
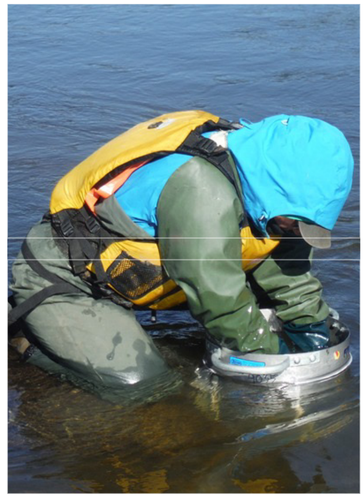


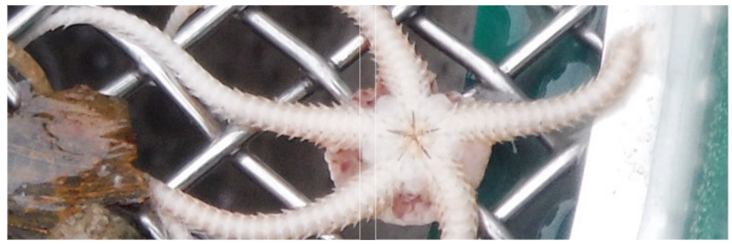

Prepared for:

TMAC RESOURCES

DORIS PROJECT

2016 Aquatic Effects Monitoring Program Report

March 2017

The business of sustainability

ERM

TMAC Resources Inc.

DORIS PROJECT

2016 Aquatic Effects Monitoring Program Report

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Project #0346325-0005

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EXECUTIVE SUMMARY

The Doris Project (the Project) is located on the Hope Bay Belt (the Belt), an 80 by 20 km property along the south shore of Melville Sound in Nunavut. TMAC Resources Inc. (TMAC) acquired the Belt from Newmont Corporation in March 2013. The acquisition included exploration and mineral rights over the Belt, including the Doris 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 site was seasonally closed during the winter of 2012/2013. TMAC re-opened the Doris Camp in March of 2013 for the purposes of conducting site water management and environmental compliance programs and to support exploration activities which have continued through 2016. Following notification to the Nunavut Water Board (NWB) and Nunavut Impact Review Board (NIRB), construction was resumed during the summer of 2015 and continued in 2016.

This report provides the results of the 2016 Aquatic Effects Monitoring Program (AEMP) for the Doris site. The AEMP was designed to detect effects on the aquatic environment largely due to discharge of tailings effluent from the Tailings Impoundment Area (TIA). However, to date, no mine tailings have been placed in the TIA.

The AEMP was conducted in accordance with the *Doris North Gold Mine Project: Aquatic Effect Monitoring Plan* (Rescan 2010c). Five stream sites (Doris Outflow, Roberts Outflow, Little Roberts Outflow, Reference B Outflow, and Reference D Outflow), five lake sites (Doris Lake North, Doris Lake South, Little Roberts Lake, Reference Lake B, and Reference Lake D), and three marine sites (Roberts Bay East, Roberts Bay West, and REF-Marine 1) were monitored. Aquatic components evaluated in 2016 included the following: lake and marine under-ice dissolved oxygen concentrations; 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 density, taxa richness, evenness, diversity, and Bray-Curtis Index. Statistical and/or graphical analyses were performed in order to determine whether there were any apparent effects of Project activities on the aquatic monitoring components in the exposure sites in 2016. The analyses included comparisons of baseline data to current (2016) data and/or comparisons of reference sites to exposure sites through time. Lake and marine fish communities were last surveyed in 2010 (Rescan 2011) and were not resurveyed in 2016.

Table 1 presents a summary of the overall findings of the evaluation of effects for the 2016 AEMP, as well as the corresponding section in this report in which to find the discussion of the evaluation of effects for each monitoring component. Differences in the aquatic monitoring components between baseline years and 2016 were attributed to natural spatial or temporal variability, and there was no evidence of adverse effects to the aquatic environment resulting from Project activities.

Table 1. Summary of Evaluation of Effects for 2016 Aquatic Effects Monitoring Program

Evaluated Variable	Stream Exposure Sites	Lake Exposure Sites	Marine Exposure Sites	Report Section
Winter Dissolved Oxygen	Not Evaluated	No Effect	No Effect	3.1
Secchi Depth	Not Evaluated	No Effect	Not Evaluated	3.2
Water Quality	No Effect	No Effect	No Effect	3.3
Sediment Quality	No Effect	No Effect	No Effect	3.4
Primary Producers	No Effect	No Effect	No Effect	3.5
Benthic Invertebrates	No Effect	No Effect	No Effect	3.6

ᐊᐅᓚᑦᑎᔾᑯᑦ ᓇᐃᓈᖅᓯᒪᔪᑦ ᐅᓂᒃᑳᑦ

ᑐᐊᕆᔅᒥ (Doris) ᐱᓕᕆᐊᒃᓴᖅ (ᐱᓕᕆᐊᒃᓴᖅ) ᓇᔪᕝᕕᖓ Hᐆᑉ ᐱ ᐱᐅᕿᑦᑐᖅ (ᑕᑉᓯ) (Hope Bay Belt), 80-ᒥᑦ ᐊᒻᒪᓗ 20-ᒥᑦ km-ᓂᒃ ᐃᓂᖃᖅᑐᖅ ᓂᒡᕠᐊᓂᑦ ᓴᓴᐳᑉ ᒥᐅᕕᐅᓪ ᓴᐅᙱᓂ (Melville Sound) ᓄᓇᕗᑦ. TMAC-ᑯᑦ ᐱᔪᓐᓇᐅᑎᖃᓚᐅᖅᑐᑦ ᐱᐅᙴᓂᒃ ᓂᐅᒪᓐᑦ (Newmont) ᑯᐊᐳᕆᓴᙱᓂᑦ ᒪᔾ 2013-ᖑᑎᓪᓗᒍ. ᐱᔪᓐᓇᐅᑎ ᐃᓚᒋᔾᖃᖅᑐᖅ ᕿᓂᖅᓱᕐᓂᖅ ᐊᒻᒪᓗ ᐅᔾᕋᐅᔾᕐᓂᒃ ᐱᔪᓐᓇᕐᓂᖅ ᐱᐅᕿᒥᑦ, ᐃᓚᒋᓗᒍ ᑐᐊᕆᔅ ᐅᔾᕋᖕᓂᐊᕝᕕᖓᓂᑦ ᐊᒻᒪᓗ ᐱᔪᓐᓇᐅᑎᖏᑦ, ᓚᐃᓴᖏᑦ ᐊᒻᒪᓗ ᐊᖏᖅᑕᐅᓯᒪᔪᑦ ᐱᕙᓪᓕᐊᓂᕐᒧᑦ ᐱᔾᐅᓯᒪᓕᖅᑐᑦ ᓇᒻᒥᓂᖃᓕᖅᑐᓂᒃ. 2012 ᓄᙳᐊᓂ, ᓂᐅᕕᖅᑕᐅᖅᑳᖅᑎᓐᓇᒍ, Hᐅᑉ ᐱ ᐱᐅᑦ ᐱᓕᕆᐊᒃᓴᖓ ᒥᐊᓂᕆᔾᐅᓚᐅᖅᑐᖅ ᐊᒻᒪᓗ ᐊᐅᓚᑎᑕᐅᓪᓗᓂ, ᐊᒻᒪᓗ ᓇᔪᕝᕕᖓ ᒪᑐᓯᒪᓚᐅᖅᑐᖅ ᐅᑭᐅᖑᑎᓪᓗᒍ 2012/2103-ᖑᑎᓪᓗᒍ. TMAC-ᑯᑦ ᒪᑐᐃᒃᑲᓂᓚᐅᖅᑐᑦ ᑐᐊᕆᔅ ᑕᒻᒫᕝᕕᖓᓂᑦ ᒪᔾ 2013-ᖑᑎᓪᓗᒍ ᐱᔾᔪᑎᖃᖅᑐᒍ ᐱᓕᕆᐊᖃᕐᓂᕐᒧᑦ ᐃᒪᐅᑉ ᐊᐅᓚᓂᖓᓄᑦ ᐊᒻᒪᓗ ᐊᕙᑎᖓᓄᑦ ᐱᔪᓐᓇᕐᓂᕐᒧᑦ ᐱᓕᕆᐊᒃᓴᐃᑦ ᐊᒻᒪᓗ ᐃᑲᔪᕐᓗᒋᑦ ᕿᒥᕐᕈᐊᓂᕐᒧᑦ ᐱᕙᓪᓕᐊᔪᓂᒃ ᑲᔪᓯᓯᒪᔪᒃᑯᑦ 2016-ᒥ. ᒪᓕᒃᓗᒍ ᖃᐅᔨᒃᑲᐃᔾᔪᑎᒥᒃ ᓄᓇᕗᒻᒥ ᐃᒪᓕᕆᔨᒃᑯᑦ ᑲᑎᒪᔨᕐᔪᐊᖏᓐᓂᑦ ᐊᒻᒪᓗ ᓄᓇᕗᒻᒥ ᐊᕙᑎᓕᕆᔨᒃᑯᑦ ᑲᑎᒪᔨᖏᓐᓂᑦ, ᓴᓇᒃᑲᓐᓂᓕᓚᐅᖅᑐᑦ ᐊᐅᔾᖓᓂ 2015 ᐊᒻᒪᓗ ᑲᔪᓯᓪᓗᓕ 2016-ᒥ.

ᑕᒪᓐᓇ ᐅᓂᒃᑳᓕᐊᖅ ᐅᖃᐅᓯᖃᖅᑐᑦ ᖃᓄᐃᓕᐅᖅᓯᒪᔪᓂᒃ 2016 ᐃᒪᕐᒥᐅᑕᓂᒃ ᐱᕙᓪᓕᐊᔪᓂᒃ ᖃᐅᔨᓴᕐᓂᖅ ᐱᓕᕆᐊᒃᓴᖅ (AEMP) ᑐᐊᕆᔅ ᓇᔪᕝᕕᖓᓂ. AEMP-ᑯᑦ ᐋᖅᑭᒃᑕᐅᓯᒪᔪᖅ ᖃᐅᔨᓴᕐᓗᓂ ᐱᕙᓪᓕᐊᔪᓂᒃ ᐃᒪᕐᒥᐅᑕᓂᒃ ᐊᕙᑎᐊᓂᒃ ᐱᔾᔪᑎᖃᓗᐊᖅᑐᖅ ᓴᐅᔾᐅᕙᓪᓕᐊᔪᓂᒃ ᓴᐅᖏᕕᒋᔾᐅᕚᖕᓂᖓᔫᑉ ᓇᔪᕝᕕᐊᓂ (TIA). ᑭᓯᐊᓂ, ᐅᓪᓗᒧᑦ, ᐅᔾᕋᖕᓂᐊᕝᕕᖕᓄᑦ ᓴᐅᔾᐅᔪᖃᖅᓯᒪᙱᑦᑐᖅ TIA-ᒧᐊᖅᑎᑕᐅᓗᑎᒃ.

AEMP-ᑯᖅ ᐱᓕᕆᐊᕆᔾᐅᓚᐅᖅᑐᖅ ᒪᓕᒃᓗᒍ *ᑐᐊᕆᔅ ᐅᐊᖕᓇᖓᓂᑦ ᖃᓐᓄᖃᓂᒃ ᐅᔾᕋᖕᓂᐊᕝᕕᖓᓂᒃ ᐱᓕᕆᐊᒃᓴᖅ: ᐃᒪᕐᒥᐅᑕᓂᒃ ᐱᕙᓪᓕᐊᔪᓂᒃ ᖃᐅᔨᓴᕐᓂᖅ ᐸᕐᓇᐅᑎᖓᓂᒃ* (ᖃᐅᔨᓴᕈᑕᐅᒃᑲᓂᖅᑐᖅ 2010c). ᑕᓪᓕᒪᐃᑦ ᑰᕝᕖᑦ (ᑐᐊᕆᔅ ᑰᕝᕕᒃ, ᕿᐳᑦ ᑰᕝᕕᒃ, ᓕᑐ ᕿᐳᑦ ᑰᕝᕕᒃ, ᕆᕗᕆᓐᔅ B ᑰᐃᕝᕕᒃ ᐊᒻᒪᓗ ᕆᕗᕆᓐᔅ D ᑰᕝᕕᒃ) ᑕᓪᓕᒪᐃᑦ ᑕᓲᑦ ᓇᔪᕝᕕᖏᑦ (ᑐᐊᕆᔅ ᐅᐊᖕᓇᖓᓂ, ᓂᒡᕠᐊᓂᓗ, ᕿᐳᑦ ᐱ ᑕᓯᖓ, ᕆᕗᕆᓐᔅ B ᐊᒻᒪᓗ D), ᐊᒻᒪᓗ ᐱᖓᓱᑦ ᐃᒪᕐᒥᐅᑕᐃᑦ ᓇᔪᕝᕖᑦ (ᕿᐳᑦ ᐱ ᑲᓇᖕᓇᖓᓂ ᐊᒻᒪᓗ ᐱᖓᓐᓇᖓᓂ ᐊᒻᒪᓗ REF-Marine 1) ᖃᐅᔨᓴᖅᑕᐅᓚᐅᖅᑐᑦ. ᐃᒪᕐᒥᐅᑕᐃᑦ ᖃᐅᔨᓴᖅᑕᐅᓚᐅᖅᑐᖅ 2016-ᒥ ᐅᑯᐊᖑᓚᐅᖅᑐᑦ: ᑕᓯᐅᑉ ᐊᒻᒪᓗ ᑕᕆᐅᑉ ᓯᑯᑉ ᐊᑖᓂ ᐊᓂᖅᓵᕈᑎᒃᓴᐃᑦ ᐃᓚᒃᓴᐅᑎᖓᓂᒃ: ᑕᓯᖅ ᓯᓯ (Secchi) ᐃᑎᓂᖓ: ᑰᑦ, ᑕᓲᑦ, ᐊᒻᒪᓗ ᑕᕆᐅᕐᒥ ᐊᒻᒪᓗ ᓴᐅᔾᐅᓂᑯᐃᑦ ᖃᓄᐃᓐᓂᖏᑦ: ᑰᒃ, ᖁᐊᔾᕐᓇᐅᑏᑦ ᐊᖏᓂᖏᑦ; ᑕᓲᑦ ᐊᒻᒪᓗ ᑕᕆᐅᑉ ᐱᕈᖅᓯᐊᑦ ᐆᒪᔪᖏᓐᓂᒃ ᐊᖏᓂᖏᓐᓂᒃ: ᐊᒻᒪᓗ ᑰᑦ, ᑕᓲᑦ ᐊᒻᒪᓗ ᑕᕆᐅᑉ ᓇᑎᐅᕐᒥᐅᑕᖏᓐᓂᒃ ᐆᒪᔪᓂᒃ ᐊᖏᓂᖏᑦ, ᐆᒪᔪᓂᒃ ᐊᒻᒪᓗ ᐱᕈᖅᓯᐊᓂᒃ ᐊᖏᓂᖏᓐᓂᒃ, ᒪᓂᖓ, ᐊᖏᓂᖓ ᐊᒻᒪᓗ ᒥᑭᔪᓂᒃ ᖃᐅᔨᓴᕐᓂᖅ. ᓈᓴᐃᓂᖅ ᐊᒻᒪᓗ/ᐅᕝᕙᓘᓐᓃᑦ ᓇᒦᓐᓂᖏᓐᓂᒃ ᖃᐅᔨᓴᕐᓂᖅ ᐱᓕᕆᐊᕆᔾᐅᓚᐅᖅᑐᑦ ᖃᐅᔨᒍᑕᐅᔪᓐᓇᕐᓗᒋᑦ ᐱᕙᓪᓕᐊᔪᓂᒃ ᐱᓕᕆᐊᒃᓴᒧᒃ ᐱᕙᓪᓕᐊᓂᖓᓄᑦ ᐃᒪᕐᒥᐅᑕᓂᒃ ᖃᐅᔨᓴᕐᓂᒃᑯᑦ ᕿᒥᕐᕈᐊᖅᑎᓪᓗᒋᑦ ᓇᔪᕝᕕᐅᔪᓂᑦ 2016-ᖑᑎᓪᓗᒍ. ᖃᐅᔨᓴᖅᑕᐅᓚᐅᖅᑐᑦ ᐊᔾᔨᒌᙱᑦᑐᒃᑯᑦ ᓇᔪᕝᕕᐅᔪᓂᑦ ᑎᑎᕋᖅᓯᒪᔪᒃᑯᑦ ᒫᓐᓇᒃᑯᑦ (2016) ᑎᑎᕋᖅᓯᒪᔪᒃᑯᑦ ᐊᒻᒪᓗ/ᐅᕝᕙᓘᓐᓃᑦ ᐊᔾᔨᒌᙱᑦᑐᓂᒃ ᑎᑎᕋᖅᑕᐅᓯᒫᓂᒃᑐᓂᒃ ᓇᔪᕝᕕᖕᓂᙶᖅᑐᓂᒃ ᐊᐅᓚᑎᓪᓗᒋᑦ. ᑕᓲᑦ ᐊᒻᒪᓗ ᑕᕆᐅᑉ ᐃᖃᓗᐃᑦ ᓇᔪᕝᕕᖏᑦ ᑭᖑᓪᓕᒃᑯᑦ ᖃᐅᔨᓴᖅᑕᐅᓚᐅᖅᑐᑦ 2010-ᖑᑎᓪᓗᒍ (ᖃᐅᔨᓴᖅᑕᐅᒃᑲᓐᓂᖅᑐᑎᒃ 2011) ᐊᒻᒪᓗ ᖃᐅᔨᓴᖅᑕᐅᙱᑦᑐᑎᒃ 2016-ᒥ.

ᓇᓗᓇᐃᒃᑯᑕᖅ 1 ᑕᑯᑎᑦᑎᔪᖅ ᓇᓗᓇᐃᒃᑯᑕᓂᒃ ᖃᓄᐃᓕᐅᖅᓯᒪᔪᓂᒃ ᖃᐅᔨᓴᖅᑎᓪᓗᒋᑦ ᐱᕙᓪᓕᐊᔪᓂᒃ 2016 AEMP-ᑯᓐᓄᑦ, ᐊᒻᒪᓗ ᑭᐅᔾᔪᑎᖏᑦ ᓇᓗᓇᐃᒃᑯᑕᓂ ᑖᓯᒪ ᐅᓂᒃᑳᖏᓐᓂ ᐅᖃᐅᓯᐅᔪᓂᒃ ᖃᐅᔨᓴᕐᓂᕐᒧᑦ ᐱᕙᓪᓕᐊᔪᓂᒃ ᖃᐅᔨᓴᖅᑕᐅᓯᒪᔪᓂᒃ ᐊᔾᔨᒋᙱᑦᑐᒃᑯᑦ. ᐊᔾᔨᒋᙱᓐᓂᖏᑦ ᐃᒪᕐᒥᐅᑕᓂᒃ ᖃᐅᔨᓴᕐᓂᖅ

ᐅᑭᐅᒋᔭᑎᒍᑦ ᐊᒻᒪᓗ 2016 ᐱᔭᐅᓯᒪᔪᑦ ᑕᐃᒪᐃᓐᓂᖅᐸᓄᑦ ᐅᕝᕙᓘᓐᓃᑦ ᐊᔾᔨᒌᙱᓚᐅᑲᕐᓂᖅᐸᒍᑦ, ᐊᒻᒪᓗ ᖃᐅᔨᓯᒪᙱᑦᑐᑦ ᐊᖏᔪᒃᑯᑦ ᐱᙳᓪᓕᐊᔪᓂᒃ ᐃᒪᕐᒥᐅᑕᓂᒃ ᓇᔪᕐᕕᐅᔪᓂᒃ ᐱᓕᕆᐊᒃᓴᐅᑉ ᐃᓚᖅᐸᓂ.

ᓇᓗᓇᐃᒃᑯᑕᖅ 1. ᓇᐃᓈᖅᓯᒪᔪᑦ ᖃᐅᔨᓴᖅᑕᐅᓂᒍᑦ ᐱᙳᓪᓕᐊᔪᑦ 2016 ᐃᒪᕐᒥᐅᑕᐃᑦ ᐱᙳᓪᓕᐊᔪᓂᒃ ᖃᐅᔨᓴᕐᓂᖅ ᐱᓕᕆᐊᒃᓴ

ᖃᐅᔨᓴᖅᑕᐅᓯᒪᔪᑦ	ᑯᕝᕕᐅᔪᑦ ᓇᔪᕐᕕᖕᒋᑦ	ᑕᓯᕐᒥ ᓇᔪᕐᕕᖕᒋᑦ	ᑕᕆᐅᒥ ᓇᔪᕐᕕᖅᐸ	ᐅᓂᒃᑳᓕᐅᖅᑕᐅᔪᑦ ᓇᓗᓇᐃᒃᑯᑕᐃᑦ
ᐅᑭᐅᒃᑯᑦ ᐃᓚᒃᓴᐃᑦ ᐊᓂᖅᓵᖅᓴᐃᑦ	ᖃᐅᓴᖅᑕᐅᙱᑦᑐᑦ	ᓱᓐᓂᙱᑦᑐᑦ	ᓱᓐᓂᙱᑦᑐᑦ	3.1
ᓯᓯ (Secchi) ᐃᑎᓂᖅᐸ	ᖃᐅᓴᖅᑕᐅᙱᑦᑐᑦ	ᓱᓐᓂᙱᑦᑐᑦ	ᖃᐅᓴᖅᑕᐅᙱᑦᑐᑦ	3.2
ᐃᒪᐅᑉ ᖃᓄᐃᑦᑑᓂᖅᐸ	ᓱᓐᓂᙱᑦᑐᑦ	ᓱᓐᓂᙱᑦᑐᑦ	ᓱᓐᓂᙱᑦᑐᑦ	3.3
ᓴᐅᔭᐅᓂᑯᐃᑦ ᖃᓄᐃᑦᑑᓂᖅᐸ	ᓱᓐᓂᙱᑦᑐᑦ	ᓱᓐᓂᙱᑦᑐᑦ	ᓱᓐᓂᙱᑦᑐᑦ	3.4
ᓯᕗᓪᓕᒃᑯᑦ ᓂᕿᒋᔭᐅᕙᒃᑐᖅ	ᓱᓐᓂᙱᑦᑐᑦ	ᓱᓐᓂᙱᑦᑐᑦ	ᓱᓐᓂᙱᑦᑐᑦ	3.5
ᐃᒪᐅᑉ ᐊᑖᓂ ᐆᒪᔪᑦ ᕿᒥᕐᓗᖃᙱᑦᑐᓂᒃ	ᓱᓐᓂᙱᑦᑐᑦ	ᓱᓐᓂᙱᑦᑐᑦ	ᓱᓐᓂᙱᑦᑐᑦ	3.6

IHUMALIURUTIKHANUT NAILIYAUHIMAYUT

Hamna Doris Havaariyakhaat (Havaariyakhaat) nayugaat uvaniittuq Kapihiliktuk (Uyaraqtarvik), uvani 80 nut 20 km havaangit hinaaniittuq tununnganit hinaani Melville Sound Nunavunmi. TMAC Resources Inc. (TMAC) ilitturviuhimayangit Nunam ilangani hamanngat Newmont Kuapuriisan uvani Qiqailruq 2013 mi. Hamna ilitturningit ilaliutigiyait qauyiharnikhait uyuraqtarviuyukhat piyunnautikhait Nunangani ilangani, ilaliutigiyait hamna Doris Kulu Uyaraqtarvik piyunnautigivlugillu, laisikhainiglu, unalu aulattitiyukhallu pivallianikhait tuniyauhimayut nanminiriyaraluangit. Kinguani 2012 mi, niuviqtinnatik, hamna Kapihiliktuk Havaangit amiriyauhimagaluaqtut ihuaqhaivlutik, unalu havagviat umikhimagaluaqtut ukiungani2012/2013. TMAC angmaffaarmivlugit hamna Doris Havagvikhaat uvani Qiqailruq 2013 mi hivuniginahuaqhugit aullaqtirivlugulu nayugaanit imaita amiqhaivlutik avatingillu angiqtaunianut piliriakhait ikayurahuaqhugillu qauyiharnikhat hulidjuhiit huli havakhimmaaqhugit uvani 2016 mut. Malikhugulu naunaitkuhikhait uvunga Nunavunmi Imarnut Katimayit (NWB) Nunavut Avatiliqiyit Katimayitalu (NIRB), havaangit aullaqtilirmivlugit auyami 2015 mi huli havakhimmaaqhutik 2016 milu.

Una unipkaangit ilaliutigiyait kiudjuhingit haffumani 2016 mi Imarmiuttanut Atuliqtauyukhanut Amiqhaivikhangit Piliriakhat (AEMP) haffumani Doris havagvianut. Hamna AEMP tiliuqhimayauyut naunaiqhiivlutik atuliqtauyukhanut uumani imarmiuttait avatikhanut angitqiyaanit unguvaqtigiami attarviit qurluangit hamanngat Attarviit Nutqarutaat Iningit (TIA). Kihiani, ublumimut, uyaraqtarviuhimaittut attarviit iliuraihimanngittut uvani TIA nit.

Una AEMP aullaqtiqhimagaluaqtuq atauttimut uuminngat *Doris Nuat Kulu Uyaraqtarvik Havaangit: Imarmiuttanut Atuliqtauyukhanut Amiqhaivikhat Upalungaiyautikhaq* (Rescan 2010c). Tallimat kuugannuat nayugaanit (Doris Qurluarningit, Roberts Qurluarningit, Mikiyunnuaq Roberts Qurluarningit, Reference B Qurluarningit , unalu Reference D Qurluarningit), unalu tallimat tattit nayugaanit (Doris Tahiq Hivuraanit, Doris Tahiq Tununnga, Mikiyunnuaq Roberts Tahiq, unalu Reference Tahiq B, unalu Reference Tahiq D), unalu pingahut imarmiuttat nayugaat (Roberts Bay Kivataa, Roberts Bay Uataa, unalu REF-Imarmiuttaq 1) amiqhaihimagaluaqtut. Imarmiuttait ilaliutingit ihivriuqhimayauyut uvani 2016 mi ilagivluniuk hapkuanguyut: tahiq imarmiuttait hikum ataaniittut nunguttut anirnilgit atuqpaktangit; tahiup ataaniittuni uumayulgit hitingnia; kuukkait, tahiq, imarmiuttat imangit hiuraillu nakuudjuhia; kuukkam qurluarningit hakugingnialu, tahiq imarmiuttanillu kumaruit amihuuningit; kuukkangillu tahiq imarmiuttanillu iluaniittut avatingit hivituningit, amihuit uumayuit amihurningit, naliriiqtut, unalu Bray-Curtis Ilitturningit. Naunaiyainingit unalu/takunnaqtuugumi naunaiyaiyut pivlutik ihumaliurahuarlutik qanuq aktuqhimayaukpata Havaatigut hulidjuhiit uvanngat imarmiuttat amiqhainikhainut ilaliutainit takunnaqtut nayugaanit 2016 mi. Hamna naunaiyainingit ilaliutigiyait aallatqiinguyut haffumani turaarviuhimayut nayugaanit takunnaqtuugumik nayugaanit qakugunnguraangat. Tahiq imarmiuttait iqalut nunaqatigiiktut naunaiqtauhimagaluaqtut 2010 mi (Rescan 2011) ihivriuqtauhimaittullu 2016 mi.

Naunaitkutaq 1 takunnaqhuni nainaaqhimayuq haffumani tamainnut naunaiqhiigaluaqtut ilittuqhiuvlutik aktuqtaunianut haffumani 2016 AEMP, uuminngattauq ilitturvikhainnut ilangani uvani unipkaarunmi naunaiqhiiyukhat niplautigihimagaluaqtangit haffumani ihivriurningit aktuqtaunianut tamainnut ilittuqhimayauyut ilangani unipkaarunmi ihivriurningit aktuqtaunianut tamainnut amirihimayauyut ilaliutait. Aallatqiit iluani imarmiuttait amiqhainikhainut ilaliutingit uvanngat kigliliugainnut ukiunganit uvani 2016 mi ilitarihimayauyut ilitquhiita akuningit uuminngaluuniit nunamiunit aallatqiingutingit, unalu ilihimaittut ilittuqhiivikhainit nakuunngittunik aktuqtaunianut imarmiuttanit avatingit Havaariyauyum huliyakhainnut.

Naunaitkutaq 1. Nainaaqhimayuq uumani Ihivriuqtauningit Atuliqtauyukhanut haffumani 2016 mi Imarmiuttat Atuliqtaunianut Amiqhainikhanut Piliriakhaq

Ihivriurningit Aallannguqtiqattaqtut	Kuukkat Ilittuqhimayut Nayugaat	Tahit Ilittuqhimayut Nayugaat	Taryurmit Ilittuqhimayut Nayugaat	Unipkaarutingit Ilangani
Imarmiuttat Nunguttut Anirningit	Ihivriuqtaunngittut	Atuliqtaqanngittut	Atuliqtaqanngittut	3.1
Uuktuutiningit Ihiqagiakhaa imaup qaangani	Ihivriuqtaunngittut	Atuliqtaqanngittut	Ihivriuqtaunngittut	3.2
Imaup Nakuurningit	Atuliqtaqanngittut	Atuliqtaqanngittut	Atuliqtaqanngittut	3.3
Hiuraq Nakuurningit	Atuliqtaqanngittut	Atuliqtaqanngittut	Atuliqtaqanngittut	3.4
Hivunngani Nanminiqutingit	Atuliqtaqanngittut	Atuliqtaqanngittut	Atuliqtaqanngittut	3.5
Uumayuit Taryum Natiani Ittut	Atuliqtaqanngittut	Atuliqtaqanngittut	Atuliqtaqanngittut	3.6

SOMMAIRE

Le projet Doris (le projet) est situé sur la ceinture de Hope Bay (la ceinture), une propriété de 80 sur 20 km le long de la rive sud du détroit Melville au Nunavut. TMAC Resources inc. (TMAC) a acquis la ceinture auprès de Newmont Corporation en mars 2013. L'acquisition comprenait des droits de prospection et d'exploitation minière sur la ceinture, y compris la mine d'or Doris et ses permis, ses licences et ses autorisations d'aménagement accordés aux propriétaires précédents. À la fin de 2012, avant la vente, le projet de la ceinture de Hope Bay a été mis en état d'entretien et de maintenance, et le site a été fermé de manière saisonnière pendant l'hiver 2012-2013. TMAC a rouvert le camp Doris en mars 2013 afin de mener des programmes de gestion de l'eau du site et de conformité environnementale, ainsi que pour soutenir les activités de prospection qui se sont poursuivies jusqu'en 2016. Après la notification à l'Office des eaux du Nunavut (OEN) et à la Commission du Nunavut chargée de l'examen des répercussions (CNER), la construction a repris au cours de l'été 2015 et s'est poursuivie en 2016.

Le présent rapport fournit les résultats du Programme de surveillance des répercussions sur le milieu aquatique (PSRMA) 2016 pour le site Doris. Le PSRMA a été conçu pour détecter les répercussions sur le milieu aquatique attribuables en grande partie à l'évacuation des effluents de résidus de la zone de retenue des résidus (ZRR). Cependant, à ce jour, aucun résidu minier n'a été placé dans la ZRR.

Le PSRMA a été mené conformément au projet *Doris North Gold Mine* : *Plan de surveillance des répercussions sur le milieu aquatique* (Rescan 2010c). Cinq sites de cours d'eau (l'exutoire Doris, l'exutoire Roberts, l'exutoire Little Roberts, l'exutoire Référence B et l'exutoire Référence D), cinq sites de lacs (le lac Doris Nord, le lac Doris Sud, le lac Little Roberts, le lac Référence B et le lac Référence D) et trois sites marins (la baie Roberts Est, la baie Roberts Ouest et REF-Marine 1) ont été surveillés. Les composantes aquatiques évaluées en 2016 comprenaient les éléments suivants : les concentrations d'oxygène dissous sous la glace dans les milieux lacustres et marins, la profondeur des lacs d'après le disque de Secchi, la qualité de l'eau des cours d'eau, des lacs, des milieux marins et du sédiment, la biomasse de périphyton des cours d'eau, la biomasse du phytoplancton des milieux lacustres et marins, la densité de la communauté d'invertébrés benthiques des cours d'eau, des lacs et des milieux marins, la richesse taxonomique, l'homogénéité, la diversité et l'indice de Bray-Curtis. Des analyses statistiques et graphiques ont été menées pour déterminer si les activités du projet avaient pu affecter les composantes de surveillance aquatique des sites d'exposition en 2016. Les analyses comprenaient des comparaisons des données de référence aux données actuelles (2016) ou à des comparaisons de sites de référence aux sites d'exposition dans le temps. Les communautés de poissons lacustres et marins ont été examinées pour la dernière fois en 2010 (Rescan 2011) et n'ont pas été réexaminées en 2016.

Le tableau 1 présente un résumé des conclusions générales de l'évaluation des répercussions pour le PSRMA 2016, ainsi que la section correspondante de ce rapport dans laquelle se trouve la discussion concernant l'évaluation des répercussions pour chaque composante de suivi. Les différences entre les composantes de surveillance aquatique entre les années de référence et 2016 ont été attribuées à la variabilité spatiale ou temporelle naturelle et il n'y avait aucune preuve de répercussions néfastes sur le milieu aquatique résultant des activités du projet.

Tableau 1. Sommaire de l'évaluation des répercussions sur le Programme de surveillance des répercussions sur le milieu aquatique 2016

Variable évaluée	Sites d'exposition de cours d'eau	Sites d'exposition de lacs	Sites d'exposition marins	Section du rapport
Oxygène dissous d'hiver	Non évalué	Aucun effet	Aucun effet	3.1
Profondeur d'après le disque de Secchi	Non évalué	Aucun effet	Non évalué	3.2
Qualité de l'eau	Aucun effet	Aucun effet	Aucun effet	3.3
Qualité du sédiment	Aucun effet	Aucun effet	Aucun effet	3.4
Producteurs primaires	Aucun effet	Aucun effet	Aucun effet	3.5
Invertébrés benthiques	Aucun effet	Aucun effet	Aucun effet	3.6

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Field-related logistics support was provided by TMAC, Acasta HeliFlight, Braden Burry Expediting, and Nuna Logistics.

DORIS PROJECT

2016 Aquatic Effects Monitoring Program Report

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GLOSSARY AND ABBREVIATIONS

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

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
the Belt	Hope Bay Belt
Benthos	Benthic invertebrates
BTD	Below the Dyke (mineral deposit)
Bq	Becquerel
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
Degrees of Freedom	The term *degrees of freedom* refers to the number of items that can be freely varied in calculating a statistic without violating any constraints. Such items typically include observations, categories of data, frequencies, or independent variables. Because the estimation of parameters imposes constraints on a data set, a degree of freedom is generally sacrificed for each parameter that must be estimated from sample data before the desired statistic can be calculated (Eisenhauer 2011).
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	ERM Consultants Canada Ltd.
Exposure areas	Areas anticipated to be potentially influenced by mining-related activities as part of the Doris Project.
F	Family richness
GA	Graphical analysis
HBML	Hope Bay Mining Limited
ILBT	Impact level-by-time
INAC	Indigenous and Northern Affairs Canada
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 Plan	the Doris North Gold Mine Project: Aquatics Effects Monitoring Plan
the Project	the Doris 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 seawater 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
$\mathbf{Z_{1\%}}$	The 1% euphotic depth, i.e., the depth of the water column at which 1% of the surface irradiance reaches.

1. INTRODUCTION

The Doris Project (the Project) is located on the Hope Bay Belt (the Belt), an 80 by 20 km property along the south shore of Melville Sound in Nunavut (Figure 1-1). The Belt consists of a greenstone 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 approximately 125 km southwest of Cambridge Bay (Iqaluktuttiaq) 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 Belt from Newmont Corporation in March 2013. The acquisition included exploration and mineral rights over the Belt, including the Doris Gold Mine and its permits, licences, and authorizations for development received by previous owners. In late 2012, prior to the sale, the Hope Bay Project was placed into care and maintenance, and the site was seasonally closed during the winter of 2012/2013. TMAC re-opened the Doris Camp in March of 2013 for the purposes of conducting site water management and environmental compliance programs and to support exploration activities which continued through 2016. Following notification to the Nunavut Water Board (NWB) and Nunavut Impact Review Board (NIRB), construction was resumed during the summer of 2015 and continued in 2016.

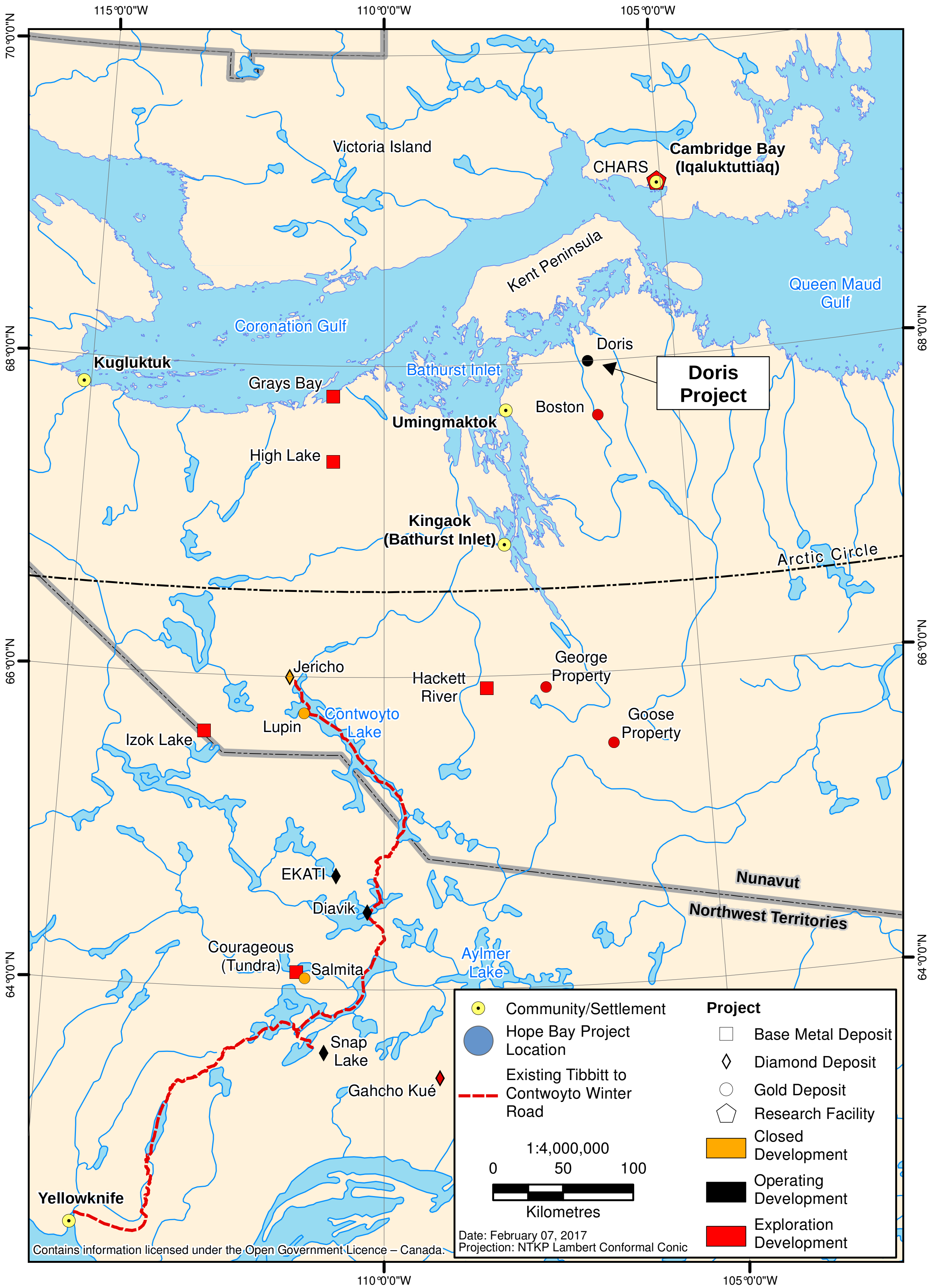
This report provides the results of the 2016 Aquatic Effects Monitoring Program (AEMP) for the Doris site. The AEMP was designed to detect effects on the aquatic environment largely due to discharge of tailings effluent from the Tailings Impoundment Area (TIA). However, to date, no mine tailings have been placed in the TIA.

The AEMP was conducted according to the *Doris North Gold Mine Project: Aquatic Effects Monitoring Plan* (the Plan; Rescan 2010c). The Plan was developed to comply with Part K, Item 7 and Part K, Item 8 of the Doris North Nunavut Water Board (NWB) Type A Water Licence (No. 2AM-DOH0713, issued September 19, 2007; NWB 2007). The Plan was approved by the NWB on March 25, 2010, under Motion 2009-23-L04.

On September 12, 2013, a renewed and amended Type A Water Licence was issued to TMAC. Part K, Item 7 of this Type A Water Licence (NWB Licence #2AM-DOH1323) required that a revised Plan be submitted to the NWB for approval six months prior to Operations. A revised Plan (TMAC 2016) was submitted and approved according to this requirement with the issuance of the amended water licence on December 16, 2016. Monitoring under the revised Plan will commence in 2017.

Figure 1-1
Doris Project Location

ERM



1.1 OBJECTIVES

The Plan design was driven by the requirements of the Metal Mining Effluent Regulations (MMER; SOR/2002-222) and the anticipated location of Project activities during the Construction, Operation, and Closure phases of the mine. The MMER stipulates that mines are required to conduct Environmental Effects Monitoring (EEM) if mine effluent discharge rates exceed 50 m^3 per day and deleterious substances are discharged into any waterbody 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 AEMP were to monitor and evaluate potential effects of Project activities on the following components in waterbodies in the Project area:

- water quality and water column structure;
- sediment quality;
- primary producer biomass (phytoplankton and periphyton);
- benthic invertebrate community (density and taxonomy); and
- fish.

Fish were last sampled in 2010 (Rescan 2011). The second year of fish monitoring was postponed from 2013 in alignment with the postponement of the mine development schedule.

1.2 2016 PROJECT ACTIVITIES

The Project was in the construction phase throughout 2016. Construction activities included completion of the processing plant building and initiation of construction of the processing plant, tailings discharge pipeline, reclaim water pipeline and associated emergency catchment basins. TMAC relocated and commissioned a 400,000 L tank in the 15,000,000 L tank farm at Roberts Bay for the storage of Jet-A fuel. Improvements to the permanent powerhouse and installation of a glycol heat recapture system to heat the process plant building began. TMAC continued earthworks activities related to the process plant camp pad and improvements of the Doris Airstrip. Advancement of the TIA access road toward the future location of the South Dam continued and a Reagent Storage berm and Explosives Storage berm were also constructed (Figure 1.2-1).

Underground development continued in 2016. Significant activities included the delivery of additional mining equipment via sealift. TMAC developed a new ramp and multiple levels in Doris North to expand the mine and prepare for longhole production in 2017. Longhole stope drilling and blasting was successfully started in late 2016. Underground exploration diamond drilling was completed in 2016 to define the new Doris Below The Dyke (BTD) mineral resource. Additional ramp development began in 2016 to access the BTD in 2017 and expand the mine life of Doris North. Ore from the development drifting was stockpiled on surface for processing in 2017.

In the fall, TMAC successfully concluded the 2016 sealift including the purchase and delivery of 12,000,000 L of diesel fuel, 400,000 L of Jet-A fuel, delivery of the components necessary to complete construction of the processing plant, tailings and reclaim lines, and the reagents required for commissioning and start-up of the plant in early 2017. Additional underground and surface equipment arrived to expedite the development of the Doris project site.

TMAC continued with diamond-drill exploration near Doris and Madrid deposits in 2016, and completed an airborne geophysics program of the Hope Bay Belt and the nearby Elu belt crown mineral claims.

In 2016 there was no water discharged from the TIA into Doris Creek.

The main potential interactions between the Project and the aquatic freshwater and marine environment relevant to Type A Water Licence 2AM-DOH1323 applicable to the 2016 field season (i.e., prior to the issuance of the amended Water Licence on December 16, 2016) were:

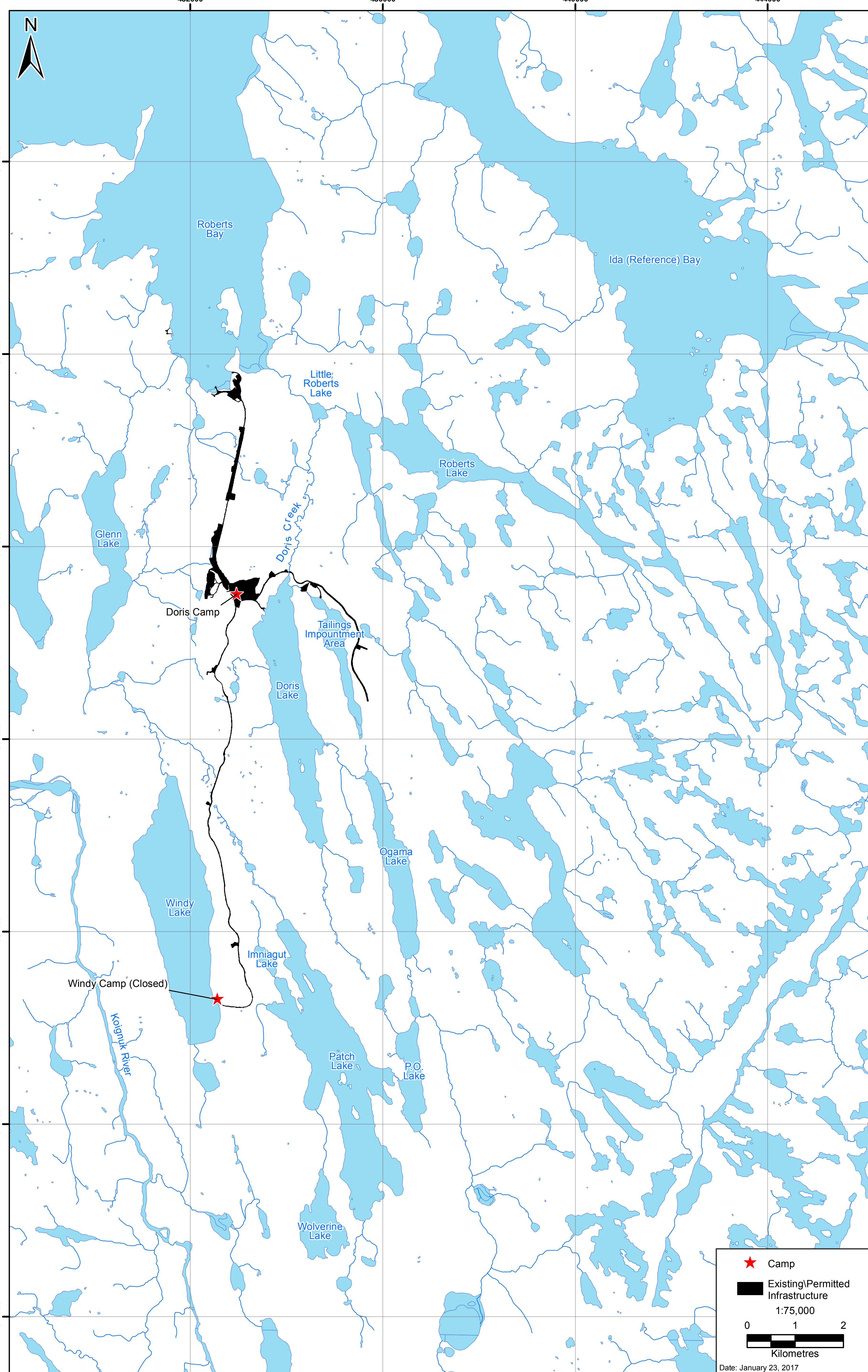
- the operation of the TIA: treated effluent from this facility is expected to be released into Doris Outflow where it would flow successively through Little Roberts Lake and into Little Roberts Outflow before entering Roberts Bay. However, no water was discharged in 2016;
- shipping activity at the marine jetty in southern Roberts Bay;
- construction of roads and infrastructure;
- runoff from site infrastructure, roads, waste rock (seepage from these sites are monitored through the Quarry and Waste Rock Monitoring Program and reported separately on an annual basis);
- accidental spills.

Mitigation measures to reduce the potential for adverse effects to stream, lake, and marine habitats in the Project area included surface water runoff management, dust abatement measures, site water management, tailings management, quarry and waste rock management, and waste management.

1.3 REPORT STRUCTURE

This document presents the methods, effects analysis, and conclusions of the 2016 Program. Detailed sampling and data analysis methodology, raw data, and results from the 2016 Program (including water column structure, water quality, sediment quality, primary producers, and benthic invertebrates) are provided in Appendix A. Supplemental information relevant to the 2016 effects analysis is provided in Appendix B.

Figure 1.2-1
Existing Infrastructure, Doris Project



2. METHODS

2.1 SUMMARY OF STUDY DESIGN

The 2016 Program was conducted in accordance with the Doris North Gold Mine Project: Aquatic Effects Monitoring Plan (Rescan 2010c).

2.1.1 Study Area and Sampling Locations

The AEMP study area included those areas that may be influenced by mining-related activities as part of the 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 (Table 2.1-1; Figure 2.1-1). Two marine exposure sites and one marine reference site were also sampled (Table 2.1-1; Figure 2.1-1). Sampling sites, the aquatic components sampled, Project infrastructure, and the projected flow path of the treated TIA effluent as per the current Type A Water Licence 2AM-DOH1323 are shown in Figure 2.1-1.

2.1.1.1 Exposure Sites

The principal exposure sites in the AEMP study area are those waterbodies downstream of discharge from the TIA. From upstream to downstream, these 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 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 TIA discharge path. A receiving environment site is in eastern Roberts Bay (RBE) where Little Roberts Outflow enters the marine habitat.

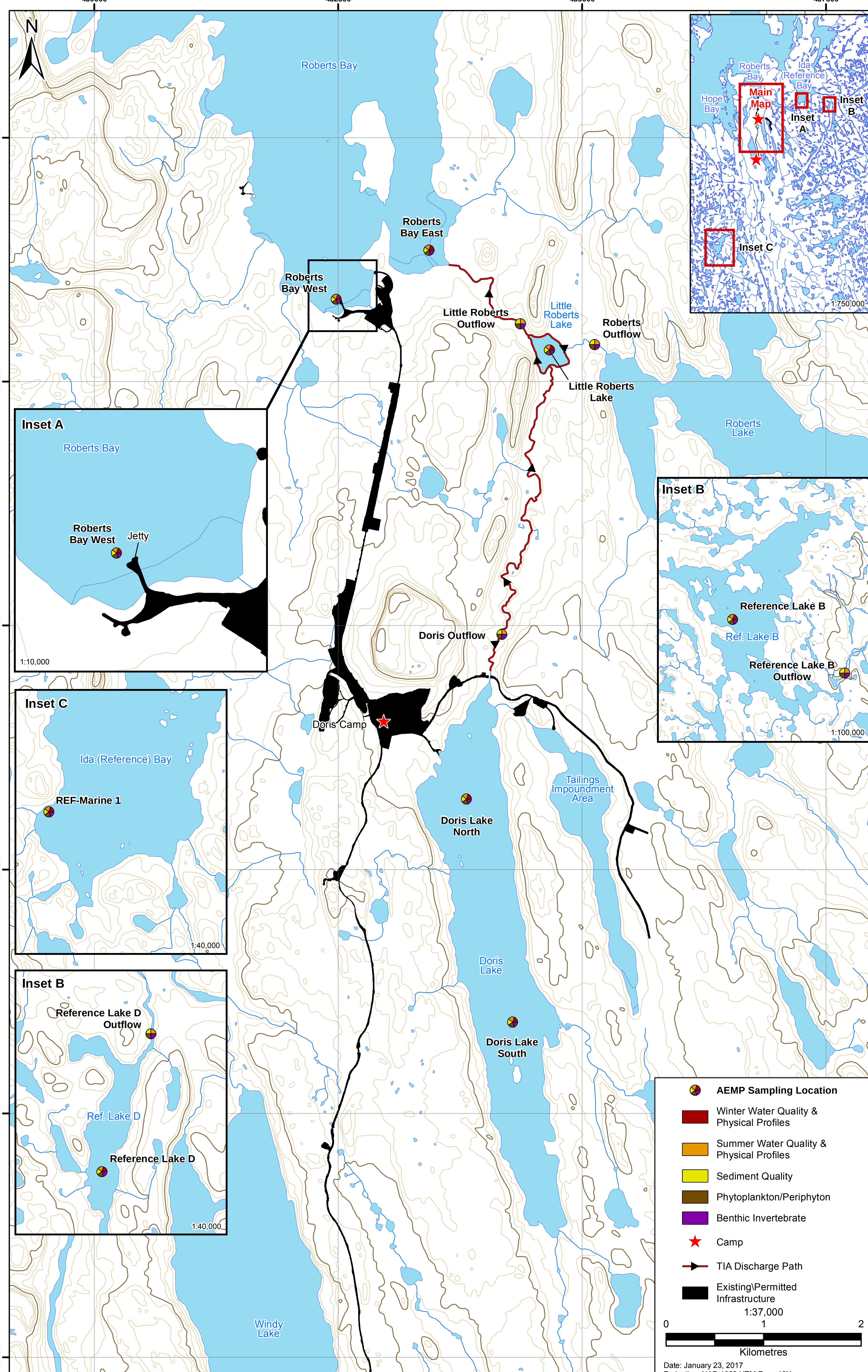
In addition to the sampling sites that could potentially be affected by TIA discharge, sites were also selected to capture other potential effects of the Project. These sites include two sampling locations in Doris Lake (adjacent to site infrastructure and roads), and a single site in western Roberts Bay (Roberts Bay West; RBW) near the marine jetty (roads, site infrastructure, marine loading/unloading activities).

Although Roberts Outflow is considered an exposure stream site, this stream is not expected to be affected by the Project but rather serves to characterize any influence of non-project related activities on Little Roberts Lake and its outflow. Non-project influences on Little Roberts Lake and its outflow may result from an abandoned silver mine (now closed by Indigenous and Northern Affairs Canada (INAC)) and past neighbouring exploration activity (North Arrow Minerals Inc.) on the upstream Roberts Outflow. Collecting information from this Roberts Outflow location thus enables differentiation of such non-Project effects from potential effects of TIA discharge upstream.

Table 2.1-1. AEMP Sampling Locations, Descriptions, and Purposes, Doris Project, 2016

Sampling Location	Coordinates (13W)	Description	Purpose
Streams			
Doris Outflow	434177E 7559910N	Immediately downstream of (former) discharge point from the TIA	First exposure site downstream of (former) 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
Little Roberts Outflow	434367E 7563094N	Stream downstream of Little Roberts Lake	Second exposure stream downstream of (former) TIA discharge location
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
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
Lakes			
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)
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
Little Roberts Lake	434665E 7562826N	Small lake downstream of Doris Outflow	First and only lake exposed to upstream TIA discharge
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 Lake D	447566E 7561301N	Small reference lake located west of the Project	Reference lake meant to closely resemble the morphology, habitat, and fish community of Little Roberts Lake
Marine			
Roberts Bay West (Jetty; RBW)	432479E 7563346N	Small marine bay where jetty is located	Potential exposure marine area due to marine activities and infrastructure
Roberts Bay East (RBE)	433430E 7563850N	Marine bay into which Little Roberts Lake drains	Marine receiving environment for freshwater system downstream of (former) TIA discharge location
Ida (Reference) Bay (REF-Marine 1)	441152E 7563018N	Marine bay located west of the Project	Marine reference area meant to provide a reference for the two potential marine exposure sites (Roberts Bay East, Roberts Bay West (Jetty))

Figure 2.1-1
AEMP Sampling Locations, Doris Project, 2016



In all, there are three stream exposure sites, three 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 2016 sampling to improves the comparability with the Doris North sampling location, which is also in a deep basin (> 10 m deep; Figure 2.1-1). The Little Roberts Lake sampling location was moved approximately 90 m in 2014 to a deeper location so representative under-ice samples could be collected. The 2016 sampling location in Little Roberts Lake was consistent with the 1995 to 1997, 2003 to 2009, 2014, and 2015 sampling location (Figure 2.1-1).

2.1.1.2 Reference Sites

Three reference areas were included in the AEMP: two lake/stream outflow systems (Reference Lakes/Outflows B and D) and one marine site (Ida Bay; Figure 2.1-1). The two lake/stream outflow areas (Reference Lake B/Reference B Outflow and Reference Lake D/Reference D Outflow) were used as reference sites for comparability with exposure freshwater sites. Reference Lake D (area: 0.6 km^2) was selected as a suitable reference analogue for Little Roberts Lake (area: 0.1 km^2) based on its size and a direct linkage to the marine environment. Reference Lake B (7.7 km^2) was selected as a comparable lake to Doris Lake (3.4 km^2). A marine reference site in southern Ida Bay (REF-Marine 1) was selected for comparability with the two marine exposure sites in Roberts Bay. These reference areas were chosen with two features in mind:

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

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

2.1.2 2016 Sampling Schedule

Sampling was conducted in accordance with the schedule outlined in the Plan and is summarized in Table 2.1-2 (Rescan 2010c). For 2016, the sampling program commenced in April with under-ice sampling and ended in September. Physical characteristics (e.g., temperature, dissolved oxygen) and water quality (e.g., nutrients and metals) were collected in streams, lakes, and the marine environment four times during the sampling period, at least one month apart (whenever possible), thereby aligning with MMER guidelines (Schedule 5, s.7 [1-2]). Phytoplankton (as chlorophyll *a*) was collected during all lake surveys and periphyton (as chlorophyll *a*) was collected during the open water stream surveys (July, August, and September). Sediment quality and benthos samples were collected once in August.

Table 2.1-2. Sampling Schedule Summary, Doris Project, 2016

Waterbody	Variable	Sampling Dates
Streams	Water Quality	June 12-13
		July 14-17
		August 14-19
		September 15-19
	Sediment Quality	August 14-19
	Periphyton Biomass	July 14-17*
		August 14-19*
		September 14-19*
	Benthos	August 14-19
Lakes	Physical Limnology	April 15-18
		July 13-18
		August 10-20
		September 15-19
	Water Quality	April 23-25
		July 13-18
		August 10-20
		September 15-19
	Sediment Quality	August 10-20
	Phytoplankton Biomass	April 15-18
		July 13-18
		August 10-20
		September 15-19
	Benthos	August 10-20
Marine	Physical Oceanography	April 16-18
		July 13
		August 12-13
		September 15-18
	Water Quality	April 16-18
		July 13
		August 12-13
		September 15-18
	Sediment Quality	August 12-13
	Phytoplankton Biomass	April 16-18
		July 13
		August 12-13
		September 15-18
	Benthos	August 12-13

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

2.2 EVALUATION OF EFFECTS

Baseline data collected between 1995 and 2009 in the Project area were compared against 2016 data to determine whether there were adverse changes to the aquatic environment that could be directly attributed to Project activities. Data from 2010 to 2015 were not included in the baseline years for the effects analysis because substantial Project infrastructure was in place or under construction by 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. No suitable baseline data were available for benthos, so the benthos evaluation of effects was based on a comparison of trends over time from 2010 to 2016 between reference and exposure sites.

2.2.1 Variables Subjected to Evaluation

Table 2.2-1 presents the physical, chemical, and biological variables that were evaluated in 2016. 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 also included in the assessment. Periphyton and phytoplankton biomass were also evaluated.

Table 2.2-1. Variables Subjected to Effects Analysis, Doris Project, 2016[a]

Category	Variable
<u>Physical Limnology</u>	
Effluent Characterization and Water Quality Variables[c]	Dissolved Oxygen[d] Secchi Depth
<u>Water Quality</u>	
Deleterious Substances[b]	Total Suspended Solids[d] Cyanide, Total[d] Arsenic, Total[d] Copper, Total[d] Lead, Total[d] Nickel, Total[d] Zinc, Total[d] Radium-226

(continued)

Table 2.2-1. Variables Subjected to Effects Analysis, Doris Project, 2016[a] (completed)

Category	Variable
Water Quality (*cont'd*)	
Effluent Characterization and Water Quality Variables[c]	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]
Sediment Quality	
	Particle Size[e] Total Organic Carbon[e] Arsenic[d] Cadmium[d] Chromium[d] Copper[d] Lead[d] Mercury[d] Zinc[d]
Biology	
	Phytoplankton and Periphyton Biomass Benthic Invertebrate Density[e] Taxa Richness[e] Simpson's Evenness Index[e] Simpson's Diversity Index[e] Bray-Curtis Index[e]

Notes:
[a] 2010 was year 1 of fish data collection. Fish sampling was not undertaken in 2016.
[b] Variables regulated as deleterious substances as per Schedule 4 of the MMER.
[c] Variables required for effluent characterization and water quality monitoring as per Schedule 5 of the MMER.
[d] Variables that have CCME water or sediment quality guidelines for the protection of aquatic life.
[e] Variables required as part of the benthic invertebrate surveys as per Schedule 5 of the MMER.

2.2.2 Baseline Data and Effects Analysis

Baseline physical, chemical, and biological data have been collected in the Doris 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 2016 data.

The approaches used to assemble the appropriate baseline datasets and to determine whether there were any effects on evaluated variables in 2016 are discussed below. Key determining factors for the inclusion of baseline data included the proximity of baseline sampling sites to 2016 sampling sites, the depth of sampling (for sediment quality and benthos), and sampling methodology (for sediment quality, periphyton, phytoplankton, and benthos). In the case of benthos, pre-2010 baseline data were not considered comparable because of methodological differences; therefore, 2010 to 2015 data were incorporated into the effects analysis for 2016. 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), ERM Rescan (2014), ERM (2015, 2016). Full details of the rationale used in the selection of baseline data that could be used for comparison with the 2016 data are provided in Appendix B.

All statistical analyses were run using R version 3.2.2. 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.

2.2.2.1 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 mine tailings-related TIA effluent has been discharged to the aquatic environment to date.

Ice cover usually forms in October or November in the Doris region, and remains until June or July of the following year. Waterbodies in the Doris 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 one of construction.

Baseline under-ice dissolved oxygen measurements have been collected several times at the 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.

<u>Effects Analysis</u>

The potential for effects on under-ice dissolved oxygen concentrations was assessed by graphical analysis. For winter dissolved oxygen concentrations to warrant concern and be considered an effect, concentrations from 2016 had to be noticeably different from all available baseline years. For example, if 2016 dissolved oxygen concentrations were different from 2005, but similar to 2007, it was concluded that there were no 2016 Project effects at that exposure site. Dissolved oxygen concentrations and inter-annual trends at the reference sites were also considered in the effects analysis. Dissolved oxygen concentrations were compared against CCME guidelines for the protection of aquatic life (CCME 2016b) to determine if baseline or 2016 concentrations dropped below recommended levels.

2.2.2.2 Secchi Depth

Data Selection

Secchi depths have been measured at lake sites in the Doris Project area since 1995. The selection of historical lake data to include in the effects analysis was based on similarity of baseline sampling locations to 2016 sampling locations. At least three years of baseline Secchi depth data are available for Doris Lake South, Doris Lake North, and Little Roberts Lake. Pre 2010 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 2016 reached the bottom sediments (Appendix A), indicating that the euphotic zone extended throughout the entire shallow water column. At site RBW, the Secchi depth reached the bottom in August and September 2016, but not in July 2016 (although the calculated euphotic zone extended throughout the 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 there was no indication of water clarity concerns, Secchi depth was not evaluated for the Roberts Bay sites RBW and RBE.

Effects Analysis

Graphical analysis of annual mean Secchi depths were used to compare before (baseline) and after (2016) data at the exposure sites to before and after data 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 2016 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 (2016). 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.

A significance level of 0.05 was used when reviewing the results. In the monitoring context, a false positive (i.e., type I error, determining impact when none exists) is more tolerable than a false negative (i.e., type II error, determining no effect when in fact there is one). There is a direct trade-off between the two error rates, as reducing one type of error generally results in an increase in the other type of error. No correction for the large number of statistical tests was applied to the false positive (type I) error rate. Therefore, there are likely false positives in the analyses that were conducted, which is a conservative and environmentally protective approach.

If the before-after comparison revealed that the mean Secchi depth in 2016 was significantly different from the baseline mean, a before-after-control-impact (BACI) analysis, which is a standard method used to assess an environmental effect, was conducted. The BACI analysis compares the mean before and after at the exposure site with the mean before and after at a corresponding reference site, to see if there is a parallel change and, thus, trends which are attributable to a natural process. A significance level of 0.05 was used when reviewing the results. A BACI analysis could only be performed if baseline and 2016 data were available for both the exposure site and the reference site. Because there were 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, the change likely resulted from a natural phenomenon and was unrelated to the 2016 Project activities. Note that BACI results are only discussed in the text if a significant difference was detected by the before-after analysis for exposure sites, but all BACI results are included in Appendix B and presented in the report figures.

2.2.2.3 Water Quality

<u>Data Selection</u>

Water quality samples have been collected in the Project area since 1995 (Figure 2.2-1). The selection of historical data to include in the effects analysis was based on the similarity of baseline sampling locations to 2016 sampling locations, methodology (e.g., lake 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 2016 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 some previous AEMP reports because the 1996 to 2000 sampling site was more than 1 km north of the 2010 Doris Lake South sampling site (Figure 2.2-1). In 2011, the Doris Lake South sampling site was moved into deeper water approximately 500 m away from the 1996 to 2000 sampling site, and has remained at this location for 2016 sampling. Therefore, the historical 1996 to 2000 data were considered comparable to the 2016 water quality data and were included in the 2016 effects analysis for Doris Lake South. The Little Roberts Lake sampling location was moved approximately 90 m in 2014 to a deeper location to improve the ability to obtain representative samples under-ice. The 2016 sampling location was consistent with the 1995 to 1997 and 2003 to 2009 baseline sampling location (as well as the 2014 and 2015 AEMP sampling location) for Little Roberts Lake and all baseline data were therefore retained in the effects analysis (except for some shoreline grabs collected in 1995; see Appendix B).

Effects Analysis

All 18 evaluated water quality variables presented in Table 2.2-1 were screened against relevant CCME guidelines for the protection of freshwater and marine aquatic life (CCME 2016b). For each variable, a graph showing annual mean variable concentrations for all available years is presented alongside a graph comparing before-after means at the exposure sites to before-after means at the reference sites. This graphical analysis was used to identify trends and to supplement the results of the statistical analyses. Relevant CCME guidelines were included on these graphs and also in Appendix A.

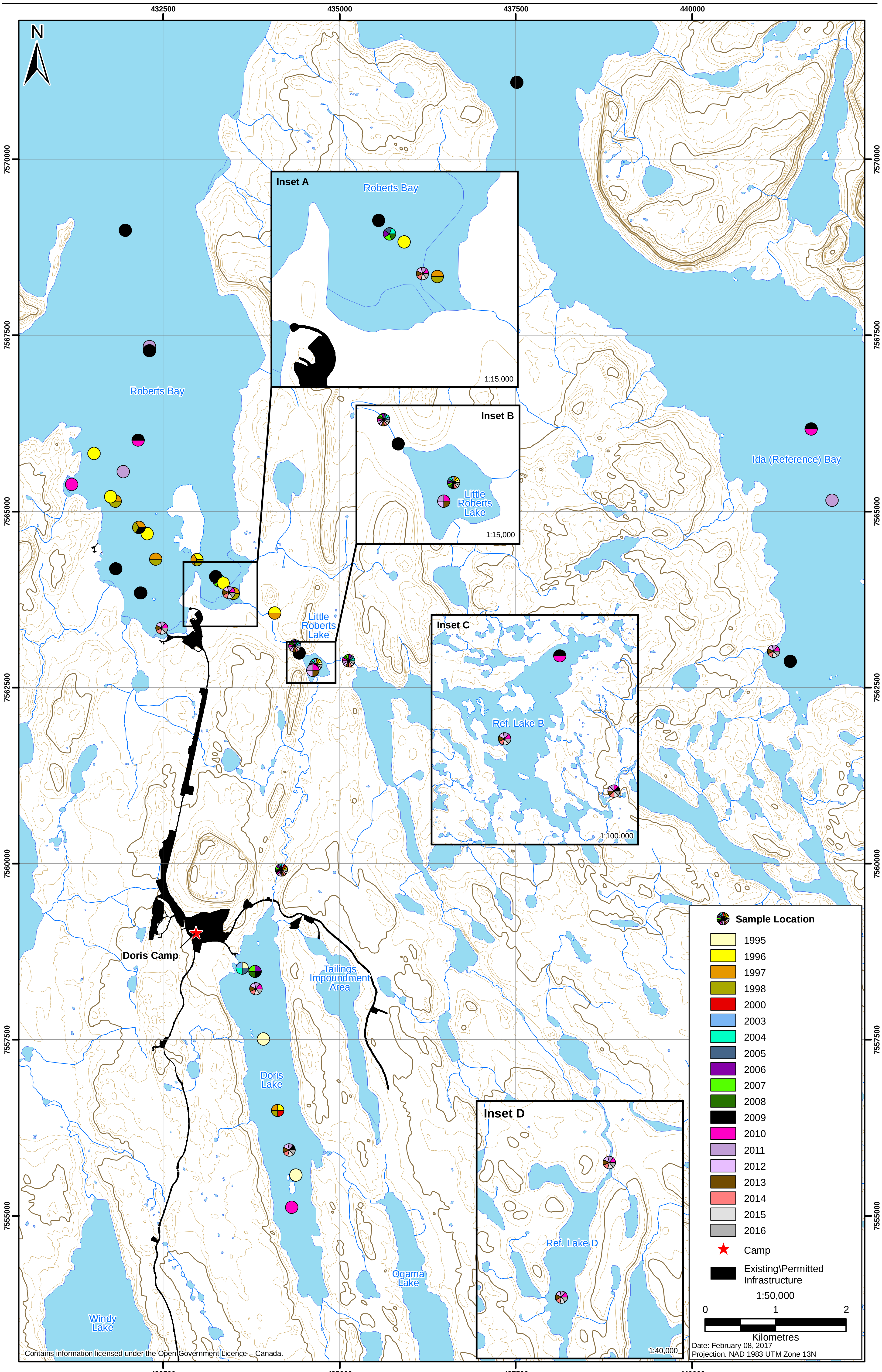
For each waterbody, a before-after comparison between the baseline mean and the 2016 mean was conducted for each of the 18 evaluated variables (provided that baseline data were available). A mixed model ANOVA was used for this before-after comparison. This model included fixed effects of *period* (before vs. after) and *season* (early vs. late, see below), 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 (2016). 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). A significance level of 0.05 was used when reviewing the results.

The interpretation of the before-after analyses, the conditions under which a subsequent BACI analyses was conducted, the BACI methodology, and the interpretation and presentation of the BACI results are described in Section 2.2.2.2. Details specific to the water quality analyses are described below.

For lake and marine water quality variables, the before-after change for each exposure site was compared against the change at the corresponding reference site for the BACI analysis. For stream water quality variables, the before-after change for each exposure site was compared against the change obtained using data from both reference streams (Reference B Outflow and Reference D Outflow). Although no baseline data were available for Reference D Outflow, data collected from this site in 2016 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 less than 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 statistical outputs provided in Appendix B).

Figure 2.2-1
Water Quality Sampling Stations, Doris Project, 1995 to 2016



A value equal to half of 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. If the substitution of half versus the full detection limit affected the conclusions of the effects assessment, differences were discussed in the text. Values determined to be outliers were excluded from the statistical analyses. In most cases, outliers were baseline values that were less than 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. Lists of outliers identified for water quality variables are available in Appendix B.

2.2.2.4 Sediment Quality

<u>Data Selection</u>

Baseline sediment quality sampling has been conducted six times in the freshwater and marine study area since 1997 (Figure 2.2-2). The selection of historical data was based partially on the proximity of baseline sampling sites to the 2016 sites and the similarity of sampling techniques. However, the most important criterion in the historical sediment quality data selection process was that baseline (1995 to 2009) samples had to be collected from a similar depth as the 2016 samples, since greater metal concentrations are often associated with greater 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 greater 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 2016 Doris Lake South data. The sediment samples collected from the marine reference site in Ida Bay (REF-Marine 1) in 2016 were collected from an average depth of 6.2 m, so sediment samples collected from both 5 m and 9 m depth in Ida Bay in 2009 were included in the baseline dataset, while samples collected from 14 m depth in 2009 were excluded because these were not considered comparable to 2016 data.

<u>Effects Analysis</u>

The nine sediment quality variables presented in Table 2.2-1 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 2016a). Relevant CCME guidelines were included on effects analysis graphs, and also in Appendix A.

Before-after comparisons were used to determine if mean 2016 sediment quality concentrations 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 (2016). Each waterbody was treated independently and each variable was treated separately. A significance level of 0.05 was used when reviewing the results.

The interpretation of the before-after analyses, the conditions under which a subsequent BACI analyses was conducted, the BACI methodology, and the interpretation and presentation of the BACI results are described in Section 2.2.2.2. Details specific to the sediment quality analyses are described below.

For lakes sites, there were no appropriate baseline sediment quality 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., there is a significant interaction effect), the implication is that the Project may be 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 change for each exposure site was compared against the change at the corresponding reference site (REF-Marine 1) for the BACI analysis. For stream sediment quality variables, the before-after change for each exposure site was compared against the change obtained using data from both reference streams (Reference B Outflow and Reference D Outflow). Although no baseline data were available for Reference D Outflow, data collected from this site in 2016 contributed some information on the year-effect, which improved the precision of the BACI analysis.

Like water quality, highly censored variables (i.e., > 70% of data less than the detection limit) were considered unreliable and were not subjected to effects analysis. Censored data that were included in the analyses were substituted with a value equal to one half the detection limit.

2.2.2.5 Primary Producers

Data Selection

Primary producer (phytoplankton and periphyton) biomass sampling has been conducted in the Doris Project area since 1997 (Figure 2.2-3). The main criteria for the selection of historical periphyton and phytoplankton biomass data for inclusion in the effects analysis was the proximity of baseline sampling sites to 2016 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 effects analysis as these were not comparable to the discrete surface samples collected in 2016).