PHASE 2
DRAFT ENVIRONMENTAL IMPACT STATEMENT

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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.

7-day low flow	The minimum average 7-day flow that occurs over a specified period, such as a month, season or year.
ADCP	Acoustic Doppler current profiler.
Annual runoff	Annual runoff is a measure of the hydrological response of a drainage basin. It is often presented as a depth, in mm, over an entire basin allowing direct comparison with precipitation totals.
Arctic nival	Hydrological regime in which snow melt is the major hydrological event producing runoff and continuous permafrost impedes deep infiltration reducing base flow and winter flow.
AWR	All weather road
Base flow	The groundwater component of flow discharge that is attributed to soil moisture and groundwater drainage into a channel.
Break-up	The melting and dissipation of the ice cover on a waterbody.
CEA	Cumulative Effects Assessment
DFO	Fisheries and Oceans Canada
Discharge	The volume of flow moving through a cross section of a stream in a given unit of time; commonly expressed in cubic meters per second.
CRA fisheries	commercial, recreational, and Aboriginal fisheries
Drainage Basin/ Watershed/ Catchment Area	The zone or portion of land that contributes water to the surface water runoff that flows past a given point along a stream channel.
EAAA	Existing and Approved Authorizations
EIS	Environmental Impact Statement
Ephemeral	A stream which flows only during or after rain or snow-melt and has no base flow component.
Freeze-up	The formation of an ice cover on a waterbody.
Freshet	In channels, the relatively high annual peak water discharge period resulting from spring/summer meltwater runoff of the snowpack accumulated over the winter.
Hydrograph	A graphic presentation of the variation in discharge with elapsed time, based on data of stream gauging at a given hydrometric station on a stream.

Intermittent	A stream which flows only part of the year.
LSA	Local Study Area
MAR	Mean Annual Runoff
masl	Metres Above Sea Level
NAD 83	North American Datum of 1983. The horizontal control datum for the U.S., Canada, Mexico, and Central America, based on a geocentric origin and the Geodetic Reference System 1980.
MOMB	Marine outfall mixing box
NIRB	Nunavut Impact Review Board
NSA	Nunavut Settlement Area
NTKP	Naonaiyaotit Traditional Knowledge Project
NWB	Nunavut Water Board
Permafrost	Bedrock, organic or earth material that has temperatures below 0°C persisting over at least two consecutive years.
PDA	Potential Development Area
Project, the	Hope Bay Project
RSA	Regional Study Area
Stage	The height of the water surface in a stream above its bed or a fixed level near the bed.
Stage-Discharge Curve	A curve derived from concurrently measured stage and discharge data that is used to estimate the discharge for any given observed stage. Often referred to as a rating curve for a hydrometric station.
TIA	Tailings Impoundment Area
Unit Discharge	An index of discharge normalized by drainage area. This index allows for direct comparison of the potential rate of water volumes that can be expected from various sized drainage basins.
UTM	Universal Transverse Mercator. A mathematical transformation (map projection) of the earth's surface to create a flat map sheet.
VEC	Valued Ecosystem Component
WRR	Winter road route
WRSA	Waste Rock Storage Areas
WSC	Water Survey of Canada

1. Surface Hydrology

Surface hydrology is a key component of the biophysical environment; it is linked to other ecosystem components including surface water quality, fish and fish habitat, and aquatic resources. Surface water is protected under federal legislation (e.g., *Canada Water Act* 1985). An understanding of the surface hydrology, and its interactions with a project, is critical to support an environmental effects assessment as well as to contribute to engineering analysis and the design of water management features.

In this section, the potential effects of the proposed Phase 2 of the Hope Bay Project, in combination with existing and approved projects, on surface hydrology are assessed by comparing predicted project-affected streamflows with pre-development (i.e., baseline) streamflows.

Alteration of surface hydrology could potentially affect other Valued Ecological Components (VECs); effects on these VECs are assessed in the following effects assessment sections:

- Volume 5, Section 4, Freshwater Water Quality;
- Volume 5, Section 5, Freshwater Sediment Quality; and
- Volume 5, Section 6, Freshwater Fish.

This section follows the effects assessment methodology described in Volume 2, Section 4 of the Environmental Impact Statement (EIS)

1.1 INCORPORATION OF TRADITIONAL KNOWLEDGE

Traditional Knowledge (TK) information was gathered by the Kitikmeot Inuit Association (KIA) in a report titled *Inuit Traditional Knowledge for TMAC Resources Inc., Hope Bay Project, Naonaiyaotit Traditional Knowledge Project (NTKP)* report (Banci and Spicker 2016; hereafter referred to as the TK report). The TK report provides recorded and georeferenced TK pertaining to the Hope Bay Project.

1.1.1 Incorporation of Traditional Knowledge for Existing Environment and Baseline Information

The TK report was reviewed for information pertinent to surface water hydrology. According to the information provided in the TK report, Inuit have seen changes in hydrology over the past few decades. The TK report reflects observations of some hydrologic processes including the ice break-up process in the streams:

> *Around the falls in the rivers, where the water is deeper, there are always fish during the winter, such as at Kugyoak and Kunayok. The smaller rivers dry up. The fish can't go up river or go downstream because the rivers are frozen.*
>
> *These rivers that we call flooded sometimes overflow before the land melts. The river is flowing under the snow and over top of the ice. That is what we call flooded. The ice and river would be flooded and the ice would be opening up when the river overflows. Once the rivers overflow, it's hard on the people who are hunting because they get stuck in between the rivers. If they didn't have a boat they would have to wait for the water to subside.*

> *When we used to walk around south of here, there used to be lots of natural water spring everywhere. These are not as visible anymore and the land seems to be getting dry every year.*
>
> *I can see some differences from the 1940s and 1950s until now. There has been a very big difference because of climate change already from the 1940s right up until now. It's because permafrost is receding very fast and the permafrost is melting. Permafrost is coming up to the surface in some places.*

1.1.2 Incorporation of Traditional Knowledge for VEC Selection

The TK report was reviewed to refine the potential VEC list for freshwater environment. Rivers and lakes were identified in the TK report as Inuit's source of water and important fish habitat. TK was combined with data from public consultation and baseline surveys to determine which valued components would potentially interact with the proposed Project, and should therefore be evaluated for inclusion in the candidate VEC list.

As a result of this process, and in consideration of the EIS guidelines (NIRB 2012a), Surface Hydrology was selected as a candidate VEC for the EIS (Volume 2, Section 4, Effects Assessment Methodology).

1.1.3 Incorporation of Traditional Knowledge for Spatial and Temporal Boundaries

The results of the TK report were considered when developing the spatial and temporal boundaries for the Project. The TK report showed that specific and general fishing locations extend along both shores of Melville Sound, but are concentrated along the southern shore extending both east and west of Roberts Bay. General fishing areas also extend inland along the entire length of the Hope Bay Greenstone Belt. Therefore, the entire Project area was included within the spatial boundaries of the assessment. The temporal boundary of the assessment was extended into the future to simulate the hydrologic recovery at Post-closure.

1.1.4 Incorporation of Traditional Knowledge for Project Effects Assessment

The results of the TK report were considered when developing the effects assessment for surface hydrology. Fish and fish habitat is important to Inuit and, therefore, fish habitat (including water quantity) was considered in selecting the surface hydrology effects assessment locations.

1.1.5 Incorporation of Traditional Knowledge for Mitigation and Adaptive Management

The importance of lakes and rivers as Inuit's source of water and important fish habitat was considered when developing mitigation and adaptive management plans for surface hydrology.

1.2 EXISTING ENVIRONMENT AND BASELINE INFORMATION

The Hope Bay Project (the Project) is situated within the Queen Maud Gulf Lowlands, which covers the east-central portion of the West Kitikmeot region (Figure 1.2-1). The entire Project watersheds drain into Roberts Bay and Hope Bay (Figure 1.2-2). The northern portion of the Hope Bay Belt consists of several watersheds (including Windy, Doris, and Roberts watersheds) that drain into Roberts Bay near the existing mine infrastructure. The southern portion of the belt (including the Aimaokatalok watershed and its tributaries) flows into the Koignuk River that drains into Hope Bay west of the existing Doris infrastructure.

Figure 1.2-1

Hope Bay
Phase 2 Project Location

The Project area is characterized by extensive networks of lakes, low relief hummocky topography, and exposed bedrock uplands. The local topography ranges from sea level at Roberts Bay to 158 m at the summit of Doris mesa, 3 km inland.

Climate in the region can be described as a subarctic desert with limited rainfall. The region is characterized by long dark winters and short bright summers. The ground is covered in snow from October to June in most years.

Rivers in the region have streamflow typical of the Arctic nival regime (Church 1974). The long and severe Arctic winter, and brief time when air temperatures are above freezing, limit surface water flow to a short period. Surface water flow typically begins in late May or early June and rapidly rises to peak annual flow by early- to mid-June. Snow that accumulated over the long winter is usually the dominant contributor of water to streamflow on an annual basis. Shortly after air temperature rises above freezing, the snow melts rapidly.

After the snowmelt-fed freshet, streamflow steadily decreases to a time minimum, which typically occurs in August. Due to the presence of continuous permafrost there is limited groundwater supply to smaller streams; however, there may be interaction between groundwater systems and larger rivers and/or lakes through taliks. Fall rain events often augment streamflow and produce moderate flow after the summer minimum. In October, air temperature normally dips below freezing, precipitation begins to fall as snow, and streamflow ceases for the winter except in rivers with very large watersheds.

Lakes are common in the region. Runoff is stored in lakes and gradually released, attenuating hydrologic events that would otherwise cause a rapid response in streamflow, such as the snowmelt peak flow and responses to precipitation events. Evaporation from lake surfaces is greater than evaporation from tundra, so runoff is generally lower in watersheds with extensive open water. Lakes are ice-covered from approximately October to June most years.

1.2.1 Regulatory Framework

Surface hydrology is protected under federal legislation, including the *Canada Water Act (1985)* and *Fisheries Act (1985)*.

Canada Water Act (1985) provides a framework for collaboration among the federal and provincial or territorial governments in management of the water resources including research and the planning and implementation of programs relating to the conservation, development and utilization of water resources.

Fish and fish habitat are protected under the *Fisheries Act (1985)*, which was amended in 2012. The *Fisheries Act* includes a prohibition against causing serious harm to fish that are part of or support a commercial, recreational, and Aboriginal fisheries (CRA fisheries). The *Fisheries Act* regulates surface hydrology by provisioning for flow and passage.

1.2.2 Data Sources

1.2.2.1 Available Onsite Hydrologic Data

Project hydrometric monitoring began in 1993 at several sites where streamflow and water levels were manually measured. Automated hydrometric monitoring began in 1996 and has continued to the present, although the size of the monitoring network has varied throughout this time. Hydrometric stations are identified in Figure 1.2-3 and Table 1.2-1.

Figure 1.2-2
Watersheds in the Hope Bay Project Area

Figure 1.2-3a
Hydrometric Monitoring Stations in the Northern Part of the Project Area

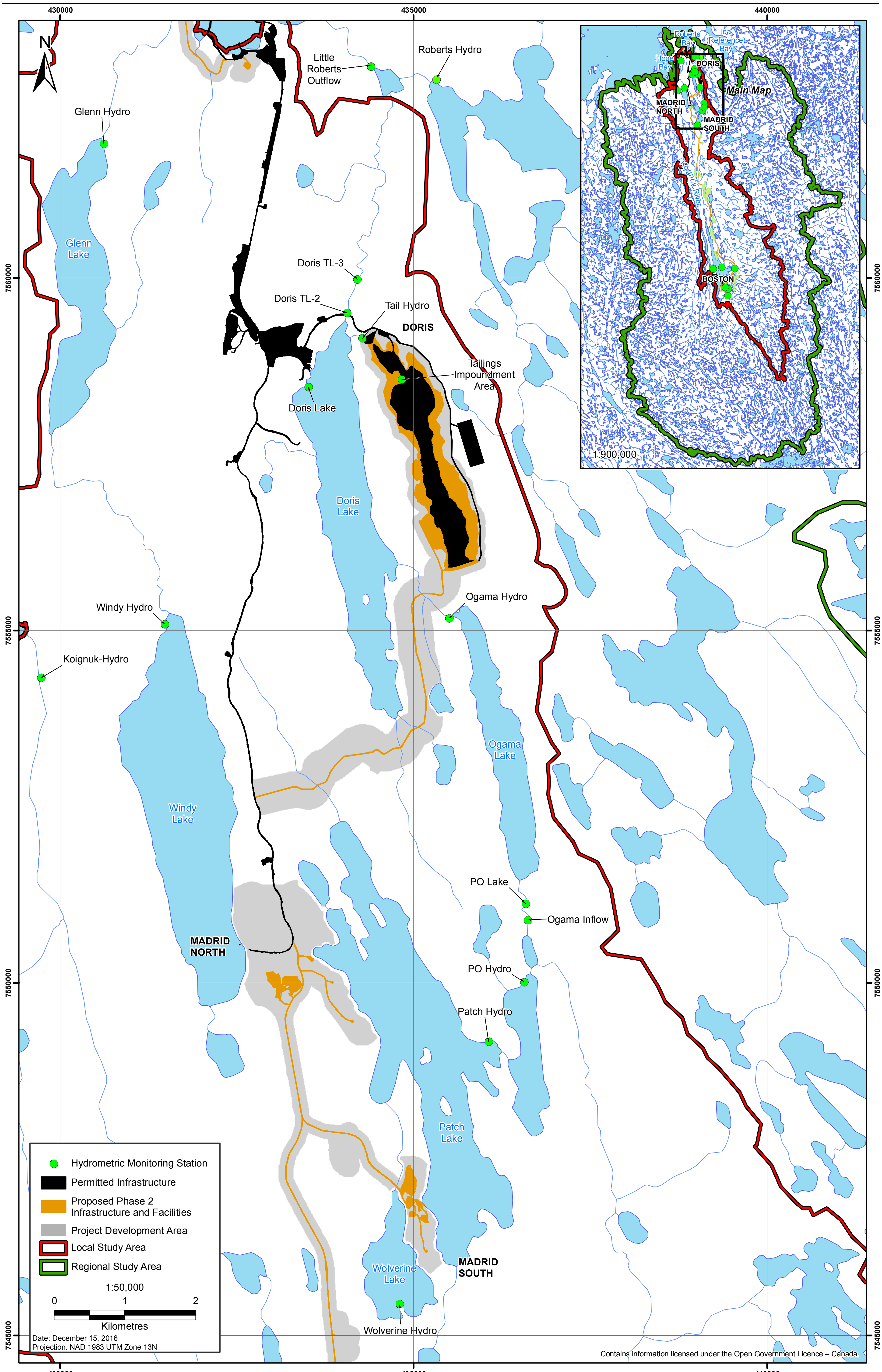

Figure 1.2-3b
Hydrometric Monitoring Stations in the Southern Part of the Project Area

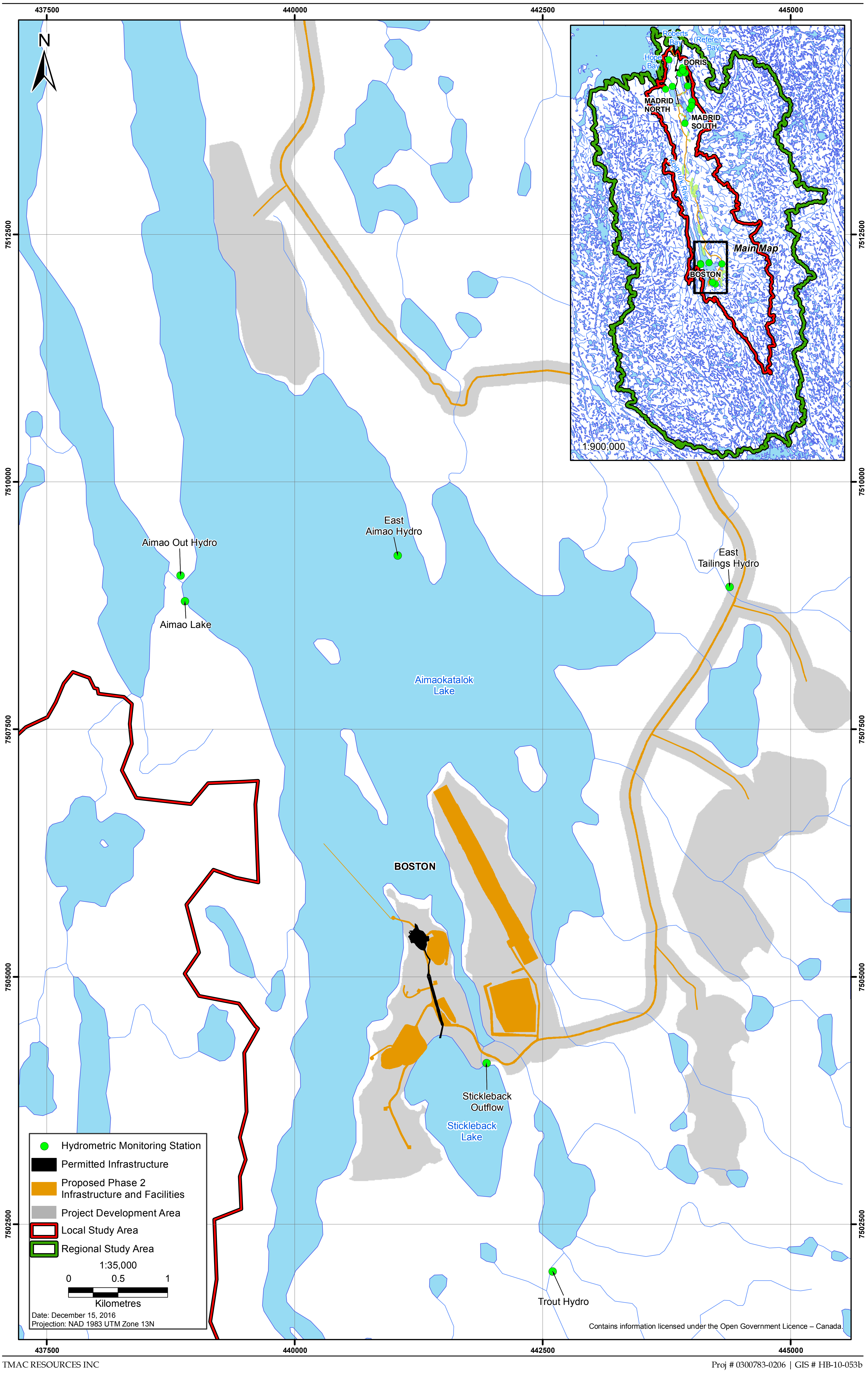

Table 1.2-1. Hydrometric Monitoring Stations

Hydrometric Station	Monitoring Type	UTM Coordinates*		Drainage Area (km^2)	Years of Automated Data Collection
		Easting	Northing		
Roberts Hydro	Lake/Stream Water Level	435,325	7,562,815	98	2003-2016
Doris Lake	Lake Water Level	433,512	7,558,452	n/a	2004-2016
Doris Hydro and Doris TL-2	Stream Water Level	434,059	7,559,504	95	1996-1998, 2000, 2003-2016
Doris TL-3	Stream Water Level	434,204	7,559,985	95	2011-2016
Little Roberts Outflow	Stream Water Level	434,271	7,563,159	199	2003-2008
Ogama Hydro	Lake/Stream Water Level	435,501	7,555,173	75	1996-1998, 2006-2011
Ogama Inflow	Stream Water Level	436,617	7,550,891	65	1997
Patch Hydro	Lake/Stream Water Level	436,062	7,549,169	32	2006-2011
PO Lake	Lake Water Level	436,584	7,551,126	n/a	2007-2011
PO Hydro	Stream Water Level	436,565	7,550,014	68	2007-2011
Wolverine Hydro	Lake Water Level	434,802	7,545,443	n/a	2006-2011
Tailings Impoundment Area (Tail Lake)	Lake Water Level	434,832	7,558,560	n/a	2004-2016
Tail Hydro	Stream Water Level	434,273	7,559,147	4.4	2000, 2004-2010
Windy Hydro	Lake/Stream Water Level	431,481	7,555,089	14	2006-2016
Glenn Hydro	Lake/Stream Water Level	430,616	7,561,906	32	1996-1998, 2000, 2006-2009
Koignuk-Hydro	Stream Water Level	429,731	7,554,332	2,937	2006-2011
Aimao Out Hydro	Stream Water Level	438,847	7,509,056	1,224	2006-2008, 2010
Aimao. In. Hydro	Stream Water Level	441,637	7,499,326	725	2006-2008, 2010
Aimao Lake	Lake Water Level	438,892	7,508,794	n/a	
East Aimao Hydro	Stream Water Level	441,038	7,509,257	363	2006-2008, 2010-2011
East Tailings Hydro	Stream Water Level	444,385	7,508,941	8	2010-2011
Trout Hydro	Stream Water Level	442,599	7,502,024	27	2011
Stickleback Outflow	Stream Water Level	441,934	7,504,127	2.8	1998, 2006-2008, 2011

** UTM Zone 13W, NAD83*
n/a = Drainage area is not applicable; the station only monitors lake elevation.

This hydrologic data set includes:

- stream water level (stage) measurements during the open-water season;
- manual stream discharge measurements and water level surveys;
- development of stage-discharge relationships (rating curves) and production of annual hydrographs at each of the monitoring locations;
- analysis of flow duration and calculation of annual and monthly runoff at monitoring locations; and
- channel geometry surveys.

A summary description of the methods used to collect these data is provided in Section 1.2.3. These data, in conjunction with other data sources (such as long-term regional data), were used to the characterize baseline surface hydrology conditions (Section 1.2.4). Full details of the baseline programs used to collect hydrometric information are described in the following reports:

- 1993-2002 Data Compilation Report for Meteorology and Hydrology (Appendix V5-1A; Rescan 2002);
- Doris North 2003 Meteorology and Hydrology Baseline (Appendix V5-1B; AMEC, 2003);
- Doris 2008 Hydrology Baseline Update, 2004-2008, draft Report (Appendix V5-1C; Golder 2009);
- Hope Bay Belt 2009 Hydrology Baseline Report (Appendix V5-1D; Rescan 2009);
- Doris North 2010 Hydrology Compliance Report (Appendix V5-1F; Rescan 2010);
- Hope Bay Belt 2010 Hydrology Baseline Report (Appendix V5-1E; Rescan 2011a);
- Doris North 2011 Hydrology Compliance Report (Appendix V5-1H; Rescan 2011b);
- Hope Bay Belt 2011 Hydrology Baseline Report (Appendix V5-1G; Rescan 2012a);
- Doris North 2012 Hydrology Compliance Report (Appendix V5-1I; Rescan 2012b);
- Doris North 2013 Hydrology Compliance Monitoring Report (Appendix V5-1J; ERM Rescan 2014);
- Doris North 2014 Hydrology Compliance Monitoring Program Memorandum (Appendix V5-1K; ERM 2015); and
- Doris North 2015 Hydrology Compliance Monitoring Program Memorandum (Appendix V5-1L; ERM 2016).

1.2.2.2 Available Regional Hydrologic Data

Data are available from hydrometric stations operated by the Water Survey of Canada (WSC) (Table 1.2-2 and Figure 1.2-4). The drainage areas of these stations range from 217 km^2 to 46,200 km^2. Data from these stations provide background information on the regional surface water hydrology.

1.2.3 Methods

This section provides a description of methods used to collect and analyze the surface hydrology baseline information, including the standards, field collection, analysis, and modelling.