2013

Annex A.5-1. Stream Periphyton Biomass Data, Doris North Project, 2013

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	12-Jun-13	17-Jul-13	35	100	L1339221-1	1	0.688	0.250	0.220
Doris OF	12-Jun-13	17-Jul-13	35	100	L1339221-2	2	0.011		
Doris OF	12-Jun-13	17-Jul-13	35	100	L1339221-3	3	0.050		
Doris OF	17-Jul-13	19-Aug-13	33	100	L1353312-10	1	0.391	0.275	0.064
Doris OF	17-Jul-13	19-Aug-13	33	100	L1353312-11	2	0.172		
Doris OF	17-Jul-13	19-Aug-13	33	100	L1353312-12	3	0.263		
Doris OF	19-Aug-13	18-Sep-13	30	100	L1368112-10	1	0.159	0.394	0.138
Doris OF	19-Aug-13	18-Sep-13	30	100	L1368112-11	2	0.635		
Doris OF	19-Aug-13	18-Sep-13	30	100	L1368112-12	3	0.387		
Roberts OF	13-Jun-13	18-Jul-13	35	100	L1339221-4	1	0.123	0.125	0.018
Roberts OF	13-Jun-13	18-Jul-13	35	100	L1339221-5	2	0.157		
Roberts OF	13-Jun-13	18-Jul-13	35	100	L1339221-6	3	0.096		
Roberts OF	18-Jul-13	16-Aug-13	29	100	L1353312-1	1	0.371	0.292	0.052
Roberts OF	18-Jul-13	16-Aug-13	29	100	L1353312-2	2	0.195		
Roberts OF	18-Jul-13	16-Aug-13	29	100	L1353312-3	3	0.310		
Roberts OF	16-Aug-13	17-Sep-13	32	100	L1368112-1	1	0.324	0.247	0.043
Roberts OF	16-Aug-13	17-Sep-13	32	100	L1368112-2	2	0.244		
Roberts OF	16-Aug-13	17-Sep-13	32	100	L1368112-3	3	0.174		
Little Roberts OF	12-Jun-13	18-Jul-13	36	100	L1339221-7	1	0.083	0.109	0.049
Little Roberts OF	12-Jun-13	18-Jul-13	36	100	L1339221-8	2	0.040		
Little Roberts OF	12-Jun-13	18-Jul-13	36	100	L1339221-9	3	0.204		
Little Roberts OF	18-Jul-13	17-Aug-13	30	100	L1353312-7	1	0.183	0.174	0.023
Little Roberts OF	18-Jul-13	17-Aug-13	30	100	L1353312-8	2	0.130		
Little Roberts OF	18-Jul-13	17-Aug-13	30	100	L1353312-9	3	0.210		
Little Roberts OF	17-Aug-13	17-Sep-13	33	100	L1368112-4	1	0.256	0.187	0.051
Little Roberts OF	17-Aug-13	17-Sep-13	33	100	L1368112-5	2	0.089		
Little Roberts OF	17-Aug-13	17-Sep-13	33	100	L1368112-6	3	0.216		
Reference B OF	13-Jun-13	19-Jul-13	36	100	L1339221-13	1	0.122	0.074	0.027
Reference B OF	13-Jun-13	19-Jul-13	36	100	L1339221-14	2	0.070		
Reference B OF	13-Jun-13	19-Jul-13	36	100	L1339221-15	3	0.029		
Reference B OF	19-Jul-13	22-Aug-13	34	100	L1353312-13	1	0.031	0.068	0.018
Reference B OF	19-Jul-13	22-Aug-13	34	100	L1353312-14	2	0.087		
Reference B OF	19-Jul-13	22-Aug-13	34	100	L1353312-15	3	0.086		
Reference B OF	22-Aug-13	23-Sep-13	32	100	L1368112-13	1	0.290	0.131	0.081
Reference B OF	22-Aug-13	23-Sep-13	32	100	L1368112-14	2	0.083		
Reference B OF	22-Aug-13	23-Sep-13	32	100	L1368112-15	3	0.020		
Reference D OF	13-Jun-13	18-Jul-13	35	100	L1339221-10	1	0.181	0.169	0.059
Reference D OF	13-Jun-13	18-Jul-13	35	100	L1339221-11	2	0.264		
Reference D OF	13-Jun-13	18-Jul-13	35	100	L1339221-12	3	0.061		
Reference D OF	18-Jul-13	17-Aug-13	30	100	L1353312-4	1	0.515	0.410	0.133
Reference D OF	18-Jul-13	17-Aug-13	30	100	L1353312-5	2	0.146		
Reference D OF	18-Jul-13	17-Aug-13	30	100	L1353312-6	3	0.570		
Reference D OF	17-Aug-13	18-Sep-13	34	100	L1368112-7	1	0.150	0.142	0.028
Reference D OF	17-Aug-13	18-Sep-13	34	100	L1368112-8	2	0.091		
Reference D OF	17-Aug-13	18-Sep-13	34	100	L1368112-9	3	0.186		

SE = standard error of the mean



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits, which ranged from 0.01 to 0.2 µg chl a/L.

Figure A.5-2

Phytoplankton Biomass (as Chlorophyll *a*) in Lake Sites, Doris North Project, 2013

Annex A.5-2. Lake Phytoplankton Biomass Data, Doris North Project, 2013

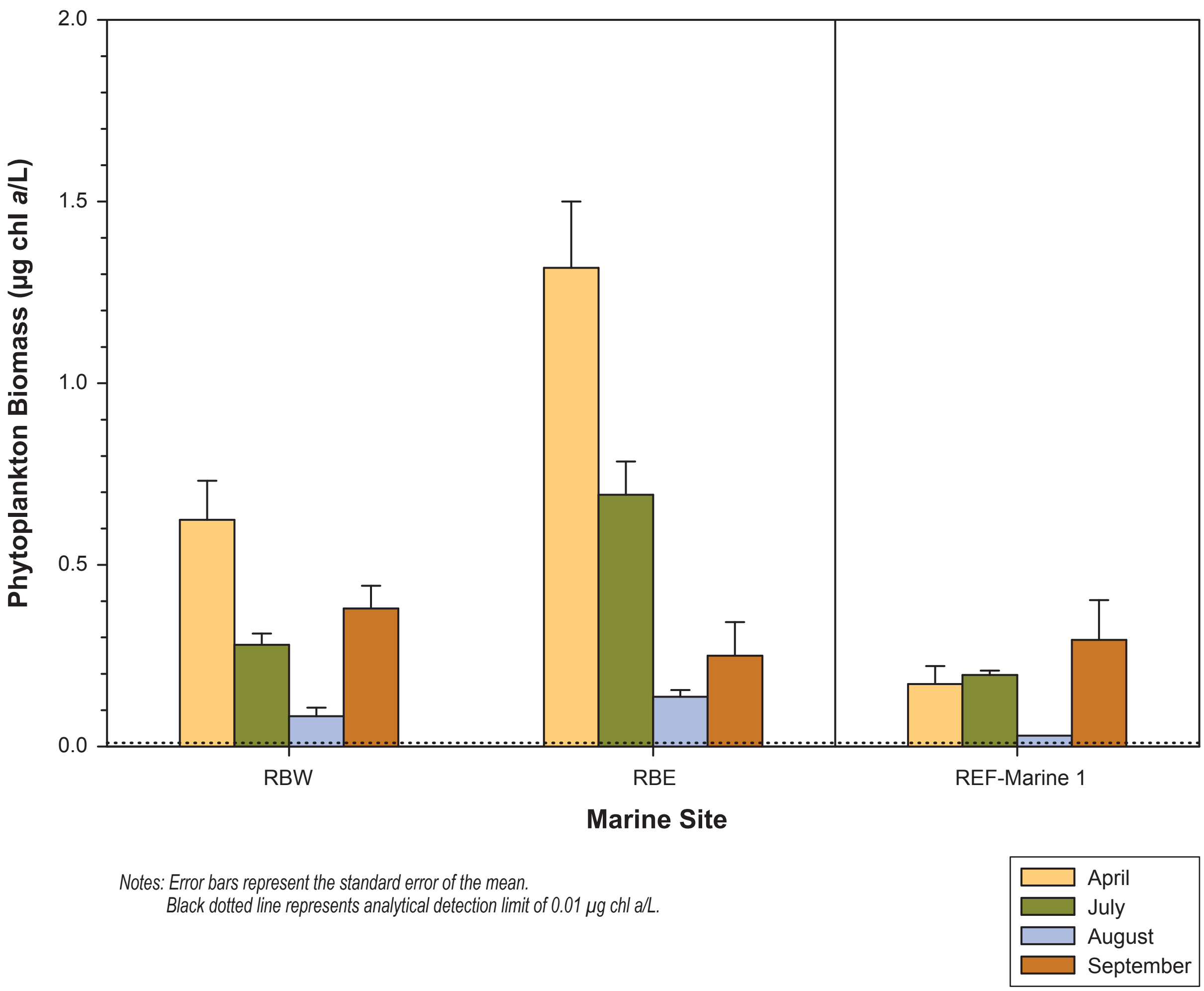
Lake Site	Date Sampled	Depth Sampled	ALS Sample ID	Replicate #	Phytoplankton Biomass (µg chl *a* /L)	Mean	SE
Doris Lake South	26-Apr-13	1 m	1	L1317792-4	6.93	11.9	2.57
Doris Lake South	26-Apr-13	1 m	2	L1317792-5	13.3		
Doris Lake South	26-Apr-13	1 m	3	L1317792-6	15.5		
Doris Lake South	19-Jul-13	1 m	1	L1339221-19	12.2	12.4	0.87
Doris Lake South	19-Jul-13	1 m	2	L1339221-20	11.0		
Doris Lake South	19-Jul-13	1 m	3	L1339221-21	14.0		
Doris Lake South	20-Aug-13	1 m	1	L1353306-16	7.17	5.26	1.67
Doris Lake South	20-Aug-13	1 m	2	L1353306-17	6.67		
Doris Lake South	20-Aug-13	1 m	3	L1353306-18	1.93		
Doris Lake South	20-Sep-13	1 m	1	L1370337-4	9.53	9.64	0.53
Doris Lake South	20-Sep-13	1 m	2	L1370337-5	10.6		
Doris Lake South	20-Sep-13	1 m	3	L1370337-6	8.79		
Doris Lake North	25-Apr-13	1 m	1	L1317792-1	10.5	10.7	0.15
Doris Lake North	25-Apr-13	1 m	2	L1317792-2	11.0		
Doris Lake North	25-Apr-13	1 m	3	L1317792-3	10.7		
Doris Lake North	17-Jul-13	1 m	1	L1339221-16	12.5	12.0	0.58
Doris Lake North	17-Jul-13	1 m	2	L1339221-17	10.8		
Doris Lake North	17-Jul-13	1 m	3	L1339221-18	12.6		
Doris Lake North	20-Aug-13	1 m	1	L1353306-19	3.15	3.65	0.31
Doris Lake North	20-Aug-13	1 m	2	L1353306-20	4.22		
Doris Lake North	20-Aug-13	1 m	3	L1353306-21	3.57		
Doris Lake North	20-Sep-13	1 m	1	L1370337-7	8.92	5.11	1.94
Doris Lake North	20-Sep-13	1 m	2	L1370337-8	2.55		
Doris Lake North	20-Sep-13	1 m	3	L1370337-9	3.85		
Reference Lake B	28-Apr-13	1 m	1	L1317792-16	2.15	2.06	0.04
Reference Lake B	28-Apr-13	1 m	2	L1317792-17	2.02		
Reference Lake B	28-Apr-13	1 m	3	L1317792-18	2.02		
Reference Lake B	19-Jul-13	1 m	1	L1339221-22	0.620	0.68	0.03
Reference Lake B	19-Jul-13	1 m	2	L1339221-23	0.680		
Reference Lake B	19-Jul-13	1 m	3	L1339221-24	0.730		
Reference Lake B	18-Aug-13	1 m	1	L1353306-10	0.780	0.68	0.16
Reference Lake B	18-Aug-13	1 m	2	L1353306-11	0.900		
Reference Lake B	18-Aug-13	1 m	3	L1353306-12	0.370		
Reference Lake B	23-Sep-13	1 m	1	L1370337-13	0.670	0.43	0.15
Reference Lake B	23-Sep-13	1 m	2	L1370337-14	0.140		
Reference Lake B	23-Sep-13	1 m	3	L1370337-15	0.470		
*Little Roberts Lake	27-Apr-13	0 m	1	*L1317792-7	*166	*159	*8.88
*Little Roberts Lake	27-Apr-13	0 m	2	*L1317792-8	*169		
*Little Roberts Lake	27-Apr-13	0 m	3	*L1317792-9	*141		
Little Roberts Lake	20-Jul-13	0.5 m	1	L1339221-25	3.77	3.30	0.24
Little Roberts Lake	20-Jul-13	0.5 m	2	L1339221-26	2.97		
Little Roberts Lake	20-Jul-13	0.5 m	3	L1339221-27	3.15		
Little Roberts Lake	21-Aug-13	0.5 m	1	L1353306-22	3.06	1.61	0.72
Little Roberts Lake	21-Aug-13	0.5 m	2	L1353306-23	0.880		
Little Roberts Lake	21-Aug-13	0.5 m	3	L1353306-24	0.900		
Little Roberts Lake	19-Sep-13	0.5 m	1	L1370337-1	3.50	2.40	0.61
Little Roberts Lake	19-Sep-13	0.5 m	2	L1370337-2	2.30		
Little Roberts Lake	19-Sep-13	0.5 m	3	L1370337-3	1.40		
Reference Lake D	28-Apr-13	1 m	1	L1317792-19	9.14	11.9	2.04
Reference Lake D	28-Apr-13	1 m	2	L1317792-20	10.7		
Reference Lake D	28-Apr-13	1 m	3	L1317792-21	15.9		
Reference Lake D	21-Jul-13	1 m	1	L1339221-28	0.750	0.70	0.03
Reference Lake D	21-Jul-13	1 m	2	L1339221-29	0.670		
Reference Lake D	21-Jul-13	1 m	3	L1339221-30	0.670		
Reference Lake D	18-Aug-13	1 m	1	L1353306-13	1.05	0.97	0.33
Reference Lake D	18-Aug-13	1 m	2	L1353306-14	1.50		
Reference Lake D	18-Aug-13	1 m	3	L1353306-15	0.370		
Reference Lake D	21-Sep-13	1 m	1	L1370337-10	0.920	0.79	0.08
Reference Lake D	21-Sep-13	1 m	2	L1370337-11	0.810		
Reference Lake D	21-Sep-13	1 m	3	L1370337-12	0.640		

SE = standard error of the mean

Little Roberts Lake site was too shallow for sampling at 1 m depth

April samples were collected at 1 m under the ice

** Samples collected from Little Roberts Lake in April were not included in report results because these samples were contaminated by sediment. There was only 20 cm of water below the ice, and the sediments were disturbed by the augering process.*



Notes: Error bars represent the standard error of the mean.
Black dotted line represents analytical detection limit of 0.01 µg chl a/L.

Figure A.5-3

Phytoplankton Biomass (as Chlorophyll *a*) in Marine Sites, Doris North Project, 2013

Annex A.5-3. Marine Phytoplankton Biomass Data, Doris North Project, 2013

Marine Site	Date Sampled	Depth Sampled	ALS Sample ID	Replicate #	Phytoplankton Biomass (µg chl *a* /L)	Mean	SE
RBW	27-Apr-13	1 m	L1317792-13	1	0.724	0.62	0.11
RBW	27-Apr-13	1 m	L1317792-14	2	0.739		
RBW	27-Apr-13	1 m	L1317792-15	3	0.409		
RBW	20-Jul-13	0.5 m	L1339221-31	1	0.220	0.28	0.03
RBW	20-Jul-13	0.5 m	L1339221-32	2	0.300		
RBW	20-Jul-13	0.5 m	L1339221-33	3	0.320		
RBW	14-Aug-13	1 m	L1353306-1	1	0.060	0.08	0.02
RBW	14-Aug-13	1 m	L1353306-2	2	0.130		
RBW	14-Aug-13	1 m	L1353306-3	3	0.060		
RBW	20-Sep-13	1 m	L1370447-1	1	0.410	0.38	0.06
RBW	20-Sep-13	1 m	L1370447-2	2	0.470		
RBW	20-Sep-13	1 m	L1370447-3	3	0.260		
RBE	27-Apr-13	1 m	L1317792-10	1	1.49	1.32	0.18
RBE	27-Apr-13	1 m	L1317792-11	2	0.953		
RBE	27-Apr-13	1 m	L1317792-12	3	1.51		
RBE	20-Jul-13	0.5 m	L1339221-34	1	0.730	0.69	0.09
RBE	20-Jul-13	0.5 m	L1339221-35	2	0.830		
RBE	20-Jul-13	0.5 m	L1339221-36	3	0.520		
RBE	14-Aug-13	0.1 m	L1353306-4	1	0.100	0.14	0.02
RBE	14-Aug-13	0.1 m	L1353306-5	2	0.160		
RBE	14-Aug-13	0.1 m	L1353306-6	3	0.150		
RBE	21-Sep-13	0.5 m	L1370447-4	1	0.250	0.25	0.09
RBE	21-Sep-13	0.5 m	L1370447-5	2	0.410		
RBE	21-Sep-13	0.5 m	L1370447-6	3	0.090		
REF-Marine 1	28-Apr-13	1 m	L1317792-22	1	0.079	0.17	0.05
REF-Marine 1	28-Apr-13	1 m	L1317792-23	2	0.187		
REF-Marine 1	28-Apr-13	1 m	L1317792-24	3	0.249		
REF-Marine 1	21-Jul-13	0.5 m	L1339221-37	1	0.220	0.20	0.01
REF-Marine 1	21-Jul-13	0.5 m	L1339221-38	2	0.190		
REF-Marine 1	21-Jul-13	0.5 m	L1339221-39	3	0.180		
REF-Marine 1	15-Aug-13	1 m	L1353306-7	1	0.030	0.03	0.00
REF-Marine 1	15-Aug-13	1 m	L1353306-8	2	0.030		
REF-Marine 1	15-Aug-13	1 m	L1353306-9	3	0.030		
REF-Marine 1	28-Sep-13	1 m	L1371637-1	1	0.210	0.29	0.11
REF-Marine 1	28-Sep-13	1 m	L1371637-2	2	0.160		
REF-Marine 1	28-Sep-13	1 m	L1371637-3	3	0.510		

SE = standard error of the mean

RBE site was too shallow for sampling at 1 m depth

April samples were collected at 1 m under the ice

A.6 2013 BENTHIC INVERTEBRATES

The following sections present the benthic invertebrate taxonomy data collected in August 2013 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

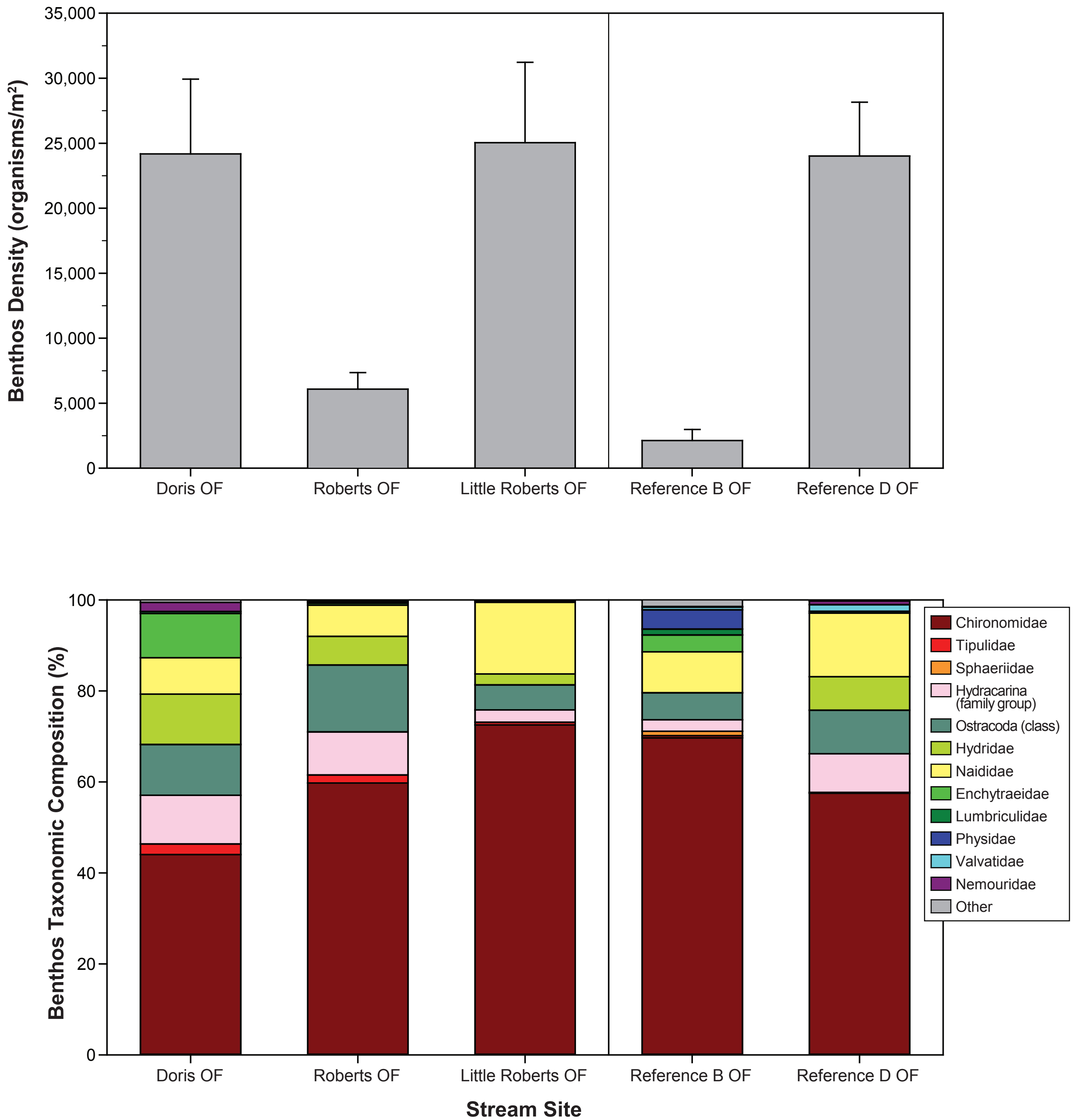
Figure A.6-4 presents the density and taxonomic composition of lake benthos communities. Figure A.6-5 presents the family richness, Simpson's Evenness Index, and the Simpson's Diversity Index, and Figure A.6-6 presents the Bray-Curtis Index calculated for lake benthos communities. Annex A.6-3 provides 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 of replicates.
Stacked bars represent the mean of replicate samples.

Figure A.6-1

Benthos Density and Taxonomic Composition in Stream Sites, Doris North Project, August 2013

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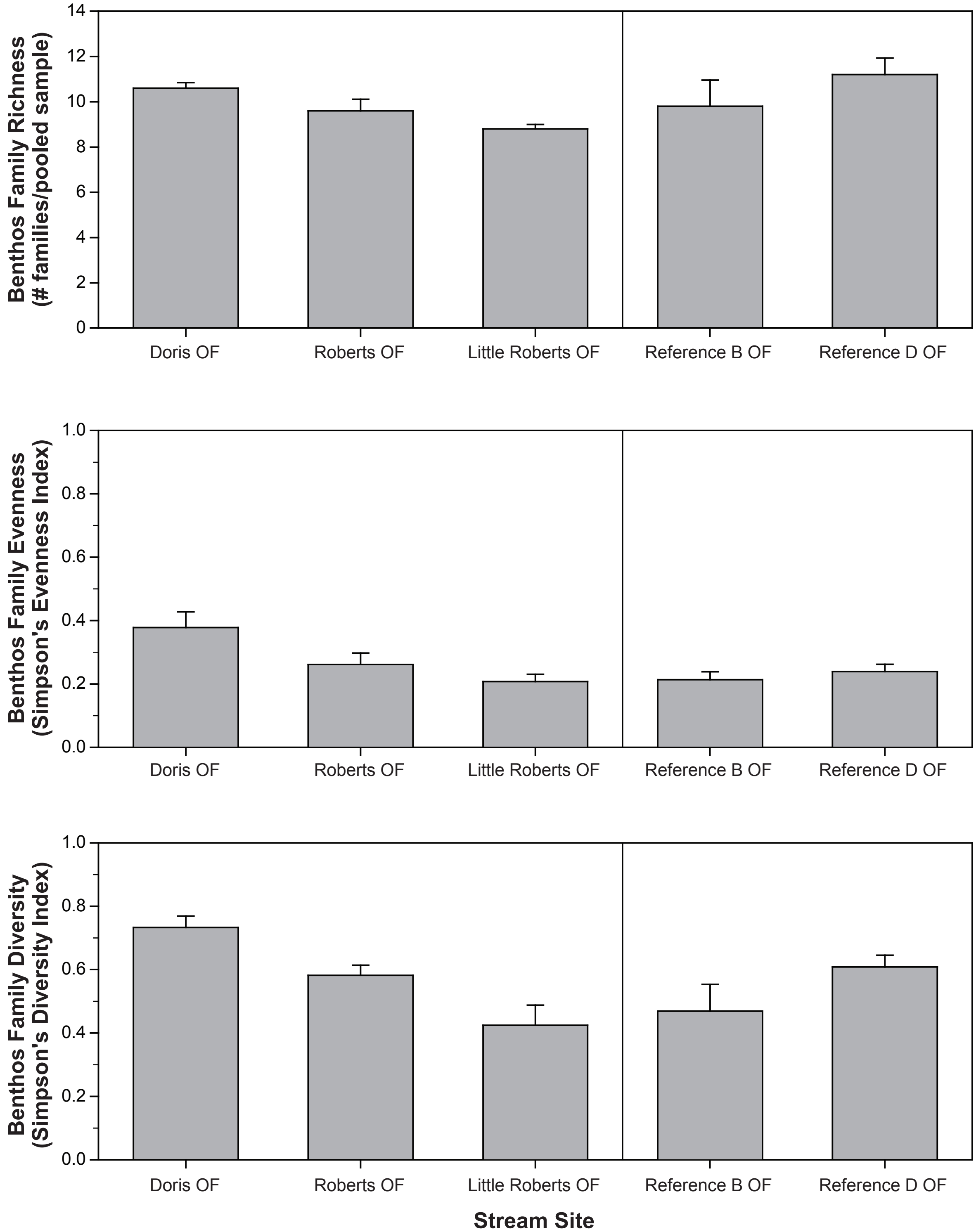
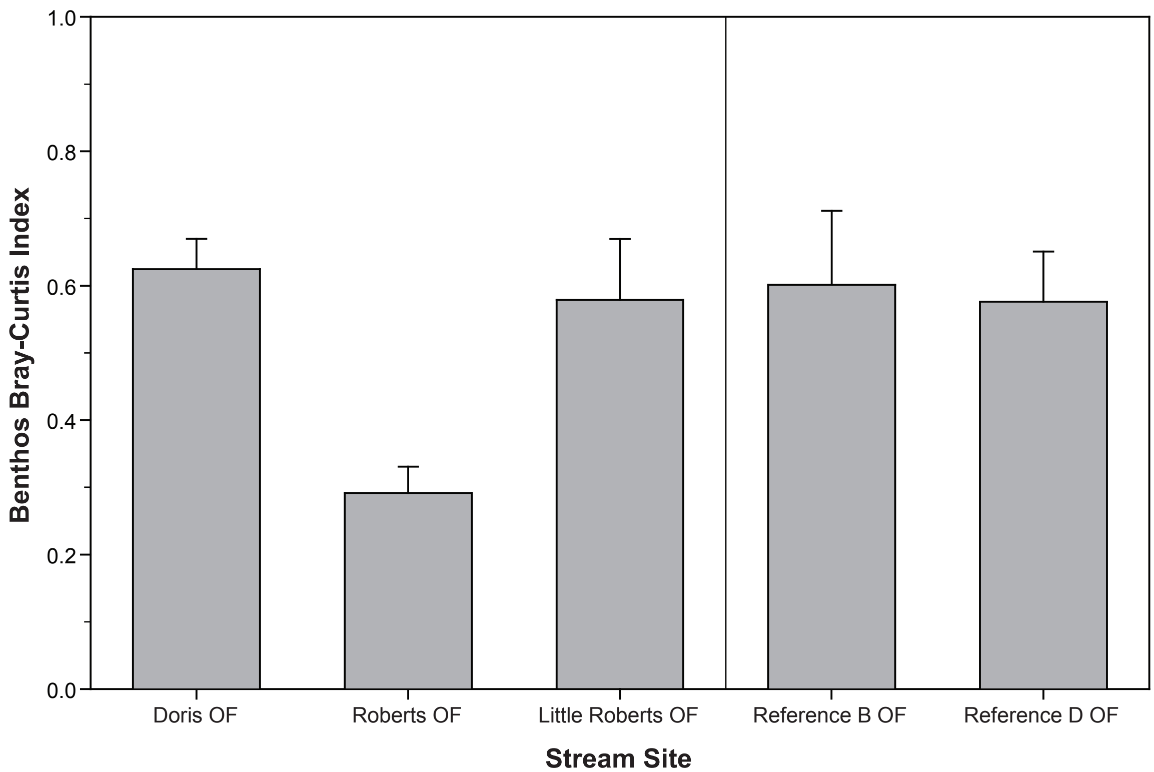


Notes: Error bars represent the standard error of the mean of replicates.

Figure A.6-2

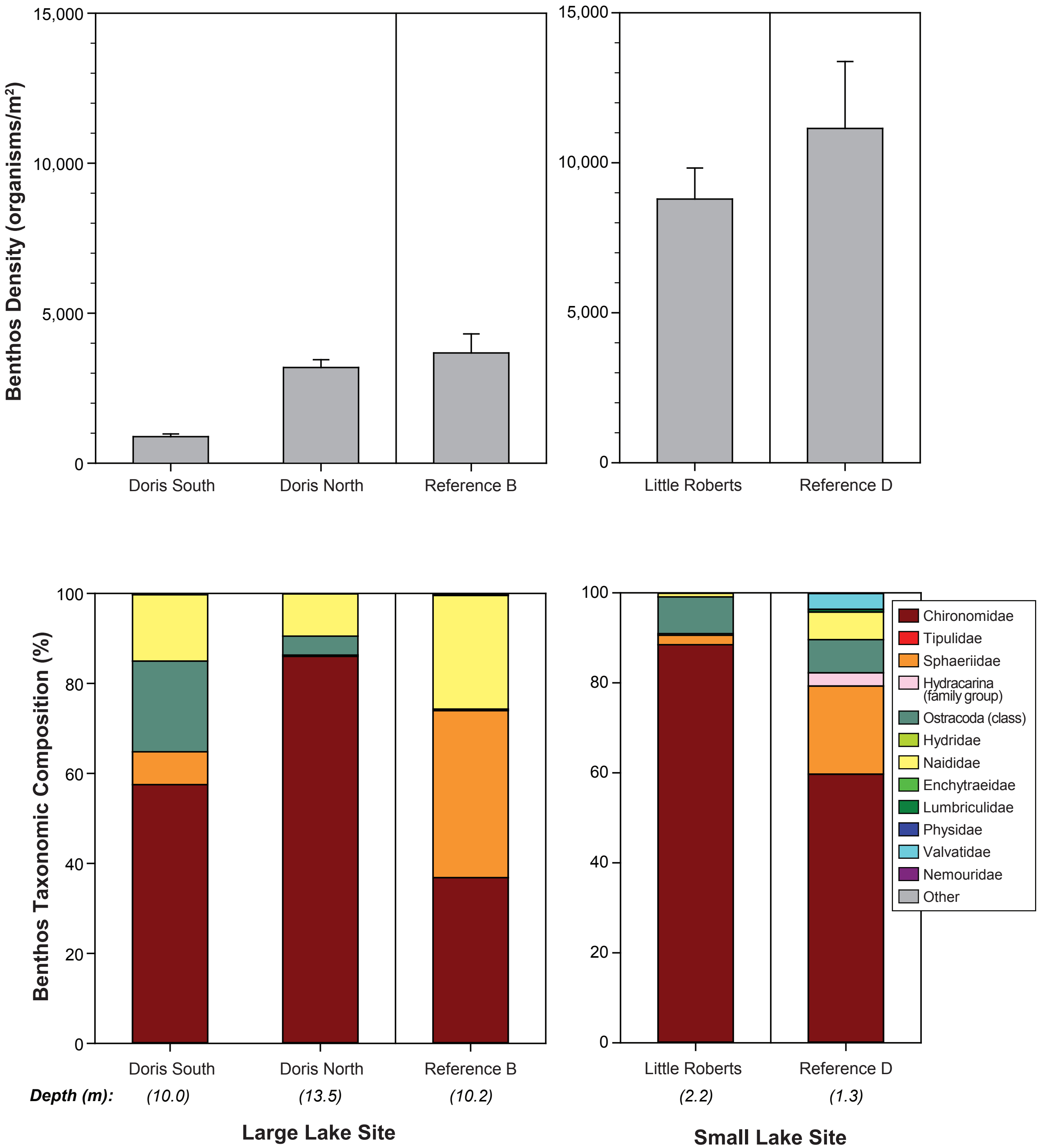
Benthos Richness, Evenness, and Diversity in Stream Sites, Doris North Project, August 2013



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

Figure A.6-3

Benthos Bray-Curtis Index for Stream Sites, Doris North Project, August 2013



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

Figure A.6-4

Benthos Density and Taxonomic Composition in Lake Sites, Doris North Project, August 2013

Annex A.6-1. Stream Benthos Taxonomy Data, Doris North Project, 2013

Taxonomic Identification					Roberts OF					Little Roberts OF					Doris OF					Reference B OF					Reference D OF				
					16-Aug-13					17-Aug-13					19-Aug-13					22-Aug-13					17-Aug-13				
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	Rep-1	Rep-2	Rep-3	Rep-4	Rep-5
Coelenterata	Hydridae	-	-	*Hydra*	48	32	80	72	281	200	180	200			261	660	480	640	1200						560	120	360	1004	480
Microturbellaria*	-	-	-	-				1							1				20				64	21			40	40	
Nematoda*	-	-	-	-	381	279	668	512	592	561	120	805	1271	1336	124	158	350	737	578	3	8		24	21	360	890	284	308	518
Oligochaeta - cocoon*					8		2		120			2			8	20	40		12	1									
Oligochaeta	Enchytraeidae	-	-	-		8		24						1	188	561	200	1438	897			32	16	160				1	
	Lumbriculidae	-	-	-	11		3		4	6	2	9	4	7	1	69	31	25	14				4	88	8	35	25	14	22
	Naididae	Naidinae	-	-	40			8	20	1320	640	1920	160	840	17	220	400	160	240		22	8	8	100	1320	522	641	1412	760
	Naididae	Tubificinae	-	-	61	103	293	17	85	95	25	8	41	98	87	245	182	921	372	2			54	198			2		
Gastropoda	Physidae	-	-	*Physa*																	11	38	53	4					
	Valvatidae	-	-	*Valvata sincera*									41							1	1	10			140	161	69		38
Pelecypoda	Sphaeriidae	-	-	(i/d)																			16	36					
		-	-	*Pisidium*									1											1					
Hydracarina	-	-	-	-	126	119	365	227	14	88	169	338	55	212	169	336	148	1248	2148	8		37	1	5	730	382	61	1182	990
Copepoda - Cyclopoida*	Cyclopidae	Cyclopinae	-	*Acanthocyclops*			20		20		20	40	40	80						8	9		64	20					
Copepoda - Cyclopoida*	Ergasilidae	-	-	*Ergasilus*																			32						
Copepoda - Harpacticoida*	-	-	-	-	8							80		280		80	360	320	80		2	8	16	20	360	320	80	600	40
Ostracoda	-	-	-	-	64	136	340	264	480	200	141	520	481	560	96	960	1408	728	560	1	3	40	56	180	680	760	680	280	80
Cladocera*	Chydoridae	-	-	*Eurycercus*						11	3	275	331	556									34	139			40		
	Chydoridae	-	-	-																					40		80	40	
	Daphnidae	-	-	*Daphnia*																									40
Malacostraca	Mysidae	-	-	*Mysis relicta*	2																								
Ephemeroptera	Baetidae	-	-	*Baetis*	1	1	1	5							25	10		10	45	1		8							
	Ephemerellidae	-	-	*Ephemerella*				2														12			1	4			4
Plecoptera		-	-	*Nemoura*	1	3	5	6	3	1	20	5		18	31	276	10	172	117			2	2		60	94	11	30	64
Trichoptera		-	-	(pupa)*																								4	
	Brachycentridae	-	-	*Brachycentrus*																		12	1					22	14
	Hydroptilidae	-	-	*Agraylea*																				1			8		8
	Limnephilidae	-	-	*Grensia praeterica*						5	2	3	1			1	1	1								1	1		
Coleoptera	Dytiscidae	-	-	*Oreodytes*																			1						
		-	-	*Stictotarsus*																				1		4	1		
	Haliplidae	-	-	*Haliplus*																							1		
Diptera	Chironomidae	-	-	(pupa)	17	1	3	2		2		3	1	44	20			8	129	1		16			48	8		98	40
		Tanypodinae	Pentaneurini	(i/d)									40													1			
				Ablabesmyia																1									
				Thienemannimyia group	102	113	212	188	159	272	232	506	119	509	78	808	527	1085	116	5	2		12	54	176	484	46	250	90
			Procladiini	*Procladius*					1			1	6										10	23					
		Diamesinae	Diamesini	(i/d)																		8							
				Potthastia longimana group			1			2		3	3	80											40	81			
				Pseudokiefferiella	35	73	196	43	26	40		390	51	73	28		82	40	1204	5	1	12			315	194	84	1368	544
		Orthocladiinae	-	(i/d)	72	128	80	96	20	920	100	2160	760	1880	64	584	1760	1440	720			8	1		684	640	120	520	680
			Orthocladiini	*Brillia*	8																								
				Cricotopus / Orthocladius	426	475	721	341	301	403	341	1047	562	890	96	60	521	884	1121	4	5	138	16		1614	204	162	346	1118
				Corynoneura	8		20															16			80				
				Doncricotopus					20	160	60	40					40												
				Eukiefferiella		8		1										4	80	1		33			40		1	238	874
				Euryhapsis				1		11		83	1	1	10	8	9	181				2			134	394	6	168	156
				Hydrosmittia																	3		8		40			40	
				Nanocladius						80	60		80	40		20	200								160	80		160	40
				Parakiefferiella	8	64	260	144		40	100	120	520	480	32	184	204	400	160						40				
				Psectrocladius						5	22	56	141	53				4		3			13	197	14	162	214	272	2
				Synorthocladius		8	100	16	20			40		40	8	120	40	404				16			40			80	
				Thienemanniella													40					8			40		40	240	40
				Tvetenia		11	27	16	4	2		11	4	9	7	2	24	162	498	1	1	5			103	109	1	198	44
				Zalutschia								80	80		8										40	4		40	

Annex A.6-1. Stream Benthos Taxonomy Data, Doris North Project, 2013

Taxonomic Identification					Roberts OF					Little Roberts OF					Doris OF					Reference B OF					Reference D OF				
					16-Aug-13					17-Aug-13					19-Aug-13					22-Aug-13					17-Aug-13				
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**	**Rep-1**	**Rep-2**	**Rep-3**	**Rep-4**	**Rep-5**
Diptera *(cont'd)*	Chironomidae *(cont'd)*	Chironominae	Chironomini	*Chironomus*																			17						
				Cryptochironomus								42	1											4					
				Demicryptochironomus						1	1																		
				Dicrotendipes						7	2	13	17	41	1		1			35	71	27	46	25	128	89	84		
				Polypedilum	8						20		40												40			80	40
				Sergenta						2		40	4	8		1	52	4	1				8						
				Stictochironomus	12	1	98	21	57	8	1	88	48	46	23	62	51	120	2	1			66	74			1		
			Tanytarsini	(i/d)								160	40	480	1										40	4			
				Cladotanytarsus		8		8			60	400	241	284	3	20	40	80								40			
				Constempellina		24	80			120	60	1000	160	600			40	160						20	80	40	200	40	80
				Micropsectra										40															
				Micropsectra / Tanytarsus			20			640	200	1040	200	960		80	280	80							320	200	120	160	80
				Paratanytarsus						50	86	501	307	891	8				1	42	7		200	118	92	120	42	138	40
				Rheotanytarsus				1		280	40	641	40	160				80				2			600	44	40	904	1280
				Stempellinella							20	40															40		
				Tanytarsus	16	16	181	32	80	281	180	882	1040	840	56	240	280	80	160	19	40	104	56	200	320	321	40	360	160
	Simulidae	-	-	*Metacnephia*																	1								
		-	-	*Simulium*															4										
		-	-	*Simulium* - pupa	2		2																						
	Tipulidae	-	-	*Tipula*	21	13	83	30	22	44	14	46	37	50	67	172	135	89	104	1	1	1	3	5	5	16	13		4
Terrestrial*	-	-	-	-	1	1	1		1			2		12	3		4				2				4				8
Fish*	Gasterosteidae	-	-	*Pungitius pungitius* (Ninespine Stickleback)																						1	1		
TOTAL number of individuals					**1487**	**1625**	**3862**	**2078**	**2330**	**5857**	**2921**	**13640**	**6969**	**12499**	**1521**	**5957**	**7940**	**11705**	**10583**	**144**	**190**	**603**	**902**	**1715**	**9496**	**6529**	**3639**	**10637**	**8378**

Notes:

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

i/d = immature or damaged

Cladocerans and cyclopoid copepods were excluded because they are generally planktonic.

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

Immature organisms that were not identifiable to the family level (oligochaete cocoons, and trichopteran pupa) were excluded from the community analysis.

Taxonomic groups that made up a minor proportion of the total assemblage and were not identifiable to the family level (microturbellarians) were excluded from the community analysis.

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, 2013

	Doris OF					
	Min	Max	Median	Mean	SD	SE
Density (#/m^2)	4,809	36,972	24,951	24,174	12,867	5,754
Family Richness	10.0	11.0	11.0	10.6	0.5	0.2
Simpson's Diversity Index	0.61	0.82	0.74	0.73	0.08	0.04
Simpson's Evenness Index	0.26	0.54	0.35	0.38	0.11	0.05
Bray-Curtis Index	0.50	0.73	0.63	0.62	0.10	0.05

	Little Roberts OF					
	Min	Max	Median	Mean	SD	SE
Density (#/m^2)	9,646	43,181	18,497	25,042	13,819	6,180
Family Richness	8.0	9.0	9.0	8.8	0.4	0.2
Simpson's Diversity Index	0.27	0.61	0.40	0.42	0.14	0.06
Simpson's Evenness Index	0.15	0.28	0.19	0.21	0.05	0.02
Bray-Curtis Index	0.26	0.77	0.61	0.58	0.20	0.09

	Roberts OF					
	Min	Max	Median	Mean	SD	SE
Density (#/m^2)	3,781	11,010	5,434	6,088	2,841	1,271
Family Richness	8.0	11.0	10.0	9.6	1.1	0.5
Simpson's Diversity Index	0.50	0.69	0.57	0.58	0.07	0.03
Simpson's Evenness Index	0.20	0.40	0.23	0.26	0.08	0.04
Bray-Curtis Index	0.17	0.38	0.28	0.29	0.09	0.04

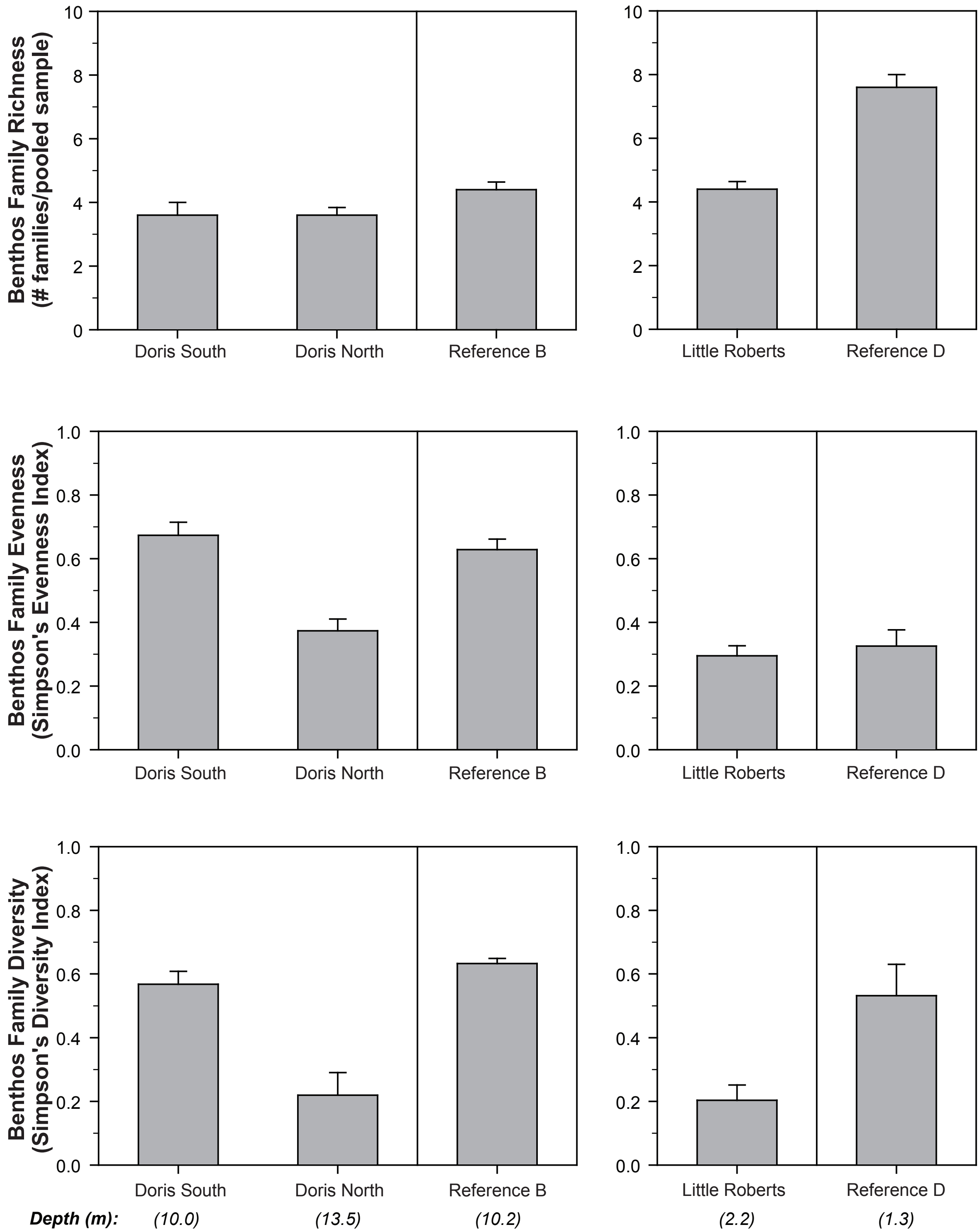
	Reference B OF					
	Min	Max	Median	Mean	SD	SE
Density (#/m^2)	458	5,188	2,066	2,124	1,908	853
Family Richness	7.0	12.0	11.0	9.8	2.6	1.2
Simpson's Diversity Index	0.20	0.70	0.52	0.47	0.19	0.08
Simpson's Evenness Index	0.17	0.30	0.18	0.21	0.06	0.03
Bray-Curtis Index	0.26	0.85	0.57	0.60	0.25	0.11

	Reference D OF					
	Min	Max	Median	Mean	SD	SE
Density (#/m^2)	10,813	33,490	26,986	24,015	9,266	4,144
Family Richness	9.0	13.0	12.0	11.2	1.6	0.7
Simpson's Diversity Index	0.50	0.74	0.60	0.61	0.08	0.04
Simpson's Evenness Index	0.17	0.29	0.25	0.24	0.05	0.02
Bray-Curtis Index	0.31	0.71	0.66	0.58	0.17	0.07

Notes:

SD - Standard deviation of the mean

SE - Standard error of the mean



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

Figure A.6-5

Benthos Richness, Evenness, and Diversity in Lake Sites, Doris North Project, August 2013

TMAC RESOURCES

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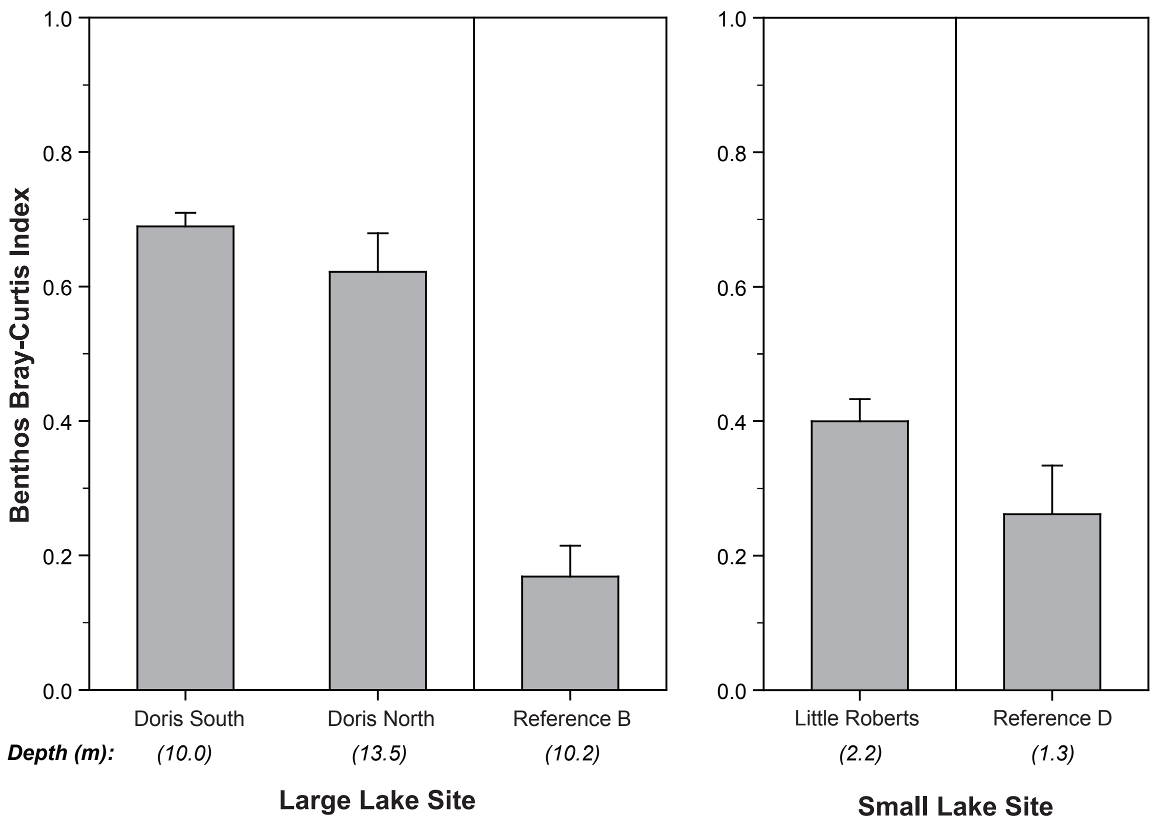
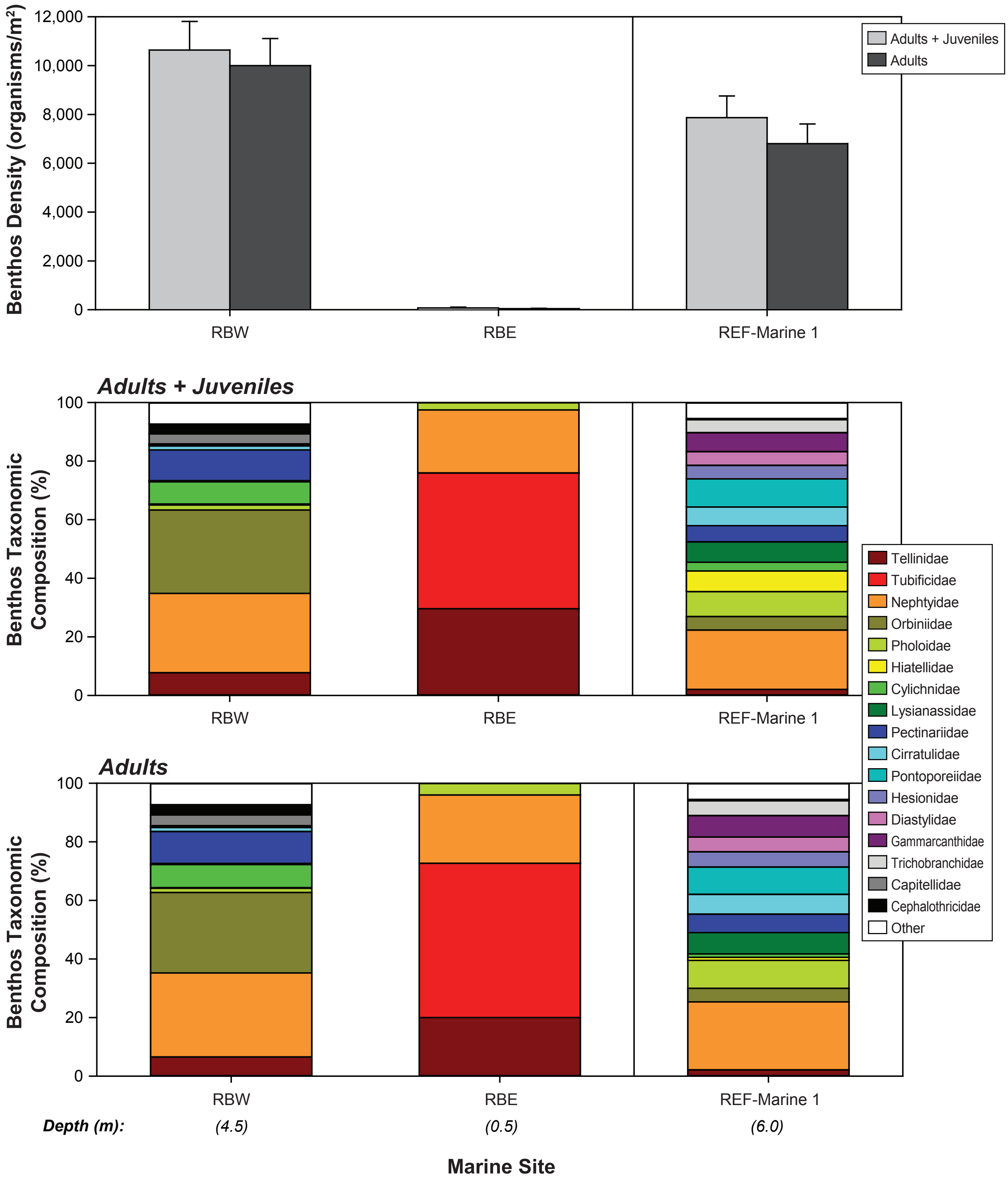


Notes: Error bars represent the standard error of the mean of replicates.

Figure A.6-6

Benthos Bray-Curtis Index for Lake Sites, Doris North Project, August 2013



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

Figure A.6-7

Benthos Density and Taxonomic Composition in Marine Sites, Doris North Project, August 2013

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Annex A.6-3. Lake Benthos Taxonomy Data, Doris North Project, 2013

Taxonomic Identification					Doris Lake North					Doris Lake South					Little Roberts Lake					Reference Lake B					Reference Lake D				
					21-Aug-13					20-Aug-13					21-Aug-13					18-Aug-13					20-Aug-13				
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**	**Rep-1**	**Rep-2**	**Rep-3**	**Rep-4**	**Rep-5**
Microturbellaria*	-	-	-	-																	1								
Nematoda*	-	-	-	-	1		1				2				2	11	3	16	4	44	131	113	32	11	160	181	399	189	312
Oligochaeta - cocoon*					68	9	5	5	29	33	22	1	7	14						3									
Oligochaeta	Lumbriculidae	-	-	-																2			1			4	1	4	14
	Naididae	Naidinae	-	-													4												
	Naididae	Tubificinae	-	-	55	4	14	3	11	25	9		3	7	1	2	14	1		14	95	109	94	29	21	6	61	39	43
Gastropoda	Valvatidae	-	-	*Valvata sincera*																					29	43	12	21	28
Pelecypoda	Sphaeriidae	-	-	(i/d)	1		1		1	2	3					6	4	21	3	47	27	43	35	37	3	43	36	101	143
		-	-	*Sphaerium*																3	1	2			2	10	2	1	6
		-	-	*Pisidium*							4	13			1	5	7	11	8	38	47	49	51	33	5	46	53	75	135
Hydracarina	-	-	-	-												2			9			1			1	21	18	17	44
Copepoda - Calanoida*	-	-	-	-	19	22	15	1	7	4	7	2	1	1									2						
Copepoda - Cyclopoida*	Cyclopidae	Cyclopinae	-	*Acanthocyclops*											4	7		16	28										
Copepoda - Harpacticoida*	-	-	-	-																					8				
Ostracoda	-	-	-	-	6	6	7	18	9	12	9	15	22	5	18	50	44	104	28		1		1	1	32	80	16	64	88
Cladocera*	Daphnidae	-	-	*Daphnia*							1																		
	Holopedidae	-	-	*Holopedium gibberum*										1															
Malacostraca	Mysidae	-	-	*Mysis relicta*															1					1					
Isopoda	Chaetiliidae	-	-	*Saduria entomon*						1																			
Trichoptera	Hydroptilidae	-	-	(i/d)																						1			
Diptera	Chironomidae	-	-	(pupa)	1	1		1	5			1	1								1								
		Tanypodinae	Pentaneurini	(i/d)																								1	
				Ablabesmyia											3	3			4							21			
				Thienemannimyia group																								1	
			Procladiini	*Procladius*						1	2	2	3	2	33	71	59	49	64	2	2	1	2		13	29	27	2	32
		Diamesinae	Diamesini	*Potthastia longimana* group												2											1		1
			Protanypini	*Protanypus*																4	4	5	3	7					
		Prodiamesinae		*Monodiamesa*	1					12	5	4	9	7							1				1				
		Orthocladiinae	Orthocladiini	*Abyskomyia*												1													
				Cricotopus / Orthocladius																							8	8	8
				Heterotrissocladius																	1	4							
				Parakiefferiella																								8	1
				Psectrocladius															1	14	9	22	12	12	9	2	1	6	6
				Zalutschia						1						1	4		9	33	58	39	38	17	32			24	8
		Chironominae	Chironomini	*Chironomus*	99	173	229	224	207	1		3	2		70	88	110	77	111							21	1		
				Cladopelma																									9
				Cryptochironomus																						1	21	14	6
				Polypedilum																								1	
				Sergenta											48	7	1	37	67						8	60		2	3
				Stictochironomus						9	11	17	16	13					1						5		29	13	
			Tanytarsini	(i/d)												3													
				Constempellina																							8		8
				Corynocera																2	22	81	6	1	46	61	24	25	47
				Paratanytarsus											11	30	38	113	80	1	10	18	6	3	350	726	36	94	102
				Stempellinella																									32
				Tanytarsus						8	9	9	15	6	195	505	217	202	308	6	29			3	129	130	56	64	8
	Empididae	-	-	*Chelifera*																							1	1	1
Terrestrial*	-	-	-	-	2	1			2					2															
TOTAL number of individuals					**253**	**216**	**272**	**252**	**271**	**109**	**84**	**67**	**79**	**58**	**386**	**794**	**505**	**647**	**726**	**213**	**440**	**487**	**283**	**155**	**854**	**1486**	**811**	**775**	**1085**

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 and cladocerans were excluded because they are generally planktonic.

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

Immature organisms that were not identifiable to the family level (oligochaete cocoons) were excluded from the community analysis.

Taxonomic groups that made up a minor proportion of the total assemblage and were not identifiable to the family level (microturbellarians) were excluded from the community analysis.

Terrestrial organisms 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.6-4. Lake Benthos Summary Statistics, Doris North Project, 2013

	Doris Lake South					
	Min	Max	Median	Mean	SD	SE
Density (#/m^2)	593	1,067	948	886	202	90
Family Richness	3.0	5.0	3.0	3.6	0.9	0.4
Simpson's Diversity Index	0.46	0.65	0.59	0.57	0.09	0.04
Simpson's Evenness Index	0.58	0.81	0.64	0.67	0.09	0.04
Bray-Curtis Index	0.63	0.75	0.69	0.69	0.05	0.02

	Doris Lake North					
	Min	Max	Median	Mean	SD	SE
Density (#/m^2)	2,415	3,719	3,452	3,191	585	262
Family Richness	3.0	4.0	4.0	3.6	0.5	0.2
Simpson's Diversity Index	0.10	0.50	0.16	0.22	0.16	0.07
Simpson's Evenness Index	0.30	0.50	0.37	0.37	0.08	0.04
Bray-Curtis Index	0.40	0.71	0.67	0.62	0.13	0.06

	Little Roberts Lake					
	Min	Max	Median	Mean	SD	SE
Density (#/m^2)	5,630	11,496	9,111	8,791	2,317	1,036
Family Richness	4.0	5.0	4.0	4.4	0.5	0.2
Simpson's Diversity Index	0.10	0.36	0.16	0.20	0.11	0.05
Simpson's Evenness Index	0.23	0.39	0.28	0.30	0.07	0.03
Bray-Curtis Index	0.33	0.48	0.36	0.40	0.07	0.03

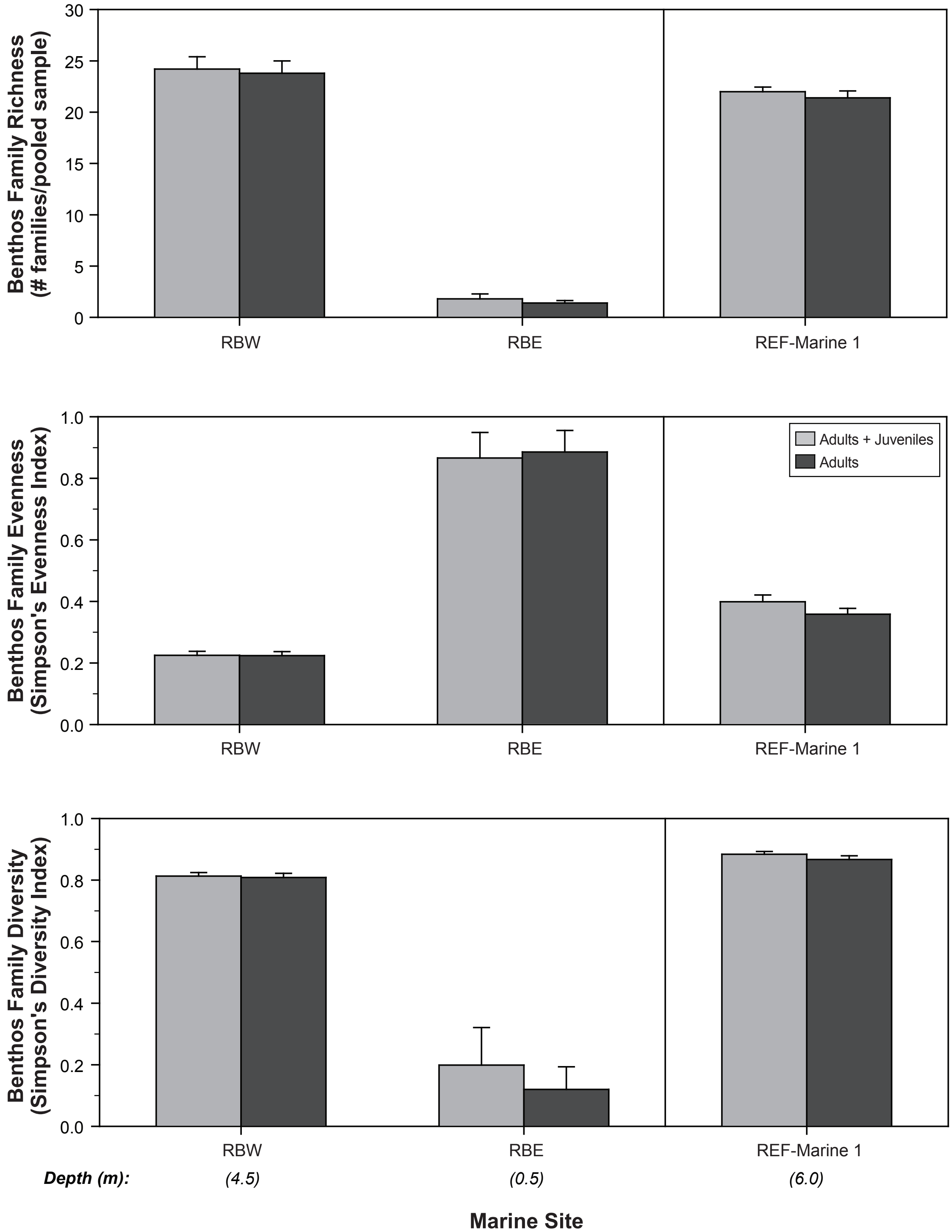
	Reference Lake B					
	Min	Max	Median	Mean	SD	SE
Density (#/m^2)	2,133	5,541	3,689	3,677	1,425	637
Family Richness	4.0	5.0	4.0	4.4	0.5	0.2
Simpson's Diversity Index	0.57	0.67	0.65	0.63	0.04	0.02
Simpson's Evenness Index	0.55	0.71	0.60	0.63	0.07	0.03
Bray-Curtis Index	0.002	0.27	0.21	0.17	0.10	0.05

	Reference Lake D					
	Min	Max	Median	Mean	SD	SE
Density (#/m^2)	6,104	19,333	10,163	11,147	4,990	2,232
Family Richness	6.0	8.0	8.0	7.6	0.9	0.4
Simpson's Diversity Index	0.25	0.72	0.66	0.53	0.22	0.10
Simpson's Evenness Index	0.19	0.45	0.37	0.33	0.11	0.05
Bray-Curtis Index	0.08	0.46	0.19	0.26	0.16	0.07

Notes:

SD - Standard deviation of the mean

SE - Standard error of the mean



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

Figure A.6-8

Benthos Richness, Evenness, and Diversity in Marine Sites, Doris North Project, August 2013

Annex A.6-5. Marine Benthos Taxonomy Data, Doris North Project, 2013

Taxonomic Identification		REF-Marine 1										RBE										RBW									
		15-Aug-13										14-Aug-13										14-Aug-13									
		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	
Taxa	Family	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
FORAMINIFERA																															
Foraminifera indet.*		1		1		9				1												7				5		2		13	
CNIDARIA																															
Athecata indet fragment*																						1									
Campanularidae indet fragment	Campanularidae																					1									
Hydrozoa sp. indet.*	Hydrozoa (Class)																									3					
Actiniaria indet.*	Anthozoa (Class)	1																				1									
NEMERTEA																															
Anopla indet.*																						2				2				2	
Cephalothrix sp.	Cephalothricidae									1												44		7		25		36		17	
Cerebratulus sp.	Lineidae																					4		3		3		2		1	
Enopla indet.*																						2									
Nemertea sp indet.*	Nemertea (Phylum)												5											3		1		7		3	1
ANNELIDA																															
Polychaeta Errantia																															
Bipalponephtys nr neotena	Nephtyidae	48	2	73	2	87	1	159		182	3											152		112	1	270	2	264	1	200	
Eteone longa	Phyllodocidae			1		1		1		1														1		9		15		4	
Eteone nr. pacifica	Phyllodocidae																					1									
Eteone sp.	Phyllodocidae																					1	3								
Eulalia bilineata	Phyllodocidae																					1		1				1			
Eunoe sp.	Polynoidae					4	1				2																			1	
Exogone sp.	Syllidae	1																												1	
Harmothoe imbricata Cmplx.	Polynoidae			1																				1							
Lumbrineris sp.	Lumbrineridae							1																							
Micropodarke sp.	Hesionidae																					1				2		1			
Nephtys ciliata	Nephtyidae																							1				1			
Nephtys sp.	Nephtyidae											1				2															
Nereimya sp.	Hesionidae	35	3	20		17		15		13																					
Pholoe nr. inornata	Pholoidae	9		70	3	92	3	13		39	1			1												1	1	2		10	
Pholoe nr longa	Pholoidae	1		4		4	2			4												7	4	3		15		8	3	5	5
Pholoe sp.	Pholoidae																					1			1						
Phyllodoce groenlandica	Phyllodocidae																							1	2				1		
Phyllodoce sp.	Phyllodocidae																									5		4		3	
Polynoidae sp indet.	Polynoidae																													1	
Polychaeta Sedentaria																															
Aphelochaeta sp.	Cirratulidae	47	4	14		15		14	6	21	3											3		7		24		9	3	5	2
Aricidea catherinae	Paraonidae	4		6		18		10		2												10	2	11		14		14		9	
Asabellides lineata	Ampharetidae	1																													
Capitella capitata Cmplx.	Capitellidae					1																				2	1			2	
Cirratulidae indet.	Cirratulidae					4		5		8																					
Clymenura nr polaris	Maldanidae	1		1				6		1												1								1	
Laonome kroeyeri	Sabellidae					1																									
Leitoscoloplos sp.	Orbiniidae	8		12	1	23		52	17	17												150	39	116	10	247	11	209	10	212	25
Mediomastus sp.	Capitellidae	3		2						1												48		18	1	22		9		19	
Pectinaria granulata	Pectinariidae	24		35		27	1	32	1	23												141		42	1	51	4	91		51	3
Pygospio nr elegans	Spionidae																							1							
Minuspio cirrifera	Spionidae																					2		2							
Prionospio steenstrupi	Spionidae																					1		1		1		1			
Scoloplos armiger	Orbiniidae																							2		2		2		3	
Terebellides stroemi	Trichobranchidae	8		20		38	1	25	1	31																					
Oligochaeta																															
Tubificidae indet.	Tubificidae											5	4	4	1					2											

Annex A.6-5. Marine Benthos Taxonomy Data, Doris North Project, 2013

Taxonomic Identification		REF-Marine 1										RBE										RBW									
		15-Aug-13										14-Aug-13										14-Aug-13									
		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	
Taxa	Family	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
ARTHROPODA																															
Amphipoda																															
Amphipoda indet (damaged)*																												1			
Apherusa glacialis	Calliopiidae	27																													
Boeckosimus affinis	Lysianassidae							1																							
Gammaracanthus loricatus	Gammarcanthidae	7	1	50	2	42	1	32		52												1								1	
Ischyrocerus anguipes	Ischyroceridae																					1									
Metopa sp.	Stenothoidae	1																													
Monoculodes sp.	Oedicerotidae					1																1						1		1	
Onisimus sp.	Lysianassidae							6		2																					
Orchomene minuta	Lysianassidae	1		139	13	31	1	10		10	6													8							
Paroediceros lynceus	Oedicerotidae			1				1			1																				
Pontoporeia femorata	Pontoporeiidae	10	5	82	14	47	2	53	8	44	13											3				3		3	3	6	
Protomedeia sp.	Isaeidae			1																											
Weyprechtia pinguis	Calliopiidae			4																											
Copepoda																															
Harpacticoida indet.*												16		17		1						1									
Ostracoda																															
Ostracoda sp indet.*	Ostracoda (Class)	4		2		3																2				2		1		3	
Cumacea																															
Brachydiastylis resima	Diastylidae	10	2	6		1		4																		3					
Diastylis rathkei	Diastylidae	1		25	4	9		61		7	1																				
Isopoda																															
Saduria entomon	Idoteidae																					2								1	
MOLLUSCA																															
Gastropoda																															
Buccinidae indet.	Buccinidae																					2				3	4		1	1	
Cylichnidae indet.	Cylichnidae		1								15											13		3		21		10		18	
Cylichna alba	Cylichnidae							16		12												53		18		52	1	57	3	36	4
Cylichna sp.	Cylichnidae		6			1	9	1	21																						
Haminoea solitaria*																						2		2		1		3		4	
Philine sp.	Philinidae																					6		5		7		3		6	
Retusa obtusa	Retusidae																					2		2		2		3		6	
Bivalvia																															
Astarte borealis	Astartidae	1																				5		2		5		2		9	1
Clinocardium ciliatum	Cardiidae																									1		1			
Hiatella arctica	Hiatellidae	2	20	7	39	5	48	7	5	4	52											2	5	2		1		1			
Macoma balthica	Tellinidae	6	1	5		10	1	7	1	15	1		3		2			1				52		43		56	1	42	13	6	10
Macoma calcarea	Tellinidae	2				1		1														5		3		1		4		4	
Macoma sp.	Tellinidae						1																7		3		15		5		6
Musculus discors	Mytilidae			1	3		2		1																						
Mya truncata	Myidae	1	3			1	3	1														1		1				1			2
Mytilus trossulus	Mytilidae			1	2	1		1																						1	
Portlandia arctica	Yoldiidae					1																									
Serripes groenlandicus	Cardiidae																					9		3		10		6		1	
CHORDATA																															
Rhizomolgula globularis	Molgulidae																							1							
MISCELLANEOUS																															
Unid invert egg case*																							2		4				2		
Nematoda*												17		2																	
TOTAL number of individuals		265	48	584	83	495	77	535	61	491	98	39	12	24	3	3	0	1	0	2	0	745	62	426	23	872	40	817	45	667	59

Notes:

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

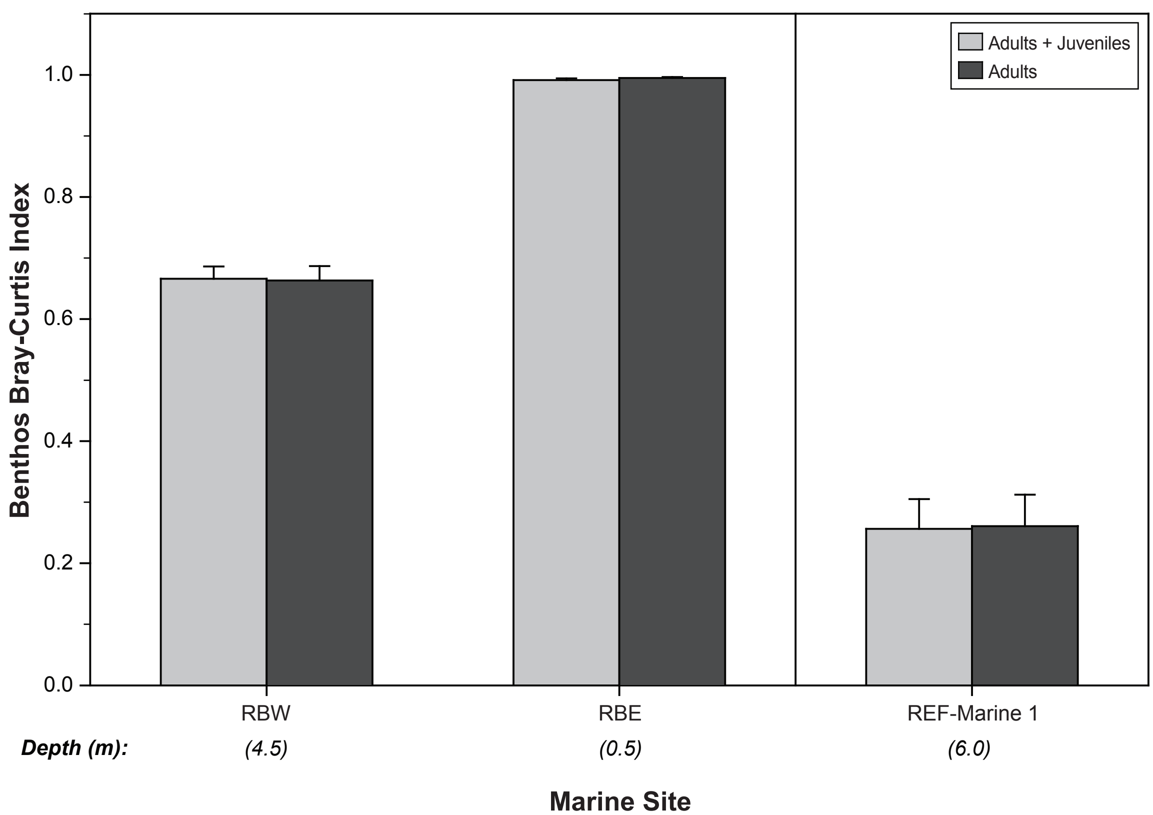
Nematodes and harpacticoid copepods were excluded because they are meiofauna and are not adequately sampled using a 500 um sieve bucket.

Taxonomic groups that were not identifiable to the family level were excluded from the community analysis.

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).

A = adult

J = juvenile



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

Figure A.6-9

Benthos Bray-Curtis Index for Marine Sites, Doris North Project, August 2013

Annex A.6-6. Marine Benthos Summary Statistics, Doris North Project, 2013

	Roberts Bay West (RBW) - Adults and Juveniles					
	Min	Max	Median	Mean	SD	SE
Density (#/m^2)	6,377	13,014	11,406	10,641	2,611	1,168
Family Richness	22.0	28.0	23.0	24.2	2.7	1.2
Simpson's Diversity Index	0.78	0.85	0.81	0.81	0.03	0.01
Simpson's Evenness Index	0.18	0.25	0.23	0.23	0.03	0.01
Bray-Curtis Index	0.59	0.70	0.69	0.67	0.05	0.020

	Roberts Bay West (RBW) - Adults					
	Min	Max	Median	Mean	SD	SE
Density (#/m^2)	6,101	12,435	10,536	10,003	2,479	1,109
Family Richness	22.0	28.0	22.0	23.8	2.7	1.2
Simpson's Diversity Index	0.77	0.85	0.80	0.81	0.03	0.01
Simpson's Evenness Index	0.18	0.25	0.22	0.22	0.03	0.01
Bray-Curtis Index	0.58	0.71	0.69	0.66	0.05	0.02

	Roberts Bay East (RBE) - Adults and Juveniles					
	Min	Max	Median	Mean	SD	SE
Density (#/m^2)	14	188	29	75	75	33
Family Richness	1.0	3.0	1.0	1.8	1.1	0.5
Simpson's Diversity Index	0.00	0.53	0.00	0.20	0.27	0.12
Simpson's Evenness Index	0.62	1.00	1.00	0.87	0.19	0.08
Bray-Curtis Index	0.98	1.00	0.99	0.99	0.01	0.003

	Roberts Bay East (RBE) - Adults					
	Min	Max	Median	Mean	SD	SE
Density (#/m^2)	14	87	29	46	31	14
Family Richness	1.0	2.0	1.0	1.4	0.5	0.2
Simpson's Diversity Index	0.00	0.32	0.00	0.12	0.16	0.07
Simpson's Evenness Index	0.69	1.00	1.00	0.89	0.16	0.07
Bray-Curtis Index	0.99	1.00	0.99	0.99	0.004	0.002

	Ida Bay (REF-Marine 1) - Adults and Juveniles					
	Min	Max	Median	Mean	SD	SE
Density (#/m^2)	4,449	9,623	8,522	7,870	1,991	890
Family Richness	21.0	23.0	22.0	22.0	1.0	0.4
Simpson's Diversity Index	0.86	0.90	0.88	0.88	0.02	0.01
Simpson's Evenness Index	0.33	0.45	0.39	0.40	0.05	0.02
Bray-Curtis Index	0.14	0.41	0.27	0.26	0.11	0.05

	Ida Bay (REF-Marine 1) - Adults					
	Min	Max	Median	Mean	SD	SE
Density (#/m^2)	3,754	8,420	7,101	6,806	1,799	805
Family Richness	19.0	23.0	22.0	21.4	1.5	0.7
Simpson's Diversity Index	0.82	0.89	0.87	0.87	0.03	0.01
Simpson's Evenness Index	0.29	0.40	0.36	0.36	0.04	0.02
Bray-Curtis Index	0.13	0.43	0.27	0.26	0.12	0.05

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, 2013

Sample ID	# from First Sort	1st QAQC Re-sort # Found	Initial Sort Efficiency (%)	Re-sort Required?	2nd QAQC Re-sort # Found	Final Efficiency (%)
Freshwater						
Roberts Outflow, rep 4	2078	19	99.1	N	-	99.1
Doris Outflow, rep 1	1521	28	98.2	N	-	98.2
Reference B Outflow, rep 3	603	1	99.8	N	-	99.8
Doris Lake North, rep 5	271	2	99.3	N	-	99.3
Little Roberts Lake, rep 5	726	9	98.8	N	-	98.8
Marine						
REF-Marine 1, rep 1	313	0	100	N	-	100
REF-Marine 1, rep 2	667	0	100	N	-	100
REF-Marine 1, rep 3	572	1	98	N	-	98
REF-Marine 1, rep 4	596	0	100	N	-	100
REF-Marine 1, rep 5	589	1	98	N	-	98
RBE, rep 1	34	0	100	N	-	100
RBE, rep 2	25	0	100	N	-	100
RBE, rep 3	3	0	100	N	-	100
RBE, rep 4	1	0	100	N	-	100
RBE, rep 5	2	0	100	N	-	100
RBW, rep 1	807	0	100	N	-	100
RBW, rep 2	449	1	98	N	-	98
RBW, rep 3	912	1	99	N	-	99
RBW, rep 4	862	0	100	N	-	100
RBW, rep 5	726	2	97	N	-	97

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

2013 Evaluation of Effects Supporting Information

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Appendix B. 2013 Evaluation of Effects Supporting Information

List of Tables

Appendix B. 2013 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 2013 evaluation of effects.

B.1.1 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 2013 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 2013 sampling locations, methodology, and sampling depth.

B.1.2 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 2013 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 2013 samples, the proximity of baseline sampling sites to the 2013 sites, and the similarity of sampling techniques.

B.1.3 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 2013 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 2013 AEMP sampling sites, and the comparability of sampling methodologies.

Table B.1-1. Baseline Data Selection Rationale for Water Quality, Doris North Project, 2013

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	\\10.47.0.190\new\0203925 BHP -	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 2003-2013 sampling site.
	1997	June, July, August	None	All	• 1996-1997 sampling site was further downstream than the 2003-2013 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, 2013 (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 2013 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 a site SW3	Excluded shoreline grabs from July and August	• Shoreline grabs from July and August are from a shallow, near-shore site that is not comparable to the 2013 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 2013 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, 2013 (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 2013 RBW site.
	1997	August	None	All	• 1996-1998 sampling sites were >1 km away from 2013 RBW site.
	1998	July	None	All	• 1996-1998 sampling sites were >1 km away from 2013 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 2013 RBW site, and excluded deep samples because only surface samples were collected in 2013.
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 2013 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 2013 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 2013 REF-Marine 1 site, and excluded deep samples because only surface samples were collected in 2013.

Table B.1-2. Baseline Data Selection Rationale for Sediment Quality, Doris North Project, 2013

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 2013 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 2013 RBW site.
	2002	August	Included shallow site RB4	Excluded sites RB1, RB2, RB3	• RB1 and RB2 were >1 km from 2013 RBW site; RB3 was a mid-depth site.
	2009	August	None	All	• Sites were all ~0.4 km or more away from 2013 RBW site.
RBE (shallow)	1997	August	None	All	• Sampling site in eastern basin was closer to the mouth of Little Roberts Outflow than the 2013 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 Chlorophyl *a*), Doris North Project, 2013

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 2009-2013 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 2009-2013 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 2013).
	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 2013).

(continued)

Table B.1-3. Baseline Data Selection Rationale for Primary Producer Biomass (as Chlorophyl *a*), Doris North Project, 2013 (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 (Phytoplankton; *cont'd*)					
Doris North *(cont'd)*	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 2013).
	2009	April, August	All	None	
Little Roberts	1996	August	None	All	• Chlorophyll *a* concentrations were not measured (only abundance and taxonomy data).
	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 2013).
	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 2013).
	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 2013).
	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 2013 RBW site, and excluded deep samples because only surface samples were collected in 2013.
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 2013).

(continued)

Table B.1-3. Baseline Data Selection Rationale for Primary Producer Biomass (as Chlorophyl *a*), Doris North Project, 2013 (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 (Phytoplankton; *cont'd)*					
RBE *(cont'd)*	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 2013).
	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 2013 REF-Marine 1 site, and excluded deep samples because only surface samples were collected in 2013.

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, 2013

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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 2013. 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 (three 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 variable 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 variable 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":

$$BACI = \left(\mu_{PA} - \mu_{PB}\right) - \left(\mu_{RA} - \mu_{RB}\right)$$

where μ_{PA} is the mean variable reading in the *Project* class of sites *after* Project initiation, μ_{PB} is the mean variable reading in the *Project* class of sites *before* Project initiation, μ_{RA} is the mean variable reading in the *reference* class of sites *after* Project initiation, and μ_{RB} is the mean variable 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. The results from the analysis that compared the mean prior to 2010 (before initiation of construction) to the mean for 2013 are presented in Tables Large Lake-1 and Small Lake-1. There was no evidence of a change in the mean Secchi depth for any exposure lake between the before and after periods.

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). Because no Secchi depth measurements were made in Reference Lake D prior to construction, no BACI comparison can be made for Little Roberts Lake (small lake).

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
Variable	p-value	p-value	p-value
Secchi Depth	0.2732	0.6831	-

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 in bold face. 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
Variable	p-value	p-value
Secchi Depth	0.8618	0.8954

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 in bold fare.

Table Small Lake-1. Summary of Test for No Difference in Mean between Before and After Periods for Small Lake Secchi Depth

	Period	
	Small Lake Site	
	Little Roberts	Reference D
Variable	p-value	p-value
Secchi Depth	0.2596	-

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 in bold face.
No pre-construction Secchi depth readings were collected at Reference Lake D, so no before-after comparison was possible.

Appendix B.2.2. Statistical Methodology and Results for Water Quality Evaluation of Effects, Doris North Project, 2013

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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; 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 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 variable. 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 variables 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 variables, 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 variable over time and to assess if changes in the means may reflect an impact of the Project.

1.6.1 Before vs. After Analysis

The first analysis conducted compares the mean readings for all years prior to 2010 (before initiation of construction) to the mean for 2013. Each waterbody is treated independently, and each water quality variable 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) variable 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 variable 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:

$$\frac{\frac{22}{1}+\frac{25+27}{2}}{2} = 24.0\ \mu\text{g/L}$$

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 2013 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 variable 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 variable 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":

$$BACI = \left(\mu_{PA} - \mu_{PB}\right) - \left(\mu_{RA} - \mu_{RB}\right)$$

where μ_{PA} is the mean variable reading in the *Project* class of sites *after* Project initiation, μ_{PB} is the mean variable reading in the *Project* class of sites *before* Project initiation, μ_{RA} is the mean variable reading in the *reference* class of sites *after* Project initiation, and μ_{RB} is the mean variable 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 variable 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, nitrate, cyanide, and radium-226 and the results of the analyses for these variables 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 radium-226 and aluminum in Little Roberts OF, and arsenic 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 of any variable between Project 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 site data is found in Table Marine-1. High levels of censoring in all marine exposure sites were found for radium-226 and mercury variables and the results of the analyses for these variables will be non-informative and should be discarded.

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 2013. 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. However, the results of the BACI comparison (Table Marine-4) failed to find evidence of a differential response in the means of these variables 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, cyanide, and radium-226 variables and the results of the analyses for these variables 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.

The results from the analysis that compared the means before and after Project construction are presented in Table Small Lake-3. There was no evidence of a change in the mean between the before and after periods for any variable. 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, cyanide, and radium-226 variables and the results of the analyses for these variables will be non-informative and should be discarded. High levels of censoring were also found for the reference lake only for total suspended solids and molybdenum. This will make the BACI comparison difficult to interpret for these variables.

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 hardness, cyanide, and mercury in Doris Lake South, and arsenic, molybdenum, and zinc in Doris Lake North (Table Large Lake-3). However, the BACI comparison failed to find evidence of a differential response for any variable in the mean between any Project site and the reference site over the before and after periods (Table Large Lake-4).

References

Helsel, D.R. (2005). Nondetects and Data Analysis.Wiley: New York.

Hurlbert, S.H. (1984) Pseudoreplication and the Design of Ecological Field Experiments. Ecological Monographs 54: 187-211.

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 (Before Outliers Removed) for Stream Sampling

	Stream Site				
	Doris OF	Little Roberts OF	Ref. B OF	Ref. D OF	Roberts OF
Variable	Proportion Censored	Proportion Censored	Proportion Censored	Proportion Censored	Proportion Censored
Aluminum (Al)	0.00	0.00	0.00	0.00	0.00
Alkalinity	0.00	0.00	0.00	0.00	0.00
Ammonia	0.32	0.41	**0.86**	**0.75**	0.39
Arsenic (As)	0.06	0.03	0.07	0.00	0.00
Cyanide (CN)	**0.88**	**0.77**	**1.00**	**1.00**	**0.81**
Cadmium (Cd)	**0.76**	0.69	**1.00**	**1.00**	**0.71**
Copper (Cu)	0.00	0.00	0.07	0.00	0.00
Iron (Fe)	0.00	0.00	0.07	0.00	0.00
Hardness	0.00	0.00	0.00	0.00	0.00
Mercury (Hg)	**0.75**	0.68	0.50	0.00	0.55
Molybdenum(Mo)	0.05	0.00	**0.79**	0.00	0.00
Nickel (Ni)	0.05	0.00	0.43	0.00	0.00
Nitrate	**0.84**	**0.95**	0.21	**1.00**	**0.84**
Lead (Pb)	0.24	0.26	1.00	1.00	0.19
Radium-226 (Ra)	**0.91**	**0.94**	**1.00**	**1.00**	**1.00**
Total Suspended Solids (TSS)	0.14	0.05	**1.00**	0.50	0.03
Zinc (Zn)	0.28	0.33	**1.00**	**1.00**	0.19
pH	0.00	0.00	0.00	0.00	0.00

Notes: Dataset includes all baseline years up to and including 2009 and 2013.
Proportions ≥0.70 are in bold face.

Table Stream-2. Summary of Potential Outliers from the Stream Data

Stream	Variable	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	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	Hg	2003	28JUL03	1	0.000025	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 Variables

	Effect				
	Period Stream Site				
	Doris OF	Little Roberts OF	Ref. B OF	Ref. D OF	Roberts OF
Variable	p-value	p-value	p-value	p-value	p-value
Aluminum (Al)	0.3568	**0.0051**	0.0996	.	0.0290
Alkalinity	0.2009	0.6233	0.3012	.	0.0277
Ammonia	0.7725	0.2296	**<0.0001**	.	0.1436
Arsenic (As)	0.3946	0.2722	0.3402	.	**0.0074**
Cyanide (CN)	0.6344	0.3238	.	.	0.3110
Cadmium (Cd)	0.4278	0.7289	**<0.0001**	.	0.7195
Copper (Cu)	0.2031	0.2113	0.7901	.	0.4339
Iron (Fe)	0.6316	0.4189	0.9384	.	0.1945
Hardness	0.2785	0.2032	0.4643	.	0.0850
Mercury (Hg)	0.8954	0.9875	0.1895	.	0.0988
Molybdenum (Mo)	0.0901	0.5685	0.5575	.	0.1773
Nickel (Ni)	0.5300	0.2504	0.7900	.	0.0775
Nitrate	0.9462	0.5926	0.8490	.	0.2316
Lead (Pb)	0.2746	0.0793	**<0.0001**	.	0.0589
Radium-226 (Ra)	0.2144	**0.0030**	.	.	**<0.0001**
Total Suspended Solids (TSS)	0.6270	0.2083	**<0.0001**	.	0.4599
Zinc (Zn)	0.5902	0.3005	**<0.0001**	.	0.4896
pH	0.3820	0.3575	0.6105	.	0.3308

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 in bold face.
In some cases, no analysis could be done because of the high degree of censoring, the lack of variation in a variable 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 Variables for Individual Project Stream Sites

	Stream Site		
	Doris OF	Little Robert OF	Roberts OF
Variable	p-value	p-value	p-value
Aluminum (Al)	0.6093	0.2224	0.3340
Alkalinity	0.4085	0.5855	0.3272
Ammonia	0.3885	0.6025	0.4565
Arsenic (As)	0.7696	0.4400	0.0506
Cyanide (CN)	.	.	.
Cadmium (Cd)	0.0947	0.9240	0.8801
Copper (Cu)	0.6278	0.8838	0.9508
Iron (Fe)	0.8172	0.3665	0.4745
Hardness	0.3604	0.2901	0.5223
Mercury (Hg)	0.0777	0.6736	0.1221
Molybdenum (Mo)	0.3236	0.8156	0.6951
Nickel (Ni)	0.7783	0.2439	0.5944
Nitrate	0.3181	0.1917	0.4167
Lead (Pb)	0.5620	0.2607	0.2688
Radium-226 (Ra)	.	.	.
Total Suspended Solids (TSS)	0.9771	0.1894	0.8392
Zinc (Zn)	0.5634	0.4690	0.4977
pH	0.7717	0.7237	0.7396

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 in bold face.
In some cases, no analysis could be done because of the high degree of censoring, the lack of variation in a variable 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**
Variable	**Proportion Censored**	**Proportion Censored**	**Proportion Censored**
Aluminum (Al)	0.10	0.36	0.56
Alkalinity	0.00	0.00	0.00
Ammonia	0.48	**1.00**	**0.89**
Arsenic (As)	0.03	0.00	0.00
Cyanide (CN)	**0.82**	0.62	**0.88**
Cadmium (Cd)	0.30	0.00	0.11
Copper (Cu)	0.00	0.00	0.00
Iron (Fe)	0.10	0.27	0.67
Hardness	0.00	0.00	0.00
Mercury (Hg)	**0.70**	**0.73**	0.67
Molybdenum (Mo)	0.03	0.09	0.00
Nickel (Ni)	0.10	0.00	0.00
Nitrate	**0.79**	0.45	0.44
Lead (Pb)	0.50	**0.73**	**1.00**
Radium-226 (Ra)	**0.86**	**1.00**	**0.88**
Total Suspended Solids (TSS)	0.10	0.45	**0.78**
Zinc (Zn)	0.27	0.55	0.67
pH	0.00	0.00	0.00

Notes: Dataset includes all baseline years up to and including 2009, and 2013.
Proportions ≥0.70 are in bold face.

Table Marine-2. Summary of Potential Outliers from the Marine Data

Site	Variable	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
RBE	Nitrate	1996	28AUG96	1	2.500000	1

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 Variables

	Effect		
	Period Marine Site		
	RBE	RBW	REF-Marine 1
Variable	**p-value**	**p-value**	**p-value**
Aluminum (Al)	0.6091	0.5776	0.7773
Alkalinity	0.0442	.	.
Ammonia	0.2645	.	**<0.0001**
Arsenic (As)	0.7726	0.1173	0.2383
Cyanide (CN)	0.6805	.	.
Cadmium (Cd)	0.7449	0.3767	0.5769
Copper (Cu)	0.5751	0.8245	0.6399
Iron (Fe)	0.5457	0.4969	0.9565
Hardness	0.3978	0.5777	.
Mercury (Hg)	0.2827	**<0.0001**	**0.0001**
Molybdenum (Mo)	0.1305	0.1700	0.5512
Nickel (Ni)	0.7444	0.3785	0.6545
Nitrate	0.9611	0.8255	0.4672
Lead (Pb)	0.6634	0.0803	.
Radium-226 (Ra)	0.9343	.	.
Total Suspended Solids (TSS)	0.2411	**0.0056**	0.0186
Zinc (Zn)	0.6901	0.1773	**<0.0001**
pH	0.9248	0.7066	0.8451

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 in bold face.
In some cases, no analysis could be done because of the high degree of censoring, the lack of variation in a variable 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 Variables for Individual Project Marine Sites

	Marine Project Site	
	RBE	RBW
	p-value	p-value
Variable		
Aluminum (Al)	0.7486	0.6464
Alkalinity	.	.
Ammonia	0.5150	**<0.0001**
Arsenic (As)	0.1823	0.7935
Cyanide (CN)	.	.
Cadmium (Cd)	0.4558	0.9503
Copper (Cu)	0.7627	0.7619
Iron (Fe)	0.6992	0.5485
Hardness	.	.
Mercury (Hg)	0.5676	0.7134
Molybdenum (Mo)	0.9190	0.1077
Nickel (Ni)	0.6709	0.7446
Nitrate	0.5080	0.9521
Lead (Pb)	0.6971	0.6919
Radium-226 (Ra)	.	.
Total Suspended Solids (TSS)	0.4584	0.2660
Zinc (Zn)	0.8696	0.2322
pH	0.8557	0.9439

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 in bold face.
In some cases, no analysis could be done because of the high degree of censoring, the lack of variation in a variable 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

	Small Lake Site	
	Little Roberts	Reference D
Variable	Proportion Censored	Proportion Censored
Aluminum (Al)	0.00	0.00
Alkalinity	0.03	0.00
Ammonia	0.34	**0.86**
Arsenic (As)	0.09	0.14
Cyanide (CN)	**0.83**	**1.00**
Cadmium (Cd)	**0.80**	**1.00**
Copper (Cu)	0.00	0.00
Iron (Fe)	0.00	0.00
Hardness	0.00	0.00
Mercury (Hg)	0.57	0.00
Molybdenum (Mo)	0.06	0.00
Nickel (Ni)	0.03	0.00
Nitrate	0.66	0.57
Lead (Pb)	0.20	**0.86**
Radium-226 (Ra)	**0.82**	**1.00**
Total Suspended Solids (TSS)	0.11	0.43
Zinc (Zn)	0.23	**0.86**
pH	0.00	0.00

Notes: Dataset includes all baseline years up to and including 2009, and 2013.
Proportions ≥0.70 are in bold face.

Table Small Lake-2. Summary of Potential Outliers from the Small Lake Data

Lake	Variable	Year	Date	Rep	Reading	Censored (1=yes 0=no)
Little Roberts	Ammonia	2007	24MAY07	1	0.240000	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	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 Variables

	Effect	
	Period Small Lake Site	
	Little Roberts	Reference D
Variable	p-value	p-value
Aluminum (Al)	0.3895	.
Alkalinity	0.6409	.
Ammonia	0.5536	.
Arsenic (As)	0.6903	.
Cyanide (CN)	0.5385	.
Cadmium (Cd)	0.8368	.
Copper (Cu)	0.7123	.
Iron (Fe)	0.8359	.
Hardness	0.5756	.
Mercury (Hg)	0.5198	.
Molybdenum (Mo)	0.2013	.
Nickel (Ni)	0.7653	.
Nitrate	0.9098	.
Lead (Pb)	0.5884	.
Radium-226 (Ra)	.	.
Total Suspended Solids (TSS)	0.6681	.
Zinc (Zn)	0.6801	.
pH	0.0814	.

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 in bold face.
In some cases, no analysis could be done because of the high degree of censoring, the lack of variation in a variable 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

	Large Lake Site		
	Doris North	Doris South	Reference B
Variable	Proportion Censored	Proportion Censored	Proportion Censored
Aluminum (Al)	0.00	0.04	0.00
Alkalinity	0.00	0.00	0.00
Ammonia	0.25	0.63	0.62
Arsenic (As)	0.11	0.29	0.25
Cyanide (CN)	**0.83**	**1.00**	**1.00**
Cadmium (Cd)	**0.73**	**0.98**	**0.75**
Copper (Cu)	0.01	0.00	0.06
Iron (Fe)	0.04	0.16	0.44
Hardness	0.00	0.00	0.00
Mercury (Hg)	0.46	**0.72**	0.50
Molybdenum (Mo)	0.07	0.31	**0.81**
Nickel (Ni)	0.00	0.22	0.44
Nitrate	0.68	0.56	0.69
Lead (Pb)	0.22	0.43	0.50
Radium-226 (Ra)	**0.93**	**0.80**	**1.00**
Total Suspended Solids (TSS)	0.09	0.17	**0.88**
Zinc (Zn)	0.18	0.49	0.62
pH	0.00	0.00	0.00

Notes: Dataset includes all baseline years up to and including 2009, and 2013.
Proportions ≥0.70 are in bold face.

Table Large Lake-2. Summary of Potential Outliers from the Large Lake Data

Lake	Variable	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	Variable	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

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 Variables

	Effect Period Large Lake Site		
Variable	**Doris North p-value**	**Doris South p-value**	**Reference B p-value**
Aluminum (Al)	0.1751	0.5197	**0.0001**
Alkalinity	0.1277	0.1313	0.0327
Ammonia	0.4704	0.1382	**<0.0001**
Arsenic (As)	**0.0023**	0.4093	0.0725
Cyanide (CN)	**0.3736**	**<0.0001**	.
Cadmium (Cd)	0.8029	0.3995	**<0.0001**
Copper (Cu)	0.4922	0.2935	0.0727
Iron (Fe)	0.5705	0.5859	**0.0018**
Hardness	0.0447	**0.0093**	0.0371
Mercury (Hg)	0.3154	**<0.0001**	**0.0001**
Molybdenum (Mo)	**<0.0001**	0.9464	0.1399
Nickel (Ni)	0.7459	0.5511	0.3497
Nitrate	0.1611	0.3759	**0.0040**
Lead (Pb)	0.3098	0.3207	0.1414
Radium-226 (Ra)	**0.0009**	.	.
Total Suspended Solids (TSS)	0.5361	0.8854	**<0.0001**
Zinc (Zn)	**<0.0001**	0.4573	0.0171
pH	0.4146	0.3910	0.5354

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 in bold face.
In some cases, no analysis could be done because of the high degree of censoring, the lack of variation in a variable 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 Variables for Individual Project Large Lake Sites

	Large Lake Site	
	Doris South	Doris North
Variable	p-value	p-value
Aluminum (Al)	0.2474	0.0597
Alkalinity	0.7670	0.6746
Ammonia	0.4049	0.8782
Arsenic (As)	0.4458	0.0336
Cyanide (CN)	.	.
Cadmium (Cd)	0.7178	0.7420
Copper (Cu)	0.2157	0.2536
Iron (Fe)	0.3980	0.3610
Hardness	0.2095	0.4109
Mercury (Hg)	0.0440	0.0405
Molybdenum (Mo)	0.9844	0.0459
Nickel (Ni)	0.1393	0.0202
Nitrate	0.4040	0.5908
Lead (Pb)	0.0204	0.1563
Radium-226 (Ra)	.	.
Total Suspended Solids (TSS)	0.8757	0.5822
Zinc (Zn)	0.5632	0.3065
pH	0.8983	0.7419

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 in bold face.
In some cases, no analysis could be done because of the high degree of censoring, the lack of variation in a variable 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, 2013

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 variables 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 variable. 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 variables fall into one of the two first categories.

1.3 TRANSFORMATIONS

For most variables, 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 sediment particle size composition (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 variable 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 2013. Each waterbody is treated independently and each sediment quality variable is treated separately.

The final statistical model (in standard shorthand notation) is:

$$Y = Period + Year(period)\text{-}R$$

Where *Y* is the (mean) variable 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 variable 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 2013 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 variable 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 variable 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":

$$BACI = \left(\mu_{PA} - \mu_{PB}\right) - \left(\mu_{RA} - \mu_{RB}\right)$$

where μ_{PA} is the mean variable reading in the *Project* class of sites *after* Project initiation, μ_{PB} is the mean variable reading in the *Project* class of sites *before* Project initiation, μ_{RA} is the mean variable reading in the *reference* class of sites *after* Project initiation, and μ_{RB} is the mean variable 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 variable 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 were found for cadmium (at all sites) and mercury (at Doris Outflow and Reference D Outflow). As a consequence, the results of the analyses for these variables 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, and % silt, % clay, % TOC, chromium, copper, lead, and zinc in Little Roberts Outflow.

The results of the BACI comparison (Table Stream-3) found evidence of a differential change in % clay, % TOC, lead, mercury, 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 were found for cadmium (at all sites), mercury (at RBE), and % gravel (at RBW) and the results of the analyses for these variables 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, chromium, copper, lead, and zinc.

A BACI analysis 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 variable (at all sites except Reference Lake B) and the results of the analyses for this variable 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 copper concentration in Doris Lake South; % silt, % clay, and copper concentration in Doris Lake North; and lead concentration 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
Variable	Proportion Censored	Proportion Censored	Proportion Censored	Proportion Censored	Proportion Censored
% Clay (<4μm)	0.33	0.00	0.17	0.33	0.00
% Gravel (>2mm)	0.00	0.33	0.00	0.00	0.00
% Sand (2.0mm - 0.063mm)	0.00	0.00	0.00	0.00	0.00
% Silt (0.063mm – 4μm)	0.17	0.00	0.00	0.00	0.00
Arsenic (As)	0.00	0.00	0.00	0.00	0.00
Cadmium (Cd)	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
Chromium (Cr)	0.00	0.00	0.00	0.00	0.00
Copper (Cu)	0.00	0.00	0.00	0.00	0.00
Lead (Pb)	0.33	0.00	0.33	0.00	0.00
Mercury (Hg)	**0.83**	0.33	0.67	**1.00**	0.67
Total Organic Carbon	0.17	0.33	0.00	0.33	0.00
Zinc (Zn)	0.00	0.00	0.00	0.00	0.00

Notes: Dataset includes all baseline years up to and including 2009, and 2013.
Proportions ≥0.70 are in bold face.

Table Stream-2. Summary of Test for No Difference in Mean between Before and After Periods for Stream Sediment Quality Variables

	Doris OF	Little Roberts OF	Reference B OF	Reference D OF	Roberts OF
Variable	P-value	P-value	P-value	P-value	P-value
% Clay (<4μm)	0.3732	**0.0005**	0.4277	.	.
% Gravel (>2mm)	**0.0023**	0.0125	0.2487	.	.
% Sand (2.0mm - 0.063mm)	**0.0001**	0.0934	0.0281	.	.
% Silt (0.063mm - 4μm)	0.9100	**0.0003**	0.6468	.	.
Arsenic (As)	0.4904	0.0634	0.9157	.	.
Cadmium (Cd)	**<0.0001**	**<0.0001**	**<0.0001**	.	.
Chromium (Cr)	0.1602	**0.0070**	**0.0033**	.	.
Copper (Cu)	0.3694	**0.0018**	0.8188	.	.
Lead (Pb)	0.4330	**0.0021**	0.8601	.	.
Mercury (Hg)	0.3739	0.0112	0.1509	.	.
Total Organic Carbon	0.6963	**0.0003**	0.0470	.	.
Zinc (Zn)	0.2689	**0.0041**	**0.0067**	.	.

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 in bold face.
In some cases, no analysis could be done because of the high degree of censoring, the lack of variation in a variable 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 Variables for Individual Project Stream Sites

	Stream Site	
	Doris OF	Little Roberts OF
Variable	p-value	p-value
% Clay (<4μm)	0.7086	**0.0009**
% Gravel (>2mm)	0.1787	0.0221
% Sand (2.0mm - 0.063mm)	0.0363	0.4491
% Silt (0.063mm - 4μm)	0.6800	0.0225
Arsenic (As)	0.4743	0.0520
Cadmium (Cd)	0.7153	0.7153
Chromium (Cr)	0.4875	0.0194
Copper (Cu)	0.3669	0.0599
Lead (Pb)	0.4636	**0.0035**
Mercury (Hg)	0.0821	**0.0016**
Total Organic Carbon	0.0307	**0.0001**
Zinc (Zn)	0.4768	**0.0018**

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 in bold face.
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

	Marine Site		
	RBE	RBW	REF-Marine 1
Variable	Proportion Censored	Proportion Censored	Proportion Censored
% Clay (<4μm)	0.00	0.00	0.00
% Gravel (>2mm)	0.00	**0.88**	0.67
% Sand (2.0mm - 0.063mm)	0.00	0.00	0.00
% Silt (0.063mm - 4μm)	0.00	0.00	0.00
Arsenic (As)	0.00	0.00	0.00
Cadmium (Cd)	**1.00**	**0.75**	**0.83**
Chromium (Cr)	0.00	0.00	0.00
Copper (Cu)	0.00	0.00	0.00
Lead (Pb)	0.00	0.00	0.50
Mercury (Hg)	**1.00**	0.50	0.50
Total Organic Carbon	0.67	0.62	0.00
Zinc (Zn)	0.00	0.00	0.00

Notes: Dataset includes all baseline years up to and including 2009, and 2013.
Proportions ≥0.70 are in bold face.

Table Marine-2. Summary of Test for No Difference in Mean between Before and After Periods for Marine Sediment Quality Variables

	Marine Site		
	RBE	RBW	REF-Marine 1
Variable	p-value	p-value	p-value
% Clay (<4μm)	.	0.2822	**0.0002**
% Gravel (>2mm)	.	0.4816	0.0645
% 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)	.	**0.0006**	0.2080
Chromium (Cr)	.	**<0.0001**	**0.0001**
Copper (Cu)	.	**<0.0001**	**0.0001**
Lead (Pb)	.	**0.0037**	**0.0001**
Mercury (Hg)	.	0.0447	**0.0008**
Total Organic Carbon	.	**<0.0001**	**0.0006**
Zinc (Zn)	.	**0.0004**	**0.0002**

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 in bold face.
In some cases, no analysis could be done because of the high degree of censoring, the lack of variation in a variable over time, or data are only available from one period (i.e., no "before" data available).

Table Lake-1. Summary of the Proportion of Measurements that were Below Detection Limit

	Lake Site				
	Doris North	Doris South	Little Roberts	Reference B	Reference D
Variable	Proportion Censored	Proportion Censored	Proportion Censored	Proportion Censored	Proportion Censored
% Clay (<4μm)	0.00	0.00	0.00	0.00	0.00
% Gravel (>2mm)	**0.83**	**1.00**	**0.83**	0.00	**1.00**
% Sand (2.0mm - 0.063mm)	0.17	0.17	0.00	0.00	0.00
% Silt (0.063mm - 4μm)	0.00	0.00	0.00	0.00	0.00
Arsenic (As)	0.00	0.00	0.00	0.00	0.00
Cadmium (Cd)	0.00	0.14	0.14	0.00	0.00
Chromium (Cr)	0.00	0.00	0.00	0.00	0.00
Copper (Cu)	0.00	0.00	0.00	0.00	0.00
Lead (Pb)	0.00	0.00	0.00	0.00	0.00
Mercury (Hg)	0.00	0.00	0.00	0.00	0.00
Total Organic Carbon	0.00	0.00	0.00	0.00	0.00
Zinc (Zn)	0.00	0.00	0.00	0.00	0.00

Notes: Dataset includes all baseline years up to and including 2009 and 2013.
Proportions ≥0.70 are in bold face.

Table Lake-2. Summary of Test for No Difference in Mean between Before and After Periods for Lake Sediment Quality Variables

	Lake Site				
Variable	Doris North p-value	Doris South p-value	Little Roberts p-value	Reference B p-value	Reference D p-value
% Clay (<4μm)	0.8432	**0.0021**	0.0262	.	.
% Gravel (>2mm)	0.2381	**<0.0001**	0.3930	.	.
% Sand (2.0mm - 0.063mm)	0.1693	0.1182	0.5294	.	.
% Silt (0.063mm - 4μm)	0.9344	**0.0007**	0.0280	.	.
Arsenic (As)	0.5985	0.7839	0.1949	.	.
Cadmium (Cd)	0.0207	0.8298	0.8533	.	.
Chromium (Cr)	0.3625	0.5692	0.4220	.	.
Copper (Cu)	**0.0001**	**<0.0001**	0.4669	.	.
Lead (Pb)	0.0140	0.0313	**0.0001**	.	.
Mercury (Hg)	0.3017	0.8022	0.9344	.	.
Total Organic Carbon	0.3120	0.2390	0.5657	.	.
Zinc (Zn)	0.8298	0.5961	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 in bold face.
In some cases, no analysis could be done because of the high degree of censoring, the lack of variation in a variable 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, 2013

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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's periphyton 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 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 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 2013. 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 2013 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 variable of interest; *Period* is the effect of period (before or after construction); *Season* is the effect of season (four 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 variable 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 variable reading in the *Project* class of sites *after* Project initiation,μ_{PB} is the mean variable reading in the *Project* class of sites *before* Project initiation,μ_{RA} is the mean variable reading in the *reference* class of sites *after* Project initiation, and μ_{RB} is the mean variable 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 Little Roberts OF and 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	Variable	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

Variable	Proportion Censored	Doris OF p-value	Little Roberts OF p-value	Reference B OF p-value	Reference D OF p-value	Roberts OF p-value
logPeriphyton	0.00	0.2471	.	.	.	.

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 in bold face.

Table Stream-3. Summary of BACI Comparison of Stream Periphyton Biomass for Individual Project Sites

	Doris OF	Little Roberts OF
Variable	p-value	p-value
logPeriphyton	0.0711	0.0811

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 in bold face.
In Roberts OF stream, no readings were taken pre-construction, so no BACI comparison was 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
logPhytoplankton	0.2	0.2	0.00

Table Marine-2. Summary of BACI Comparison of Marine Phytoplankton Biomass for Individual Project Sites

	Marine Site	
	RBE	RBW
Variable	p-value	p-value
logPhytoplankton	0.7810	0.2702

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 in bold face.

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
Variable	Proportion Censored	p-value	p-value	p-value
logPhytoplankton	0.00	0.7760	0.4835	.

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 in bold face.

Table Large Lake-2. Summary of BACI Comparison of Large Lake Phytoplankton Biomass for Individual Project Sites

	Large Lake Site	
	Doris North	Doris South
Variable	p-value	p-value
logPhytoplankton	0.6619	0.8276

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 in bold face.

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
Variable	Proportion Censored	p-value	p-value
logPhytoplankton	0.00	0.9992	.

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 in bold face.
In Reference D, no readings were taken pre-construction, so no BACI comparison was possible.

Appendix B.2.5. Statistical Methodology and Results for Benthos Evaluation of Effects, Doris North Project, 2013

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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 variable values tended to increase with the mean in some waterbodies, but there was no consistent pattern. Given that few 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 variable; *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 variable independently. However, the variables 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 variable value over time is presented in Table Stream-1. There was evidence for non-parallelism in Simpson's Evenness Index at Doris OF and in the Bray-Curtis Index at Roberts OF.

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 for all evaluated variables with the exception of density at RBE.

For the adult-only data, non-parallelism was detected in all evaluated variables.

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 for both Doris Lake South and Doris Lake North. No evidence of non-parallelism was found for any benthos variable 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		
Variable	Doris OF p-value	Little Roberts OF p-value	Roberts OF p-value
Bray-Curtis	0.0469	0.4374	**<0.0001**
Density	0.1793	0.0439	0.0449
Diversity	0.2641	0.6716	0.7345
Evenness	**0.0007**	0.2574	0.3519
Richness	0.3327	0.3378	0.4113

***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 in bold face.*

Table Marine-1. Summary of Tests for Parallelism for the Marine Benthos Data (Adults and Juveniles Pooled)

	Effect	
	Class*Year Marine Site	
Variable	RBE p-value	RBW p-value
Bray-Curtis	**0.0001**	**0.0048**
Density	0.2355	**<0.0001**
Diversity	**0.0026**	**0.0002**
Evenness	**0.0081**	**<0.0001**
Richness	**<0.0001**	**0.0022**

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 in bold face.

Table Marine-2. Summary of Tests for Parallelism for the Marine Benthos Data (Adults Only)

	Effect	
	Class*Year Marine Site	
Variable	RBE p-value	RBW p-value
Bray-Curtis	**<0.0001**	**0.0087**
Density	**<0.0001**	**<0.0001**
Diversity	**0.0004**	**<0.0001**
Evenness	**0.0015**	**<0.0001**
Richness	**<0.0001**	**0.0007**

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 in bold face.

Table Large Lake-1. Summary of Tests for Parallelism for the Large Lake Benthos Data

	Effect	
	Class*Year Large Lake Site	
Variable	Doris North p-value	Doris South p-value
Bray-Curtis	**<0.0001**	**<0.0001**
Density	0.1145	0.0196
Diversity	0.0129	0.1032
Evenness	0.7727	0.0671
Richness	0.0495	0.1019

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 in bold face.

Table Lake-Small-1. Summary of Tests for Parallelism for the Small Lake Benthos Data

	Effect
	Class*Year Small Lake Site
Variable	Little Roberts p-value
Bray-Curtis	0.6586
Density	0.5180
Diversity	0.3006
Evenness	0.0659
Richness	0.0428

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 in bold face.