TECHNICAL SUPPORTING DOCUMENT

Mary River Project | Phase 2 Proposal | FEIS Addendum | August 2018

TSD 14

Freshwater Biota and Habitat Assessment





FRESHWATER BIOTA AND HABITAT ASSESSMENT TECHNICAL SUPPORTING DOCUMENT SUMMARY

The Freshwater Biota and Habitat Assessment Technical Supporting Document provides an assessment of effects of the Phase 2 Proposal on freshwater biota and habitat. The Phase 2 Proposal builds on the extensive baseline studies and assessments carried out since 2011 for the larger Approved Project and is thus closely linked to the FEIS and previous addendums.

The freshwater biota in the region includes two fish species, Arctic char (*Salvelinus alpinus*) and nine-spine stickleback (*Pungitius pungitius*), and numerous invertebrate species on which these fishes rely. There are no freshwater Species at Risk or Species of Conservation Concern known to exist in the Qikiqtani Region. Arctic Char was used as a key indicator species in the assessment. Activities associated with the Phase 2 Proposal may affect freshwater biota and habitat due to in-water construction activities; effluent discharges; changes in total suspended solids and sedimentation rates; and changes in habitat availability and connectivity.

The installation of bridge and culvert infrastructure within watercourses will result in the permanent destruction and/or alteration of char habitat and may impede fish passage (e.g., due to increased velocities). The rivers that will be crossed by bridges may provide some summer feeding habitat and serve as a migration corridor for adult char, however, there is no known spawning or overwintering char habitat that will be affected along the planned North Railway route. Bridges and culverts will be designed with best practice fish passage considerations in consultation with, and approval of, DFO. Therefore, with approved fish passage engineering, bridge and culvert installations associated with the North Railway are not expected to affect Arctic char at the regional population level.

Water is withdrawn from some lakes and streams for use with dust suppression near the Mine Site. These water withdrawal sites are located in known or potential Arctic char habitat. Modeling predictions, based on planned water withdrawal rates, suggest all but two waterbodies will experience water reductions of less than 10%, and the effects of water withdrawals on Arctic char habitat are not expected to influence char at the population level. With the planned sediment and erosion control, and water management mitigation, the effects of sedimentation to Arctic char and char habitat are expected to be negligible.

Based on the present assessment and planned mitigation, activities proposed as part of the Phase 2 Proposal are not predicted to result in significant adverse residual effects on freshwater biota and habitat.

RÉSUMÉ DE LA DOCUMENTATION TECHNIQUE COMPLÉMENTAIRE SUR L'ÉVALUATION DU BIOTE ET DE L'HABITAT D'EAU DOUCE

La documentation technique complémentaire à l'évaluation du biote et de l'habitat d'eau douce et comporte une évaluation des impacts de la proposition de la phase 2 sur le biote et l'habitat d'eau douce. La proposition de la phase 2 est fondée sur les études préliminaires et les évaluations complètes réalisées depuis 2011 pour l'ensemble du projet approuvé et est donc étroitement liée à l'énoncé des incidences environnementales (EIE) et aux addendas précédents.

Le biote d'eau douce de la région comprend deux espèces de poissons, soit l'omble chevalier (*Salvelinus alpinus*) et l'épinoche à neuf épines (*Pungitius pungitius*); on retrouve également de nombreuses espèces d'invertébrés dont dépendent ces poissons. Il n'y a aucune espèce d'eau douce en péril ni aucune espèce préoccupante pour la conservation dans la région de Qikiqtani. L'omble chevalier a été utilisé comme espèce indicatrice clé dans l'évaluation. Les activités associées à la proposition de la phase 2 peuvent affecter le biote et l'habitat d'eau douce en raison des activités de construction dans l'eau, les rejets d'effluents, les changements dans le total des solides en suspension et les taux de sédimentation et les changements dans la disponibilité et la connectivité de l'habitat.

L'installation d'un pont et de ponceaux dans les cours d'eau entraînera la destruction et/ou l'altération permanentes de l'habitat des ombles chevaliers et peut entraver le passage des poissons (p. ex. en raison de l'augmentation de la vitesse du débit d'eau). Les rivières qui seront traversées par des ponts peuvent fournir un habitat d'alimentation estival et servir de corridor de migration pour l'omble adulte, mais il n'existe aucun habitat de frai ou d'hivernation de l'omble connu qui sera touché le long du trajet prévu du chemin de fer du Nord. Les ponts et les ponceaux seront conçus en tenant compte des meilleures pratiques en matière de passage du poisson, en consultation avec le MPO et avec son approbation. Par conséquent, avec un aménagement approuvé de passage des poissons, les installations de ponts et de ponceaux associés au chemin de fer du Nord ne devraient pas avoir d'incidence sur l'omble chevalier au niveau de la population régionale.

De l'eau est prélevée de certains lacs et cours d'eau pour être utilisée dans les opérations de suppression de la poussière près du site minier. Ces sites de prélèvement d'eau sont situés dans des habitats connus ou potentiels d'ombles chevaliers. Les prévisions de modélisation, basées sur les taux de prélèvements prévus, suggèrent que tous les plans d'eau subiront des réductions d'eau inférieures à 10 %, et les effets des prélèvements d'eau sur l'habitat de l'omble chevalier ne devraient donc pas influencer la population d'ombles. Avec le contrôle prévu des sédiments et de l'érosion et les mesures d'atténuation par la gestion de l'eau, les effets de la sédimentation sur l'habitat de l'omble chevalier et sur ses populations devraient être négligeables.

Selon la présente évaluation et les mesures d'atténuation prévues, les activités du projet proposées dans le cadre de la proposition de la phase 2 ne devraient pas entraîner d'effets résiduels négatifs importants sur le biote et l'habitat d'eau douce.

ᐃᒪᑦᑎᐊᕙᐅᑉ ᐆᒪᔪᖏᑦ ᓇᔪᒐᖏᑕᓗ ᖃᒥᕐᖒᔾᐅᓂᖏᓄᑦ ᐱᔭᕆᐊᕐᑐᔪᓄᑦ ᐃᑲᔪᐃᔾᔪᑎᑦ ᑎᑎᖅᑲᑦ ᐅᓂᒃᑳᓕᐊᑦ

ᐃᒪᑦᑎᐊᕙᐅᑉ ᐆᒪᔪᖏᑦ ᓇᔪᒐᖏᑕᓗ ᖃᒥᕐᖒᔾᐅᓂᖏᓄᑦ ᐱᔭᕆᐊᕐᑐᔪᓄᑦ ᐃᑲᔪᐃᔾᔪᑎᑦ ᑎᑎᖅᑲᑦ ᐅᓂᒃᑳᓕᐊᑦ ᐱᑕᖃᖅᑎᑦᑎᕗᑦ ᖃᒥᕐᖒᐃᓂᒻᒥᒃ ᐊᒃᑐᐃᓂᖃᓐᓂᖓᓄᑦ ᓴᓇᐅᒪᓂᐊ 2 ᐅᒃᑑᑎᖓᑕ ᐃᒪᑦᑎᐊᕙᐅᑉ ᐆᒪᔪᖏᓄᑦ ᓇᔪᒐᕆᔾᔪᖏᓄᑦ. ᓴᓇᐅᒪᓂᐊ 2 ᐅᒃᑑᑎᖓ ᐃᓚᒋᐊᕆᔭᖃᖅᑐᖅ ᖄᖓᒍᑦ ᐊᖏᓖᔪᑦ ᑐᙵᕕᑦ ᖃᐅᔨᓴᕕᓃᑦ ᐊᕙᑖᓄᑦ ᖃᒥᕐᖒᐃᓂᖅ ᑕᐃᑲᖓᑦ 2011–ᒥ ᑖᔅᓯᒨᖓ ᐃᓗᐃᑦᑑᔪᒧᑦ ᐊᖏᖅᓯᒪᔭᒧᑦ ᐅᔾᕋᓐᓂᐊᓐᓂᒧᑦ ᑕᐃᒫᓪᓗ ᓂᒃᓯᒃᓯᒪᓂᖃᖅᐳᖅ ᑭᖑᓪᓕᖅᐹᑉ ᐅᓂᒃᑳᖏᓄᑦ FEIS ᓱᕗᓂᐊᒍᓪᓗ ᐅᐃᒍᒋᐊᖅᑕᐅᓂᑰᔪᒃᑯᑦ.

ᐃᒪᑦᑎᐊᕙᐅᑉ ᐆᒪᔪᖏᑦ ᐅᔾᕋᓐᓂᐊᕝᕕᐅᔪᒥᒃ ᐃᓚᖃᖅᑐᑦ ᒪᕿᓐᓂᒃ ᐃᖃᓘᑉ ᐆᒪᔪᖏᓐᓂᒃ, ᐃᖃᓗᐃᑦ (ᓵᑉᕕᓕᓇᕐ ᐋᑉᕕᓇᔅ) ᐊᒻᒪᓗ ᓂᑎᓪᓕᐋᔪᐃᑦ (ᐳᖏᑎᐋᔅ ᐳᖏᑎᐋᔅ), ᐊᒻᒪᓗ ᐊᒥᓯᐋᓗᐃᑦ ᖃᒥᓪᓗᖃᖏᑦᑐᑦ ᖁᐱᕆᑦ ᐃᖃᓗᖏᓄᑦ ᓂᕿᒋᔭᐅᓲᑦ. ᐅᓪᓗᒥ ᐃᒪᑦᑎᐊᕙᐅᑉ ᐃᖃᓗᖏᑦ ᐅᓗᕆᐊᓇᖅᑐᒥ ᐊᒻᒪᓘᓐᓃᑦ ᐃᖃᓗᐃᑦ ᐃᓱᒫᓘᑎᒋᔭᑦ ᓄᖑᓪᓐᓂᖏᓄᑦ ᐱᑕᖃᕐᑎᒃ ᕿᑭᖅᑕᓂ ᓄᓇᖏᓂ. ᐃᖃᓗᐃᑦ ᐊᑐᖅᑕᐅᓪᓗᑎᒃ ᐊᑐᓛᑦ ᐃᐸᓐᓂᓲᑦ ᓂᔾᔪᑎᒋᓪᓗᒋᑦ ᖃᐅᔨᓵᖑᓂᐊᒍᑦ. ᐱᓕᕆᐊᑦ ᐊᒃᑐᐊᓂᖃᖅᑐᑦ ᓴᓇᐅᒪᓂᐅᑉ 2 ᐅᒃᑑᑎᖏᓄᑦ ᐊᒃᑐᐃᔪᓐᓇᖅᑐᑦ ᐃᒪᑦᑎᐊᕙᐅᑉ ᐆᒪᔪᖏᓂᑦ ᓇᔪᒐᖏᓐᓪᓗ ᐱᓪᓗᒋᑦ ᐃᒪᐅᑉ ᐃᓚᖓᓂ ᓴᓇᔪᖃᓐᓂᐊᓄᑦ; ᑭᓈᓗᐃᑦ ᑭᕕᔭᐅᓂᖏᓄᑦ; ᐊᓯᔾᔨᓂᖏᓄᑦ ᐃᒪᐅᑉ ᐃᓚᒋᓲᖏᓄᑦ ᓯᐅᕋᓇᔭᖏᓄᓪᓗ; ᐊᒻᒪᓗ ᐊᓯᔾᔨᓂᖏᓄᑦ ᓇᔪᒐᓇᔭᐅᓱᑉ ᐃᒪᖏᓂᒃ ᐅᑎᖅᑕᕋᕝᕕᒋᓲᖏᑕᓗ ᑰᕈᐃᑦ.

ᐃᓕᐅᕋᐃᓂᖏᑦ ᐃᑳᕝᕕᓂᒃ ᑯᒍᑎᓂᓪᓗ ᐱᖁᑎᔾᔪᐊᓂᒃ ᐃᓗᐊᒍᑦ ᑰᓐᓂᐅᓲᑦ ᓴᖅᑮᒐᔭᖅᑐᖅ ᓱᕋᐃᓂᒻᒥᒃ ᐋᖅᑭᒐᓴᐅᖏᑦᑐᒥᒃ ᐊᒻᒪ/ ᐅᕝᕙᓗ ᐊᓯᔾᔨᖅᑕᐅᓂᖓᑕ ᐃᖃᓗᑦ ᓇᔪᒐᖏᑦ ᓯᒥᒐᓛᑐᐃᓐᓇᓇᐊᖃᖅᑲᓗᓂᔾᔪᒃ ᐃᖃᓗᐃᑦ ᐃᑳᖅᑕᓐᓂᖏᑦ (ᓲᓪᓗ, ᑰᓐᓂᖅᓴᐅᓕᕈᓂ). ᑕᒪᒃᑯᐊ ᑰᑦ ᐃᑳᕝᕕᓕᐅᖅᑕᐅᓂᐊᖅᑐᑦ ᐃᓚᖓᒍᑦ ᐊᐅᔭᒃᑯᑦ ᓂᕿᓯᐅᕝᕕᐅᓲᑦ ᐃᑳᖅᑕᕝᕕᐅᓪᓗᑎᓪᓗ ᐃᖃᓗᖏᓄᑦ, ᑭᓯᐊᓂᓕ, ᖃᐅᔨᒪᓂᒃ ᓱᕌᕿᔭᕝᕙᓐᓂᒃ ᐱᑕᖃᑦᑎᒃ ᐊᒻᒪᓗᓐᓃᑦ ᐃᑭᕝᕕᐅᓲᑦ ᐃᖃᓗᓐᓄᑦ ᓇᔪᖏᓐᓂᒃ ᐊᒃᑐᖅᑕᐅᒐᔭᖅᑐᑦ ᐸᓐᓃᖑᔪᒃᑯᑦ ᐅᐊᖓᓚ ᓄᓇᓯᐅᑎᑰᑦᑲᕝᕕᐊᑕ ᐃᓂᐊᒍᑦ. ᐃᑳᕝᕖᑦ ᑰᒍᑎᖏᓪᓗ ᓴᓇᔭᐅᒪᓗᑎᒃ ᐱᐅᓛᓂᒃ ᐃᓕᖅᑯᓯᓇᔭᓄᑦ ᐊᑐᓪᓗᑎᒃ ᐃᓱᒪᒋᔭᖃᓪᓗᑎᒃ ᑐᓴᕋᓯᐊᓪᓗᑎᒃ, ᐊᖏᖅᑕᐅᓗᑎᓪᓗ ᐃᒪᒥᐅᑕᓕᓇᔾᑯᓐᓄᑦ. ᑕᐃᒪᐃᓐᓂᐊᓄᑦ, ᐊᖏᖅᑕᐅᓯᒪᓗᑎᒃ ᐃᑳᕝᕕᑦ ᐃᖃᓗᖃᖅᑐᒃᑯᑦ ᓴᓇᔭᐅᒪᓂᖓ, ᐃᑳᕝᕖᑦ ᑰᒍᑎᖏᓪᓗ ᐃᓕᔭᐅᔪᑦ ᐊᒃᑐᐊᓂᓪᓚᑦ ᐅᐊᖓᓚ ᓄᓇᓯᐅᑎᑰᑦᑲᕝᕕᐊᓄᑦ ᓂᓇᐅᒋᔭᐅᓇᑎᒃ ᐊᒃᑐᐃᒐᔭᓐᓂᖏᑕ ᐃᖃᓗᓐᓂᒃ ᐊᒥᓲᓂᖏᑦ ᐅᓄᕈᓐᓃᖅᑎᑕᐅᓗᑎᒃ.

ᐃᒥᖅᑕᕐᓲᖑᔪᒧᑦ ᐃᓚᖏᓂᒃ ᑕᓯᓐᓂᒃ ᑰᖑᔪᓂᓪᓗ ᐳᔩᕈᓐᓃᕈᑎᔅᓴᓄᑦ ᐱᓕᕆᔾᔪᑎᓄᑦ ᐅᔾᕋᓐᓂᐊᕝᕕᐅᑉ ᓄᓇᖏᒍᑦ. ᑕᒪᒃᑯᐊ ᐃᒥᖅᑕᕝᕖᑦ ᐃᓂᖃᖅᑑᑎᒃ ᖃᐅᔨᒪᔭᐅᔪᓂᒃ ᐱᑕᖃᐃᓐᓇᓇᐊᓕᓐᓂᓪᓗ ᐃᖃᓗᑦ ᓇᔪᒐᓖᖏᑕ ᐃᒪᖏᓂᒃ. ᖃᓇᓴᐅᔭᒃᑯᑦ ᑕᐅᑐᙱᐊᕈᐃᑦ ᓇᓚᐅᑦᑖᕈᑎᑦ, ᒪᓕᒃᑯᑦ ᐃᒥᖅᑕᓐᓂᓇᓲᕗᑦ, ᓇᓗᓇᐃᓇᕗᑦ ᑕᒪᐃᓐᓂᒃ ᐃᒥᖅᑕᕝᕕᕗᑦ ᒪᕿᒃ ᐱᔪᓐᓇᑎᒃ ᐃᒪᐃᔭᕋᔭᖅᑐᑦ ᑐᖕᖓᒍᑦ 10%, ᐊᒻᒪᓗ ᐃᒥᖅᑕᓐᓂᕗᑦ ᐃᖃᓗᐃᑦ ᓇᔪᖅᑕᖏᓐᓂᒃ ᐊᒃᑐᐃᔭᐅᔾᔭᕋᓯᒋᓇᓂ ᐃᖃᓗᑦ ᐊᒥᓲᓂᖏᑕ ᐅᓄᕈᓐᓃᖅᑎᑕᐅᓂᖏᑕᓗ. ᐸᓐᓃᓇᓯᒪᔪᑦ ᓯᐅᖅᑲᖓᓄᑦ ᑰᒃᑐᓄᓪᓗ ᓄᖑᓴᖅᑕᐃᓕᒪᔾᔪᑎᑦᑎᒍᑦ, ᐃᒥᓕᓇᓂᒧᓪᓗ ᑲᒪᔾᔪᑎᑦᑎᒍᑦ ᓄᖅᑲᖑᑎᑦᑎᓂᒻᒥᒃ, ᐊᒃᑐᐊᓂᖓ ᓯᐅᖅᑭᓇᓂᒻᒥᒃ ᐃᖃᓗᓐᓄᑦ ᓇᔪᓲᖏᓄᓪᓗ ᐃᒪᓐᓄᑦ ᐊᖏᕚᔾᔭᕋᓯᕆᔭᐅᖏᑦᑐᖅ.

ᑐᙵᓪᓗᓂ ᐅᓪᓗᒥ ᖃᒥᕐᖒᐃᓂᐅᔪᒧᑦ ᐸᓐᓃᖑᔪᓄᓪᓗ ᓄᖅᑲᖓᑎᑦᑎᔾᔪᑎᖃᓄᑦ, ᐅᔾᕋᓐᓂᐊᖅᑐᑦ ᐱᓕᕆᓂᖏᑦ ᐊᑐᖅᑕᐅᔪᒪᔪᑦ ᐃᓕᒋᔭᐅᔪᑦ ᑖᔅᓯᒪ ᓴᓇᐅᒪᓂᐊ 2 ᐅᒃᑑᑎᖓᒍᑦ ᓇᓚᐅᑦᑖᖏᒍᑦ ᓴᖅᑮᒐᔭᖏᑦᑐᖅ ᐊᖏᔪᒥᒃ ᐱᐅᙱᑦᑐᒥᒃ ᐃᒪᑦᑎᐊᕙᐅᑉ ᐆᒪᔪᖏᓂᑦ ᓇᔪᒐᖏᑕᓗ ᐃᒪᖏᓂᒃ.

Baffinland Iron Mines Corporation

Mary River Project – Phase 2 Proposal

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BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT - PHASE 2 PROPOSAL

TECHNICAL SUPPORTING DOCUMENT NO. 14:

FRESHWATER BIOTA AND HABITAT ASSESSMENT

Prepared for:

Baffinland Iron Mines Corporation

Prepared by:

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ABBREVIATIONS, ACRONYMS, AND UNITS

AEMP	Aquatic effects monitoring program
ARD	Acid rock drainage
°C	Degree(s) Celsius
DFO	Fisheries and Oceans Canada
DO	Dissolved oxygen
ECCC	Environment and Climate Change Canada
ERP	Early Revenue Phase
FAD	*Fisheries Act* Directive
FEIS	Final Environmental Impact Statement
GCM	Global Climate Models
ha	Hectare(s)
HADD	Harmful alteration, disruption, and destruction
INAC	Indigenous and Northern Affairs Canada
LSA	Local Study Area
m	Metre(s)
m^2	Square metre(s)
MHTO	Mittimatalik Hunters and Trappers Organization
ML	Metal leaching
mm	Millimetre(s)
Mtpa	Million tonnes per annum
NIRB	Nunavut Impact Review Board
PDA	Potential Development Area
TREEP	Tote Road Earthworks Execution Plan
TSD	Technical Supporting Document
TSS	Total suspended solids
Vmax	High slope, high flow
Vmin	Low slope, low flow
YOY	Young-of-the-year

1.0 INTRODUCTION

1.1 OVERVIEW OF THE PHASE 2 PROPOSAL

The Mary River Project is an operating iron ore mine located in the Qikiqtani Region of Nunavut (Figure 1-1). Baffinland Iron Mines Corporation (Baffinland; the Proponent) is the owner and operator of the Project. As part of the regulatory approval process, Baffinland submitted a Final Environmental Impact Statement (FEIS) to the Nunavut Impact Review Board (NIRB), which presented in-depth analyses and evaluation of potential environmental and socioeconomic effects associated with the Project.

In 2012, NIRB issued Project Certificate No 005 which provided approval for Baffinland to mine 18 million tonnes per annum (Mtpa) of iron ore, construct a railway to transport the ore south to a port at Steensby Inlet which operates year-round, and to ship the ore to market. The Project Certificate was subsequently amended to include the mining of an additional 4.2 Mtpa of ore, trucking this amount of ore by an existing road (the Tote Road) north to an existing port at Milne Inlet, and shipping the ore to market during the open water season. The total approved iron ore production was increased to 22.2 Mtpa (4.2 Mtpa transported by road to Milne Port, and 18 Mtpa transported by rail to Steensby Port). This is now considered the Approved Project. The 18 Mtpa Steensby rail project has not yet been constructed, however 4.2 Mtpa of iron ore is being transported north by road to Milne Port currently. Baffinland recently submitted a request for a second amendment to Project Certificate No.005 to allow for a short-term increase in production and transport of ore via road through Milne Port from the current 4.2 Mtpa to 6.0 Mtpa.

The Phase 2 Proposal (the third project certificate amendment request) involves increasing the quantity of ore shipped through Milne Port to 12 Mtpa, via the construction of a new railway running parallel to the existing Tote Road (called the North Railway). The total mine production will increase to 30 Mtpa with 12 Mtpa being transported via the North Railway to Milne Port and 18 Mtpa transported via the South Railway to Steensby Port. Construction on the North Railway is planned to begin in late 2019. Completion of construction of the North Railway is expected by 2020 with transportation of ore to Milne Port by trucks and railway ramping up as mine production increases to 12 Mtpa by 2020. Shipping from Milne Port will also increase to 12 Mtpa by 2020. Construction of the South Railway and Steensby Port will commence in 2021 with commissioning and a gradual increase in mine production to 30 Mtpa by 2024. Shipping of 18 Mtpa from Steensby Port will begin in 2025.

Phase 2 also involves the development of additional infrastructure at Milne Port, including a second ore dock. Shipping at Milne Port will continue to occur during the open water season, and may extend into the shoulder periods when the landfast ice is not being used to support travel and harvesting by Inuit. Various upgrades and additional infrastructure will also be required at the Mine Site and along both the north and south transportation corridors to support the increase in production and construction of the two rail lines.

An overview map of the Mary River Project showing the locations of the Tote Road, Milne Port, Mine Site and proposed North Railway is provided in Figure 1-2.

1.2 SCOPE

This technical supporting document (TSD) provides an assessment of effects of the Phase 2 Proposal on freshwater biota and habitat, through detailed consideration of effects on the key indicator Arctic Char (*Salvelinus alpinus*). A detailed quantification of the effects of construction of the North Railway on char habitat, one of the key activities affecting the freshwater environment, is provided in Appendix 1.

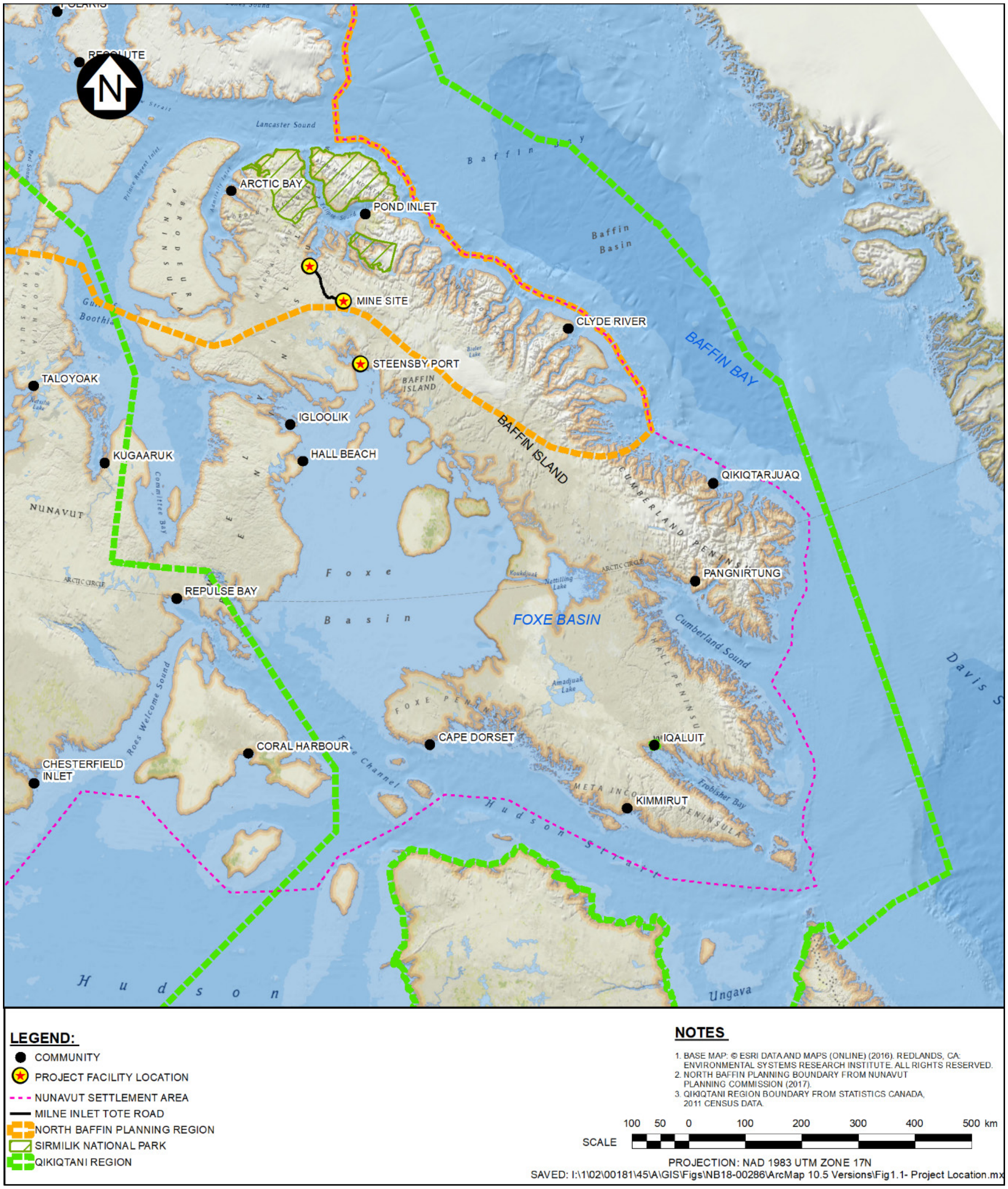


Figure 1-1. Project location map.

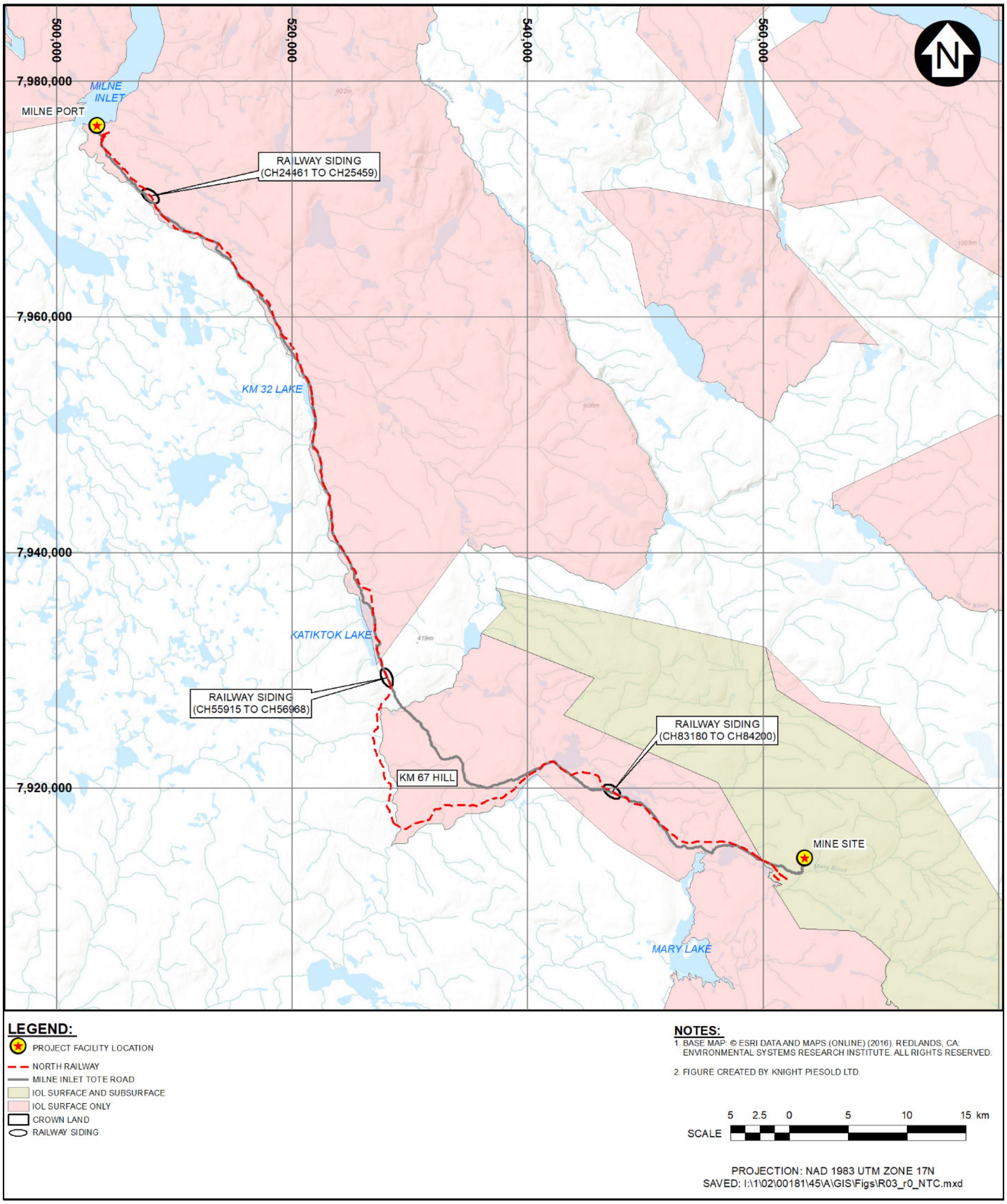


Figure 1-2. Location of Project Activities.

1.3 CONSULTATION

According to Baffinland (2017a), very few comments were received on the freshwater aquatic environment during the Phase 2 Proposal consultation activities. An Arctic Bay community member asked if Pond Inlet residents eat the fish and if it is safe to do so. A member of the Mittimatalik Hunters and Trappers Organization (MHTO) stated that the MHTO would like to see baseline studies similar to what was done for Steensby including studies on seals, cod and Arctic Char in the (Milne Inlet) area before shipping can occur.

2.0 FRESHWATER BIOTA AND HABITAT

2.1 BACKGROUND

The current operating Project affects freshwater biota and habitat across three local study areas (LSAs; Milne Port, the Northern Transportation Corridor, and the Mine Site); previously assessed Project effects on freshwater biota and habitat are described in detail in the Approved Project and are summarized below. The assessments characterised effects on Arctic Char health and condition, habitat, and direct mortality.

2.1.1 Effects on Arctic Char Health and Condition

Changes in water and/or sediment quality may directly affect the health and condition of Arctic Char through alteration in the suitability of the water or sediment to support char (e.g., decreases in dissolved oxygen [DO]). Water and sediment quality changes described in the Approved Project were considered in terms of potential effects on char.

Effects of the Project on water and sediment quality that were assessed include those related to airborne emissions (i.e., dust), aqueous point sources (e.g., waste rock stockpile runoff, treated sewage effluent, settling ponds), and non-aqueous point sources (e.g., use of explosives, introduction of sediment from construction activities, site runoff, airstrip use). Effects of these predicted changes on Arctic Char and char habitat were assessed across each of the Project study areas.

2.1.2 Effects on Arctic Char Habitat

Habitat was defined as the physical conditions required for life history stages and other biota in the ecosystem that form the basis of the food web in which Arctic Char are a component (i.e., productive capacity). Effects were defined in terms of “productive capacity” to address guidance provided in Fisheries and Oceans Canada (DFO 1998) respecting effects on fish habitat. Productive capacity may be defined as the natural ability of habitat to support or produce fish and other aquatic organisms upon which fish depend (DFO 1986).

Alteration, disruption, and destruction of Arctic Char habitat may occur through a number of pathways including:

- Construction of infrastructure within a stream or lake (e.g., culvert stream crossing, lake encroachments, water intakes, bridge piers);
- Creation of an obstruction to fish passage (e.g., installation of a physical barrier, increases in water velocities beyond the swimming capability of char, and reductions in flows or water levels);
- Changes in substrate composition due to introduction of dust (i.e., sedimentation on the lake or stream bottom);
- Loss or alteration of habitat due to water withdrawals or diversions; and
- Effects on other aquatic biota that form the base of the food web and/or that serve as food sources for char (e.g., algae, benthic invertebrates).

Effects of the Project on Arctic Char habitat related to these effects pathways were assessed in the Approved Project and included quantification of lost and altered habitat, changes in habitat quality, and a fish passage assessment for stream crossings and water diversions.

2.1.3 Effects on Direct Mortality of Arctic Char

The potential for the Project to cause direct mortality of Arctic Char were assessed in the Approved Project. Pathways of effect that were considered included the potential for egg stranding in relation to winter water withdrawals and consequent lake level reductions, fish entrainment and impingement associated with water intakes, egg mortality due to deposition of sediment on Arctic Char spawning habitat, blasting, and fish stranding. Effects were assessed for all Project study areas.

2.2 PROJECT MONITORING

Monitoring of freshwater fish and fish habitat has been undertaken in the Mine Site area and along the Tote Road throughout the construction and operation phases of the Mary River Project and includes comparisons to multiple years of baseline studies conducted to define pre-Project conditions. Results of the construction and operation monitoring for the Project are described in the NIRB annual reports (Baffinland 2014a, 2015a, 2016a, 2017b, 2018a). A brief summary and key findings of these programs through 2017 is provided below.

2.2.1 Mine Site

Field programs were initiated in the Mine Site area in 2006 and have continued through the construction and operation periods. The focus of these programs has evolved to incorporate knowledge gained and to reflect the potential effects of the Project on freshwater fish and habitat. An Aquatic Effects Monitoring Program (AEMP) was first developed in 2014 (Baffinland 2014b) and has been modified (Baffinland 2015b, 2016b) since it was first implemented in Year 1 of operation (2015).

Three years of operation monitoring have been completed to date (2015 to 2017) and have included:

- Effluent toxicity testing;
- Lake sedimentation (measure of the quantity of sediments deposited on the lake bottom over time);
- Phytoplankton (measure of abundance);
- Benthic macroinvertebrates (measures of abundance and community composition); and
- Arctic char (measures of abundance, condition, growth, and reproduction).

Some changes in freshwater biota and habitat observed in the Mine Site area that have been attributed to mine operation include indications of low level nutrient enrichment in some locations and increases in lake sedimentation rates.

The Approved Project predicted that sedimentation rates in Camp Lake and Sheardown Lake would increase as a result of dust deposition from Mine operations, but that the annual thickness of accumulated sediment in the lakes would not exceed 1 millimetre (mm) over the egg incubation period. The lake sedimentation monitoring program conducted as part of the AEMP measures deposited sediment during the open-water and ice-cover seasons using sediment traps to generate aerial deposition rates (i.e., mg/cm^2/day). These values are converted to a sediment thickness estimate by applying a dry bulk density factor. A site-specific (i.e., Sheardown Lake NW) bulk density factor has not been established; therefore, results are converted to estimates of accumulation (mm/year) based on published values in the literature, and more recently using bulk density measurements collected from sediments in a nearby stream.

Sedimentation rates in Sheardown Lake NW were higher in the winter of 2015-2016 relative to baseline studies (Minnow Environmental Inc. 2017a). In spring of 2016 a snowmelt event resulted in the release of runoff containing sediments and discoloured water to a tributary to Sheardown Lake. A second snowmelt event resulted in release of runoff containing sediments into a tributary to Camp Lake. These sediment releases at the Mine Site, in conjunction with sediment issues identified in spring 2016 at streams along the Tote Road, resulted in a Letter of Non-Compliance from Indigenous and Northern Affairs Canada (INAC) and a *Fisheries Act* Directive (FAD) from Environment and Climate Change Canada (ECCC). In response, Baffinland completed a number of construction projects to control sediment. A summary of the work completed and plans for more improvements were presented in a Completion Report which was accepted by DFO. Baffinland is working to reduce dust levels and control sediment to minimize the impact of future freshet events.

In 2016 and 2017, annual lake sedimentation rates in Sheardown Lake NW were greater than the baseline period, but remained within the range predicted for the Approved Project and within the published range of sedimentation rates for arctic lakes (Minnow Environmental Inc. 2016a, 2017a, 2018a). The corresponding calculated thickness of deposited sediment varied notably depending on which bulk density value was applied. Using a bulk density measurement from Sheardown Lake Tributary 1 sediments, sediment accumulation thickness in the lake has remained below 1 mm (the threshold applied for adverse effects on char eggs) during the Arctic Char egg incubation period since operation was initiated (Minnow Environmental Inc. 2016a, 2017a, 2018a). Higher rates (>1 mm) were estimated using unpublished bulk density data obtained from Canadian Shield lakes in northwestern Ontario. The latter approach likely resulted in an overestimate due to differences in density between particulate material from shield and Arctic lakes (Minnow Environmental Inc. 2016 a, 2017a, 2018a).

Fish population monitoring conducted in Sheardown Lake in 2016 and 2017, years in which higher sedimentation rates were observed, indicated a relatively high abundance of healthy, young-of-the-year (YOY) char which suggested no adverse effects of sedimentation on egg hatch success, larval emergence, and early life stage growth. In fact, in 2017 catches and size (length and weight) of YOY char in Sheardown Lake NW were significantly higher than char from a reference lake.

Although some changes in the aquatic environment were observed, monitoring of the biological communities (i.e., phytoplankton, benthic macroinvertebrates, and Arctic Char) conducted during the first three years of operation (2015 to 2017) indicated that with one possible exception, there were no adverse mine-related influences on the biota of the Mine Site waterbodies and watercourses (Minnow Environmental Inc. 2016b, 2017b, 2018b). The only mine-related adverse effect on biota in Mine Site waterbodies was observed in 2017 at Sheardown Lake Tributary 12. At this tributary, changes in the benthic invertebrate community assemblage relative to reference conditions and baseline studies were observed which appeared to be related to potential flow reduction and/or sedimentation (Minnow Environmental Inc.2018b).

2.2.2 Tote Road

Detailed aquatic habitat and fish use assessments of watercourse crossings along the Tote Road were conducted prior to (2006-2007) and following construction, including various upgrades, during the Bulk Sampling Program and the Early Revenue Phase (ERP) of the Project (Baffinland 2009, 2010, 2011, 2012a, 2013a, 2014c, 2015c, 2016c, 2017c; Knight Piésold 2007a,b, 2008). Since 2010, annual surveys have been conducted at all fish-bearing crossings to confirm continued fish presence and accessibility to habitat upstream and downstream of installed culverts.

Some issues regarding fish passage and condition of stream crossings have been noted in the annual surveys conducted since 2009, including:

- Improperly embedded culverts or culverts not placed in the main flow pathway;
- Perched culverts;
- High velocities due to undersized or insufficient number of culverts preventing or limiting fish passage;
- Blockage of culverts as a result of slumping embankments, misplaced rip-rap, or damage incurred during snow and ice-clearing prior to freshet;
- Scour pools below overflow culverts that attract fish during high spring flows, but become isolated as water levels decrease, resulting in fish stranding;
- Instream debris such as plastic road reflectors, damaged silt fence material, and other litter; and
- Road dust from heavy traffic burying instream substrate and covering nearshore vegetation upstream and downstream of crossings.

Baffinland has taken a number of steps and implemented various mitigation measures to correct issues identified at the fish-bearing crossings, including:

- Reinstallation of improperly embedded or placed culverts;
- Installation of access improvement structures (e.g., nature-like fishways) and reinstallation of culverts where culverts became perched;
- Adding additional culverts and/or increasing the size of culverts to improve flows and reduce high velocity and erosion events;
- Removal of blockages and reinforcement of embankments at some streams;
- Salvage fisheries have been conducted in areas prone to stranding events;
- Removal of accumulated debris in streams;
- Implementation of various dust and sediment and erosion control measures including:
  - Watering and addition of a binding agent to the road surface;
  - Road resurfacing using high quality and durable granular fills;
  - Rip-rap placement and check dam construction in roadside ditches;
  - Rip-rap armoring of culvert inlets and outlets;
  - Installation of silt fencing, installation of geojute, and use of flocculation;
  - Removal of eroded materials from roadside ditch, creeks, and streams; and
  - Berm construction.

Dust and erosion and sedimentation issues were identified in spring 2016 in streams located along the Tote Road corridor. Various mitigation measures were implemented in response to this occurrence and two mitigation action plans (Dust Mitigation Action Plan; Golder 2016a; and Sedimentation Mitigation Action Plan; Golder 2016b) were developed in which additional mitigation actions were identified.

Most fish passage issues identified in the annual monitoring surveys have been effectively mitigated. However, issues at some crossings have persisted and will require additional mitigation to rectify, including persistent perches and excessive road sedimentation. Baffinland is committed to continued monitoring and mitigation including annual monitoring at fish-bearing crossings and development and implementation of a Tote Road Earthworks Execution Plan (TREEP) to improve fish passage issues and erosion and sedimentation, which have been noted at several crossings.

2.3 ASSESSMENT METHODOLOGY

The methods used herein to assess effects of the Phase 2 Proposal on freshwater fish and fish habitat are largely consistent with the FEIS (Volume 7, Section 4.5.1; Baffinland 2012b), with the exception of the points noted below. In brief, the assessment approach was focused on Arctic Char as the key indicator and applied the criteria described in the FEIS for assessing the magnitude of effects on Arctic Char health and condition, habitat, and direct mortality. Residual effects identified in the water quantity and water and sediment quality assessments (Knight Piésold 2018) were considered here as they may relate to effects on Arctic Char.

Assessment of the potential effects of the Project on Arctic Char along the Northern Transportation Corridor was completed through a combination of empirical data collected through field surveys and a desktop assessment using detailed site imagery (see Appendix 1 for details). As the latter approach is associated with greater uncertainty than the former, where sites could not be classified as either char-bearing or not char-bearing with high confidence, the potentially affected habitat was assumed to support Arctic Char to provide a conservative (i.e., maximum potential impact) assessment.

Consideration was also given to the quality and usage of various habitats, in conjunction with the overall availability of similar habitat when assigning a magnitude ranking. For example, loss of a portion of low quality and abundant rearing habitat was considered to have a lower magnitude of effect than loss of limiting habitat, such as spawning habitat.

Potential for the Project to affect fish passage at stream crossings along the North Rail alignment was assessed through hydraulic modeling to estimate velocities at all known or potential char-bearing crossings, in conjunction with fish passage criteria in the published scientific literature and knowledge of conditions in streams located within the rail alignment corridor. This exercise was completed to assist with identification of the railway culvert crossings that will require design for fish passage in the detailed engineering design phase.

Criteria used for evaluating effects of the rail stream crossings on Arctic Char passage were modified since the submission of the Approved Project to reflect recent changes in the scientific literature regarding approaches for assessing fish passage. Specifically, criteria presented in Katopodis and Gervais (2016) were applied for the fish passage screening assessment. The approach presented in Katopodis and Gervais (2016) involves application of several equations for a specific group of fish to calculate the probability of fish passage for a specified fish size (i.e., length) and swimming distance (i.e., culvert length). The equations applicable to Arctic Char were applied on a crossing by crossing basis to identify those rail culvert installations where fish passage may be impeded or partially impeded by water velocity conditions and may therefore require mitigation. A detailed description of this approach is provided in Appendix 1. For illustrative purposes, velocity criteria for a range of culvert sizes for a 100 mm fish are presented in Table 2-1.

Table 2-1. Velocity criteria (m/s) for a 100 mm Arctic Char for a range of culvert lengths, calculated from equations provided in Katopodis and Gervais (2016).

Culvert Length (m)	95% Passage (95% Low) [1]	75% Passage (75% Low) [1]	50% Passage (Mean) [1]	25% Passage (75% High) [1]	5% Passage (95% High) [1]
5	0.33	0.48	0.81	1.35	1.94
10	0.27	0.38	0.64	1.07	1.54
15	0.23	0.33	0.56	0.94	1.35
20	0.21	0.30	0.51	0.85	1.22
25	0.20	0.28	0.47	0.79	1.13
30	0.18	0.26	0.44	0.74	1.07
35	0.17	0.25	0.42	0.70	1.01
40	0.17	0.24	0.40	0.67	0.97
45	0.16	0.23	0.39	0.65	0.93
50	0.15	0.22	0.37	0.63	0.90
55	0.15	0.22	0.36	0.61	0.87
60	0.15	0.21	0.35	0.59	0.85
65	0.14	0.20	0.34	0.57	0.82
70	0.14	0.20	0.33	0.56	0.80
75	0.14	0.19	0.33	0.55	0.79

NOTES:

1. TEXT IN BRACKETS REFERS TO TERMINOLOGY FROM KATOPODIS AND GERVAIS (2016).

2.4 CLIMATE CHANGE CONSIDERATIONS

A summary of climate change forecasts relevant to the Phase 2 Proposal is provided in Baffinland (2018b). A general intensification of the global hydrological cycle, and of precipitation extremes, is expected with a future warmer climate. Simulations predict both global precipitation and global evaporation to increase by 1 to 3% per 1 degree Celsius (°C) of global warming. With respect to the Project area, zonal mean precipitation (i.e., average precipitation across all longitudes for a given latitude), will very likely increase in high latitudes.

Projected changes in precipitation indicate increases in the winter and open-water seasons under most model scenarios. Though effects of increased precipitation are predicted to be somewhat offset by concomitant increases in evaporation, stream discharge is expected to increase, particularly during the spring freshet (due to increased snowpack).

Air temperature is also projected to increase into the future, most notably during the winter period (2018b). These changes may in turn alter water temperature and thermal regimes of freshwater ecosystems. These general predictions (increased air temperature and increased discharge) are consistent with those assessed for the Approved Project.

Climate change effects related to air temperature and precipitation/evaporation may have direct and indirect effects on freshwater biota in the Project study area. A vulnerability assessment of Arctic Char was conducted to assess the sensitivity of char to climate-induced habitat change and vulnerability to exposure to climate change (Baffinland 2018b). As noted by Baffinland (2018b), Arctic char biology exhibits traits that provide both resilience and sensitivity to climate-induced habitat change. The species is resilient due to its large population size, broad geographic distribution, and diversity of diet. At the same time, its ability to successfully adapt to expected climate change might be restricted by its dependence on a specific temperature range in certain stages of the life cycle, complexity of the reproductive strategy (i.e., undertakes migrations), habitat specificity, and individual site fidelity. These sensitivities are, however, more applicable to anadromous than land-locked char due to the requirement to undertake seasonal migrations to complete the life cycle; as described in detail in the FEIS (Baffinland 2012b), the Mine Site, Milne Port, and Northern Transportation Corridor LSAs contain little (Milne Port) or no (Mine Site and Northern Transportation Corridor) anadromous char habitat.

The overall vulnerability score assigned to Arctic Char was high (9 out of 10; Baffinland 2018b). The key factors contributing to this vulnerability score are reliance on a narrow range of water temperatures for various life stages, potential for changes in hydrological regimes to affect char habitat, the relatively slow growth rate of this species, and the likelihood of exposure to climate change-induced changes in water temperature and hydrology (Baffinland 2018b). However, as noted above, the assessment considered anadromous and land-locked Arctic Char collectively and vulnerability of the two life history strategies may differ.

As noted by Reist et al. (2006a) in a review on the effects of climate change on Arctic fish, it is difficult to predict the precise effects of climate change on “higher-order biota”. In general, effects related to increased temperatures on freshwater Arctic fish may include:

- Increased growth of biota and higher overall productivity of freshwater ecosystems due to increases in water temperatures and/or lengthening of the open-water period due to shifts in ice-on and ice-off dates;
- Increased competition between species where species extend their current ranges;
- Seasonal movements and life history characteristics (e.g., timing of spawning) may be altered due to changes in water temperatures and/or changes in the length of the open-water period;
- Increased water temperatures may affect the availability and suitability of habitats for certain biota. For example, adult Arctic Char demonstrate a preference for cooler, deeper water in the open-water season and it has been suggested that the volume of water with temperatures below 6^{o}C during the open-water season may be a limiting factor for large Arctic Char (>400 mm) in small Arctic lakes (Dick et al. 2009). Increasing water temperatures may reduce the quantity of preferred habitat, alter habitat use, and/or reduce Arctic char condition; and
- Depending on the degree by which water temperatures are increased, effects on fish and other aquatic biota may range from slightly positive (due to temperature-dependent growth rates) to highly detrimental (i.e., where temperatures are acutely lethal).

Aquatic biota and habitat may also be affected through indirect pathways related to climate change-induced effects on hydrology. Specifically, the predicted increases in air temperatures and changes in precipitation patterns (i.e., increased) are predicted to cause increases in stream discharge and lake water levels, higher peaks in hydrographs due to increased intensity of storm events, and a smaller and earlier spring freshet. The duration of the open-water season would also increase.

Global Climate Model (GCM) predictions regarding precipitation are as follows (from Baffinland 2018b):

- Under minimum scenarios, precipitation may remain essentially unchanged out to 2065;
- Under median scenarios, both summer and winter could get slightly wetter, with annual precipitation increasing 4 to 5% by 2035 and 6 to 12% by 2065; and
- Under maximum scenarios, both summer and winter could get wetter, with annual precipitation increasing 4 to 5% by 2035 and 14 to 22% by 2065.

Substantive changes in hydrology could in turn affect freshwater biota through a number of pathways, including:

- Increased stream discharges and lake water levels may increase overall quantities of aquatic habitat but may also affect the relative quantities and quality of various types of aquatic habitat;
- Earlier ice-off and later ice-on may increase productivity of aquatic ecosystems;

- The timing of seasonal movements, including anadromous migrations of Arctic char, may be altered; and
- Increased discharge and peaks in the hydrograph may alter fish passage and upstream access to habitat (i.e., increased velocities).

Potential effects of climate change on water and sediment quality in the Project LSAs include:

- An increase in concentrations and loading of total suspended solids (TSS) due to increases in overall and peak stream discharge and melting of permafrost and increased erosion;
- Increased concentrations of nutrients in water due to increased runoff and erosion; and
- Potential changes in DO due to shifts in the duration of ice-cover (potential increase in DO) and increases in water temperatures (potential decreases in DO and/or increased occurrence and duration of thermal stratification).

Changes in water quality due to increased discharge and water temperature may result in increased productivity of Arctic aquatic ecosystems (Reist et al. 2006b).

Climate change has been incorporated into the design of the Phase 2 Proposal and is considered in terms of interactions with Project effects in Section 2.6.

2.5 EFFECTS ASSESSMENT

Table 2-2 summarizes Project interactions and the nature of effects to freshwater biota and habitat at each LSA.

Table 2-2. Potential incremental effects to freshwater biota and habitat due to the Phase 2 Proposal.

Project Interaction	Milne Port	Northern Transportation Corridor	Mine Site
Minor Realignments to the Milne Inlet Tote Road	No change[1]	Minor realignment of short road sections and relocation of existing stream crossings	No change[1]
Construction of North Railway	No change[1]	Construction of watercourse crossings, pond/lake encroachments/infilling, and diversions along the North Railway	No change[1]
Water Withdrawals	No change	Additional water sources for construction and operation of the Northern Transportation Corridor	No change[1]
Dust Deposition	Increase in dust deposition due to increased stockpiling and shiploading of ore	Minor change[2]	Decrease in dust deposition due to relocation of secondary crushing to Milne Port[3]
Changes in Water and Sediment Quality	Minor change	Development of quarries, drilling, blasting, and excavation of rock cuts	Minor change[3]

NOTES:

1. EFFECTS RELATED TO THE NORTH RAIL AND TOTE ROAD CONSIDERED WITHIN THE NORTHERN TRANSPORTATION CORRIDOR.
2. NO MEANINGFUL CHANGE IN THE EFFECTS OF ROAD DUST DUE TO INCREASED TRAFFIC FOR THREE YEARS IS ANTICIPATED DUE TO CONCURRENT INCREASES IN DUST SUPPRESSION EFFORTS.
3. DUST DEPOSITION IS EXPECTED TO DECREASE AT THE MINE SITE RELATIVE TO THE APPROVED PROJECT, AS ASSESSED IN THE FEIS AND FEIS ADDENDUM.

To focus the assessment, potential interactions of the Phase 2 Proposal with freshwater biota and habitat were ranked as follows (Table 2-3):

- 0 – No interaction – No assessment required;
- 1 – Minor interaction – Not subject to detailed assessment; or
- 2 – Major interaction – Subject to a detailed assessment.

Table 2-3. Phase 2 Proposal minor and major interactions with freshwater biota and habitat.

Project Infrastructure or Activity	Level of Interaction
North Railway	
Construct temporary and permanent culvert crossings	2
Construct bridges with piers at four large crossings	2
Construct stream diversions along rail corridor	2
Construct lake/pond encroachments/infilling along rail corridor	2
Changes in water and/or sediment quality from acid rock drainage (ARD)/metal leaching (ML)	1
Tote Road	
Increased flows at crossings that will receive diversions due to the North Railway	1
Short-term traffic increase associated with increased ore haulage to 6 Mtpa and to support rail construction	1
Increased water withdrawals for dust suppression	2
Construct new culvert crossings and relocate existing culvert crossings	2
Milne Port	
Increased dust deposition at Milne Port	1
Short term increases in suspended sediment in Phillips Creek during freshet	1
Mine Site	
Increased water withdrawals [1]	2
Increased sedimentation in lakes	2
Changes in water and/or sediment quality (dust deposition)	2

NOTES:

1. EFFECTS RELATED TO THIS ACTIVITY CONSIDERED WITHIN THE NORTHERN TRANSPORTATION CORRIDOR.

The Phase 2 Proposal will not involve any changes to the South Rail project (South Railway and Steensby Port). Potential effects of the Project that are associated with minor interactions with Arctic Char are described below; effects associated with major interactions are described in sections 2.5.1 through 2.5.5.

At Milne Port, minor alterations to local drainage and surface water quality and sediment quality will occur as a result of additional infrastructure within a larger Project Development Area (PDA; Knight Piésold 2018). However, with the exception of potential effects related to dust deposition, none of the drainages that may be affected by the Phase 2 Proposal support freshwater Arctic Char within the Milne Port area, and nearly all site runoff enters the marine environment. Though increases in effluent volumes will be generated from larger ore stockpiles and an expanded sewage treatment plant, these effluents are discharged to the marine environment and there is therefore no effect on freshwater char.

The Phase 2 Proposal will involve the transport, stockpiling, and handling of ore along the Milne Inlet Tote Road and Milne Port and will result in deposition of dust with subsequent effects on water and sediment quality. However, the predicted effects described in the Freshwater Assessment are similar to those described in the ERP Addendum to the FEIS (Baffinland 2013b). Specifically, the Freshwater Assessment (Knight Piésold 2018) indicates potential increases in TSS in Phillips Creek between 1 and 9 mg/L during the spring runoff period. The ERP Addendum to the FEIS also predicted increases of this magnitude for Phillips Creek. Available information indicates limited (or possibly no) usage of Philips Creek by Arctic Char, and un-surveyed streams in the dust deposition area are not expected to provide Arctic Char habitat or marginal habitat at best. Therefore, the risk of exposure of Arctic Char to dust-related effects on water quality is therefore limited.

Because the predicted effects of dust on water quality in the Milne Port LSA are unchanged from those described in the ERP Addendum to the FEIS, in addition to low risk of exposure to Arctic Char, effects of the Phase 2 Proposal on this pathway are considered to be negligible and are not assessed further.

Temporary culvert installations will be constructed near the proposed bridges at CV-15-5 and CV-85-3, along a temporary haul road near the temporary ore stockpile at km 56, and at several quarry sites near the rail and road to facilitate construction of the rail. Culvert design details are not currently available, precluding calculation of the areas of habitat that would be affected by these installations. However, as the crossings will be in place for a maximum of two years, the impacts on char habitat would be short-term and the area that would be affected is expected to negligible in relation to the total available habitat along these watercourses. Crossings would be removed and the sites restored; fish passage will also be provided at sites that support Arctic Char. Effects related to these activities are therefore considered to be negligible and not assessed further.

Construction of the North Railway and new and relocated crossings along the Milne Inlet Tote Road have the potential to affect Arctic Char through a number of key pathways including:

- In-stream construction activities may obstruct fish passage;
- In-stream construction may mobilize sediments, thereby increasing concentrations of TSS which may adversely affect char;
- In-stream construction may result in the stranding of fish (e.g., as a result of water diversions);
- Installation of infrastructure within watercourses and waterbodies (e.g., bridges, culverts, and lake/pond encroachments/infilling) will result in destruction and/or alteration of char habitat;
- Water diversions due to rock cuts made to maintain a relatively constant grade along the railway may result in the loss and/or alteration of Arctic Char habitat upstream and/or downstream of the cuts;
- Arctic Char habitat in waterways receiving diverted flow may be altered due to increased flows; and
- Watercourse crossings (i.e., bridges and culvert installations) may block or impede fish passage (e.g., due to increased velocities).

The Project may affect water quality, and in turn affect Arctic Char, through a number of pathways, as described in Knight Piésold (2018), including:

- Various construction activities that result in erosion and sedimentation in Arctic Char habitat;
- Dust deposition;
- Site preparation;
- Development of new quarries; and
- Drilling, blasting, and excavation of rock cuts.

As described in Knight Piésold (2018), there will be a temporary (3-year) increase in traffic along the Tote Road, resulting in an increase in dust emissions that remains within the same magnitude of effects assessed previously for this pathway. Once the North Railway is fully operational, truck traffic will be substantially reduced, and dust emissions generated within the transportation corridor will also be substantially reduced. Minimal windblown dust emissions from the rail cars are expected while in transit (FEIS Volume 5, Section 2.6.3.2). Therefore, this effect was not assessed further.

Exposure of rock surfaces to weathering and erosion, and the subsequent potential for alterations to water quality due to ARD and/or ML was assessed in detail in Knight Piésold (2018). Development of quarries and rock cuts for construction of the North Railway will expose fresh rock surfaces to weathering and oxidation processes. These materials have the potential to leach metals and/or generate acid rock drainage which may adversely affect Arctic Char. The water quality assessment indicates that the risk associated with development of quarries and borrow pits and generation of ARD/ML is low based on previous testing as well as the mitigation measures identified in the existing Borrow Pit and Quarry Management Plan (Baffinland 2014d). The management plan includes a requirement for site-specific geochemical testing of rocks prior to quarrying and a provision that should issues be identified, the quarry would be avoided.

As described by Knight Piésold (2018), though there may be less flexibility for avoiding ARD/ML issues associated with rock cuts for construction of the North Railway, a number of steps will be taken to assess the ARD/ML generation potential and to mitigate for potential adverse effects on water quality including:

- Consideration of re-routing of the railway to avoid areas identified to be of potential concern;
- Rock excavated from areas where ARD/ML issues have been identified will not be used for embankment fill and will be disposed of in a suitable fashion to avoid issues in other systems; and
- Exposed rock faces will be managed on a site-specific level and may include covering exposed faces with non-ARD/ML materials and/or placing limestone within the seepage path.

Blasting will be undertaken to develop new aggregate sources for construction of the North Railway. The use of explosives can result in runoff of ammonia and other nitrogen-containing compounds, and drilling, blasting and excavation of rock at quarries and rock cuts have the potential to increase sediment loadings into local water sources. As described in Knight Piésold (2018), the scale of these activities are consistent with what was assessed in the Approved Project for the South Railway, and Baffinland's now-operational management plans are appropriate to deal with these issues during the Phase 2 Proposal.

Based on the management and mitigation measures identified by Knight Piésold (2018), as summarized above, effects on Arctic Char are expected to be negligible. Effects of construction of the North Railway for key pathways of effect are discussed in detail in Section 2.5.1.

The Milne Inlet Tote Road will undergo some changes to accommodate construction of the North Railway. These include:

- Realignment of the road at several locations including CH29,500, CH31,200, and CH84,500 to CH85,900, and six minor realignments to achieve a 90° crossing with the railway, which will result in new stream crossings and/or relocation of existing stream crossings; and
- A temporary ore transfer area will be constructed at km 56. A new segment of road (approximately 1.3 km in length) will be constructed and used for hauling ore until construction of the rail is complete. A short segment of the existing Tote Road will also be realigned in this area.

Effects relating to realignment of the Tote Road are described in Section 2.5.2.

The Phase 2 Proposal includes an increase in water withdrawals for dust suppression. Water withdrawals may indirectly affect Arctic Char through effects on habitat (e.g., reduced quantity of habitat), as well as directly through desiccation/freezing of eggs due to winter drawdown, entrainment or impingement of fish, and through effects on fish passage and/or stranding. Effects of water withdrawals on Arctic Char are assessed in Section 2.5.3.

The Phase 2 Proposal may affect water and sediment quality at the Mine Site LSA through changes in dust deposition. Dust may adversely affect Arctic Char through alterations to char habitat (i.e., changes in substrate and/or effects on lower trophic level biota), changes in water and/or sediment quality, and/or through increases in sedimentation rates on Arctic Char eggs. Changes to dust deposition in the Mine

Site area were assessed and described in detail by Knight Piésold (2018); effects on Arctic Char due to this change are described in Sections 2.5.4 and 2.5.5 below.

2.5.1 Construction of North Rail Watercourse Crossings, Pond/Lake Encroachments/Infilling, and Diversions Along the North Railway

The North Railway will cross, divert, or encroach/infill at a total of 465 sites in waterbodies along the corridor. All sites were assessed for the potential to support Arctic Char using remote imagery and through field studies. A total of 298 of these sites were identified as not supporting Arctic Char. A total of 167 sites were identified as occurring in known, probable, potential, or unlikely Arctic Char habitat (hereafter referred to as “char habitat”). Waterbodies where the presence of Char was considered potential or unlikely were considered as “char habitat” to provide a conservative (i.e., over-estimate of potential effects) assessment. Appendix 1 provides a detailed description of effects of North Railway infrastructure on Arctic Char habitat.

Streams that support Arctic Char that will be crossed by the North Railway are perennial or intermittent streams with predominantly gravel and cobble/boulder substrates. The largest streams (rivers crossed by bridges at CV-70-3 and CV-85-3) may provide some summer feeding habitat and serve as movement corridors for adults, but all other streams provide summer juvenile rearing habitat only. No spawning or overwintering habitat exists in any streams in the study area; spawning habitat is limited to lakes with sufficient depth. None of the waterbodies affected by the North Railway infrastructure support permanent populations of anadromous char, due to the lack of connectivity between marine habitat (e.g., Milne Inlet) and freshwater spawning habitat (i.e., lakes with sufficient depths) in the study area.

2.5.1.1 Construction

Construction of rail infrastructure in or near watercourses or waterbodies is expected to have a negligible effect on Arctic Char with implementation of appropriate mitigation measures. Work would begin with establishing required methods of sediment control, which may include silt curtains in the water and sediment fences on land. If required, stream channels would be isolated and dewatered. The work area would be kept dry with pumps running continuously where required.

For culvert installations, the stream channel would be excavated as indicated on the design drawings to allow for the placement of bedding. All fill placed under and around the culverts will be clean. Slopes will be stabilized with rocks, geotextiles and/or hydraulic seed and mulch. At the completion of construction, erosion and sediment control and temporary stream flow control would be removed.

Environmental protection measures that would be implemented as applicable include those identified by DFO in “Measures to Avoid Serious Harm to Fish and Fish Habitat” (DFO 2017), and would be developed in detail during planning for construction of the stream crossings. Railway design and associated mitigation measures also incorporate moderately likely climate change scenarios.

The following environmental protection measures will be implemented:

- In-stream work will not be conducted during the restricted activity window, September 1 through June 30, where applicable (i.e., where spawning habitat is present or at sites where fall spawning movements are occurring such as at the bridge crossing sites CV-15-5, CV-70-3, and CV-85-3) to avoid effects on Arctic Char spawning and egg incubation;
- Work in watercourses will be conducted in isolation of surface waters, if flow is present;

- If dewatering is required, fish will be salvaged prior to dewatering and released to adjacent surface waters;
- If water is pumped from within the cofferdam prior to fish salvage, screens meeting criteria set out by DFO will be used;
- Erosion and sediment control measures will be implemented prior to the start of construction and maintained until all disturbed ground has been permanently stabilized;
- Low vegetative cover within 100 metres (m) of the crossing will be preserved unless effective erosion and sediment control are in place to protect water quality;
- Measures will be implemented as soon as possible to stabilize banks disturbed by construction to avoid erosion or sediment releases to the water. Re-vegetation with natural vegetation is the preferred approach;
- Measures for managing water flowing onto the site, as well as water being pumped/diverted from the site, will be implemented such that sediment is filtered out prior to the water entering the waterbody (e.g., by discharging water to a vegetated area);
- All dredged material will be deposited in a manner to prevent its re-entry into the watercourse;
- Stabilization of slopes with rocks, geotextiles, and/or hydraulic seed and mulch;
- Application of measures to avoid serious harm to fish and fish habitat (DFO 2017) associated with blasting, including:
    - Timing of in-water work requiring the use of explosives to adhere to the fisheries timing window;
    - Isolation of the work site to exclude fish from within the blast area (e.g., using cofferdams or aquadams);
    - Conducting a fish salvage within the isolated area and releasing fish beyond the blast area prior to initiating blasting;
    - Minimizing blast charge weights used and subdividing each charge into a series of smaller charges in blastholes (i.e., decking) with a minimum 25 milliseconds (1/1000 seconds) delay between charge detonations;
    - Back-filling blast holes (stemmed) with sand or gravel to grade or to streambed/water interface to confine the blast;
    - Placement of blasting mats over top of holes to minimize scattering of blast debris around the area;
    - Avoidance of use of ammonium nitrate based explosives in or near water due to the production of toxic by-products;
    - Removal of all blasting debris and other associated equipment/products from the blast area; and
    - Adherence to DFO blasting guidelines (Wright and Hopky 1998). As specified in Project Certificate Condition No. 13, Baffinland will engage DFO if blasting is undertaken during the open-water season.
- Fill material placed below the high water level within the waterbody's flood plain will be either erosion resistant or protected from erosion and only clean fill will be used;
- No waste material resulting from work activities will be left in a manner such that it can enter the water (e.g., by being left on the ice);
- Machinery will be washed, refueled and serviced, and fuel and other materials will be stored in such a way as to prevent any deleterious substances from entering the water. Such activities typically occur at least 50 m from the high water mark;
- A spill response plan will be developed that will be implemented immediately in the event of a sediment release or spill of a deleterious substance;

- Machinery will arrive at site in a clean condition and be maintained free of fluid leaks, invasive species and noxious weeds;
- Whenever possible, machinery will be operated on land above the high water mark or on ice, in a manner that minimizes disturbance to the banks and bed of the waterbody; and
- Fording of the watercourse by machinery will be limited to a one-time event (i.e., over and back), and only if no alternative crossing method is available. If repeated crossings of the watercourse are required, a temporary crossing structure will be constructed.

2.5.1.2 Habitat Loss and Alteration

Bridges

Abutments for each of the four bridge crossing sites will encroach on stream channels and will require placement of support piers and rip-rap within river channels. Each of these sites provides habitat for Arctic Char. Two of these watercourses (streams crossed by bridges CV-70-3, CV-85-3) are located on a major outflow from Muriel Lake; these streams provide juvenile rearing habitat but are also likely to be used as movement corridors for both juveniles and adults. The bridge at CV-85-3 will be adjacent to an existing bridge/culvert installation along the Tote Road, which crosses the mouth of the stream flowing out of Muriel Lake. Bridge CV-102-1 will cross the Tom River and Bridge CV-15-5 will cross a major tributary to Phillips Creek; both of these streams provide summer juvenile rearing habitat and the latter stream is likely to support movements of adult char. None of these streams provide overwintering or spawning habitat; fish presence is limited to the open-water season under sufficient flow conditions.

Support piers will be placed on concrete pads covered in rip-rap to stabilize the stream bed. Wherever feasible, rip-rap material will be selected to match existing stream bed material to provide potential habitat for lower trophic biota and fish and to minimize alteration to fish habitat.

The total area of available stream habitat in streams with bridge crossings is calculated to be 3,983,856 m^2 (398 hectares [ha]; Table 2-4). The total area lost due to instream placement of bridge piers and abutments will be 49.7 square metres (m^2; 0.050 hectares [ha]), or 0.001% of the total available habitat. An additional 2,366 m^2 (0.237 ha), or 0.059% of the total available habitat will be altered by placement of rip-rap armouring around abutments and piers. The total area of fish habitat that will be lost or altered by installation of the four bridges will be 2,416 m^2 (0.242 ha), or 0.06% of the total available habitat.

Culvert Stream Crossings

Of the 402 culvert stream crossings, 142 will be placed in Arctic Char stream habitat. The total area of available char habitat in the study area streams where diversions or culverts will be constructed is estimated to be 8,958,286 m^2 (896 ha; Table 2-4). The total culvert footprint area, including rip-rap aprons, in streams that support Arctic Char is estimated as 30,621 m^2 (3.06 ha), or 0.34% of the total available habitat. All of the affected stream habitat is juvenile rearing and foraging habitat and this habitat is not expected to be limiting to fish populations in the region. There are no direct impacts to spawning or overwintering habitat related to direct habitat loss at culvert crossings.

In addition to the culverts described above, temporary culvert installations will be constructed near the proposed bridges at CV-15-5 and CV-85-3 to facilitate construction of the rail. Culvert design details are not currently available, precluding calculation of the areas of habitat that would be affected by these installations. However, as the crossings will be in place for up to 2 years, after which the sites would be restored, the impacts on char habitat would be short-term and the area that would be affected is expected to negligible in relation to the total available habitat along these watercourses.

Pond/Lake Encroachments/Infills

There are a number of locations where the railway will pass in close proximity to a lake or pond, in some cases close enough that the toe of the railway embankment will occupy a portion of lake bed. A number of other ponds will be crossed (i.e., infilled) by the rail alignment (total number of ponds/lakes that would be affected is 28). A total of 12 encroachments/infills were identified within lakes/ponds that may support Arctic Char.

The encroachment or infill sites in fish-bearing ponds or lakes will displace existing habitat; habitat may be used for by char for rearing and foraging. All but one of the affected lakes/ponds are known or suspected to be relatively shallow with substrates comprised primarily of fines and habitat quality is expected to be marginal.

Only one lake (at CV-71-1) is expected to provide important char habitat (i.e., a relatively large lake suspected of providing abundant summer rearing and foraging habitat). The railway will result in displacement of 1,214 m^2 (0.12 ha) of lake habitat, equivalent to 1.1% of total lake habitat, or approximately 1.3% of total shoreline length.

The total available habitat in Arctic Char ponds/lakes with anticipated railway encroachments/infilling is estimated to be 264,556 m^2 (26.5 ha; Table 2-4). The total area of displaced habitat within these waterbodies will be 9,853 m^2 (0.99 ha), or 3.7% of the total available habitat. The total nearshore habitat in the affected lakes known to support Arctic Char, expressed as shoreline length, was calculated to be 9,974 m. The total displaced nearshore habitat in these lakes will be 1,229 m, or 12.3% of available habitat in those waterbodies. These estimates conservatively include two ponds (at CV-26-1 and CV-106-1) where it has been assumed the entirety of the ponds, including nearshore habitat, will be lost due to infilling.

Culverts will be installed at lake infill sites and at the mouths of streams where the encroachments affect lake and stream outflow/inflows and will be designed to provide for fish passage.

Diversions

Construction of the North Railway will include a total of 31 cuts in streams, which will entail diversion of flows to adjacent watercourses or waterbodies. Nineteen of the diversions are located in streams, waterbodies, or low points that do not support char. The diversion of flow will not affect char habitat in downstream waters either, because the affected waterbodies are not connected to downstream char habitat or the diversion will be redirected to the same drainage at a point upstream of where it becomes char habitat. The remaining 12 diversions were identified as having the potential to result in the loss and/or alteration to Arctic Char juvenile rearing habitat.

Diversions will directly affect Arctic Char habitat in twelve streams that are known or designated as potentially supporting Arctic Char upstream and/or downstream of the cuts. For the purposes of quantifying effects on habitat, the area of these streams located upstream and downstream of the cuts to the point of the nearest downstream confluence with a river, stream, or pond was considered to be lost habitat. The total area of lost stream habitat is 19,976 m^2 (2.0 ha; Table 2-4), or approximately 0.22% of total available stream habitat crossed by the rail alignment.

All cuts in streams that discharge to large rivers will be diverted into drainages that also drain to the same downstream river system and in all cases flows will be either returned to the same tributary or to an adjacent tributary that discharges upstream into the same large river system.

Four of the cuts will result in alteration to downstream char habitat due to flow reductions. One cut (CV-90-4) will result in the diversion of one of the inflows to a downstream lake, which may result in reductions in the area of lake habitat. The proportion of the overall lake drainage basin represented by the diversion at CV-90-4 is estimated to be less than 5% and effects on lake habitat and habitat in the lake outflow were therefore considered to be negligible. The area of altered stream habitat due to flow reductions associated with diversions at CV-58-7, CV-60-4a, and CV-61-3 is estimated as 5,916 m^2 (0.59 ha), or approximately 0.07% of total char stream habitat for streams crossed by the rail alignment. For the remaining eight cuts, diverted flow is directed to a branch of the same stream, resulting in no net change in flow downstream of the first stream confluence.

Collectively, the area of lost and altered habitat due to the diversions is estimated at approximately 25,712 m^2 (2.57 ha), or 0.29% of total available stream habitat for streams crossed by the rail alignment. The affected habitat is juvenile rearing habitat, which is not expected to be limiting to fish populations in the region.

Receiving streams will experience an increase in flow and, as described in Knight Piésold (2018), where diversions cause a greater than 10% increase in flow and the combined catchment area (baseline plus diverted catchments) is greater than 0.5 km^2, there is potential to cause more frequent overbank flooding, and potential changes in permafrost, frozen soil conditions, and fluvial morphology. An assessment of the effects of the additional flows on the morphology of the receiving streams was completed to evaluate the relative risk of effects to stream morphology, fish habitat, and other considerations such as the Tote Road (Knight Piésold 2018). Twenty-two streams receiving diverted flows are considered low risk, three diversions are considered medium risk (CV-8-1/CV-8-2, CV-12-5/CV-13-1, and CV-35-4), and one was identified as of high risk (CV-59-4; Knight Piésold 2018). For diversions considered low risk, mitigation will include monitoring for a short period of time post construction (i.e., 1 to 2 years) to verify that the diversions are not causing unexpected effects.

Where diversions are considered high or moderate risk of causing measurable change to channel morphology and sediment transport, design mitigation measures can be used to address the identified risks (Knight Piésold 2018). Although diversions at the medium risk sites would not directly affect Arctic Char habitat as the diversions will be redirected to the same drainage upstream of char habitat, indirect effects could occur due to changes in water quality upstream. The medium and high risk crossings will be reviewed during detailed engineering design and appropriate mitigation measures (for example, channel armouring) will be incorporated into the designs to address potential sediment transport and channel morphology issues as required.

Without mitigation, the increased flows at CV-59-4 (i.e., the high risk site) could potentially alter important Arctic Char habitat at and downstream of the diversion. However, effects of increased flows on fish habitat are assumed to be negligible with implementation of mitigation measures which may include:

- Channel widening;
- Regrading;
- Construction of habitat features (in fish bearing streams); and
- Channel stabilization.

Monitoring would be conducted during the initial diversion period to assess potential effects on fish habitat and mitigation measures would be applied as required should issues be identified. Site-specific assessments will be undertaken during detailed engineering design of the railway. The assessments will consider fish use and length of impacted channel, and potential mitigation options will be identified and incorporated into the final design (Knight Piésold 2018).

Effects of increased flows (and associated velocities) from stream diversions on fish passage along the North Rail were considered and described below.

Fish Passage

Bridges and culverts may impede or obstruct fish passage through changes in hydrology, most notably where these changes result in increased water velocity. Impediment to fish passage is a potential issue for the North Railway and is therefore a focus for mitigation efforts.

Bridges may impede fish passage where in-stream structures result in channel constriction and increases in velocities. Each of the four bridges is located in Arctic Char habitat and will be designed to provide for fish passage. Fish passage will be assessed prior to and following bridge construction through evaluation of water velocities. Where they increase substantially, the channels will be lined with boulders to roughen the channel and alter the velocity profile. If necessary, large boulders will be placed in a staggered formation to provide velocity refugia for fish as they move through the bridge structures. In all cases, it is anticipated that instream pier or abutment placements will not alter stream hydraulics to the extent that fish passage may become an issue, although local flow characteristics may be altered somewhat.

Culverts can impede fish passage due to excessive culvert length or flow velocity, or to a combination of length and flow velocity. Construction of the railway will involve 142 crossings on streams with juvenile Arctic Char and four pond encroachment/infill sites where fish passage would be required to ensure connectivity between stream and pond habitat. As described in Appendix 1, fish passage at culvert stream crossings was assessed through hydraulic modeling to estimate water velocities, and comparison to velocity criteria calculated for each crossing using the average length of Arctic Char (100 mm) measured during Tote Road field programs. This exercise was completed to assist with identification of the railway culvert crossings that will require design for fish passage in the detailed engineering design phase.

Site specific information is not available for the crossings; therefore hydraulic modeling was conducted for two scenarios: low slope, low flow (referred to hereafter as “Vmin”); and high slope, high flow (referred to hereafter as “Vmax”; Knight Piésold 2018). Hydraulic modeling was not completed for a total of 12 sites due to lack of detailed engineering design information.

Of the 130 stream crossings in char habitat for which hydraulic modeling was completed, passage of a 100 mm Arctic Char would not be impeded at 57 (44%) and 19 (15%) sites for the Vmin and Vmax scenarios, respectively. Of the remaining sites, 72 (55%) and 99 (76%) culvert crossings may partially impede upstream movements of Arctic Char of 100 mm in length under average open-water season flows, depending on slope and flow scenarios (Appendix 1). Total loss of fish passage (i.e., velocity modeling criteria for 5% passage not met) under average flow conditions is predicted for one (1%) crossing under Vmin and 12 (9%) crossings under Vmax.

The four sites (CV-15-2, CV-15-3, CV-65-2, and CV-71-1) where the rail will encroach upon or cross pond habitat and potentially affect access between pond and stream habitat are each predicted to result in some degree of fish passage impediment (Appendix 1).

As the rail alignment was routed to remain within the Tote Road corridor wherever technically feasible, many of the rail culvert crossings will be in close proximity to existing Tote Road crossings. In some instances, the road and rail crossings will effectively become one installation. In these cases, fish passage may be impeded by the cumulative effect of the road and rail crossings. The crossing installations will be designed to provide for fish passage at char-bearing streams with consideration of the potential for cumulative effects.

As noted above, the intent of the fish passage assessment described herein was to identify crossings where additional mitigation will be required to ensure fish passage. Fish passage through culverts can be enhanced by maximizing water conveyance capacity (oversized culverts), embedding culverts and roughening the bed within the culverts (boulder placement), avoiding outlet drops, and providing downstream and upstream resting pools. However, for long culverts, especially in combination with high gradients, maintaining water velocities that fish can manage for the time it takes to pass through a culvert may not be possible.

Fish-bearing culverts will be assessed on a case-by-case basis to install appropriate fish passing promoting measures during the final detailed engineering design phase of the Project. To mitigate for potential fish passage issues at the culvert crossings, numerous design features that promote fish passage may be considered and will be incorporated wherever feasible. Mitigation measures that will be considered include:

- Installation of culverts at the same slope as the existing stream, where feasible;
- Minimization of culvert lengths;
- Culverts with lengths that exceed 50 m may be considered barriers to fish passage due to darkness. Methods to provide light inside culverts will be examined and considered where applicable;
- Culvert velocities will be compared to the velocity in the existing watercourse to determine fish passage potential. This information can be used to reassess design velocities under proposed conditions with the culvert installed;
- With the channelization of flows and conveyance in culverts, the velocity of the flows may increase. This may be mitigated by placing rocks and boulders inside the culverts (stream replication) to provide greater friction, thereby reducing velocities and increasing the flow depth and to provide resting locations for fish. Boulders may be bolted into place; and
- In culverts on steep slopes, high velocities may result in the movement of rocks inside the culvert. At these locations, baffles, baffle inserts or weirs may be installed to:
    - Assist in keeping rocks inside the culvert;
    - Maintain and increase roughness in order to reduce velocities; and
    - Provide additional resting locations for fish as they move through the culvert.

With implementation of design and mitigation measures, effects of culvert installations on fish passage are assumed to be negligible.

<u>Effects on the Productive Capacity of Arctic Char Habitat</u>

With implementation of design measures to provide for fish passage at the stream culvert installations where Arctic Char are known or suspected to be present, the rail infrastructure would result in the loss/alteration/displacement of approximately 68,602 m^2 (6.86 ha) of Arctic Char habitat, or 0.53% of the total char stream, lake/pond, and larger stream/river habitat that would be crossed/affected directly by the railway (Table 2-4). This total includes a loss/alteration/displacement of 0.06% of large river habitat due to bridges, 0.63% of primarily stream habitat due to cuts and culvert installations, and 3.7% of lake habitat due to encroachments/infilling. Nearly half (30,621 m^2 or 3.1 ha) of the area of habitat that will be lost/altered/displaced by the North Railway is associated with culvert installations.

With the exception of larger watercourses where bridge installations will be constructed (i.e., at CV-15-5, CV-70-3, and CV-85-3), all affected streams provide juvenile rearing and foraging habitat and are not used by adult char. Juvenile rearing and foraging habitat is abundant and not limiting to char in the LSA. The larger watercourses where bridges will be constructed are also migratory corridors for adult fish to spawning grounds; however, the bridges are not expected to affect this life history function. None of the waterbodies that will be affected by rail infrastructure provide overwintering or spawning habitat for char.

Effects of the Project on the productive capacity of Arctic Char habitat in the North Railway LSA relate to direct loss and alteration of habitat due to Project footprints, alterations in hydrology, and changes in water quality. Overall effects on productive capacity of habitat are expected to be negligible to small due to the low percentage of habitat affected by Project footprints, and negligible to small effects of Project construction, operation, and closure on water quality. Although the total amount of habitat affected is negligible (i.e., less than 1%), to be conservative, overall effects are ranked as of low magnitude (Level 1) to reflect the higher relative proportional effects of encroachments and infilling on lake habitat (i.e., 3.7% of the lake habitat).

The area of lost/altered char habitat that is described in detail in the preceding sections and summarized in Table 2-4 is expected to be an overestimate due to the conservative approach applied for the quantification. For previously un-surveyed lakes, ponds, and streams where the presence/absence of fish could not be confirmed with existing knowledge or through identification of barriers to fish movements, fish presence was conservatively assumed. It is expected that some of the habitat that was assumed to support char is not char habitat; the estimates are expected to be revised following completion of field surveys.

Field surveys will be completed for sites not previously visited and for which the designation regarding the presence/absence of Arctic Char is associated with high uncertainty. Monitoring at select crossings, diversions, and lake/pond infill/encroachment sites would be conducted, notably at sites deemed important char habitat, to assess fish passage and to confirm effects assessment predictions.

Table 2-4. Summary of loss of, and alteration to, Arctic Char habitat due to rail infrastructure.

Habitat/Rail Infrastructure		Arctic Char Habitat (m²)			
		Lost[1]	Altered[2]	Total	% of Available
Available Habitat Crossed by Rail	Streams/ponds: cuts and culverts	-	-	8,958,286	-
	Ponds/Lakes: encroachments and infilling	-	-	264,556	-
	Large rivers: bridges	-	-	3,983,856	-
Lost/Altered Habitat					
Bridges		50	2,366	2,416	0.06
Pond/Lake Encroachments/Infilling		9,853	-	9,853	3.72
Culvert Crossings: Streams		20,317	10,305	30,621	0.34
Cuts	Upstream	7,016	-	7,016	0.08
	Downstream	12,780	5,916	18,696	0.21
	Sub-Total	19,796	5,916	25,712	0.29
Total Stream Habitat		40,113	16,220	56,333	0.63
TOTAL		**50,016**	**18,586**	**68,602**	**-**

NOTES:

1. LOST HABITAT WAS DEFINED AS THE AREA OF THE CULVERT FOOTPRINTS, THE AREA OF ABUTMENTS AND PIERS WITHIN THE STREAMS FOR BRIDGES, AND THE AREA OF DEWATERED HABITAT AT CUTS.
2. ALTERED HABITAT WAS DEFINED AS THE AREA OF RIP-RAP APRONS FOR CULVERT INSTALLATIONS, THE AREA OF RIP-RAP ARMORING FOR BRIDGES, AND THE AREA OF HABITAT DOWNSTREAM OF DIVERSIONS WHERE FLOWS WILL BE REDUCED.

2.5.2 Milne Inlet Tote Road Stream Crossing Modifications

Realignment of the Tote Road will result in installation of nine new stream crossings and relocation of five stream crossings.

2.5.2.1 Construction

Effects related to construction of these culvert crossings are expected to be negligible with implementation of mitigation measures as described in Section 2.5.1.1.

2.5.2.2 Habitat Loss and Alteration

Realignment of the Tote Road will involve installing new stream crossings at nine sites, four of which will be in known or potential Arctic Char habitat (Table 2-5). Five existing crossings will be relocated due to the road realignment. Three of these sites, currently located in non-char habitat, will be relocated in what has been assessed through a desktop exercise as “unlikely” char habitat; the remaining two sites that will be relocated are not fish-bearing. One crossing will be relocated from Arctic Char habitat to a site that does not provide Arctic Char habitat.

Streams that support Arctic Char that are crossed by the Tote Road are perennial or intermittent streams with predominantly gravel and cobble/boulder substrates. No spawning or overwintering habitat exists in any streams in the study area; spawning habitat is limited to lakes with sufficient depth. None of the streams affected by the Tote Road infrastructure (existing and planned changes) support permanent populations of anadromous char, due to the lack of connectivity between marine habitat (e.g., Milne Inlet) and all freshwater spawning habitat (i.e., lakes with sufficient depths) in the study area.

Footprint areas for new and relocated Tote Road stream crossings that will be constructed in Arctic Char habitat could not be derived due to the lack of detailed engineering design details. However, the overall area of char habitat that will be affected by these installations will be negligible in relation to overall available stream habitat. Overall effects on Arctic Char are expected to be negligible as fish passage will be provided, thereby continuing to provide access to upstream habitat.

Table 2-5. Locations of new and relocated Tote Road stream crossings.

Crossing ID	Description	UTM Coordinates		Arctic Char Habitat	
		Easting	Northing	New Site	Existing Site
CV-131-1	New	511333	7967096	Unlikely	-
CV-060-2	New	527756	7930278	Yes	-
CV-214-1	Relocation of existing tote road culvert CV-214	541273	7921956	No	No
CV-214-2	New	541507	7922071	No	-
CV-215-1	Relocation of existing tote road culvert CV-215	541909	7922250	No	Yes
CV-216-1	New	543381	7921181	No	-
CV-216-2	New	543524	7921151	No	-
CV-020-1	New	547094	7919813	No	-
CV-020-2	New	546893	7919846	No	-
CV-146-1	Relocation of existing tote road culvert CV-146	508928	7968816	Unlikely	No
CV-146-2	Relocation of existing tote road culvert CV-146	508726	7968858	Unlikely	No
CV-146-3	Relocation of existing tote road culvert CV-146	508721	7968887	Unlikely	No
BG-13-1	New	551001	7917116	Probable	-
BG-14-1	New	550839	7917414	Yes	-

Stream diversions along the North Railway will result in increased flows in some watercourses crossed by the Tote Road. Design flows for the affected Tote Road stream crossings will be reviewed and crossings will be modified accordingly (e.g., upsized) to accommodate increased flows and provide fish passage.

2.5.3 Water Withdrawals for Dust Suppression along the Tote Road and North Railway Corridor

As described in Knight Piésold (2018), fifteen sources along the Tote Road are approved for extraction of water for dust suppression. These sources will not provide sufficient water supply for dust suppression efforts along the Tote Road or the North Railway during its construction. An additional 13 water sources have been identified based on their proximity to the railway construction and quarrying activities and increased water withdrawal rates are proposed for a number of the approved water sources to support the Phase 2 Proposal. The additional and approved water source locations are shown on Figure 2-1. With the exception of CWP10 and CWP11, each of the currently approved and proposed water sources will continue to be used for dust suppression on the Tote Road into the operation and closure phases of the Project, albeit at reduced quantities.

The Phase 2 Proposal includes water withdrawals for dust suppression at two additional lakes (km 26 Lake and Sheardown Lake) and 11 additional stream locations beyond the fifteen approved sources under the Approved Project. All withdrawals would occur in the open-water season and therefore would not affect Arctic Char eggs (i.e.., due to drawdown over the spawning/incubation period). Withdrawals for dust suppression may affect Arctic Char habitat in the open-water season by reducing water levels and/or flows.

Entrainment and impingement of fish due to water intakes will be mitigated through adherence to the DFO Freshwater Intake End-Of-Pipe Fish Screen Guideline (DFO 1995) and will be located to avoid spawning habitat to prevent entrainment of eggs. Effects of this pathway on direct mortality of Arctic Char are therefore negligible. Effects of withdrawals on Arctic Char habitat are described below.

2.5.3.1 Water Withdrawals from Lakes

With the exception of effects of water withdrawals proposed for Camp Lake, all withdrawals at lake sites are predicted to result in a reduction in lake outflows of less than 10%, and in many cases less than 1%, under all flow conditions, including a 10-year low flow (see Knight Piésold 2018 for details). Effects of these withdrawals on Arctic Char habitat are therefore considered to be negligible to small.

The outflow of Camp Lake is predicted to be reduced by less than 10% (2.0-8.5% reduction) under mean flow conditions in June, July and August. However, flow is predicted to be reduced by approximately 30% in September and under low flow conditions. The Camp Lake outflow provides marginal habitat for Arctic Char as it is a broad, shallow stream that lacks connectivity with Camp and Mary Lakes under various flow conditions, and supports only limited movement of Arctic Char. In addition, char are typically not present in the Camp Lake outflow (or other small streams in the Mine Site area) for the majority of the month of September. Char move out of streams into lakes for overwintering in late summer/early fall as water temperature decreases (movements typically begin at 5-7 ^{o}C). Although there is inter-annual variability regarding the timing of these water temperature decreases, and therefore the timing of fish movements, movements typically occur in late August/early September. Potential for reductions in, or alterations to, available habitat in September would therefore have a negligible effect on Arctic Char.

In addition, fish stranding is considered to be unlikely given that use of small streams is limited in September, that the Camp Lake outflow provides marginal habitat and frequently lacks connectivity with the lakes, and that flow reductions resulting from water withdrawals would be gradual and would thus provide opportunity for fish to actively move out of the stream if conditions became unfavourable. For these reasons, the effect of water withdrawals on Arctic Char are predicted to be of low magnitude. In addition, the previous water take assessment that supported an amendment to the Type A Water Licence estimated a 27% reduction under low flow conditions for this stream (Knight Piésold Ltd. 2014). The additional water withdrawal from Camp Lake associated with the Phase 2 Proposal represents a minor increase (from 27% to 30% reduction under low flow conditions) relative to the approved Water Licence. It is recommended that a survey of the Camp Lake outflow be conducted in the first late summer/fall following Project approval and during a low flow event when water withdrawals occur to ensure there is no stranding of Arctic Char. In the event that stranding is observed, a fish salvage would be undertaken to relocate stranded fish to Camp or Mary lakes.

2.5.3.2 Water Withdrawals from Streams

As described in Knight Piésold (2018), the process for identifying water withdrawal sites in streams considered the size of the drainage basin, the presence of fish, and the rate of water withdrawal; the thresholds applied for this screening were based on the percent flow reduction and the presence of Arctic Char. For char-bearing streams, the instantaneous water withdrawal rate would not exceed 20% of the 10-year low flow condition in a stream. At streams where the water withdrawal is less than the applicable threshold under mean flow conditions but not under the 10-year low flow, water withdrawals would only be permitted during the months of June and July (i.e., months when discharge is highest).

All existing and proposed water withdrawal sites are located in known or potential Arctic Char habitat (Table 2-6). Water withdrawals would have a negligible (i.e., < 1% decrease) effect on stream discharge under low flow conditions at 15 of the 21 stream withdrawal sites (Table 2-7). Five sites (CV099, CV087, BG50, BG17, CWP12) will experience a low magnitude (1-10%) flow reduction and one (BG32) will experience a moderate (i.e., 10-20%) flow reduction under 10-year low flows. Flow reductions would be of a similar magnitude under mean flows in September at these streams; withdrawals would result in less than a 5% reduction in flow under average flows for the remainder of the open-water season.

Cumulative reductions in discharge along the unnamed stream where three water withdrawal sites (BG50, CWP10, and CWP11) are located (southeast of Muriel Lake) would result in <1% reduction in discharge under a 10-year low flow condition at the two downstream sites. Effects on Arctic Char habitat are therefore considered to be negligible. Cumulative effects of water withdrawals along Phillips Creek are predicted to result in a 1-2% reduction (i.e., low magnitude reduction) in flows under a 10-year low flow condition. Water withdrawals in the Muriel Lake drainage (i.e., sites upstream of Muriel Lake to the lake outflow) are predicted to result in <10% reductions in discharge when considered collectively.

The DFO (2013) general framework for the technical assessment of ecological flows for fisheries in relation to water withdrawals, which is based on the principle that “the probability of degradation to ecosystems sustaining fisheries increases with increasing alteration to the natural flow conditions”, indicates that cumulative flow alterations of <10% in amplitude of the instantaneous flow in a river have a “low probability of detectable impacts to ecosystems that support commercial, recreational or Aboriginal fisheries.” Estimates of flow reductions due to water withdrawals are <10% even under low flows at all sites excepting BG32.

Site BG32 is adjacent to the existing Tote Road stream crossing and near the North Railway crossing CV-84-1. This stream provides important[1] Arctic Char foraging and rearing habitat but overwintering and spawning habitat are not present in the catchment; the nearest overwintering and spawning habitat is Muriel Lake. Spawning and overwintering habitat for Arctic Char in this region are available in relatively few waterbodies and therefore are considered critical habitat; in contrast, foraging habitat for adults and rearing habitat for juveniles is widespread and is therefore not considered critical. As this stream does not provide critical or limiting Arctic Char habitat, overall effects of flow reductions on char habitat are ranked as of low magnitude. It is recommended that monitoring be conducted at and downstream of the water withdrawal site in the first year of water withdrawals at this site in late summer/fall and during a low flow event to ensure fish passage is not impeded.

It is further noted that the assessment of flow reductions due to water withdrawals was based on a conservative assumption that withdrawals would occur every day for the open-water season (i.e., dust suppression season); as noted in Knight Piésold (2018), it is anticipated that withdrawals would actually occur at a much lower frequency with a concomitant reduction in the frequency of effects.

Overall, the magnitude of the effects of water withdrawals on Arctic Char is ranked as low. This ranking is based on the limited number of sites where water withdrawals would result in >1% flow reductions and the overall availability of Arctic Char habitat in the LSA.

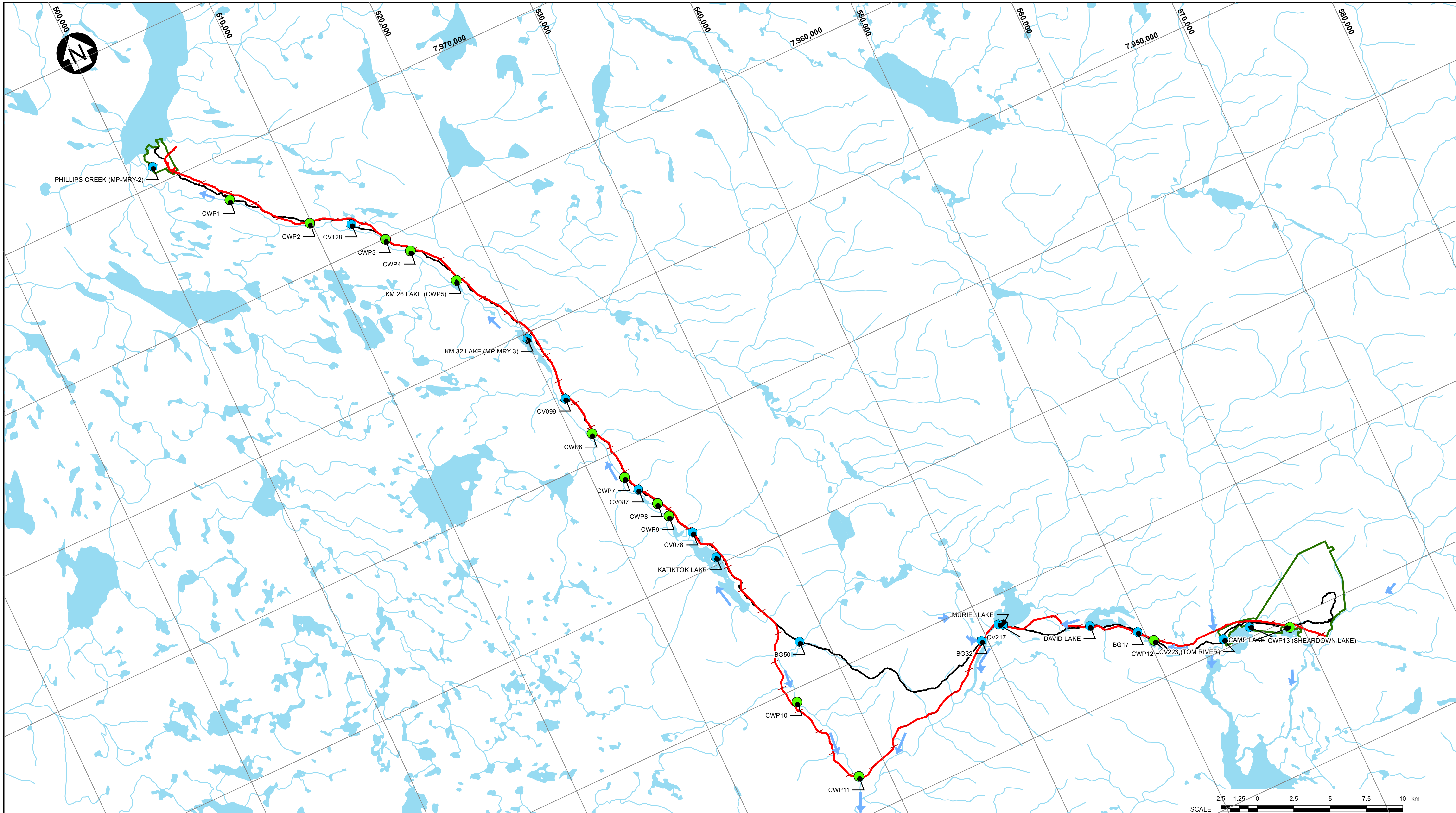
[1] Defined as habitat that is easily accessible to fish and provides abundant, suitable habitat for one or more life stages.

Table 2-6. Existing and proposed water intake locations.

Water Source	Source Type	UTM		Arctic Char Habitat Classification
		Northing	Easting	
Phillips Creek (MP-MRY-2)	Stream	7,975,254	502,829	Likely (anadromous juveniles only)
CWP1	Stream	7,970,914	506,663	Likely (anadromous juveniles only)
CWP2	Stream	7,967,146	510,978	Important (upstream of Falls)
CV128	Stream	7,965,895	513,545	Important
CWP3	Stream	7,963,947	515,215	Important
CWP4	Stream	7,962,497	516,439	Important
KM 26 Lake (CWP5)	Lake	7,958,592	518,839	Important
KM 32 Lake (MP-MRY-3)	Lake	7,953,660	521,189	Important
CV099	Stream	7,948,820	521,811	Important
CWP6	Stream	7,945,826	522,434	Important
CWP7	Stream	7,942,153	523,218	Important
CV087	Stream	7,941,040	523,704	Marginal (downstream of the Tote Road)
CWP8	Stream	7,939,580	524,497	Likely
CWP9	Stream	7,938,445	524,839	Important
CV078	Stream	7,936,787	525,852	Important
Katiktok Lake	Lake	7,934,552	526,600	Important
BG50	Stream	7,926,846	529,334	Important
CWP10	Stream	7,923,139	527,413	Important
CWP11	Stream	7,916,686	529,119	Important
BG32	Stream	7,921,622	540,706	Important
CV217	Stream	7,922,158	542,219	Important
Muriel Lake	Lake	7,921,987	542,508	Important
David Lake	Lake	7,919,396	547,885	Important
BG17	Stream	7,917,643	550,703	Important
CWP12	Stream	7,916,606	551,452	Important
CV223	Stream	7,914,691	555,818	Important
Camp Lake	Lake	7,914,684	557,793	Important
CWP13	Lake	7,913,489	560,288	Important

Table 2-7. Estimated flow reductions due to water withdrawals from streams (from Knight Piésold 2018).

Water Source	Reduction in Mean Monthly Discharge				Reduction under low flow conditions (10-year low flow)	Arctic Char Habitat Classification
	June	July	August	September		
	%	%	%	%	%	
PHILLIPS CREEK (MP-MRY-2)	0.03%	0.04%	0.12%	0.38%	0.44%	Likely (anadromous juveniles only)
CWP1	0.01%	0.01%	0.04%	0.12%	0.13%	Likely (anadromous juveniles only)
CWP2	0.01%	0.01%	0.03%	0.09%	0.10%	Important (upstream of Falls)
CV128	0.01%	0.01%	0.04%	0.13%	0.15%	Important
CWP3	0.01%	0.01%	0.03%	0.09%	0.11%	Important
CWP4	0.01%	0.01%	0.04%	0.13%	0.14%	Important
CV099	0.20%	0.26%	0.86%	2.66%	3.01%	Important
CWP6	0.02%	0.02%	0.07%	0.22%	0.25%	Important
CWP7	0.02%	0.03%	0.10%	0.31%	0.35%	Important
CV087	0.67%	0.85%	2.83%	8.77%	9.93%	Marginal (downstream of the Tote Road)
CWP8	0.02%	0.02%	0.07%	0.21%	0.24%	Likely
CWP9	0.02%	0.03%	0.08%	0.26%	0.30%	Important
CV078	0.06%	0.08%	0.26%	0.80%	0.91%	Important
BG50	0.09%	0.11%	0.37%	1.16%	1.31%	Important
CWP10	0.01%	0.01%	0.03%	0.10%	0.11%	Important
CWP11	0.01%	0.02%	0.05%	0.17%	0.19%	Important
BG32	1.02%	1.29%	4.30%	13.32%	15.08%	Important
CV217	0.01%	0.01%	0.04%	0.12%	0.13%	Important
BG17	0.25%	0.31%	1.04%	3.22%	3.65%	Important
CWP12	0.38%	0.48%	1.58%	4.91%	5.56%	Important
CV223	0.02%	0.03%	0.08%	0.26%	0.30%	Important



LEGEND

- APPROVED WATER SOURCES, LAKE
- APPROVED WATER SOURCES, STREAM
- CONSTRUCTION WATER SOURCE, LAKE
- CONSTRUCTION WATER SOURCE, STREAM
- NORTH RAILWAY CHAINAGE (m)
- PROPOSED NORTH RAILWAY
- MILNE INLET TOTE ROAD
- PROJECT DEVELOPMENT AREA
- RIVER/STREAM/DRAINAGE
- WATER
- FLOW DIRECTIONS

NOTES:

1. COORDINATE GRID IS IN KILOMETRES.
   COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
2. BASE MAP/IMAGERY: © ESRI AND DATA (ONLINE) SERVICE LAYERS (2017). REDLANDS, CA: ENVIRONMENTAL SYSTEM RESEARCH INSTITUTE. ALL RIGHTS RESERVED.
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REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
0	31OCT'17	ISSUED WITH REPORT	RAC	RF	RAC

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BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

EXISTING AND PROPOSED WATER TAKE LOCATIONS

Knight Piésold CONSULTING

P/A NO.	REF NO.	REV
NB102-181/39	1	0

2.5.4 Changes in Water and Sediment Quality at the Mine Site

Project-related changes in water and/or sediment quality have the potential to directly affect the health and condition of Arctic Char and/or indirectly through effects on other aquatic biota that are food sources for char or form a component of the food web (i.e., lower trophic level biota). Potential Project-related changes to water and sediment quality at the Mine Site are related to changes in the introduction of ore dust to streams and lakes.

An assessment of effects of dust deposition on TSS in surface water and metals in surface water and sediments is provided in Knight Piésold (2018). As the Phase 2 Proposal will involve changes to ore crushing and screening operations at the Mine Site that will reduce dust deposition relative to the Approved Project, the water quality assessment indicates that effects of this pathway will decrease with the Phase 2 Proposal. This assessment indicates that loading of total particulates will decrease by approximately 29% and 20% in Camp Lake and Sheardown Lake NW, respectively. The water quality assessment concluded that effects of ore dust on water and sediment quality at the Mine Site would be of similar or lower magnitude than previously assessed in the Approved Project and will not be significant.

The water quality assessment conservatively assigned a Level II impact magnitude rating with respect to effects of dust deposition on TSS in surface waters. The assessment was based on a maximum target of 15 mg/L TSS with mitigation. As assessed in the Approved Project, effects of dust on TSS are therefore expected to have a Level I magnitude of effect on Arctic Char health and condition for the Phase 2 Proposal; this is unchanged from the Approved Project.

The water quality assessment also indicates that effects of dust on metals in water and sediments would remain the same or decrease with the Phase 2 Proposal. Effects on water and quality were predicted to be medium to long-term (effects will occur during Project operation or beyond the life of the Project), infrequent (Level I), and limited to the LSA (Level I).

The AEMP has detected minor mine-related effects to water and sediment quality in Camp Lake and Sheardown Lake and tributaries (Minnow Environmental Inc. 2017b, 2018b), consistent with the previous assessment of effects. As noted in Section 2.2.1, monitoring of the biological communities (i.e., phytoplankton, benthic macroinvertebrates, and Arctic Char) conducted during the first three years of operation (2015 to 2017) indicated that there were no adverse mine-related influences on the biota of the Mine Site waterbodies, with the possible exception of a physical effect on the benthic invertebrate community in a tributary to Sheardown Lake (Minnow Environmental Inc. 2016b, 2017b, 2018b).

Given that dust deposition is predicted to decrease with the Phase 2 Proposal, the magnitude of effects would be expected to be lower than predicted for the Approved Project. The Phase 2 Proposal is predicted to result in a negligible change, and potentially an improvement to, water and sediment quality effects predicted in the Approved Project. Therefore, residual effects associated with the Phase 2 Proposal were not assessed further.

2.5.5 Sedimentation in Mine Site Lakes

As noted in Section 2.5.4., Phase 2 Proposal activities at the Mine Site may affect generation and subsequent introduction of dust to the freshwater environment, which could in turn adversely affect Arctic Char through alterations to preferred spawning habitat, through deposition on char eggs (leading to reduced hatching success), and by adversely affecting benthic invertebrates. The potential for dust deposition to affect char spawning habitat and eggs is limited to lakes, as spawning is not supported in streams in the vicinity of the mine.

The potential changes in dust deposition and effects on lake sedimentation rates for the Phase 2 Proposal were assessed in detail in Knight Piésold (2018). The predicted sedimentation rates for the Phase 2 Proposal are lower than those presented for the Approved Project; the FEIS predicted annual rates of deposition of 235.5 mg/cm^2/year (0.54 mm/year) and 106.4 mg/cm^2/year (0.24 mm/year) in Sheardown Lake NW and Camp Lake, respectively under the conservative assumption that all dustfall landing within each of the lake catchments is deposited in the two Mine Site lakes and was spread evenly over the surface area of the lake. The Phase 2 Proposal estimates are 177.0 mg/cm^2/year (0.4 mm/year) and 72.7 mg/cm^2/year (0.2 mm/year) for Sheardown Lake NW and Camp Lake, respectively, which is equivalent to a 25% and 32% decrease in predicted sedimentation rates relative to what was calculated in the FEIS.

As noted in Section 2.2.1, sediment deposition has been monitored in Sheardown Lake NW for one year prior to operation and for the first three years of operation. The monitoring program has found that sedimentation rates have increased in the open-water and ice-cover seasons relative to baseline conditions, but have remained within the range of sedimentation rates reported for other arctic lakes (Minnow Environmental Inc. 2016a, 2017a, 2018a, North/South Consultants Inc. 2015) and were notably lower than rates predicted for the Approved Project (Table 2-8).

Table 2-8. Summary of sedimentation rates measured in Sheardown Lake NW.

Site	Annual Sedimentation Rates (mg/cm^2/year)			
	2013-2014	2014-2015	2015-2016	2016-2017
Shallow Site 1	14.2	15.5	27.1	33.9
Shallow Site 2	11.5/16.2 [1]	15.5	31.3	26.9
Profundal Site	21.2	24.5	39.6	44.7

NOTES:

1. VALUE 1 INCLUDES RESULTS FOR ALL REPLICATE SAMPLES; VALUE 2 EXCLUDES RESULTS FOR 2 OUTLIERS.

As summarized in Section 2.2.1, fish population monitoring conducted in Sheardown Lake in 2016 indicated a relatively high abundance of healthy, YOY char, which suggested little or no adverse effects of sedimentation on egg hatch success, larval emergence, and early life stage growth. Although some changes in the aquatic environment were observed, monitoring of the biological communities (i.e., phytoplankton, benthic macroinvertebrates, and Arctic Char) conducted during the first three years of operation (2015 to 2017) indicated that there were no adverse mine-related influences on the biota of the Mine Site lakes (Minnow Environmental Inc. 2016b, 2017b, 2018b). The only mine-related adverse biological effect was observed Sheardown Lake Tributary 12, which was believed to be a result of changes to habitat.

The Approved Project applied a threshold of 1 mm/year of sediment deposition for evaluating effects on Arctic Char eggs. As discussed in Section 2.2.1, the lack of a site-specific bulk density value for deposited sediments creates uncertainty regarding the sediment accumulation thickness associated with measured and predicted sedimentation rates. Additional sediment sampling will be conducted in Sheardown Lake NW to generate a site-specific bulk density for lake sediments to facilitate accurate derivation of sediment accumulation thickness in the future.

Effects on Arctic Char egg survival and hatch are predicted to be negligible, given the following:

- Sedimentation rates are predicted to be lower than those predicted for the Approved Project;
- The assessment approach is based on a relatively conservative approach (i.e., all dust deposited in a drainage basin is assumed to be deposited in the lakes);

- Fish population monitoring conducted in Sheardown Lake in 2016 and 2017 indicated a relatively high abundance of healthy, YOY char, which suggested no adverse effects of sedimentation on egg hatch success, larval emergence, and early life stage growth; and
- Measured sedimentation rates have been substantively lower than those predicted for the Approved Project.

Effects of sedimentation on Arctic Char spawning habitat were also assessed for the Approved Project and were predicted to be of low magnitude due to implementation of mitigation measures, including sediment and erosion control, and water management such as settling ponds. Arctic Char spawning habitat is limited to LSA lakes and preferred spawning habitat is typically confined to the nearshore zone (2 - 10 m deep) where wave action typically limits accumulation of fine sediment. The nearshore areas of Camp Lake and Sheardown Lake NW are dominated by sand and to a lesser extent gravel/pebble substrate, with finer substrates dispersed primarily in deeper offshore areas, indicating accumulation of fine dust would likely occur in the deeper areas of the lakes where spawning is unlikely to occur. Existing information indicates sedimentation rates are higher at the profundal monitoring site than the two nearshore monitoring sites (Table 2-8). Effects of lake sedimentation on Arctic Char spawning habitat and in the nearshore (littoral) area of the lake are expected to be similar to or less than predicted for the Approved Project. Therefore, residual effects associated with the Phase 2 Proposal were not assessed further.

2.5.6 Significance of Residual Effects on Freshwater Fish and Fish Habitat

The effects of the Phase 2 Proposal on Arctic Char are predicted to be not significant (Table 2-9). Predicted residual effects of the Phase 2 Proposal on Arctic Char are of low magnitude (Level I), medium-term to permanent (Level II – Level III), infrequent to continuous in frequency (Level I – Level III), and confined to the LSA (Level I). Rail infrastructure including culverts, bridges, and lake/pond encroachments/infill will be removed after the operation period; stream diversions that will be constructed at cuts along the North Railway will be permanent. Effects are either likely to occur or will occur and there is a high certainty associated with the overall predictions, due to high certainty associated with predicted effects on water quantity and water quality, as well as the conservatism that was incorporated into the environmental assessment.

Table 2-9. Significance of residual effects on Arctic Char due to incremental changes associated with the Phase 2 Proposal.

Residual Effect	Residual Effect Evaluation Criteria					Significance of Residual Effect	Qualifiers	
	Magnitude	Extent	Frequency	Duration	Reversibility		Probability (Likelihood of the Effect Occurring)	Certainty (Confidence in the effects prediction)
Arctic Char habitat loss/alteration due to construction of North Railway and Tote Road Modifications	**Level I:** Effect is expected to result in a negligible decrease in the productive capacity of char habitat (i.e., < 1% of overall available habitat will be affected). Lake/pond encroachments/infilling are expected to result in low magnitude reduction in habitat and productive capacity (i.e., < 4%).	**Level I:** confined to the LSA	**Level III:** continuous	**Level II:** effects of culverts, bridges, and lake/pond encroachments/infill on char habitat will occur during the operation phase (life of the Project) **Level III:** effects due to stream diversions will be permanent	**Level II:** effect due to culverts, bridges, and lake/pond encroachments/infill will be reversible with cost/effort **Level III:** effects due to stream diversions will be irreversible	Not Significant	Effect will occur	High
Effects on Char habitat due to water withdrawals for dust suppression	**Level I:** Effect is expected to result in a low magnitude effect to overall Arctic Char habitat and productive capacity.	**Level I:** confined to the LSA	**Level I:** infrequent	**Level II:** will occur during the operation phase (life of the Project)	**Level I:** effect is reversible after activity is complete	Not Significant	Effect will occur	High

2.6 MITIGATION AND MONITORING PLAN UPDATES

As described in the preceding sections, a number of mitigation measures have been identified to reduce or eliminate residual effects on Arctic Char. Eight of Baffinland's existing management plans are relevant to freshwater biota and habitat; proposed additions or revisions to these plans to address the outcome of the freshwater biota and habitat effects assessment for the Phase 2 Proposal are presented in Table 2-10.

Table 2-10. Proposed updates to management plans to address new water quantity effects.

Management Plan	Required Update for the Phase 2 Proposal
Surface Water and Aquatic Ecosystem Management Plan	A new section will be added describing water management plans associated with the North Railway, including mitigation measures to address the effects on streams receiving diverted flows, and mitigation measures to address fish passage at select culvert crossings along the railway
Freshwater, Sewage and Wastewater Management Plan	Update to incorporate the addition of dust suppression (industrial) water sources within the Northern Transportation Corridor.
Roads Management Plan	Possible updates to incorporate any additional operational measures to mitigate the negative impacts of erosion and damage to creek crossing structures and fish habitat.
Environmental Protection Plan	No update expected to be required
Explosives Management Plan	No update expected to be required
Borrow Pit and Quarry Management Plan	No update expected to be required
Air Quality and Noise Abatement Management Plan	No update expected that is material to freshwater biota
Site Specific Quarry Management Plans (various)	Additional site-specific quarry management plans will be developed for new quarries, in accordance with the Type A Water Licence. Mitigation measures in these plans will be based on established mitigation measures described in other plans.

No changes to the freshwater fish and habitat monitoring programs are contemplated, excepting that monitoring would be expanded to include new Project components and/or areas of Project activities. This would include:

- Monitoring during construction and operation of the North Railway, and where applicable, at new or relocated stream crossings along the Tote Road, to assess fish passage at fish-bearing stream crossings; and
- A survey of the Camp Lake outflow and at water withdrawal site BG32 is recommended in the first year following Project approval in late summer/fall when water withdrawals occur and during a low flow event to ensure there is no stranding of Arctic Char. In the event that stranding is observed, a fish salvage would be undertaken to relocate stranded fish to a local waterbody.

Meaningful changes to the mitigation measures identified in each of these plans are not expected. Baffinland's AEMP and Tote Road monitoring programs will continue in their current forms.

3.0 LITERATURE CITED

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APPENDIX 1: NORTH RAILWAY FISH HABITAT QUANTIFICATION

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ABBREVIATIONS, ACRONYMS, AND UNITS

3Q10	1 in 10 year 3 day delay period
ARCH	Arctic Char
cm	Centimetre(s)
CSP	Corrugated steel pipe
EIS	Environmental Impact Statement
ERP	Early Revenue Phase
FEIS	Final Environmental Impact Statement
GIS	Geographic Information System
ha	Hectare(s)
HADD	Habitat Alteration, Disruption Or Destruction
km	Kilometre(s)
L	Lake
LP	Low point
m	Metre(s)
m^2	Square Metre(s)
m/s	Metre(s)/second
mm	Millimetre(s)
Mtpa	Million tonnes per annum
N/A	Not applicable
NM	Not modeled
NNST	Ninespine Stickleback
NSC	North/South Consultants Inc.
P	Pond
S	Stream
Vmax	High slope, high flow
Vmin	Low slope, low flow

1.0 INTRODUCTION

The Phase 2 Proposal for the Baffinland Iron Mines Corporation's ("Baffinland's") Mary River Project will consist of a near-term expansion of the current 4.2 million tonnes per annum (Mtpa) Early Revenue Phase (ERP) operation to 12 Mtpa, followed by the subsequent additional development of the originally approved 18 Mtpa South Rail operation. The near-term proposed expansion would include construction and operation of a North Railway (North Rail) adjacent to the Milne Inlet Tote Road.

The North Railway will be a heavy-haul mineral transport railway built to transport 12 Mtpa of iron ore from the Mine Site to Milne Port. The railway design is similar to that of the south railway proposed in the Final Environmental Impact Statement (FEIS; Baffinland 2012a). The railway main line will be approximately 105 kilometres (km) in length from loading station to unloading station, and 110 km in total length, and will closely parallel the Milne Inlet Tote Road along the majority of its length. A deviation from the road corridor will occur from approximately km 57 to km 84.5 due to a localized height of land; to maintain acceptable grades for the railway, it will be necessary to circle the Km 67 Hill (Figure 1-1). The maximum distance between the Tote Road and the rail alignment in the deviation will be 7 km.

This appendix estimates the amount of fish habitat that would be lost or altered by placement of North Rail infrastructure (i.e., crossings, encroachments/infilling) and construction of stream diversions and provides an initial screening assessment of potential effects on fish passage at the culvert crossings to assist with final detailed engineering design of the rail. The study area for this undertaking includes all drainages potentially affected by the rail alignment. An assessment of effects of the North Rail on Arctic Char (*Salvelinus alpinus*) is provided in the main document.

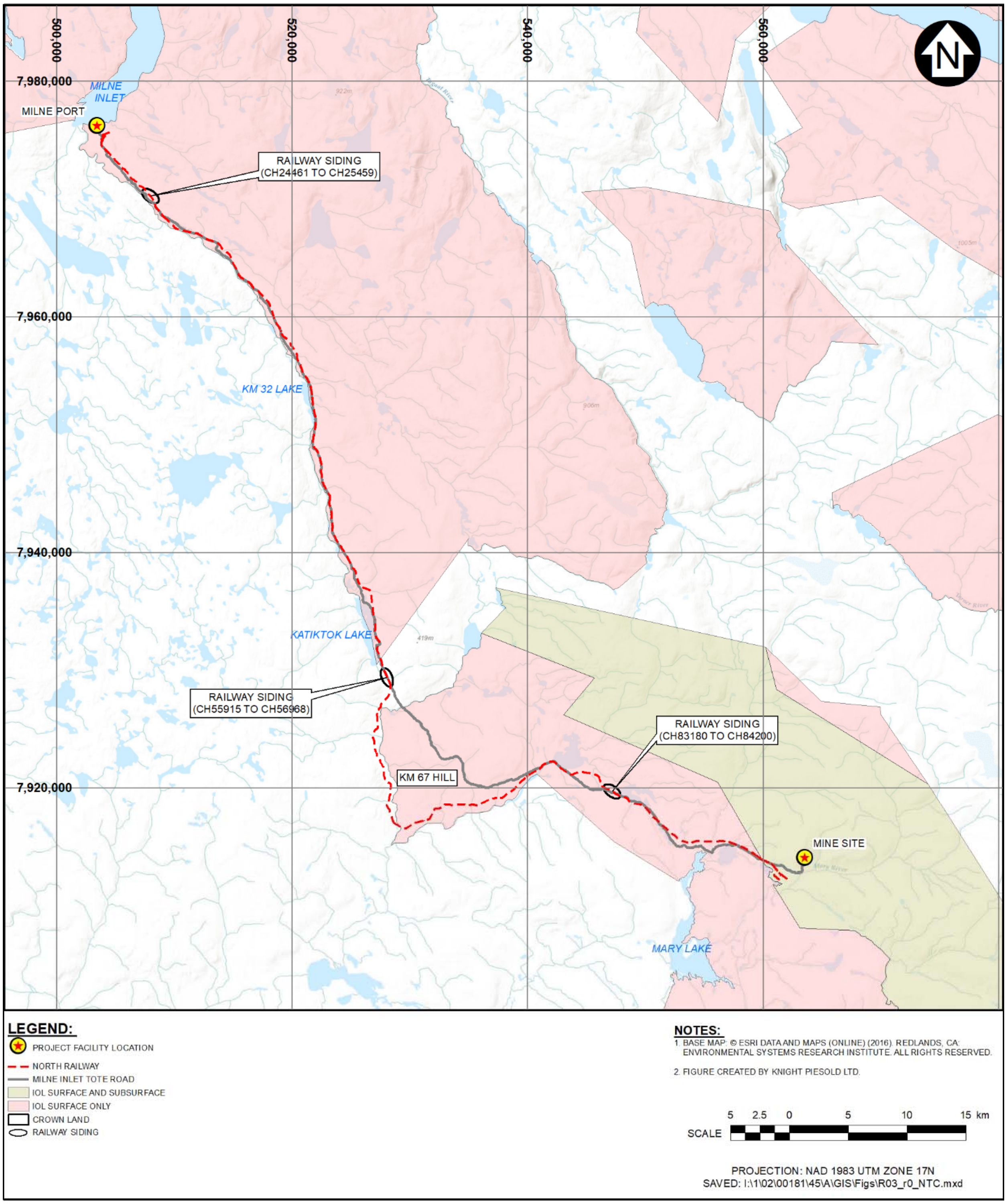

Figure 1-1. Milne Inlet Tote Road and proposed North Rail alignment.

2.0 CLASSIFICATION OF STREAMS AND WATERBODIES

The first phase of the quantification exercise involved classifying stream and lake/pond habitat that would be affected by North Rail infrastructure as fish-bearing or not-fish bearing. This exercise was completed for both of the fish species, Arctic Char and Ninespine Stickleback (*Pungitius pungitius*), present in the area. The classification was based on direct field observations (e.g., proposed crossings located in close proximity to Milne Inlet Tote Road crossings where fish presence/absence has been established based on field surveys) where available, and the examination of satellite imagery and topography. The following provides a detailed description of the approach applied for identifying fish habitat classifications for stream crossings, diversions, and pond/lake encroachments/infilling as well as the outcome of this exercise. A comprehensive list of stream crossings, bridges, cuts, and encroachments/infills is provided in Attachment 1*.*

2.1 APPROACH AND METHODS

The determination of fish habitat at watercourse crossings, diversions, and pond/lake encroachments/infilling was conducted through a desktop exercise, but incorporated direct knowledge of the study area gained over the course of 12 years of field-based study programs conducted for the Mary River Project. Field programs conducted in the North Rail study area include baseline field programs and follow-up monitoring.

Detailed aquatic habitat and fish use assessments of watercourse crossings along the Milne Inlet Tote Road were conducted prior to (2006-2007) and following construction (Knight Piésold 2007a, 2007b, 2008; Baffinland 2009, 2010, 2011, 2012b, 2013, 2014, 2015, 2016, 2017). These assessments measured physical habitat attributes over a stream distance of 100 metres (m) centred on the crossing, including substrate composition, hydrology, wetted width, high water mark, stream gradient, connectivity with overwintering habitat, and riparian and aquatic vegetation. Over the same distance, fish presence, abundance, timing of movements, and use of habitat were documented and the overall quality of the habitat was determined. If fish were not captured, the entire watercourse was surveyed for potential natural barriers to fish movement between the crossing and all possible overwintering locations. From these data, all fish-bearing streams along the Milne Inlet Tote Road were identified. Since 2010, annual surveys have been conducted at all fish-bearing crossings to confirm continued fish presence and accessibility to habitat upstream and downstream of installed culverts.

Presence and distribution of fish were also investigated in streams and ponds/lakes as part of the baseline field programs for the FEIS, and as follow-up to the FEIS, and included investigations of sites at Milne Port, in the Milne Inlet Tote Road area, and the Mine Site (Baffinland 2012a; North/South Consultants Inc. [NSC] 2014a,b; 2015a,b).

Fish habitat along the proposed North Rail corridor was assessed based on knowledge of the area, including the previously established distribution of fish along the Milne Inlet Tote Road corridor, and high resolution imagery. A two phased-approach was applied in relation to the stream crossing, diversion, and encroachment locations and the existence of information regarding the presence of fish at those sites.

Firstly, stream crossings in close proximity to an existing Milne Inlet Tote Road crossing and/or for which fish barriers have been established through previous field programs were identified as “fish habitat” or “not fish habitat” (see Section 2.1.1).

For those crossings where field information was lacking, fish habitat designations were determined based on satellite imagery as described in Section 2.1.2. A qualitative habitat rating was also assigned to each watercourse or lake (encroachments/diversions) as follows:

- No Fish Habitat: not fish-bearing;
- Marginal Habitat: provides limited quantity or quality of habitat; or
- Important Habitat: easily accessible to fish and provides abundant, suitable habitat for one or more life stages of either species.

2.1.1 Step 1: Evaluation of Crossings With Field Information

The first step of the desktop assessment was to identify all potential rail crossings, diversions, and encroachments for which supporting field information was available at the time of preparation of this report. All crossings of streams shared by, and in relatively close proximity to (within about 200 m), the Milne Inlet Tote Road were assumed to have similar habitat and, thus, fish-bearing status, except where the rail alignment is located on the opposite side of a known natural barrier to movement. Most of the known overwintering locations and barriers to fish movement in watersheds along the Tote Road and proposed rail alignment are located downstream of the corridors.

In addition, several locations along an earlier version of the proposed rail route were visited during July 2016 and assessed for detailed habitat characteristics, surveyed for fish presence, and any barriers identified. Where the current alignment overlaps with these locations, field data were used to identify fish-bearing status and habitat quality. Several sites along the proposed rail corridor were also visited in July 2017 to survey for the presence of fish, identify fish barriers, and to assess connectivity and fish habitat.

2.1.2 Step 2: Desktop Evaluation of Streams and Ponds Lacking Field Information

For streams and waterbodies for which there is no existing field information (i.e., that have not been surveyed in the field or where the crossing is distant from the existing Milne Inlet Tote Road and designations of fish habitat are less certain), a desktop analysis was conducted to classify streams/ponds as fish-bearing or non-fish bearing. The approach applied a combination of review of August 2016 orthophotography (50 centimetre [cm] resolution) and digitally-derived elevation contours (1 m) to identify potential barriers to fish passage, including steep gradients (e.g., falls), lack of surface water, lack of connectivity of a stream with overwintering habitat (i.e., lakes), and lack of an identifiable stream channel. Gradients from orthophotographs were estimated at the steepest location along a stream by measuring the angle generated from a known change in vertical elevation over a horizontal distance (typically 5-10 m). Based on field observations along the Tote Road, stream gradients exceeding 10° generally limit or block movements of fish known to use local habitat (Ninespine Stickleback and juvenile Arctic Char), particularly in very shallow, low-flow streams. At that angle, vertical drops of 20-50 cm are common along the Tote Road alignment.

The interpretation of satellite imagery for the presence of barriers (e.g., vertical drops, lack of surface flow or connectivity) was cross-checked against empirical information (i.e., barriers that been previously established based on field investigations). An example of a vertical barrier immediately downstream of the Tote Road that prevents access to otherwise high quality fish habitat at the crossing is shown in Figure 2-1. An example of a barrier to fish due to lack of surface flow is shown in Figure 2-2. The latter phenomenon is known to occur along a particular section of the Tote Road and occurs where a stream channel widens over loose cobble/gravel substrate and flows become subterranean. Stream flow resurfaces farther downstream where habitat narrows and substrate is more compact.

Lake and pond encroachments were identified based on rail embankment widths provided by Hatch Ltd. (2017a). Lakes and ponds that will be infilled or encroached upon by the rail were deemed to potentially support Arctic Char or Ninespine Stickleback by confirming connectivity to known overwintering habitat or through comparison of orthoimagery of known char and/or stickleback lakes/ponds throughout the study area with unknown waterbodies along the rail corridor. For previously un-surveyed lakes and ponds where the presence/absence of fish could not be confirmed with existing knowledge or through identification of barriers to fish movements, fish presence was conservatively assumed.

Sufficient water depth for char overwintering (≥3 m) was assessed through examination of the colouration of waterbodies (i.e., high water clarity is general indicative of deeper waterbodies in the study area) in the satellite imagery, coupled with existing knowledge of the study area ponds/lakes and drainage basin size.

Fish habitat classifications based on desktop analysis were associated with varying levels of uncertainty. However, as described in Section 4.0, for the purposes of assessing potential effects of the North Rail on fish habitat, streams or waterbodies classified as anything other than not fish-bearing, were considered to be fish habitat.

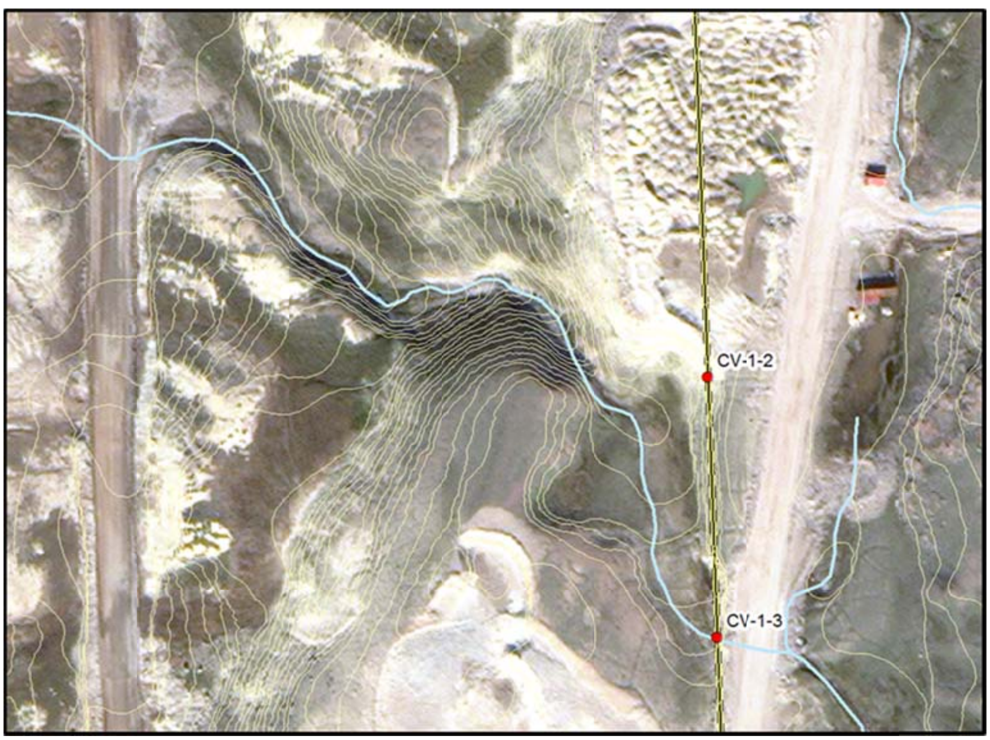

Figure 2-1. Example of a vertical barrier to fish movement located along the Milne Inlet Tote Road corridor (1 m and 5 m contour lines show steep gradient 100 m downstream of crossing CV-1-3).

Figure 2-2. Example of a barrier to fish movement due to lack of surface flow located along the Milne Inlet Tote Road corridor.

2.2 RESULTS

The majority of streams, ponds and lakes designated as known or potentially fish-bearing were identified as providing habitat for both fish species. A complete list of crossings, cuts, and encroachments and fish habitat classifications is provided in Attachment 1. Arctic Char habitat classifications along the rail corridor are shown in Maps 1 through 13 (Attachment 2).

The rail will cross, divert, or encroach/infill at a total of 465 sites in watercourses and waterbodies. Of these, a total of 167 and 185 were identified as occurring in known, probable, potential, or unlikely Arctic Char and Ninespine Stickleback habitat, respectively (Attachment 1). A total of 298 of these sites were identified as not supporting Arctic Char and 280 as not supporting Ninespine Stickleback.

The four bridge crossing sites provide habitat for both Arctic Char and Ninespine Stickleback (Table 2-1). Of the 402 culvert stream crossings, 142 and 150 culvert crossings will be placed in Arctic Char or Ninespine Stickleback stream habitat, respectively (Attachment 1).

There are a number of locations where the railway will pass in close proximity to a lake or pond, in some cases close enough that the toe of the railway embankment will occupy a portion of lake bed. A number of other ponds will be crossed (i.e., infilled) by the rail alignment (total number of ponds/lakes that would be affected is 28). A total of 12 and 22 encroachments/infill sites were identified within lakes/ponds that may support Arctic Char and Ninespine Stickleback, respectively (Table 2-2).

Construction of the North Rail will include a total of 31 cuts in streams, which will entail diversion of flows to adjacent watercourses or waterbodies. Sites were assessed on an individual basis in consideration of the drainage basins and locations where the flow would be diverted. Of these, a total of 12 cuts were identified with the potential to affect Arctic Char habitat due to direct loss of habitat downstream and/or upstream of the cut and/or due to alteration to downstream habitat from reductions in flow (Table 2-3). These sites were then assessed further to quantify the areas of lost and altered habitat (see Section 4.1.3 for a description of methods).

Table 2-1. Bridge crossings in known or potential fish habitat.

Bridge ID	UTMs		Arctic Char		Ninespine Stickleback		Habitat Quality
	Easting	Northing	Fish Bearing	Classification Uncertainty	Fish Bearing	Classification Uncertainty	
CV-15-5	514239	7965626	Yes	N/A	Yes	N/A	Important
CV-70-3	529120	7916693	Yes	N/A	Yes	Low	Important
CV-85-3	542213	7922215	Yes	N/A	Yes	N/A	Important
CV-102-1	555728	7915442	Yes	N/A	Yes	N/A	Important

N/A = not applicable

Table 2-2. Pond/lake encroachments and infilling sites in known or potential fish habitat.

Site ID	UTM Coordinates		Arctic Char			Stickleback			Potential Habitat Use at Encroachment[1]			Substrate	
	Easting	Northing	Fish Bearing	Classification Uncertainty	Habitat Quality	Fish Bearing	Classification Uncertainty	Habitat Quality	Rearing	Overwintering	Spawning	Nearshore	Offshore
CV-15-2	513781	7966188	Yes	N/A	Marginal	Yes	N/A	Important	Yes	No	Yes (NNST)	Fines overlain by cobble	Loosely compacted fines/sparse cobble
CV-15-3	513892	7966034	Yes	N/A	Marginal	Yes	N/A	Important	Yes	No	Yes (NNST)	Fines overlain by cobble	Loosely compacted fines/sparse cobble
CV-18-1	515331	7963846	No	N/A	None	Unlikely	Moderate	None - Marginal	Yes	Yes (NNST)	Yes (NNST)	Primarily Fines	Primarily Fines
CV-22-1	518123	7960950	No	N/A	None	Unlikely	Moderate	None - Marginal	Yes	No	No	Primarily Fines	Primarily Fines
CV-22-2	518232	7960617	No	N/A	None	Unlikely	Moderate	None - Marginal	Yes	No	No	Primarily Fines	Primarily Fines
CV-22-4	518370	7960198	No	N/A	None	Unlikely	Moderate	None - Marginal	Yes	No	No	Loosely compacted fines/sparse cobble	Primarily Fines
CV-26-1	519724	7957380	Potential	High	Marginal	Potential	High	Marginal	Yes	No	Yes (NNST)	Unknown; suspected predominately fines	Unknown; suspected predominately fines
CV-30-7	521712	7953143	No	N/A	None	Unlikely	Moderate	None - Marginal	Yes	No	No	Primarily Fines	Primarily Fines
CV-49-3	526097	7935754	Yes	N/A	Important	Potential	High	Important	Yes	No	No	Cobble overlain by thick layer of sediment	Primarily Fines with Patches of Cobble
CV-65-2	527828	7920934	Potential	High	None - Marginal	Potential	Low	Marginal - Important	Yes	No	Yes (NNST)	Loosely compacted fines/sparse cobble	Primarily Fines
CV-70-1	528704	7916939	No	N/A	None	Unlikely	Moderate	None - Marginal	Yes	No	No	Unknown; suspected predominately fines	Unknown; suspected predominately fines
CV-71-1	529451	7916535	Yes	Low	Important	Yes	Low	Important	Yes	No	Yes (NNST)	Unknown; suspected predominately fines	Unknown; suspected predominately fines
CV-71-2a	529708	7916558	Probable	Moderate	Marginal	Probable	Moderate	Marginal	Yes	No	No	Unknown; suspected predominately fines	Unknown; suspected predominately fines
CV-86-1	542671	7921780	No	N/A	None	Potential	High	None - Marginal	Yes	No	Yes (NNST)	Primarily Fines	Primarily Fines
CV-89-2	545729	7921121	No	Low	None	Unlikely	Moderate	None - Marginal	Yes	No	Yes (NNST)	Primarily Fines	Primarily Fines
CV-92-1	547173	7919694	No	Low	None	Unlikely	Moderate	None - Marginal	Yes	No	No	Primarily Fines	Primarily Fines
CV-99-1	552464	7915930	No	N/A	None	Potential	High	None - Marginal	Yes	No	No	Primarily Fines	Primarily Fines
CV-105-3	558875	7914578	Yes	N/A	Marginal	Yes	N/A	Marginal - Important	Yes	No	Yes (NNST)	Primarily fines with occasional cobble	Primarily fines with occasional cobble
CV-106-1	559334	7914281	Yes	N/A	Marginal	Yes	N/A	Marginal - Important	Yes	No	Yes (NNST)	Primarily fines with occasional cobble	Primarily fines with occasional cobble
CV-106-2	559615	7914085	Yes	N/A	Marginal	Yes	Low	Marginal - Important	Yes	No	Yes (NNST)	Primarily fines with occasional cobble	Primarily fines with occasional cobble
CV-106-3	559980	7913834	Yes	N/A	Marginal	Yes	Moderate	Marginal - Important	Yes	Yes (NNST)	Yes (NNST)	Primarily fines with occasional cobble	Primarily fines with occasional cobble
CV-107-1	560409	7913682	Probable	Moderate	Marginal	Probable	High	Marginal - Important	Yes	No	Yes (NNST)	Primarily fines with occasional cobble	Primarily fines with occasional cobble
CV-107-2	560529	7913655	Potential	High	Marginal	Potential	Low	None - Marginal	Yes	No	No	Primarily fines with occasional cobble	Primarily fines with occasional cobble

[1] Refers to both species unless otherwise specified.
NNST = Ninespine Stickleback; N/A = not applicable.

Table 2-3. Rail alignment cuts and summary of upstream and downstream fish habitat.

Site ID	Diversion to	UTM Coordinates		Arctic Char						Ninespine Stickleback					
				Habitat at Cut			Habitat Downstream of Cut			Habitat at Cut			Habitat Downstream of Cut		
		Easting	Northing	Fish Bearing	Classification Uncertainty	Habitat Quality	Fish Bearing	Classification Uncertainty	Habitat Quality	Fish Bearing	Classification Uncertainty	Habitat Quality	Fish Bearing	Classification Uncertainty	Habitat Quality
CV-0-2	CV-0-1	504234	7975572	No	N/A	None	No	N/A	Marginal	No	N/A	None	No	N/A	N/A
CV-8-0	CV-8-1 and CV-8-2	508293	7969747	No	N/A	None	Yes	N/A	Important	No	N/A	None	No	N/A	N/A
CV-12-4b	CV-12-5 and CV-13-1	511455	7967168	No	N/A	None	Yes	N/A	Important	No	N/A	None	No	N/A	N/A
CV-20-2	CV-20-1	517267	7962029	No	N/A	None	Yes	N/A	Important	No	N/A	None	No	N/A	N/A
CV-35-5	CV-35-4	522298	7948170	No	N/A	None	Yes	N/A	Important	No	N/A	None	No	N/A	N/A
CV-46-1a	CV-46-3	525226	7938529	No	N/A	None	Yes	N/A	Important	No	N/A	None	No	N/A	N/A
CV-58-7	CV-59-1	527650	7927282	Unlikely	Moderate	None - Marginal	Yes	N/A	Important	Unlikely	Moderate	Marginal	Yes	N/A	Important
CV-58-8	CV-59-1	527613	7927217	Potential	High	None - Marginal	Yes	N/A	Important	Potential	High	Marginal	Yes	N/A	Important
CV-59-4b	CV-59-4	527467	7926817	No	N/A	None	No	N/A	N/A	No	N/A	None	Yes	N/A	Important
CV-59-4a	CV-59-4	527329	7926595	No	N/A	None	Yes	N/A	Important	No	Low	None	Yes	N/A	Important
CV-60-4a	CV-60-5	527252	7925685	No	Low	None	Yes	N/A	Important	No	Low	None	Yes	N/A	Important
CV-61-3	CV-61-2	527023	7924876	Potential	High	Marginal - Important	Yes	N/A	Important	Potential	High	Marginal	Yes	N/A	Important
CV-62-3	CV-62-4	526951	7923938	Unlikely	Low	None - Marginal	Probable	Moderate	Marginal	Unlikely	Low	Marginal	Probable	Moderate	Marginal
CV-62-6	CV-62-5	527016	7923383	Unlikely	Low	None - Marginal	Yes	N/A	Important	Unlikely	Low	Marginal	Yes	N/A	Important
CV-62-6b	CV-62-5	527011	7923411	Unlikely	Low	None - Marginal	Yes	N/A	Important	Unlikely	Low	Marginal	Yes	N/A	Important
CV-63-3a	CV-63-3	527179	7922796	No	Low	None	No	N/A	N/A	No	Low	None	Yes	N/A	Important
CV-64-5a	CV-64-5	527688	7921835	No	Low	None	No	N/A	N/A	No	Low	None	No	N/A	N/A
CV-65-2a	CV-65-2	527803	7921140	Unlikely	Low	None - Marginal	Potential	High	Important	No	Low	None	Potential	High	Important
CV-66-2a	CV-66-2	528013	7920571	No	Low	None	No	N/A	N/A	No	Low	None	No	N/A	N/A
CV-74-7	CV-74-6	533258	7918549	Potential	High	Marginal - Important	Potential	High	Important	Potential	High	Marginal	Potential	High	Important
CV-82-1a	CV-82-1	539242	7920376	No	Low	None	No	Low	N/A	No	Low	None	No	Low	N/A
CV-90-2	CV-90-3	546181	7920409	No	Low	None	Yes	N/A	Important	Unlikely	Low	None - Marginal	Yes	N/A	Important
CV-90-4	CV-90-3	546459	7920041	No	Low	None	Yes	N/A	Important	No	Low	None	Yes	N/A	Important
CV-92-1b	CV-92-1	547125	7919725	No	N/A	None	No	N/A	N/A	No	N/A	None	No	N/A	N/A
CV-95-1	CV-94-2	550005	7918257	No	N/A	None	No	N/A	N/A	No	N/A	None	No	N/A	N/A
CV-97-6	CV-97-5	551457	7916754	No	N/A	None	Yes	N/A	Important	No	N/A	None	Yes	N/A	Important
CV-101-1a	CV-101-1	554772	7915455	No	N/A	None	No	N/A	None	No	N/A	None	Probable	Moderate	Marginal - Important
CV-101-1b	CV-101-1	554885	7915454	No	N/A	None	No	N/A	None	No	N/A	None	Probable	Moderate	Marginal - Important
CV-102-1a	CV-102-2	555891	7915441	No	N/A	None	No	N/A	N/A	No	N/A	None	Yes	N/A	Important
CV-102-5	CV-103-1	557111	7915356	No	N/A	None	No	N/A	None	No	N/A	None	Yes	N/A	Important
CV-109-1	CV-109-2	561856	7912346	Potential	High	None - Marginal	Yes	N/A	Important	Potential	Low	None - Marginal	Yes	N/A	Important

N/A = not applicable.

3.0 OVERVIEW OF FISH HABITAT

Streams that support fish that will be crossed by the North Rail are perennial or intermittent streams with predominantly gravel and cobble/boulder substrates; in some low-lying areas substrates are predominantly fines. The largest streams (rivers crossed by bridges at CV-70-3 and CV-85-3) provide some summer feeding habitat and may also serve as movement corridors for adults, but all other streams provide summer juvenile rearing habitat only. No spawning or overwintering habitat exists in any watercourse in the study area; spawning habitat is limited to lakes with sufficient depth. None of the waterbodies or watercourses affected by the North Rail infrastructure support permanent populations of anadromous char, due to the lack of connectivity between marine habitat (e.g., Milne Inlet) and freshwater spawning habitat (i.e., lakes with sufficient depths) in the study area.

3.1 MILNE INLET TOTE ROAD ALIGNMENT

The Milne Inlet Tote Road runs approximately 105 km from the Milne Port Area to the Mine Area (Figure 1-1). Designated as public use, the road was first upgraded by Baffinland in the winter of 2007/2008 to facilitate haul road travel as part of a Bulk Sampling Program. Twenty-five habitat alteration, disruption, or destruction (HADD) sites that would be created as a result of the upgrade were identified. However, following the completion of detailed 2009 and 2010 studies, three of these HADD sites (CV-040, CV-048, and CV-094) were determined to be not fish-bearing.

The Milne Inlet Tote Road environmental studies have been conducted annually since 2006. These studies were initially intended to provide baseline information on fish presence and use of available aquatic habitat in watercourses to be crossed by the Milne Inlet Tote Road. Monitoring studies were conducted following completion of initial road upgrades, the Bulk Sampling Program, construction and initial operation of the Mary River Mine, and ERP upgrades to enhance, and compare to, information collected during baseline studies.

A total of 248 watercourse crossings were identified along the Milne Inlet Tote Road during the surveys completed prior to the initial road upgrades. Major watersheds along the Tote Road include Phillips Creek, the upper Ravn River, and the Mary River. Most of the streams crossed by the road flow downstream into these larger watercourses. Many streams along the road lack persistent flows, contain an abundance of barriers separating them from potential overwintering habitat, and are largely non fish-bearing, particularly towards the Milne Inlet terminus.

Ninespine Stickleback is relatively uncommon in the Tote Road area (captured at only 11 of 248 crossings). Juvenile Arctic Char from multiple size cohorts are dominant in fish-bearing watercourses in the area; juvenile char use the available habitat for rearing and feeding during the open-water season. There is no Arctic Char spawning habitat and no overwintering habitat in any watercourse crossed by the Tote Road. Additional details on fish and fish habitat in the area is presented in Baffinland (2012a).

3.2 NORTH RAIL ALIGNMENT

3.2.1 Stream Habitat

3.2.1.1 Km 0 to km 57

Streams within the first approximately 57 km of the proposed rail alignment closely parallel the existing Tote Road, with only a few minor deviations of up to 300 m from the road alignment. As such, stream habitat at the rail crossing and diversion locations closely resembles that described for the Tote Road. Streams within the first 15 km from the Milne Inlet terminus typically flow directly into Milne Inlet or into the reach of Phillips Creek downstream of an impassable set of falls. Most of these are small, lack persistent flow, and/or have steep gradient barriers downstream of the crossings and are, therefore, not fish-bearing. The few crossings that may provide marginal fish habitat can be accessed only by anadromous juvenile Arctic Char from Milne Inlet and their use of these small streams is uncommon. Ninespine Stickleback do not appear to be present in these watercourses.

Streams crossed by the rail alignment from km 15 until the first major deviation from the Tote Road (km 57) are within the Phillips Creek catchment upstream of the impassable falls. They are typically lower gradient streams with smaller substrate sizes and riffle/pool habitat. As a result, there are fewer barriers and greater access to overwintering locations in lakes within the Phillips Creek catchment. Fish-bearing streams supporting multiple size classes of juvenile Arctic Char are more abundant in this zone; however, Ninespine Stickleback remain rare in this area.

3.2.1.2 Km 57 - km 82

From approximately km 57 to km 82, the rail alignment deviates up to nearly 7 km from the Tote Road. Smaller watercourses along this portion of the alignment flow into two branches of a major river (both branches are also crossed by bridges) that is part of the upper Ravn River watershed. One of these branches drains Muriel Lake and the other drains two large lakes to the northwest of Muriel Lake. The majority of these streams have not been previously assessed during field studies conducted along the Tote Road, or the rail crossings are downstream of known barriers near the road. The assessment of habitat and fish use for these areas was therefore limited to a desktop exercise (i.e., evaluation of orthographic imagery), as described in Section 2.1.

Watercourses within the first approximately 11 km of this section (to the west of a major unnamed river; km 57 to km 68) appear to be largely steep with low water levels and some lack defined channels. Based on the desktop assessment, many appear to have barriers to fish movement between the proposed crossing and the nearest potential overwintering location. As a result, most of these streams were deemed to be unlikely to be fish-bearing.

Gradients along the remainder of this section of the rail are much lower and connectivity with overwintering waterbodies more common, though surface flows still appear to be lacking at a number of crossings. Nonetheless, a greater number of the watercourses in this section (i.e., km 69 to km 82) are expected to be fish-bearing relative to the reach between km 58 and 68. Juvenile Arctic Char remain the most abundant fish in streams along this portion of the rail alignment, but Ninespine Stickleback are expected to be more common based on observations from previous Tote Road studies. In addition, adult Arctic Char may use the major rivers in the area as movement corridors.

3.2.1.3 Km 82 to km 110

The remainder of the proposed rail alignment (km 82 to km 110) largely parallels the Tote Road. Although there is a deviation of approximately 800 m between km 98 and 103, most of the streams crossed for the rail alignment are crossed by the Tote Road farther downstream. The area in the vicinity of Muriel Lake is relatively broad, flat terrain characterized by largely sandy watercourses that flow into or out of the lake, and provide relatively abundant fish habitat.

Watercourses crossed by the most southern 7 km of the rail (km 102 to km 110) are mainly within the Mary River sub-catchment. This region includes many spring run-off drainages providing no fish habitat, but also several large streams in close proximity to Arctic Char overwintering lakes (e.g., Mary Lake and Camp Lake), providing abundant fish habitat. Cobble/sand substrata and riffle/pool habitat dominates with water velocities occasionally exceeding 1.0 metre/second (m/s). Juvenile Arctic Char and increasing numbers of Ninespine Stickleback are likely to be present in watercourses along this portion of the alignment.

3.2.2 Lake and Pond Habitat

Sufficiently deep lakes provide overwintering and spawning habitat for Arctic Char in drainages crossed by the rail alignment. Shallow lakes and ponds may provide summer feeding and rearing habitat for Arctic Char and deeper ponds may provide overwintering habitat for Ninespine Stickleback. Many ponds in the study area do not support either fish species due to insufficient depth and/or lack of connectivity with overwintering and spawning areas. A summary of available information regarding fish presence in lakes and ponds in the study area is provided below.

There is a group of interconnected ponds between CV-14-1 and CV-15-3 on the rail alignment that are known to provide habitat for both species. Habitat within 2 m of the shore is largely a mix of fines overlain by cobble, which is typically favoured by local char, and areas of fine substrates with aquatic vegetation, which is favoured by stickleback. The cobble becomes sparser offshore, where loosely compacted fines dominate. At least two of these ponds appear to have sufficient depths to provide overwintering habitat for Ninespine Stickleback and juvenile Arctic Char, and, in one case, possibly adult char. In addition, they provide abundant summer feeding and rearing habitat and, likely, spawning habitat for Ninespine Stickleback.

There are a number of deep lakes of varying size along Phillips Creek between CV-23-3 and CV-55-1 along the rail alignment. The largest of these lakes is Katiktok Lake located at the headwaters of Phillips Creek. These lakes provide abundant habitat for all life stages of Arctic Char including spawning, feeding, and overwintering for adults. Nearshore habitat is predominantly cobble/gravel to at least 2 m depth. Though not surveyed, it is expected that offshore substrates would be characterized by a larger proportion of fines with potentially some patches of cobble/boulder.

Between CV-70-1 and CV-72-1 there are a few very small lakes (<300 m across), some of which may be deep enough for overwintering. All drain into a major river in the Upper Ravn watershed. Substrate appears to be largely fines throughout. These lakes are likely fish-bearing and likely provide summer rearing habitat for juvenile Arctic Char, though overwintering may also occur in some of the deeper lakes. It is unknown if adult char are present in these lakes.

Muriel and David lakes are the largest lakes in the Upper Ravn catchment along the rail and Tote Road alignments. Both are deep with rocky nearshore areas; though un-surveyed, offshore habitat is suspected to be comprised of fine substrate. Both lakes also likely have resident Arctic Char populations, providing habitat for all life stages.

The Mary River sub-catchment includes two lakes (Camp and Sheardown lakes) along the rail alignment. Both have been extensively studied as part of past baseline and ongoing monitoring programs for the Mary River Project. Nearshore habitat is a patchwork of sandy/gravel beaches and rocky areas; the latter areas are predominantly used by juvenile Arctic Char. Offshore substrate is mainly comprised of fines interspersed with rocky reefs where spawning is expected to occur. Both lakes have resident Arctic Char populations and provide habitat for all life stages. There are also several ponds adjacent to the proposed rail alignment between CV-105-2 and CV-107-3 that drain into Camp Lake and are known to be fish-bearing. Substrate is primarily fines with occasional cobble in these waterbodies. These ponds provide summer rearing habitat for Ninespine Stickleback and juvenile Arctic Char.

4.0 CALCULATION OF FISH HABITAT LOSS OR ALTERATION

A desktop exercise was undertaken to quantify the amount of fish habitat that would be lost, displaced, or altered by placement of infrastructure (i.e., crossings and encroachments), and stream diversions in habitat either known to, or that may potentially, support Arctic Char. All crossings and lake encroachments designated as known, probable, potential, or unlikely char habitat were retained for this assessment (hereafter collectively referred to as "char habitat"). It is expected that ground-truthing (i.e., field assessments) will demonstrate that a number of these crossings are non-fish bearing; however, all have been retained for the assessment in the interest of being conservative. As previously noted, the majority of streams, ponds, and lakes designated as known or potentially fish-bearing were identified as providing habitat for both fish species. As a result, the focus of the following discussion is on the key indicator, Arctic Char.

4.1 APPROACH AND METHODS

4.1.1 Overall Available Char Habitat

The overall available char habitat associated with streams and waterbodies that may be affected by rail infrastructure was estimated to provide context regarding the amount and types of char habitat that may be lost or altered due to construction of the North Railway. Estimates were generated as described below.

4.1.1.1 Streams

For all streams designated as Arctic Char habitat that will be crossed by the North Railway, total char habitat was estimated by identifying stream segments upstream to the nearest fish barrier or, in the absence of a barrier, to the stream's headwater. Downstream stream segments were identified to the nearest potential overwintering habitat or major river system.

Geographic Information System (GIS) stream line and lake/pond polygon layers were digitized by Eagle Mapping Ltd. based on orthographic imagery taken in August 2008. Where necessary, stream segments were updated to reflect their current drainage pattern based on orthophotography captured in August of 2016. Excepting only the most major streams that were represented as polygons, stream segments were represented in the GIS as line features which have no width and therefore no associated area.

To calculate estimated stream habitat area, a three step process was used: (1) stream segments designated as Arctic Char habitat at the rail crossing/cut were classified by stream order after Strahler (1952, 1957); (2) average bank-full widths for each stream order were calculated from widths measured during field programs conducted in the study area; and (3) the stream lines were converted into polygons to calculate habitat areas. Each step is described in more detail below.

Step 1 – Stream order classification

Stream orders were classified for each stream segment between headwaters or upstream fish barriers and overwintering habitat or major river system. Each stream segment was assigned to a stream order from 1-3. Streams with an order of 4 and greater were already represented as polygons in the GIS imagery, precluding the need to estimate their widths.

Step 2 – Estimating average bank-full widths

Average bank-full widths for stream orders 1, 2 and 3 were derived from baseline field program measurements collected at 49 Milne Inlet Tote Road and Mine area streams. Average bank-full widths were 2.8 m for stream order 1 watercourses, 6.8 m for stream order 2 watercourses, and 16.3 m for stream order 3 watercourses (Table 4-1). Sampling frequency was higher for stream order 2 and 3 watercourses at 19 and 27 streams measured, respectively, because of a focus on larger, fish-bearing streams.

Step 3 – Converting stream lines into polygons to calculate habitat areas

Stream lines were converted to polygons in a GIS by buffering lines by the average bank-full width. Overlapping areas were eliminated and merged with ponds and lakes along the watercourses to represent a final habitat area for each watercourse. Polygons were cut at the crossings to delineate upstream and downstream habitat. Habitat areas (square metres [m^2]) were automatically generated for each habitat polygon in the GIS.

For forked streams that had several crossing points at the proposed rail alignment but merged farther downstream, habitat was assigned to only one crossing to prevent double-counting habitat.

Table 4-1. Average bank-full stream widths (m) by stream order.

Stream order	Average bank-full width (m)	Count of streams
1	2.8	3
2	6.8	19
3	16.3	27
Average/Totals	8.6	49

4.1.1.2 Lake/Pond Encroachments and Crossings

For all lakes/ponds designated as Arctic Char habitat that will be encroached upon or crossed by the rail alignment, two measures of habitat were applied, both of which were measured in a GIS:

- Total shoreline length; and
- Lake/pond surface area.

4.1.2 Footprints

Project footprints in the study area that would be placed directly in freshwater ecosystems include:

- Culvert installations in streams along the railway;
- Bridge crossings along the railway; and
- Pond/lake encroachments or infilling along the railway.

Project footprint areas within Arctic Char habitat were calculated based on stream crossing (culverts and bridges) and pond/lake encroachment or infilling details provided by Hatch Ltd. (2017a).

4.1.2.1 Stream Crossings: Culvert Installations

Culvert stream crossings will consist of single or multiple galvanized corrugated steel pipe (CSP) installations with diameters between 0.9 and 1.8 m (four standard sizes) and lengths varying from approximately 6 to 51 m. Rip-rap aprons will be installed at the inflow and outflow of the culverts (Hatch 2017b).

In-stream footprints for culvert installations for which detailed engineering design details were available were calculated as: Length of culvert x the bankfull channel width. Areas of rip-rap aprons for each crossing were calculated as: diameter of culvert x 4 x bankfull channel width x 2 aprons.

As most crossings have not been assessed in the field, bankfull widths were estimated by assigning a stream order for each crossing and applying an average bankfull width derived from field measurements for that stream order (see Section 4.1.1.1 for details). Actual crossing-specific widths were used for this calculation where available.

Due to recent realignment of several sections of the North Railway, engineering design details were not available for 11 culvert crossings that will be installed in Arctic Char habitat. In these instances, footprints were estimated using the average culvert length (rounded to one decimal) and diameter (rounded to the nearest culvert size of 900, 1200, 1400, and 1800 mm) for culvert installations with defined specifications within the same stream order.

4.1.2.2 Bridges

Four bridges will be installed along the North Rail alignment at CV-15-5, CV-70-3, CV-85-3, and CV-102-1. Fish habitat will be lost due to placement of abutments and piers within the streams (i.e., within the ordinary high water level defined as the 1:2 year flood flow return level) and habitat will be altered by placement of rip-rap armouring on the abutments and surrounding the support piers. The area of lost and altered habitat was calculated for each bridge installation and compared to overall available char habitat within these streams.

4.1.2.3 Pond/Lake Encroachments and Infilling

Areas of lakes or ponds either known to, or that potentially, support Arctic Char that would be lost or displaced due to rail infrastructure were estimated in two ways:

- The area of the footprint derived from lake/pond polygons that overlap with the rail embankment width for that site was estimated based on rail embankment widths, ranging from 8-25 m, provided by Hatch (2017a). In cases where any additional lake/pond habitat would be isolated from its inflow/outflow, this area was also considered to be lost/displaced due to encroachment/infilling (see Figure 4-1 for example). The total area of the lake or pond was also calculated to facilitate derivation of the proportion of affected habitat for each waterbody; and
- The area of affected habitat was also expressed in terms of lost nearshore habitat for those sites where encroachments were limited to the edge of the waterbody. Nearshore habitat was expressed as a proportion of the shoreline length for the area that will be affected by the footprint and relative to the waterbody as a whole (i.e., total shoreline length).

The type of habitat that would be affected (i.e., depth and substrate) was also considered in terms of the overall effect on char habitat and char populations based on available information.

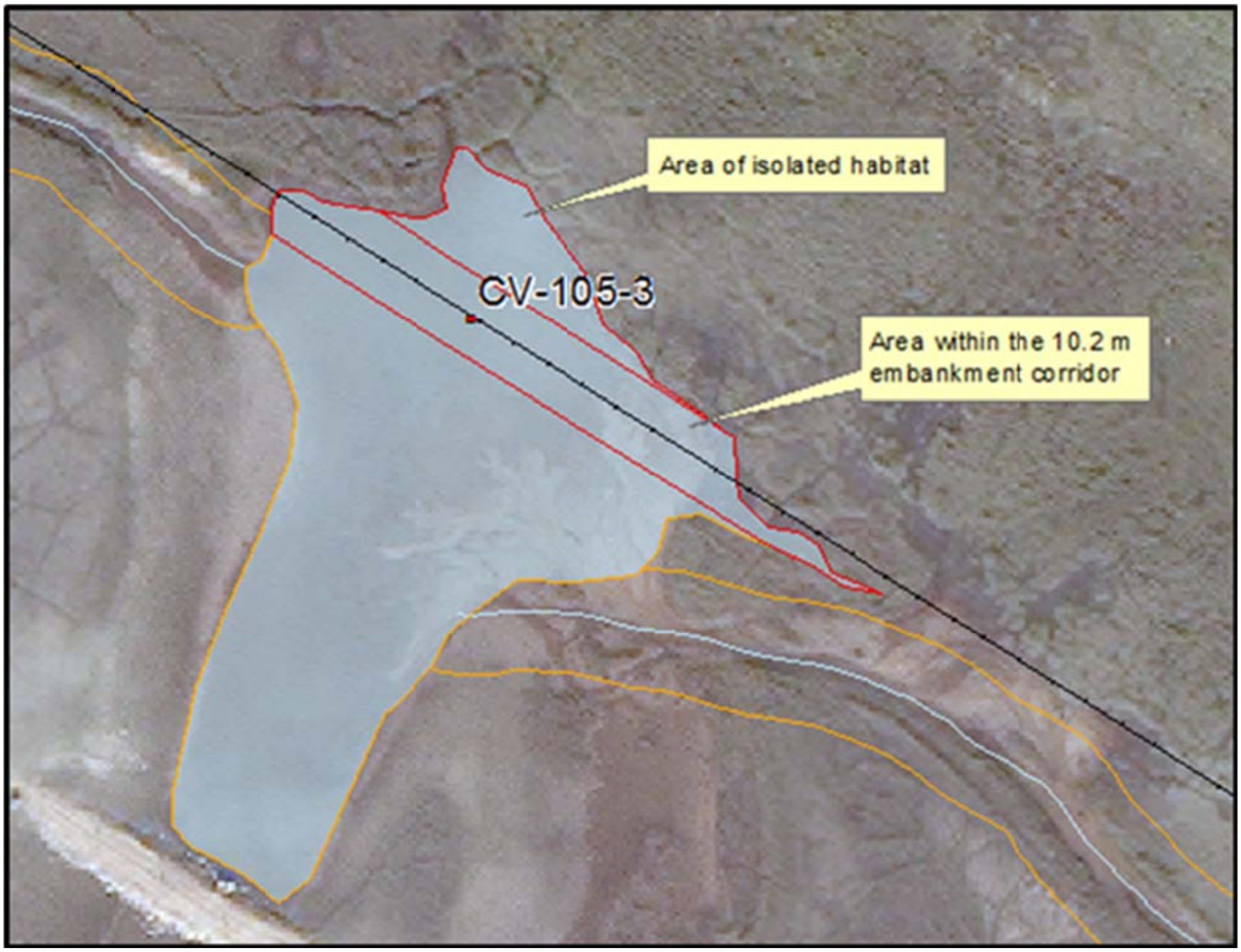

Figure 4-1. Example of a lake encroachment including an isolated area of habitat encroachment.

4.1.3 Diversions

A total of 31 streams will be diverted to adjacent watercourses along the railway alignment where culvert installations are not feasible. Effects of these diversions on fish habitat include a direct loss of habitat for watercourses that will be diverted (i.e., “diverted streams”) and alteration to char habitat downstream of the diversions due to flow reductions. Streams that will receive the diversions may experience gains in fish habitat due to increases in flows (i.e., “receiving streams”) but may also experience habitat alteration due to increased flows. Losses and/or alterations to fish habitat associated with stream diversions was assessed as described below. Potential effects of diversions on fish passage are addressed in Section 4.1.4.

4.1.3.1 Diverted Streams

Areas of fish habitat that would be directly lost due to cuts along the rail alignment were calculated as the area of the streams known to or suspected of supporting Arctic Char that would be lost due to diversion of flow. The areas of Arctic Char habitat where flow will cease due to diversions were assumed to include areas upstream of the cut as well as areas downstream of the cut to the nearest confluence with a tributary or pond/lake where char are known or suspected to be present. This approach is conservative for two reasons:

- The assessment included streams where Arctic Char may not be present (i.e., streams that could not be excluded as not char-bearing with a high level of certainty were assumed to be char habitat and were included in this calculation); and
- The approach assumed that all habitat downstream of a cut would be lost up to the nearest tributary confluence or downstream waterbody. It is expected that some diffuse contribution to stream discharge would continue to occur within these areas in at least some of the streams (i.e., flow would not be entirely lost over the entire downstream reach).

Indirect effects include alteration to downstream char habitat due to reductions in flow downstream of the cuts. These effects were assessed as follows:

- Streams Draining to Larger Watercourses: the area of a stream located downstream of direct effects on char habitat to the mouth at the larger watercourse or to the point where there will be no net change in flow due to a cut (e.g., where flow will be diverted to a branch within the same drainage basin); and
- Streams Draining to Lakes/Ponds: the area of a stream that is downstream of lost habitat up to the mouth at a pond/lake. Where flow will be diverted into a separate tributary to the same pond/lake, the net effect on the lake water level is nil. Where flow will not be returned to the same lake drainage, effects on lake habitat were considered as a percent reduction in the lake drainage basin due to the cut.

Most of the diversions will be re-directed into the same sub-catchment or to an upstream sub-catchment resulting in either no change or a small increase in flow in the downstream receiving watercourse. Overall, changes in habitat due to flow alterations in larger downstream watercourses were considered to be negligible.

4.1.3.2 Receiving Streams

Diversion of streams into adjacent watercourses could potentially result in gains in fish habitat through increases in flows and/or alterations to stream characteristics (e.g., water depth) in streams that currently support Arctic Char. In addition, increases in flows in non-fish bearing streams could conceptually "create" habitat if the increases resulted in substantive and critical changes to hydrological conditions (e.g., increasing water depth, larger and more sustained flows, conversion of diffuse flow to more channelized flow) and/or if the increased flows were sufficient to eliminate a pre-existing fish barrier thus creating access to previously inaccessible stream habitat.

However, estimation of effects (i.e., potential gains) on fish habitat in streams that will receive diverted flows is highly uncertain due to the lack of empirical information on the affected streams. In light of the uncertainty, and to adopt a conservative approach, potential gains in char habitat were not quantified as part of the assessment (i.e., it was assumed that no gains in fish habitat would occur in these streams), though it is noted this may increase habitat in some of the diverted stream systems.

Conversely, as described in Knight Piésold (2018), for receiving streams that will experience an increase in flow of greater than 10% and the combined catchment area (baseline plus diverted catchments) is greater than 0.5 km^2, there is potential to cause more frequent overbank flooding, and potential changes in permafrost, frozen soil conditions, and fluvial morphology. An assessment of the effects of the additional flows on the morphology of the receiving streams was completed to evaluate the relative risk of effects to stream morphology, fish habitat, and other considerations such as the Tote Road (Knight

Piésold Ltd. 2018). Twenty-two streams that will receive diverted flows are considered low risk, three diversions are considered medium risk (CV-8-1/CV-8-2, CV-12-5/CV-13-1, and CV-35-4), and one was identified as of high risk (CV-59-4). Diversions at the medium risk sites would not affect Arctic Char habitat as the diversions will be redirected to the same drainage upstream of char habitat. The increased flows at CV-59-4 could potentially alter important Arctic Char habitat at, and downstream of, the diversion.

Effects of increased flows on fish habitat are assumed to be negligible with implementation of mitigation measures. Monitoring would be conducted during the initial diversion period to assess potential effects on fish habitat and mitigation measures would be applied as required should issues be identified. Effects of increased flows (and associated velocities) from stream diversions on fish passage along the North Rail were considered and described below.

4.1.4 Fish Passage

Potential for the Project to affect fish passage at stream crossings along the North Rail alignment was assessed through hydraulic modeling to estimate velocities at all known or potential char-bearing crossings, in conjunction with fish passage criteria in the published scientific literature and knowledge of conditions in streams located within the rail alignment corridor. This exercise was completed to assist with identification of the railway culvert crossings that will require design for fish passage in the detailed engineering design phase.

Mean open-water season discharge (June to October) was determined from site-specific and regional data, and water depth and velocity through each culvert was determined as described in Knight Piésold (2018). The modelled average flow velocity estimates (i.e., average velocities for mean open-water season discharge) were used, as was done previously in the FEIS (Baffinland 2012a) for the south rail, rather than the 1 in 10 year 3 day delay period (3Q10) estimates, as they were considered to be more relevant. Use of 3Q10 flows is a common practice for fish passage assessment but is more applicable to situations where potential delay of migration is the primary concern (e.g., delay of spawning runs). In the present case, all streams with culvert crossings are used exclusively for summer rearing and feeding, and periodic short-term delays to fish movement are considered a negligible effect. Additionally, velocities, particularly during the spring freshet, may create impassable conditions for juvenile Arctic Char currently (i.e., in the absence of culvert crossings). Velocities measured in natural streams that support Arctic Char in the study area during spring have ranged up to 1.8 m/s, but typically average close to 0.5 m/s.

Fish swimming speeds and endurance are affected by a number of factors including the species and body morphology and fish length. Fish passage can be affected by culvert length where long culverts (i.e., swimming distance), in combination with flow velocities create conditions that are beyond a fish's swimming capabilities. The flow velocity threshold therefore decreases as culvert length increases. Fish passage is also dependent upon the size of fish, with smaller fish generally exhibiting poorer swimming performance at a given velocity. Katopodis and Gervais (2016) recently published a guide of fish swimming performance fatigue (swim speed versus endurance time) and distance (swim distance versus water velocity) curves produced from data reported in the scientific literature. Curves were produced for six groups, including a "Salmon and Walleye" group (there were insufficient data to derive equations for Arctic Char specifically). For each fish group, Katopodis and Gervais (2016) provide a regression line and two prediction intervals (75% and 95%). The prediction intervals denote the probability that a fish will be capable of swimming the specified distance at a given velocity; the lower prediction intervals (e.g., "95% Low") are therefore more stringent than the upper intervals (e.g., "95% High") presented in Katopodis and Gervais (2016).

The equations provided by Katopodis and Gervais (2016) for the Salmon and Walleye group were used to assess effects of culvert installations on juvenile Arctic Char fish passage along the rail route. All streams with culvert rail crossings that are known or suspected of supporting char are used exclusively for summer rearing and feeding, primarily by juveniles. The size range of juvenile char captured in Milne Inlet Tote Road streams over the period of 2006-2016 ranged from 36 to 300 millimetres (mm), with an average length of 97 mm.

Fish passage criteria for a fork length of 100 mm were calculated using the regression line equations presented in Katopodis and Gervais (2016). As the equations account for both culvert length (i.e., swimming distance) and fish lengths, the assessment was conducted on a crossing by crossing basis using the designed culvert lengths and the regression line equations. For illustrative purposes, velocity criteria for a range of culvert sizes for a 100 mm fish are presented in Table 4-2.

Fish passage may also be affected by culvert length if fish avoid entering or fully traversing a culvert due to darkness within the culvert. Although such avoidance behaviour has not been conclusively demonstrated for Arctic Char at high latitudes, it was considered as a potential Project effect. The longest Tote Road culvert for which juvenile fish passage has been confirmed is 66 m long (BG-01), which is higher than the longest culvert for the North Rail (51.2 m). Therefore, this pathway of effect was not considered further for the rail crossings.

Ideally, a fish passage assessment associated with installation of stream crossings would compare predicted velocities against pre-Project velocities and fish passage velocity criteria to determine whether the installations would cause or contribute to impediments to fish passage. However, detailed information on existing velocities for all stream crossing sites is not available.

Fish passage was assessed for Arctic Char with a fork length of 100 mm under average open-water season discharge conditions as follows:

- Not Impeded: culvert velocities lower than the 95% passage criteria;
- Partially Impeded: culvert velocities between the 95% and 5% passage criteria;
- Impeded: culvert velocities higher than the 5% passage criteria.

Table 4-2. Velocity criteria (m/s) for a 100 mm Arctic Char for a range of culvert lengths, calculated from equations provided in Katopodis and Gervais (2016).

Culvert Length (m)	95% Passage (95% Low)	75% Passage (75% Low)	50% Passage (Mean)	25% Passage (75% High)	5% Passage (95% High)
5	0.33	0.48	0.81	1.35	1.94
10	0.27	0.38	0.64	1.07	1.54
15	0.23	0.33	0.56	0.94	1.35
20	0.21	0.30	0.51	0.85	1.22
25	0.20	0.28	0.47	0.79	1.13
30	0.18	0.26	0.44	0.74	1.07
35	0.17	0.25	0.42	0.70	1.01
40	0.17	0.24	0.40	0.67	0.97
45	0.16	0.23	0.39	0.65	0.93
50	0.15	0.22	0.37	0.63	0.90
55	0.15	0.22	0.36	0.61	0.87
60	0.15	0.21	0.35	0.59	0.85
65	0.14	0.20	0.34	0.57	0.82
70	0.14	0.20	0.33	0.56	0.80
75	0.14	0.19	0.33	0.55	0.79

4.2 RESULTS

For the purposes of assessment of potential effects of the North Railway on Arctic Char habitat, all crossings, cuts, and encroachments/infills designated as anything other than not Arctic Char habitat were retained for further screening in subsequent steps. As previously noted, the majority of streams, ponds and lakes designated as known or potentially fish-bearing were identified as providing habitat for both fish species and this assessment therefore inherently considers potential effects on both species. A full list of the culvert crossings, bridges, diversions, and pond/lake encroachments for the North Rail alignment is provided in Attachment 1.

4.2.1 Project Footprints

Construction of the railway will include the installation of four bridges and 142 culvert arrays on char-bearing streams and 12 lake/pond encroachments (several of which also include stream crossings in the installation) or infills in char-bearing lakes/ponds (Attachments 1 and 2). Railway crossings will be in place until the end of the operation phase; at closure all crossing structures will be removed and drainage established for long-term stability. The following provides a description of habitat that will be altered, displaced, or lost due to these footprints.

4.2.1.1 Bridges

Four bridges will be installed along the North Rail alignment at CV-15-5, CV-70-3, CV-85-3, and CV-102-1 (Table 4-3; Figure 4-2). For each of the bridges, abutments will encroach on stream channels and will require placement of support piers and rip-rap within river channels.

Two of these watercourses (streams crossed by bridges CV-70-3 and CV-85-3) are located on a major outflow from Muriel Lake (Figure 4-2); these streams provide juvenile rearing habitat but are also likely to be used as movement corridors for both juveniles and adults. The bridge at CV-85-3 will be adjacent to an existing bridge/culvert installation along the Tote Road which crosses the mouth of the stream flowing out of Muriel Lake. Bridge CV-102-1 will cross the Tom River and Bridge CV-15-5 will cross a major tributary to Phillips Creek; both of these streams provide summer juvenile rearing habitat and the latter stream is likely to support movements of adult char. None of these streams provide overwintering or spawning habitat; fish presence is limited to the open-water season under sufficient flow conditions.

Support piers will be placed on concrete pads covered in rip-rap to stabilize the stream bed. Wherever feasible, rip-rap material will be selected to match existing stream bed material to provide potential habitat for lower trophic biota and fish and to minimize alteration to fish habitat.

The total area of available stream habitat in streams with bridge crossings is calculated to be 3,983,856 m^2 (398 hectares [ha]; Table 4-3). The total area lost due to instream placement of bridge piers and abutments will be 49.7 m^2 (0.050 ha), or 0.001% of the total available habitat. An additional 2,366 m^2 (0.237 ha), or 0.059% of the total available habitat will be altered by placement of rip-rap armouring around abutments and piers. The total area of fish habitat that will be lost or altered by installation of the four bridges will be 2,416 m^2 (0.242 ha), or 0.06% of the total available habitat. As described in Section 4.2.3.1, velocities are not expected to be sufficiently altered to affect fish passage.

Table 4-3. Areas of lost and altered Arctic Char habitat due to installation of bridge crossings.

Bridge	Arctic Char Habitat			Lost Habitat (m^2)	Altered Habitat (m^2)	Total Lost and Altered Habitat (m^2)	% of Available Habitat
	Fish Bearing	Classification Uncertainty	Habitat Quality				
CV-15-5	Yes	N/A	Important	14.6	769	784	0.02
CV-70-3	Yes	N/A	Important	10.5	677	688	0.02
CV-85-3	Yes	N/A	Important	10.5	677	688	0.02
CV-102-1	Yes	N/A	Important	14.0	242	256	0.01
Totals				**49.7**	**2,366**	**2,416**	**0.06**

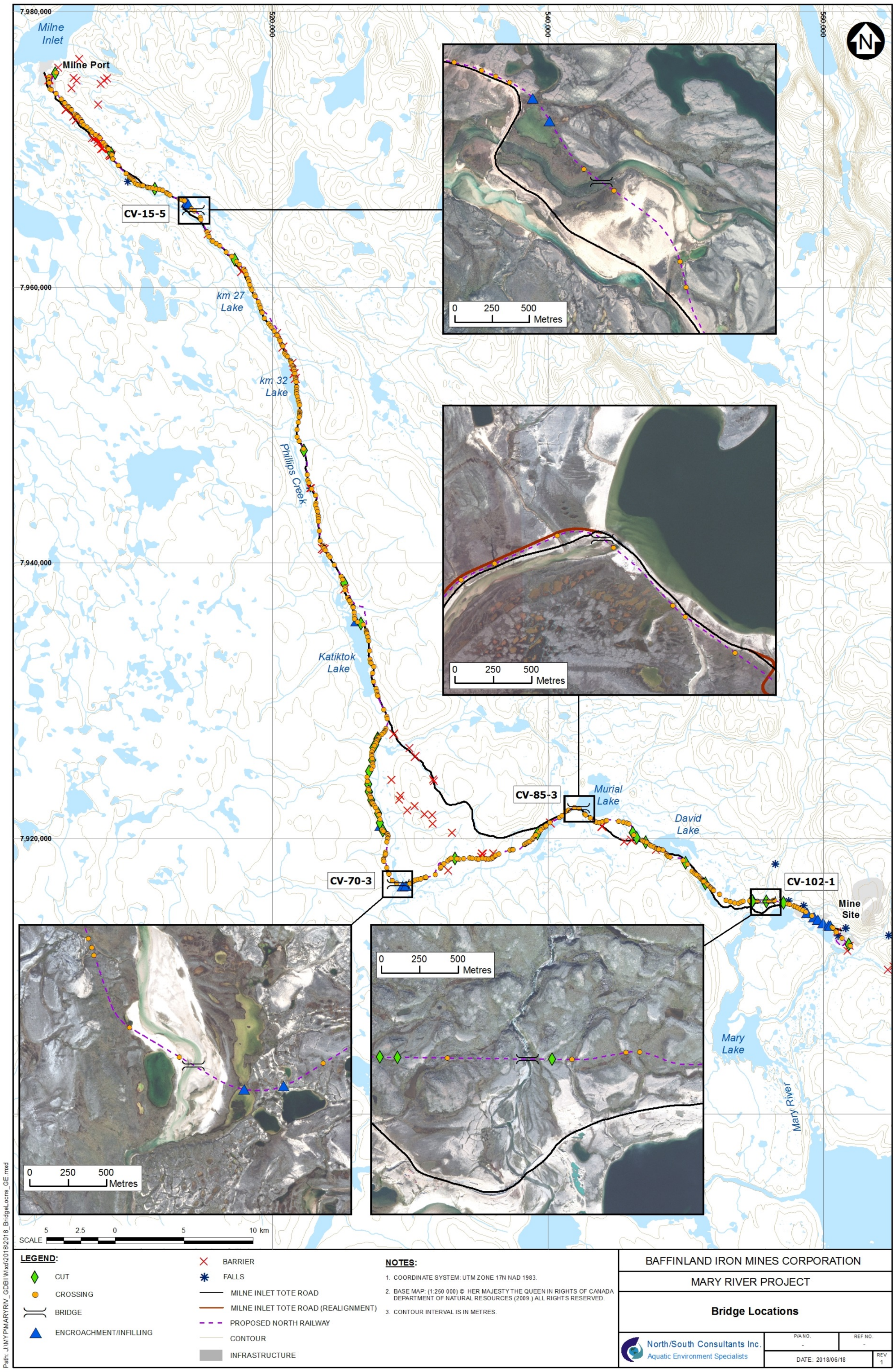

Figure 4-2. Locations of bridges along the North Rail corridor.

4.2.1.2 Stream Crossings: Culvert Installations

All culvert installations were designed on the basis of a 200-year return period flow, and a 10-year, three-day delay flow was incorporated into culvert designs for all fish-bearing streams. The culverts are therefore large relative to normal capacity requirements (Hatch 2017a). To the extent possible, the natural channel width will be maintained within crossing structures. Culverts will be designed to provide for fish passage.

Maintaining channel width and providing nature-like substrate within culverts will likely result in some colonization by lower trophic level biota and habitat use by fish, but for the purposes of this assessment it is assumed that all culvert placements in fish-bearing streams will represent a habitat loss equivalent to the area of natural stream bed occupied.

The total area of available char habitat in the study area streams where diversions or culverts will be constructed is estimated to be 8,958,286 m^2 (896 ha). The total culvert footprint area, including rip-rap aprons, in streams that support Arctic Char is estimated as 30,621 m^2 (3.06 ha), or 0.34% of the total available habitat. All of the affected stream habitat is juvenile rearing and foraging habitat. There are no direct impacts to spawning or overwintering habitat related to direct habitat loss at culvert crossings.

In addition to the culverts described above, temporary culvert installations will be constructed near the proposed bridges at CV-15-5 and CV-85-3, at CV-059-1 and CV-060-1 along a temporary haul road near the temporary ore stockpile at km 56, and at several quarry sites near the rail and road to facilitate construction of the rail. Culvert design details are not currently available, precluding calculation of the areas of habitat that would be affected by these installations. However, as the crossings will be in place for 2 years, after which the sites would be restored, the impacts on char habitat would be short-term and the area that would be affected is expected to negligible in relation to the total available habitat along these watercourses.

4.2.1.3 Lake/Pond Encroachments and Crossings

A total of 12 potential encroachment or infill sites in Arctic Char pond/lake habitat were identified through the desktop assessment (Table 2-2). The encroachment or infill sites in fish-bearing ponds or lakes will displace existing habitat; habitat is likely to be used for rearing and foraging. Most of the affected ponds are known or suspected to be relatively shallow with substrates comprised primarily of fines and habitat quality is expected to be marginal in all but one lake (lake at CV-71-1).

Only one lake (crossed at CV-71-1) is expected to provide important char habitat (i.e., a relatively large lake suspected of providing abundant summer rearing and foraging habitat). The railway will result in displacement of 1,214 m^2 (0.12 ha) of lake habitat, equivalent to 1.1% of total lake habitat, or approximately 1.3% of total shoreline length (Table 4-4). All other ponds/lakes that are known to or could potentially support Arctic Char that will be affected by the railway provide known or suspected marginal habitat.

The total available habitat in Arctic Char ponds/lakes with anticipated railway encroachments/infilling is estimated to be 264,556 m^2 (26.5 ha). The total area of displaced habitat within these waterbodies will be 9,853 m^2 (0.99 ha), or 3.7 % of the total available habitat (Table 4-4). In terms of nearshore habitat in the affected lakes known to support Arctic Char, the total nearshore habitat, expressed as shoreline length, in the lakes known to support Arctic Char that will be affected by encroachments or infill was estimated to be

9,974 m. The total displaced nearshore habitat in these lakes is estimated to be 1,229 m, or 12.3% of available habitat in those waterbodies. These estimates conservatively include two ponds (at CV-26-1 and CV-106-1) where it has been assumed the entirety of the ponds, including nearshore habitat, will be lost due to infilling.

Culverts will be installed at lake infill sites and at the mouths of streams where the encroachments affect lake and stream outflow/inflow and will be designed to provide for fish passage.

Table 4-4. Summary of lost/displaced habitat due to lake/pond encroachments and infilling along the North Rail alignment.

Site ID	Arctic Char			Potential Char Habitat Use at Encroachment			Pond/Lake Shoreline			Area		
	Fish Bearing	Classification Uncertainty	Habitat Quality	Rearing	Overwintering	Spawning	Total (m)	Lost/Displaced (m)	Lost/Displaced (%)	Total (m^2)	Lost/Displaced (m^2)	Lost/Displaced (%)
CV-15-2	Yes	N/A	Marginal	Yes	No	No	1,930	50	2.6	59,030	722	1.2
CV-15-3	Yes	N/A	Marginal	Yes	No	No	1,121	50	4.5	44,419	523	1.2
CV-26-1 [1]	Potential	High	Marginal	Yes	No	No	209	209	100	3,114	3,114	100
CV-65-2	Potential	High	None - Marginal	Yes	No	No	177	46	26.2	1,700	541	31.8
CV-71-1	Yes	Low	Important	Yes	No	No	3,092	39	1.3	110,640	1,214	1.1
CV-71-2a	Probable	Moderate	Marginal	Yes	No	No	105	17	15.8	650	72	11.0
CV-105-3	Yes	N/A	Marginal	Yes	No	No	344	144	41.7	3,774	1,090	28.9
CV-106-1 [1]	Yes	N/A	Marginal	Yes	No	No	81	81	100	375	375	100
CV-106-2	Yes	N/A	Marginal	Yes	No	No	611	371	60.7	4,404	1,310	29.7
CV-106-3	Yes	N/A	Marginal	Yes	No	No	668	106	15.9	20,246	281	1.4
CV-107-1	Probable	Moderate	Marginal	Yes	No	No	818	95	11.6	8,102	585	7.2
CV-107-2	Potential	High	Marginal	Yes	No	No	818	21	2.5	8,102	27	0.3
Totals							**9,974**	**1,229**	**12.3**	**264,556**	**9,853**	**3.7**

[1] Assumed all habitat lost or displaced.
N/A = not applicable

4.2.2 Diversions

Cuts will be made at a total of 31 streams or low points along the North Rail alignment and flow from each cut will be diverted to adjacent watercourses or waterbodies along the alignment (Table 4-5). Each site was assessed individually for potential loss or alteration to char habitat upstream and downstream of the diversions through consideration of fish distribution and the alteration in flows.

Nineteen of the diversions are located in waterbodies or low points that do not support char. The diversion of flow will not affect char habitat in downstream waters either because the affected waterbodies are not connected to downstream char habitat or the diversion will be redirected to the same drainage at a point upstream of where it becomes char habitat. The remaining 12 diversions were identified as having the potential to result in the loss and/or alteration to Arctic Char habitat. These effects are summarized below and in Table 4-5.

Diversions will directly affect Arctic Char habitat in twelve streams that are known or designated as potentially supporting Arctic Char upstream and/or downstream of the cuts. For the purposes of quantifying the area of lost habitat, the area of these streams located upstream and downstream of the cuts to the point of the nearest downstream confluence with a river, stream, or pond was considered to be lost habitat. The total area of lost stream habitat is 19,796 m^2 (2.0 ha), or approximately 0.22% of total available stream habitat crossed by the rail alignment.

All cuts in streams that discharge to large rivers will be diverted into drainages that also drain to the same downstream river system and, in all cases flows will be either returned to the same tributary or to an adjacent tributary that discharges upstream into the same large river system.

Four of the cuts will result in alteration to downstream char habitat due to flow reductions. One cut (CV-90-4) will result in the diversion of one of the inflows to a downstream lake which may result in reductions in the area of lake habitat. The proportion of the overall lake drainage basin represented by the diversion at CV-90-4 is estimated to be less than 5% and effects on lake habitat and habitat in the lake outflow were therefore considered to be negligible. The area of altered stream habitat due to flow reductions associated with diversions at CV-58-7, CV-60-4a, and CV-61-3 is estimated as 5,916 m^2 (0.59 ha), or approximately 0.07% of total available stream habitat for streams crossed by the rail alignment. For the remaining eight cuts, diverted flow is directed to a branch of the same stream, resulting in no net change in flow downstream of the first stream confluence.

Collectively, the area of lost and altered habitat due to the diversions is estimated at approximately 25,712 m^2 (2.57 ha), or approximately 0.29% of total available stream habitat for streams crossed by the rail alignment.

Table 4-5. Areas of lost and altered stream habitat due to cuts along the rail alignment.

Site ID	Diversion to	Arctic Char Habitat at Cut	Effects Summary	Area of Habitat Loss or Alteration (m^2)				
				Lost			Altered	Total
				Upstream	Downstream	Subtotal	Downstream	
CV-0-2	CV-0-1	No	No effect on char habitat. Cut stream is not char habitat and is redirected to the same drainage.	-	-	0	-	0
CV-8-0	CV-8-1 and CV-8-2	No	No effect on char habitat. Diversion returned to same drainage upstream of char habitat.	-	-	0	-	0
CV-12-4b	CV-12-5 and CV-13-1	No	No effect on char habitat. Nearest downstream char habitat is Phillips Creek. Flow diverted to adjacent stream that flows upstream into Phillips Creek.	-	-	0	-	0
CV-20-2	CV-20-1	No	No char habitat at or downstream of cut (first available downstream habitat is Phillips Creek). Diversion redirected into branch of same stream; no downstream alteration of habitat.	-	-	0	-	0
CV-35-5	CV-35-4	No	No effect on char habitat. Cut is in non-char habitat and is diverted to non-char habitat. Diversion returned to same drainage upstream of char habitat.	-	-	0	-	0
CV-46-1a	CV-46-3	No	No effect on char habitat. Cut is in non-char habitat and is diverted to non-char habitat. Diversion returned to same drainage upstream of char habitat.	-	-	0	-	0
CV-58-7	CV-59-1	Unlikely	Potential loss of char habitat upstream and downstream of cut. Alteration to small segment of downstream stream due to reduction in flow.	691	268	959	433	1,392
CV-58-8	CV-59-1	Potential	Potential loss of char habitat upstream and downstream of cut. No alteration to downstream char habitat; diversion is returned to char habitat in same drainage upstream of confluence with cut stream.	294	236	529	-	529
CV-59-4b	CV-59-4	No	No effect on char habitat. Stream to be diverted is not char habitat and is diverted to char-bearing stream upstream in the larger drainage.	-	-	0	-	0
CV-59-4a	CV-59-4	No	Assumed potential loss of habitat downstream of the cut (lower reach of the stream potentially used by char). No alteration to downstream habitat as flow is directed into the same watercourse upstream of this cut.	-	698	698	-	698
CV-60-4a	CV-60-5	No	No char habitat at cut but stream may support char downstream of cut. Stream crossed at CV-60-4 is known to support char and will experience small reduction in flow due to cut.	-	277	277	1,518	1,795
CV-61-3	CV-61-2	Potential	Cut will result in direct habitat loss upstream and downstream and habitat alteration downstream due to reduced flows at the lower end of the stream.	230	1,867	2,097	3,965	6,062
CV-62-3	CV-62-4	Unlikely	May result in loss of char habitat upstream and downstream of cut. No alteration to habitat due to flow reductions as cut is redirected back into the same drainage.	83	1,322	1,406	-	1,406

Table 4-5. - continued -

Site ID	Diversion to	Arctic Char Habitat at Cut	Effects Summary	Area of Habitat Loss or Alteration (m^2)				
				Lost			Altered	Total
				Upstream	Downstream	Subtotal	Downstream	
CV-62-6	CV-62-5	Unlikely	May result in loss of char habitat upstream and downstream of cut. No potential for downstream alteration to char habitat as cut is redirected to the same drainage.	2,973	3,218	6,191	-	6,191
CV-62-6b	CV-62-5	Unlikely	May result in loss of char habitat upstream and downstream of cut. No potential for downstream alteration to char habitat as cut is redirected to the same drainage.	183	167	350	-	350
CV-63-3a	CV-63-3	No	Cut is not in char habitat and flow is diverted to potential char habitat. No potential for downstream effects (cut is in a low point). Potential for gain in char habitat in receiving stream.	-	-	0	-	0
CV-64-5a	CV-64-5	No	Cut is not in char habitat (cur is at a low point and not a watercourse) and is diverted into non-char habitat.	-	-	0	-	0
CV-65-2a	CV-65-2	Unlikely	Assumed lost char habitat upstream and downstream in cut stream. Downstream habitat alteration assumed to be negligible due to small area of stream to be diverted.	42	495	537	-	537
CV-66-2a	CV-66-2	No	Cut is in a low point (not habitat) and is diverted to non-char habitat. No loss of char habitat or alteration to downstream habitat.	-	-	0	-	0
CV-74-7	CV-74-6	Potential	Cut may result in loss of char habitat upstream and downstream of the cut. No potential for downstream habitat alteration as cut is directed into adjacent stream that converges with cut stream. Potential for gain in char habitat in receiving stream.	2,250	1,468	3,718	-	3,718
CV-82-1a	CV-82-1	No	Cut is not in a watercourse. No potential for effects on char habitat.	-	-	0	-	0
CV-90-2	CV-90-3	No	Cut located in fishless habitat but potential marginable habitat at downstream end of stream. No potential for downstream alteration to char habitat as cut is redirected to the same drainage.	-	639	639	-	639
CV-90-4	CV-90-3	No	No direct loss of char habitat due to known barrier at the inflow of the stream to the downstream lake. Char habitat would be altered in downstream lake due to loss of flow from this stream. Loss of habitat in lake and lake outflow considered to the negligible due to limited reduction in total inflow.	-	-	0	-	0
CV-92-1b	CV-92-1	No	No effect on char habitat. Flow redirected into same stream, upstream of char habitat in the drainage basin.	-	-	0	-	0
CV-95-1	CV-94-2	No	Site is a low point and does not provide char habitat and flow returned to same drainage. No effect on char habitat.	-	-	0	-	0
CV-97-6	CV-97-5	No	Stream to be diverted in not char habitat. No alteration to downstream habitat as flow redirected to same drainage.	-	-	0	-	0
CV-101-1a	CV-101-1	No	Cut located in fishless habitat. No alteration of char habitat downstream as cut is redirected to same drainage at the confluence with downstream watercourse.	-	-	0	-	0
CV-101-1b	CV-101-1	No	Cut located in fishless habitat. No alteration of char habitat downstream as cut is redirected to same drainage at the confluence with downstream watercourse.	-	-	0	-	0

Table 4-5. - continued -

Site ID	Diversion to	Arctic Char Habitat at Cut	Effects Summary	Area of Habitat Loss or Alteration (m^2)				
				Lost			Altered	Total
				Upstream	Downstream	Subtotal	Downstream	
CV-102-1a	CV-102-2	No	No alteration to downstream habitat as flow is directed to adjacent stream in same drainage upstream of the confluence with the diverted stream.	-	-	0	-	0
CV-102-5	CV-103-1	No	No alteration of char habitat downstream as cut is redirected to same drainage at the confluence with downstream watercourse.	-	-	0	-	0
CV-109-1	CV-109-2	Unlikely	Direct loss of upstream and downstream stream/pond habitat. No alteration to downstream habitat as flow is redirected into the same drainage (i.e., adjacent tributary to larger downstream pond).	270	2,125	2,395	-	2,395
Totals				7,016	12,780	19,796	5,916	25,712

4.2.3 Fish Passage

4.2.3.1 Bridges

Bridges may impede fish passage where in-stream structures result in channel constriction and increases in velocities. Each of the four bridges is located in Arctic Char habitat and will be designed to provide for fish passage. Fish passage will be assessed prior to and following bridge construction through evaluation of water velocities. Where they increase substantially, the channels will be lined with boulders to roughen the channel and alter the velocity profile. If necessary, large boulders will be placed in a staggered formation to provide velocity refugia for fish as they move through the bridge structures. In all cases, it is anticipated that instream pier or abutment placements will not alter stream hydraulics to the extent that fish passage may become an issue, although local flow characteristics may be somewhat altered.

4.2.3.2 Stream Crossings: Culvert Installations

Construction of the railway will involve 142 crossings on streams with juvenile Arctic Char and four pond encroachment/infill sites where fish passage would be required to ensure connectivity between stream and pond habitat. As described in Section 4.1.4, fish passage at culvert stream crossings was assessed through hydraulic modeling to estimate water velocities and comparison to velocity criteria calculated for each crossing using the average length of Arctic Char (100 mm) measured during Tote Road field programs. Hydraulic modeling was conducted for two scenarios: low slope, low flow (referred to hereafter as “Vmin”); and high slope, high flow (referred to hereafter as “Vmax”; Knight Piésold 2018). Hydraulic modeling was not completed for a total of 12 sites due to lack of detailed engineering design information.

Of the 130 stream crossings in char habitat for which hydraulic modeling was completed, passage of a 100 mm Arctic Char would not be impeded at 57 (44%) and 19 (15%) sites for the Vmin and Vmax scenarios, respectively. Of the remaining sites, 72 (55%) and 99 (76%) culvert crossings may partially impede upstream movements of Arctic Char of 100 mm in length under average open-water season flows, depending on slope and flow scenarios (Table 4-6; Attachment 3). Total loss of fish passage (i.e., velocity modeling criteria for 5% passage not met) under average flow conditions is predicted for one (1%) crossing under Vmin and 12 (9%) crossings under Vmax.

The four sites (CV-15-2, CV-15-3, CV-65-2, and CV-71-1) where the rail will encroach upon or cross pond habitat and potentially affect access between pond and stream habitat are each predicted to result in some degree of fish passage impediment (Attachment 3).

As the rail alignment was routed to remain within the Tote Road corridor wherever technically feasible, many of the rail culvert crossings will be in close proximity to existing Tote Road crossings. In some instances, the road and rail crossings will effectively become one installation. In these cases, fish passage may be impeded by the cumulative effect of the road and rail crossings. The crossing installations will be designed to provide for fish passage at char-bearing streams with consideration of the potential for cumulative effects.

The intent of the fish passage assessment described herein was to identify crossings where additional mitigation will be required to ensure fish passage. Fish passage through culverts can be enhanced by maximizing water conveyance capacity (oversized culverts), embedding culverts and roughening the bed within the culverts (boulder placement), avoiding outlet drops, and providing downstream and upstream resting pools. However, for long culverts, especially in combination with high gradients, maintaining water velocities that fish can manage for the time it takes to pass through a culvert may not be possible.

Fish-bearing culverts will be assessed on a case-by-case basis to install appropriate fish passing promoting measures during the final detailed engineering design phase of the Project. To mitigate for potential fish passage issues at the culvert crossings, numerous design features that promote fish passage may be considered and will be incorporated wherever feasible. Mitigation measures that will be considered include:

- Installation of culverts at the same slope as the existing stream, where feasible;
- Minimization of culvert lengths;
- Culverts with lengths that exceed 50 m may be considered barriers to fish passage because of the darkness inside. Methods to provide light inside culverts will be examined and considered where applicable;
- Culvert velocities will be compared to the velocity in the existing watercourse to determine fish passage potential. This information can be used to reassess design velocities under proposed conditions with the culvert installed;
- With the channelization of flows and conveyance in culverts, the velocity of the flows may increase. This may be mitigated by placing rocks and boulders inside the culverts (stream replication) to provide greater friction, thereby reducing velocities and increasing the flow depth and to provide resting locations for fish. Boulders may be bolted into place; and
- In culverts on steep slopes, high velocities may result in the movement of rocks inside the culvert. At these locations, baffles, baffle inserts or weirs may be installed to:
    - Assist in keeping rocks inside the culvert;
    - Maintain and increase roughness in order to minimize velocities; and
    - Provide additional resting locations for fish as they move through the culvert.

Table 4-6. Summary of fish passage screening assessment for stream crossings.

Fish Passage	Number of crossings		Percent of crossings	
	Vmin	Vmax	Vmin	Vmax
>95%	57	19	44	15
<95% to 75%	17	19	13	15
<75% to 50%	33	31	25	24
<50% to 25%	20	35	15	27
<25% to 5%	2	14	2	11
<5%	1	12	1	9
Total	130	130	100	100
Not Modeled	12	12	-	-

4.2.4 SUMMARY

With implementation of design measures to provide for fish passage at the stream culvert installations where Arctic Char are known or suspected to be present, the rail infrastructure would result in the loss/alteration/displacement of approximately 68,602 m^2 (6.86 ha) of Arctic Char habitat, or 0.53% of the total char stream, lake/pond, and larger stream/river habitat that would be crossed/affected directly by the railway (Table 4-7). This total includes a loss/alteration/displacement of 0.06% of large river habitat due to bridges, 0.63% of primarily stream habitat due to cuts and culvert installations, and 3.7% of lake habitat due to encroachments/infilling.

The area of lost/altered char habitat that is described in detail in the preceding sections and summarized in Table 4-7 is expected to be an overestimate due to the conservative approach applied for the quantification. For previously un-surveyed lakes and ponds where the presence/absence of fish could not be confirmed with existing knowledge or through identification of barriers to fish movements, fish presence was conservatively assumed. It is expected that some of the habitat that was assumed to support char is not char habitat and the estimates of lost/altered habitat indicated in Table 4-7 are likely high. The estimates are expected to be revised following completion of field surveys.

Table 4-7. Summary of loss of, and alteration to, Arctic Char habitat due to rail infrastructure.

Habitat/Rail Infrastructure		**Arctic Char Habitat (m^2)**			
		Lost[1]	**Altered[2]**	**Total**	**% of Available**
Available Habitat Crossed by Rail	Streams/ponds: cuts and culverts	-	-	8,958,286	-
	Ponds/Lakes: encroachments and infilling	-	-	264,556	-
	Large rivers: bridges	-	-	3,983,856	-
Lost/Altered Habitat					
Bridges		50	2,366	2,416	0.06
Pond/Lake Encroachments/Infilling		9,853	-	9,853	3.72
Culvert Crossings: Streams		20,317	10,305	30,621	0.34
Cuts	Upstream	7,016	-	7,016	0.08
	Downstream	12,780	5,916	18,696	0.21
	Sub-Total	19,796	5,916	25,712	0.29
Total Stream Habitat		40,113	16,220	56,333	0.63
TOTAL		**50,016**	**18,586**	**68,602**	**-**

1. Lost habitat was defined as the area of the culvert footprints, the area of abutments and piers within the streams for bridges, and the area of dewatered habitat at cuts.
2. Altered habitat was defined as the area of rip-rap aprons for culvert installations, the area of rip-rap armoring for bridges, and the area of habitat downstream of diversions where flows will be reduced.

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ATTACHMENT 1. STREAM CROSSINGS, CUTS, BRIDGES, AND POND/LAKE ENCROACHMENTS/INFILLS ALONG THE NORTH RAIL ALIGNMENT

Table A1-1. List of stream crossings (culverts), bridges, cuts/diversions, and lake/pond encroachments/infills along the North Rail alignment and fish habitat summary.

Site ID	Description	Waterbody Type	Diversion to	Current UTM Coordinates		Arctic Char		Ninespine Stickleback		Habitat Quality
				Easting	Northing	Fish Bearing	Classification Uncertainty	Fish Bearing	Classification Uncertainty	
CV-0-1	Culvert	S		504289	7975593	No	N/A	No	N/A	None
CV-0-2	Cut	S	CV-0-1	504234	7975572	No	N/A	No	N/A	None
CV-0-3	Culvert	S		503796	7975281	No	N/A	No	N/A	None
CV-1-1	Culvert	S		503802	7975052	No	N/A	No	N/A	None
CV-1-2	Culvert	S		503830	7974912	No	N/A	No	N/A	None
CV-1-3	Culvert	S/P		503820	7974824	No	N/A	No	N/A	None
CV-1-4	Culvert	LP		503877	7974421	No	N/A	No	N/A	None
CV-1-5	Culvert	LP		503938	7974333	No	N/A	No	N/A	None
CV-1-6	Culvert	S		504292	7974064	No	N/A	No	N/A	None
CV-1-7	Culvert	S		504662	7973667	No	N/A	No	N/A	None
CV-1-8	Culvert	S		504895	7973426	No	N/A	No	N/A	None
CV-1-9	Culvert	S		504924	7973381	No	N/A	No	N/A	None
CV-2-1	Culvert	S		505154	7973121	No	N/A	No	N/A	None
CV-2-2	Culvert	S		505217	7973067	No	N/A	No	N/A	None
CV-3-1	Culvert	S		505388	7972906	No	N/A	No	N/A	None
CV-3-2	Culvert	S		505396	7972893	No	N/A	No	N/A	None
CV-4-1	Culvert	S		505666	7972585	No	N/A	No	N/A	None
CV-4-2	Culvert	S		505774	7972512	No	N/A	No	N/A	None
CV-4-3	Culvert	S		505836	7972435	No	N/A	No	N/A	None
CV-4-4	Culvert	S		505862	7972397	No	N/A	No	N/A	None
CV-4-5	Culvert	S		506070	7972201	No	N/A	No	N/A	None
CV-5-1	Culvert	S		506158	7972031	No	N/A	No	N/A	None
CV-5-2	Culvert	S		506172	7971999	No	N/A	No	N/A	None
CV-5-3	Culvert	S		506297	7971792	No	N/A	No	N/A	None
CV-5-4	Culvert	S		506540	7971622	No	N/A	No	N/A	None
CV-5-5	Culvert	S		506643	7971540	No	N/A	No	N/A	None
CV-5-6	Culvert	S		506661	7971526	No	N/A	No	N/A	None
CV-5-7	Culvert	S		506781	7971420	No	N/A	No	N/A	None
CV-6-1	Culvert	S		506927	7971257	No	N/A	No	N/A	None
CV-6-2	Culvert	S		507170	7971061	No	N/A	No	N/A	None
CV-6-3	Culvert	S		507417	7970910	No	N/A	No	N/A	None
CV-6-4	Culvert	S		507476	7970841	No	N/A	No	N/A	None
CV-7-1	Culvert	LP		507732	7970526	No	N/A	No	N/A	None
CV-7-2	Culvert	LP		507884	7970336	No	N/A	No	N/A	None
CV-7-3	Culvert	LP		507953	7970255	No	N/A	No	N/A	None
CV-7-4	Culvert	LP		508038	7970146	No	N/A	No	N/A	None
CV-7-5	Culvert	LP		508060	7970116	No	N/A	No	N/A	None
CV-7-6	Culvert	LP		508094	7970073	No	N/A	No	N/A	None
CV-7-7	Culvert	LP		508097	7970069	No	N/A	No	N/A	None

Table A1-1. - continued -

Site ID	Description	Waterbody Type	Diversion to	Current UTM Coordinates		Arctic Char		Ninespine Stickleback		Habitat Quality
				Easting	Northing	Fish Bearing	Classification Uncertainty	Fish Bearing	Classification Uncertainty	
CV-8-0	Cut	S	CV-8-1 and CV-8-2	508293	7969747	No	N/A	No	N/A	None
CV-8-1	Culvert	S		508311	7969712	No	N/A	No	N/A	None
CV-8-2	Culvert	S		508325	7969683	No	N/A	No	N/A	None
CV-8-3	Culvert	S		508351	7969601	No	N/A	No	N/A	None
CV-8-4	Culvert	S		508412	7969338	No	N/A	No	N/A	None
CV-9-1	Culvert	S		508805	7968873	No	N/A	No	N/A	None
CV-10-1	Culvert	LP		509365	7968264	No	N/A	No	N/A	None
CV-10-2	Culvert	LP		509637	7968011	No	N/A	No	N/A	None
CV-10-3	Culvert	LP		509653	7967999	No	N/A	No	N/A	None
CV-10-4	Culvert	LP		509829	7967867	No	N/A	No	N/A	None
CV-10-5	Culvert	S		509872	7967824	No	Low	No	Low	None
CV-11-1	Culvert	S		509931	7967723	Potential	High	Potential	High	Marginal
CV-11-2	Culvert	LP		510076	7967537	No	N/A	No	N/A	None
CV-11-3	Culvert	S		510214	7967455	No	N/A	No	N/A	None
CV-11-4	Culvert	LP		510472	7967402	No	N/A	No	N/A	None
CV-11-5	Culvert	LP		510589	7967385	No	N/A	No	N/A	None
CV-12-1	Culvert	S		510933	7967256	Unlikely	Moderate	Unlikely	Moderate	None-Marginal
CV-12-2	Culvert	S		511019	7967241	Unlikely	Moderate	Unlikely	Moderate	None-Marginal
CV-12-3	Culvert	LP		511127	7967223	No	N/A	No	N/A	None
CV-12-4	Culvert	LP		511355	7967185	No	N/A	No	N/A	None
CV-12-4b	Cut	LP	CV-12-5 and CV-13-1	511455	7967168	No	N/A	No	N/A	None
CV-12-5	Culvert	S		511552	7967152	No	N/A	No	N/A	None
CV-13-1	Culvert	LP		511798	7967111	No	N/A	No	N/A	None
CV-13-2	Culvert	LP		512120	7966981	No	N/A	No	N/A	None
CV-13-3	Culvert	S		512375	7966823	No	N/A	No	N/A	None
CV-13-4	Culvert	S		512415	7966799	Yes	N/A	Yes	N/A	Important
CV-13-5	Culvert	S		512556	7966712	No	N/A	No	N/A	None
CV-14-1	Culvert	S		513252	7966428	No	N/A	No	N/A	None
CV-14-2	Culvert	P		513436	7966375	No	N/A	No	N/A	None
CV-14-3	Culvert	P		513532	7966333	No	N/A	No	N/A	None
CV-15-1	Culvert	LP		513624	7966294	No	N/A	No	N/A	None
CV-15-2	Culvert/encroachment	S/P		513781	7966188	Yes	N/A	Yes	N/A	Marginal(ARCH) Important (NNST)
CV-15-3	Culvert/encroachment	S/P		513892	7966034	Yes	N/A	Yes	N/A	Marginal - Important
CV-15-4	Culvert	P		514123	7965711	No	Low	No	Low	None
CV-15-5	Bridge	S		514239	7965626	Yes	N/A	Yes	N/A	Important
CV-16-1	Culvert	LP		514325	7965565	No	N/A	No	N/A	None
CV-16-2	Culvert/encroachment	S/P		514768	7965089	No	N/A	No	N/A	None
CV-16-3	Culvert	S		514811	7964916	No	Low	Potential	High	Marginal
CV-17-1	Culvert	P		515261	7964025	No	N/A	No	Low	None

Table A1-1. - continued –

Site ID	Description	Waterbody Type	Diversion to	Current UTM Coordinates		Arctic Char		Ninespine Stickleback		Habitat Quality
				Easting	Northing	Fish Bearing	Classification Uncertainty	Fish Bearing	Classification Uncertainty	
CV-18-1	Encroachment	P		515331	7963846	No	N/A	Unlikely	Moderate	None - Marginal
CV-18-2	Culvert	S		515405	7963693	No	N/A	No	N/A	None
CV-18-3	Culvert	S		515607	7963389	No	N/A	No	N/A	None
CV-18-4	Culvert	S		515682	7963328	No	N/A	No	N/A	None
CV-19-1	Culvert	S		515927	7963175	No	N/A	No	N/A	None
CV-19-2	Culvert	P		516161	7963031	No	N/A	No	Low	None
CV-19-3	Culvert	S		516613	7962587	No	N/A	No	N/A	None
CV-20-1	Culvert	LP		517040	7962255	No	N/A	No	N/A	None
CV-20-2	Cut	S	CV-20-1	517267	7962029	No	N/A	No	N/A	None
CV-21-1	Culvert	LP		517391	7961887	No	N/A	No	N/A	None
CV-21-2	Culvert	LP		517607	7961640	No	N/A	No	N/A	None
CV-21-3	Culvert	LP		517928	7961308	No	N/A	No	N/A	None
CV-21-4	Culvert	LP		518010	7961196	No	N/A	No	N/A	None
CV-22-1	Pond Infilling	P		518123	7960950	No	N/A	Unlikely	Moderate	None - Marginal
CV-22-2	Encroachment	P		518232	7960617	No	N/A	Unlikely	Moderate	None - Marginal
CV-22-3	Culvert	LP		518295	7960427	No	N/A	No	N/A	None
CV-22-4	Encroachment	P		518370	7960198	No	N/A	Unlikely	Moderate	None - Marginal
CV-23-1	Culvert	S		518441	7959981	No	N/A	No	N/A	None
CV-23-2	Culvert	S		518501	7959798	No	N/A	No	N/A	None
CV-23-3	Culvert	LP		518695	7959425	No	N/A	No	N/A	None
CV-23-4	Culvert	S		518754	7959335	No	N/A	No	N/A	None
CV-24-1	Culvert	S		518988	7958946	No	N/A	No	N/A	None
CV-24-2	Culvert	S		519081	7958667	No	N/A	No	N/A	None
CV-24-3	Culvert	S		519153	7958481	No	N/A	No	N/A	None
CV-25-1	Culvert	S		519225	7958229	No	N/A	No	N/A	None
CV-25-2	Culvert	S		519507	7958144	Probable	Moderate	Probable	Moderate	Marginal - Important
CV-25-3	Culvert	S		519661	7958016	Potential	High	Potential	High	Marginal
CV-26-1	Culvert/Infill	S/P		519989	7957450	Potential	High	Potential	High	Marginal
CV-26-3	Culvert	LP		520156	7957209	No	N/A	No	N/A	None
CV-26-4	Culvert	LP		520224	7957110	No	N/A	No	N/A	None
CV-26-5	Culvert	S		520386	7956847	No	N/A	No	N/A	None
CV-27-1	Culvert	S		520406	7956775	Potential	High	Potential	High	Marginal
CV-27-2	Culvert	S		520412	7956735	Potential	High	Potential	High	Marginal
CV-27-3	Culvert	LP		520516	7956235	No	N/A	No	N/A	None
CV-27-4	Culvert	LP		520564	7956131	No	N/A	No	N/A	None
CV-27-5	Culvert	S		520699	7955833	No	N/A	No	N/A	None
CV-28-1	Culvert	LP		520722	7955784	No	N/A	No	N/A	None
CV-28-2	Culvert	S		520749	7955722	No	N/A	No	N/A	None
CV-28-3	Culvert	LP		520891	7955261	No	N/A	No	N/A	None
CV-28-4	Culvert	LP		520924	7955182	No	N/A	No	N/A	None
CV-28-5	Culvert/encroachment	P		521005	7955067	No	N/A	No	N/A	None

Table A1-1. - continued -

Site ID	Description	Waterbody Type	Diversion to	Current UTM Coordinates		Arctic Char		Ninespine Stickleback		Habitat Quality
				Easting	Northing	Fish Bearing	Classification Uncertainty	Fish Bearing	Classification Uncertainty	
CV-28-6	Culvert	S		521092	7954969	Yes	Low	Yes	Low	Important
CV-28-7	Culvert	S		521305	7954680	No	N/A	No	N/A	None
CV-29-1	Culvert	S		521341	7954608	No	N/A	No	N/A	None
CV-29-2	Culvert	S		521379	7954516	Yes	N/A	Yes	N/A	Important
CV-29-3	Culvert	S		521464	7954306	No	N/A	No	N/A	None
CV-29-4	Culvert	S		521512	7954187	No	N/A	No	N/A	None
CV-29-5	Culvert	S		521541	7954115	No	N/A	No	N/A	None
CV-30-1	Culvert	S		521569	7954040	No	N/A	No	N/A	None
CV-30-2	Culvert	LP		521609	7953873	No	N/A	No	N/A	None
CV-30-3	Culvert	S/LP		521635	7953720	No	N/A	No	N/A	None
CV-30-4	Culvert	S		521676	7953461	No	N/A	No	N/A	None
CV-30-5	Culvert	S		521687	7953363	Yes	Low	Yes	Low	Important
CV-30-6	Culvert	S		521700	7953250	No	N/A	Unlikely	Moderate	None - Marginal
CV-30-7	Pond Infilling	S/P		521712	7953143	No	N/A	Unlikely	Moderate	None - Marginal
CV-31-1	Culvert	S		521748	7952788	Yes	N/A	Yes	N/A	Important
CV-31-2	Culvert	S		521749	7952776	Yes	N/A	Yes	N/A	Important
CV-31-3	Culvert	LP		521763	7952346	No	N/A	No	N/A	None
CV-31-4	Culvert	LP		521772	7952278	No	N/A	No	N/A	None
CV-32-1	Culvert	LP		521827	7952066	No	N/A	No	N/A	None
CV-32-2	Culvert	LP		521882	7951861	No	N/A	No	N/A	None
CV-32-3	Culvert	LP		521946	7951620	No	N/A	No	N/A	None
CV-32-4	Culvert	S		521983	7951453	No	N/A	No	N/A	None
CV-33-1	Culvert	LP		521990	7951011	No	N/A	No	N/A	None
CV-33-2	Culvert	LP		521991	7950911	No	N/A	No	N/A	None
CV-33-3	Culvert	LP		521990	7950839	No	N/A	No	N/A	None
CV-33-4	Culvert	S		521976	7950733	No	N/A	No	N/A	None
CV-33-5	Culvert	S		521964	7950662	No	N/A	No	N/A	None
CV-33-6	Culvert	S		521947	7950568	Yes	N/A	Yes	N/A	Important
CV-33-7	Culvert	P		521885	7950215	No	N/A	No	N/A	None
CV-34-1	Culvert	S		521789	7949673	No	N/A	No	N/A	None
CV-34-2	Culvert	S		521801	7949153	No	N/A	No	N/A	None
CV-35-2	Culvert	S		521947	7948828	Yes	N/A	Yes	N/A	Important
CV-35-4	Culvert	S		522249	7948287	No	N/A	No	N/A	None
CV-35-5	Cut	LP	CV-35-4	522298	7948170	No	N/A	No	N/A	None
CV-37-1	Culvert	LP		522533	7946398	No	N/A	No	N/A	None
CV-38-1	Culvert	S		522570	7946000	No	N/A	No	N/A	None
CV-38-2	Culvert	S		522646	7945802	No	N/A	No	N/A	None
CV-38-3	Culvert	S		522846	7945387	No	N/A	No	N/A	None
CV-39-1	Culvert	S		523125	7944922	No	N/A	No	N/A	None
CV-40-1	Culvert	LP		523148	7944309	No	N/A	No	N/A	None
CV-40-2	Culvert	S		523147	7944150	No	N/A	No	N/A	None

Table A1-1. - continued -

Site ID	Description	Waterbody Type	Diversion to	Current UTM Coordinates		Arctic Char		Ninespine Stickleback		Habitat Quality
				Easting	Northing	Fish Bearing	Classification Uncertainty	Fish Bearing	Classification Uncertainty	
CV-40-3	Culvert	LP		523231	7943898	No	N/A	No	N/A	None
CV-40-4	Culvert	LP		523301	7943665	No	N/A	No	N/A	None
CV-41-1	Culvert	S		523332	7943397	No	N/A	No	N/A	None
CV-41-2	Culvert	S		523342	7943311	No	N/A	No	N/A	None
CV-41-3	Culvert	LP		523359	7943152	No	N/A	No	N/A	None
CV-41-4	Culvert	LP		523351	7942963	No	N/A	No	N/A	None
CV-42-1	Culvert	S		523423	7942323	No	N/A	No	N/A	None
CV-42-2	Culvert	S		523475	7941603	No	N/A	No	N/A	None
CV-43-1	Culvert	S		523647	7941268	No	N/A	No	N/A	None
CV-43-2	Culvert	LP		523721	7941127	No	N/A	No	N/A	None
CV-43-3	Culvert	S		523738	7941095	No	N/A	No	N/A	None
CV-43-4	Culvert	S		523749	7941075	No	N/A	No	N/A	None
CV-43-5	Culvert	S		523846	7940904	No	Low	No	Low	None
CV-44-1	Culvert	S		524074	7940563	No	N/A	No	N/A	None
CV-44-2	Culvert	S		524174	7940415	No	N/A	No	N/A	None
CV-44-3	Culvert	S		524536	7939827	No	N/A	No	N/A	None
CV-45-1	Culvert	LP		525004	7938965	No	N/A	No	N/A	None
CV-46-1	Culvert	LP		525118	7938743	No	N/A	No	N/A	None
CV-46-1a	Cut	P	CV-46-3	525226	7938529	No	Low	No	Low	None
CV-46-2	Culvert	S		525278	7938537	No	Low	No	Low	None
CV-46-3	Culvert	S		525380	7938336	No	N/A	No	N/A	None
CV-46-4	Culvert	S		525394	7938239	No	N/A	No	N/A	None
CV-46-6	Culvert	S		525404	7938168	No	N/A	No	N/A	None
CV-47-1A	Culvert	S		525415	7938089	No	N/A	No	N/A	None
CV-47-1B	Culvert	S		525454	7937939	No	N/A	No	N/A	None
CV-47-1	Culvert	S		525683	7937366	Yes	N/A	No	Low	Important
CV-47-2	Culvert	S		525698	7937327	Yes	N/A	Yes	N/A	Important
CV-47-3	Culvert	S		525729	7937268	Yes	N/A	Yes	N/A	Important
CV-48-1	Culvert	S/LP		525839	7937127	No	High	No	High	None
CV-48-2	Culvert	S/LP		525916	7937063	No	High	No	High	None
CV-48-3	Culvert	S/LP		526356	7936875	No	High	No	High	None
CV-48-4	Culvert	S		526523	7936808	Yes	N/A	Yes	N/A	Important
CV-49-1	Culvert	S		526690	7936443	No	Low	No	Low	None
CV-49-2	Culvert	S		526737	7936101	Potential	High	Potential	High	Marginal
CV-49-3	Culvert	S/LP		526788	7935730	No	Low	No	Low	None
CV-50-1	Culvert	S		526835	7935393	No	N/A	No	N/A	None
CV-50-2	Culvert	S		526863	7935175	No	N/A	No	N/A	None
CV-50-3	Culvert	S		526868	7935095	No	N/A	No	N/A	None
CV-50-4	Culvert	LP		526874	7934905	No	N/A	No	N/A	None
CV-50-4a	Culvert	LP		526876	7934875	No	N/A	No	N/A	None
CV-50-4b	Culvert	LP		526888	7934776	No	N/A	No	N/A	None

Table A1-1. - continued –

Site ID	Description	Waterbody Type	Diversion to	Current UTM Coordinates		Arctic Char		Ninespine Stickleback		Habitat Quality
				Easting	Northing	Fish Bearing	Classification Uncertainty	Fish Bearing	Classification Uncertainty	
CV-50-5	Culvert	S		526924	7934630	Yes	Low	Yes	Low	Marginal
CV-50-6	Culvert	S		526926	7934620	Yes	N/A	Yes	N/A	Important
CV-51-1	Culvert	LP		527006	7934331	No	N/A	No	N/A	None
CV-51-2	Culvert	LP		527054	7933628	No	N/A	No	N/A	None
CV-52-1	Culvert	S		527080	7932998	No	N/A	No	N/A	None
CV-52-2	Culvert	S		527132	7932787	No	N/A	No	N/A	None
CV-52-3	Culvert	LP		527180	7932698	No	N/A	No	N/A	None
CV-53-1	Culvert	LP		527366	7932476	No	N/A	No	N/A	None
CV-53-2	Culvert	P		527274	7932000	No	N/A	No	Low	None
CV-54-1	Culvert	S		527333	7931375	No	N/A	No	N/A	None
CV-54-2	Culvert	S		527529	7930869	No	N/A	No	N/A	None
CV-55-1	Culvert	LP		527583	7930653	No	N/A	No	Low	None
CV-55-2	Culvert	LP		527632	7930421	No	N/A	No	Low	None
CV-55-3	Culvert	S		527650	7930339	Yes	N/A	Yes	N/A	Important
CV-56-1	Culvert	S		528085	7929337	Yes	N/A	Yes	N/A	Marginal
CV-57-1	Culvert	S		528309	7928841	Yes	N/A	Yes	N/A	Marginal
CV-57-2	Culvert	S		528345	7928683	Yes	N/A	Yes	N/A	Marginal
CV-58-1	Culvert	S		528241	7927966	Probable	Moderate	Probable	Moderate	Marginal
CV-58-2	Culvert	S		528168	7927807	Yes	Low	Yes	Low	Marginal - Important
CV-58-3	Culvert	S		528109	7927716	Potential	High	Potential	High	Marginal
CV-58-4	Culvert	S		528062	7927656	Yes	Low	Yes	Low	Marginal - Important
CV-58-4a	Culvert	S		527931	7927527	Yes	Low	Yes	Low	Marginal - Important
CV-58-5	Culvert	S		527751	7927378	Probable	Moderate	Probable	Moderate	Marginal - Important
CV-58-6	Culvert	S		527681	7927318	Probable	Moderate	Probable	Moderate	Marginal - Important
CV-58-7	Cut	S	CV-59-1	527650	7927282	Unlikely	Moderate	Unlikely	Moderate	None - Marginal
CV-58-8	Cut	S	CV-59-1	527613	7927217	Potential	High	Potential	High	None - Marginal
CV-59-1	Culvert	S		527590	7927169	Probable	Moderate	Probable	Moderate	Marginal - Important
CV-59-2	Culvert	S		527553	7927052	Potential	High	Potential	High	Marginal
CV-59-3	Culvert	S		527529	7926917	Potential	High	Potential	High	None - Marginal
CV-59-4b	Cut	LP	CV-59-4	527467	7926817	No	N/A	No	N/A	None
CV-59-4	Culvert	S		527395	7926734	Yes	Low	Yes	Low	Important
CV-59-4a	Cut	S	CV-59-4	527329	7926595	No	Low	No	Low	None
CV-59-5	Culvert	S		527272	7926457	No	Low	No	Low	None
CV-60-1	Culvert	S		527202	7926246	No	Low	No	Low	None
CV-60-2	Culvert/encroachment	S/P		527214	7926070	No	Low	No	Low	None
CV-60-3	Culvert	S		527225	7925961	Probable	Moderate	Probable	Moderate	Marginal - Important
CV-60-4	Culvert	S		527243	7925782	Unlikely	Low	Unlikely	Low	None - Marginal
CV-60-4a	Cut	S	CV-60-5	527252	7925685	No	Low	No	Low	None
CV-60-5	Culvert	S		527273	7925480	Potential	High	Potential	High	Marginal - Important
CV-60-6	Culvert	S		527283	7925381	Unlikely	Low	Unlikely	Low	None - Marginal
CV-61-1	Culvert	S		527296	7925237	Probable	Moderate	Probable	Moderate	Marginal - Important

Table A1-1. - continued -

Site ID	Description	Waterbody Type	Diversion to	Current UTM Coordinates		Arctic Char		Ninespine Stickleback		Habitat Quality
				Easting	Northing	Fish Bearing	Classification Uncertainty	Fish Bearing	Classification Uncertainty	
CV-61-2	Culvert	S		527181	7925009	Probable	Moderate	Probable	Moderate	Marginal - Important
CV-61-3	Cut	S	CV-61-2	527023	7924876	Potential	High	Potential	High	Marginal - Important
CV-62-1	Culvert	S		526868	7924453	Yes	Low	Yes	Low	Important
CV-62-2	Culvert	S		526897	7924167	Probable	Moderate	Probable	Moderate	Marginal - Important
CV-62-3	Cut	S	CV-62-4	526951	7923938	Unlikely	Low	Unlikely	Low	None - Marginal
CV-62-4	Culvert	S		526975	7923621	No	Low	No	Low	None
CV-62-5	Culvert	LP		526982	7923557	No	Low	No	Low	None
CV-62-6	Cut	S	CV-62-5	527016	7923383	Unlikely	Low	Unlikely	Low	None - Marginal
CV-62-6b	Cut	S	CV-62-5	527011	7923411	Unlikely	Low	Unlikely	Low	None - Marginal
CV-63-1	Culvert	S		527058	7923177	Potential	High	Potential	High	None - Marginal
CV-63-2	Culvert	S		527100	7923086	Potential	High	Potential	High	None - Marginal
CV-63-3	Culvert	S		527162	7922964	Potential	High	Potential	High	Marginal - Important
CV-63-3a	Cut	LP	CV-63-3	527179	7922796	No	Low	No	Low	None
CV-63-4	Culvert	S		527204	7922667	Probable	Moderate	Probable	High	Marginal - Important
CV-63-4a	Culvert	S		527229	7922619	Potential	High	Potential	High	Marginal
CV-63-5	Culvert	S		527241	7922603	Potential	High	Potential	Low	Marginal
CV-64-1	Culvert	S		527295	7922538	Unlikely	Low	Unlikely	Low	None - Marginal
CV-64-2	Culvert	S		527414	7922399	Unlikely	Low	Unlikely	Low	None - Marginal
CV-64-3	Culvert	S		527482	7922239	No	Low	No	Low	None
CV-64-4	Culvert	S		527625	7921956	Yes	Low	Yes	Low	Marginal - Important
CV-64-5a	Cut	LP	CV-64-5	527688	7921835	No	Low	No	Low	None
CV-64-5	Culvert	S		527743	7921726	No	Low	No	Low	None
CV-64-6	Culvert	S		527757	7921691	No	Low	No	Moderate	None
CV-65-1	Culvert	S		527793	7921396	Probable	Moderate	Probable	High	Marginal - Important
CV-65-2a	Cut	LP	CV-65-2	527803	7921140	Unlikely	Low	No	Low	None - Marginal
CV-65-2	Pond Infilling/Culvert	P		527828	7920934	Potential	High	Potential	Low	None - Important
CV-66-1	Culvert	S		527959	7920627	Unlikely	Low	Unlikely	Low	None - Marginal
CV-66-2a	Cut	LP	CV-66-2	528013	7920571	No	Low	No	Low	None
CV-66-2	Culvert	S		528063	7920532	No	Low	No	Moderate	None
CV-66-3	Culvert	S		528328	7920342	Probable	Moderate	Probable	Low	Marginal - Important
CV-66-4	Culvert	S		528359	7920292	No	Low	No	Low	None
CV-66-5	Culvert	S		528389	7920187	No	Low	No	Low	None
CV-66-6	Culvert	S		528390	7920161	No	Low	No	Low	None
CV-66-7	Culvert	S		528378	7920014	No	Low	No	Moderate	None
CV-66-8	Culvert	S		528376	7919987	Probable	Moderate	Probable	Moderate	Marginal - Important
CV-67-1	Culvert	S		528299	7919743	Probable	Moderate	Probable	Low	Marginal - Important
CV-67-2	Culvert	S		528226	7918995	No	Low	No	Low	None
CV-68-1a	Culvert	S		528200	7918864	Yes	Low	Yes	Low	Marginal - Important
CV-68-1	Culvert	S		528199	7918838	Yes	Low	Yes	Low	Important
CV-68-2	Culvert	S		528194	7918768	No	Low	No	Moderate	None
CV-68-3	Culvert	S		528059	7918496	Probable	Moderate	Probable	Low	Marginal - Important

Table A1-1. - continued -

Site ID	Description	Waterbody Type	Diversion to	Current UTM Coordinates		Arctic Char		Ninespine Stickleback		Habitat Quality
				Easting	Northing	Fish Bearing	Classification Uncertainty	Fish Bearing	Classification Uncertainty	
CV-68-4	Culvert	S		528055	7918461	No	Low	No	High	None
CV-68-5	Culvert	S		528081	7918334	Potential	High	Potential	Low	Marginal - Important
CV-69-1	Culvert	S		528322	7917862	No	Low	No	Low	None
CV-69-2	Culvert	S		528438	7917517	Yes	Low	Yes	Low	Marginal - Important
CV-69-3	Culvert	S		528458	7917456	Yes	Low	Yes	High	Marginal - Important
CV-69-4	Culvert	S		528474	7917407	Potential	High	Potential	Moderate	Marginal - Important
CV-70-1	Encroachment	P		528704	7916939	No	N/A	Unlikely	Moderate	None - Marginal
CV-70-2	Culvert	S		529030	7916745	Yes	N/A	Yes	N/A	Important
CV-70-3	Bridge	S		529120	7916693	Yes	N/A	Yes	Low	Important
CV-71-1	Pond Infilling	S/P		529451	7916535	Yes	Low	Yes	Low	Important
CV-71-2a	Encroachment	S/P		529708	7916558	Probable	Moderate	Probable	Moderate	Marginal
CV-71-3	Culvert	S		529965	7916706	No	Low	Unlikely	Moderate	None - Marginal
CV-71-4	Culvert	S		530214	7916862	No	Low	Unlikely	Moderate	None - Marginal
CV-72-1	Culvert	S		530370	7916951	No	Low	Unlikely	Moderate	None - Marginal
CV-72-1a	Culvert	S		530587	7917015	No	Low	Unlikely	Moderate	None - Marginal
CV-72-2	Culvert	S		530784	7917069	No	Low	Unlikely	High	None - Marginal
CV-72-3	Culvert	S		531048	7917142	Potential	High	Potential	High	None - Marginal
CV-72-3a	Culvert	S		531130	7917165	Potential	High	Potential	High	None - Marginal
CV-72-4	Culvert	S		531160	7917173	Potential	High	Potential	Moderate	None - Marginal
CV-73-1	Culvert	S		531795	7917555	Unlikely	Moderate	Unlikely	Moderate	None - Marginal
CV-73-2	Culvert	S		532007	7918051	Potential	High	Potential	High	None - Marginal
CV-73-3	Culvert	S		532156	7918212	Potential	High	Potential	High	None - Marginal
CV-73-4	Culvert	S		532303	7918244	Potential	High	Potential	High	None - Marginal
CV-74-1	Culvert	S		532376	7918246	Probable	Moderate	Probable	Low	Marginal - Important
CV-74-2	Culvert	S		532406	7918246	Yes	Low	Yes	Low	Marginal - Important
CV-74-3	Culvert	S		532735	7918374	Potential	High	Potential	High	Marginal
CV-74-4	Culvert	S		532888	7918494	Potential	High	Potential	High	Marginal
CV-74-6	Culvert	S		532988	7918553	Potential	High	Potential	High	Marginal - Important
CV-74-7	Cut	S	CV-74-6	533258	7918549	Potential	High	Potential	High	Marginal - Important
CV-75-1	Culvert	S		533398	7918521	Potential	High	Potential	High	Marginal
CV-75-1a	Culvert	S		533444	7918512	Potential	High	Potential	High	Marginal
CV-75-2	Culvert	S		533559	7918501	Potential	High	Potential	Moderate	Marginal
CV-76-1	Culvert	S		533900	7918535	Probable	Moderate	Probable	High	Marginal
CV-76-1a	Culvert	S		534333	7918581	Potential	High	Potential	Low	None - Marginal
CV-76-2	Culvert	LP		534506	7918563	No	Low	No	High	None
CV-76-3	Culvert	S		534825	7918511	Potential	High	Potential	High	None - Marginal
CV-77-1	Culvert	S		534992	7918491	Potential	High	Potential	Low	Marginal
CV-77-2	Culvert	S		535267	7918560	Yes	Low	Yes	Moderate	Marginal - Important
CV-77-3	Culvert	S		535497	7918521	Probable	Moderate	Probable	Low	Marginal
CV-78-1	Culvert	LP		535691	7918488	No	Low	No	Moderate	None
CV-78-2	Culvert	S		535890	7918531	Unlikely	Moderate	Unlikely	Low	None - Marginal

Table A1-1. - continued -

Site ID	Description	Waterbody Type	Diversion to	Current UTM Coordinates		Arctic Char		Ninespine Stickleback		Habitat Quality
				Easting	Northing	Fish Bearing	Classification Uncertainty	Fish Bearing	Classification Uncertainty	
CV-78-3	Culvert	S		536006	7918599	Yes	Low	Yes	Low	Marginal - Important
CV-78-4	Culvert	LP		536163	7918706	No	Low	No	Moderate	None
CV-78-5	Culvert	S		536237	7918756	Unlikely	Moderate	Unlikely	Moderate	None - Marginal
CV-78-6	Culvert	S		536450	7918866	Probable	Moderate	Probable	Moderate	Marginal - Important
CV-79-0	Culvert	S		537243	7919138	Probable	Moderate	Probable	Moderate	Marginal - Important
CV-79-1	Culvert	S		537418	7919175	Unlikely	Moderate	Unlikely	Low	None - Marginal
CV-80-1	Culvert	S		537461	7919180	Yes	Low	Yes	Moderate	Marginal - Important
CV-80-1a	Culvert	S		537487	7919182	Unlikely	Moderate	Unlikely	Moderate	None - Marginal
CV-80-2	Culvert	S		538320	7919565	Unlikely	Moderate	Unlikely	Moderate	None - Marginal
CV-80-2a	Culvert	S		538307	7919556	Unlikely	Moderate	Unlikely	Moderate	None - Marginal
CV-80-2b	Culvert	S		538334	7919573	Unlikely	Moderate	Unlikely	Moderate	None - Marginal
CV-80-3	Culvert	S		538453	7919642	Unlikely	Moderate	Unlikely	Moderate	None - Marginal
CV-80-4	Culvert	S		538510	7919675	Unlikely	Moderate	Unlikely	Moderate	None - Marginal
CV-80-5	Culvert	S		538604	7919729	Unlikely	Moderate	Unlikely	Low	None - Marginal
CV-81-1	Culvert	S		538691	7919779	No	Low	No	Moderate	None
CV-81-2	Culvert	S		538879	7919924	Probable	Moderate	Probable	Moderate	Marginal - Important
CV-81-3	Culvert	S		538942	7920004	Probable	Moderate	Probable	Moderate	Marginal - Important
CV-81-4	Culvert	S		539077	7920175	Unlikely	Moderate	Unlikely	Moderate	None - Marginal
CV-82-1	Culvert	S		539131	7920244	Unlikely	Moderate	Unlikely	Moderate	None - Marginal
CV-82-1a	Cut	LP	CV-82-1	539242	7920376	No	Low	No	Low	None
CV-82-2	Culvert	S		539376	7920489	Unlikely	Moderate	Unlikely	Moderate	None - Marginal
CV-82-3	Culvert	S		539508	7920599	Unlikely	Moderate	Unlikely	Moderate	None - Marginal
CV-82-4	Culvert	S		539729	7920783	Probable	Moderate	Probable	Moderate	Marginal - Important
CV-83-1	Culvert	S		539835	7920871	Probable	Moderate	Probable	High	Marginal - Important
CV-83-1a	Culvert	S		539887	7920915	Potential	High	Potential	N/A	Marginal - Important
CV-83-2	Culvert	S		540162	7921134	Yes	N/A	Yes	N/A	Marginal
CV-84-1	Culvert	S		540842	7921510	Yes	N/A	Yes	Moderate	Important
CV-84-2	Culvert	S		541030	7921642	Unlikely	Moderate	Unlikely	N/A	None - Marginal
CV-84-3	Culvert	S		541294	7921948	No	N/A	No	N/A	None
CV-85-1	Culvert	S		541514	7922054	No	N/A	No	N/A	None
CV-85-2	Culvert	S		541921	7922236	No	N/A	No	N/A	None
CV-85-3	Bridge	S		542213	7922215	Yes	N/A	Yes	N/A	Important
CV-85-4	Culvert	S		542288	7922156	Yes	N/A	Yes	High	Important
CV-86-1	Encroachment	P		542671	7921780	No	N/A	Potential	High	None - Marginal
CV-86-2	Culvert	S		542753	7921708	Yes	N/A	Yes	Low	Marginal
CV-87-1	Culvert	LP		543078	7921473	No	Low	No	Low	None
CV-87-2	Culvert	LP		543392	7921247	No	Low	No	Low	None
CV-87-3	Culvert	LP		543532	7921170	No	Low	No	N/A	None
CV-87-4	Culvert	S		543736	7921141	Yes	N/A	Yes	Low	Marginal
CV-88-1	Culvert	LP		543976	7921204	No	Low	No	Low	None
CV-88-2	Culvert	S		544209	7921282	Yes	Low	Yes	Low	Marginal

Table A1-1. - continued –

Site ID	Description	Waterbody Type	Diversion to	Current UTM Coordinates		Arctic Char		Ninespine Stickleback		Habitat Quality
				Easting	Northing	Fish Bearing	Classification Uncertainty	Fish Bearing	Classification Uncertainty	
CV-88-3	Culvert	S		544259	7921299	Yes	Low	Yes	Low	Marginal
CV-88-4	Culvert	LP		545151	7921245	No	Low	No	Low	None
CV-89-1	Culvert	S		545492	7921173	Yes	Low	Yes	Moderate	Important
CV-89-2	Pond Infilling	P		545729	7921121	No	Low	Unlikely	Moderate	None - Marginal
CV-90-1	Culvert	LP		545902	7921048	No	N/A	No	Moderate	None
CV-90-2	Cut	S	CV-90-3	546181	7920409	No	Low	Unlikely	Low	None - Marginal
CV-90-3	Culvert	S		546240	7920244	No	Low	No	Low	None
CV-90-4	Cut	S	CV-90-3	546459	7920041	No	Low	No	Low	None
CV-91-0	Culvert	S		546858	7919853	No	Low	No	Low	None
CV-91-1	Culvert	S		546928	7919820	No	Low	No	Low	None
CV-91-2	Culvert	S		547012	7919781	No	Low	No	Moderate	None
CV-92-1b	Cut	S	CV-92-1	547125	7919725	No	N/A	No	N/A	None
CV-92-1	Culvert/encroachment	S/P		547173	7919694	No	Low	Unlikely	Moderate	None - Marginal
CV-92-2	Culvert	LP		547416	7919506	No	N/A	No	N/A	None
CV-92-3	Culvert	S		547521	7919456	No	N/A	No	N/A	None
CV-92-4	Culvert	S		547721	7919363	No	N/A	No	Low	None
CV-92-5	Culvert	S		547879	7919262	Yes	Low	Yes	N/A	Marginal
CV-92-6	Culvert	S		547927	7919241	No	N/A	No	N/A	None
CV-92-7	Culvert	S		548001	7919220	No	N/A	No	N/A	None
CV-92-8	Culvert	LP		548033	7919215	No	N/A	No	N/A	None
CV-92-9	Culvert	S		548062	7919211	No	N/A	No	N/A	None
CV-93-1	Culvert	LP		548228	7919188	No	N/A	No	N/A	None
CV-93-2	Culvert	LP		548355	7919148	No	N/A	No	N/A	None
CV-93-3	Culvert	LP		548601	7918857	No	N/A	No	N/A	None
CV-93-3a	Culvert	S		548670	7918765	No	N/A	No	Moderate	None
CV-93-4a	Culvert	S		548749	7918703	Probable	Moderate	Probable	Moderate	Marginal
CV-93-4b	Culvert	S		548701	7918736	Probable	Moderate	Probable	N/A	Marginal
CV-93-4	Culvert	S		548770	7918691	Yes	N/A	Yes	N/A	Important
CV-94-1	Culvert	LP		548899	7918649	No	N/A	No	N/A	None
CV-94-2	Culvert	S		549840	7918391	No	N/A	No	N/A	None
CV-95-1	Cut	LP	CV-94-2	550005	7918257	No	N/A	No	N/A	None
CV-95-2	Culvert	S		550144	7918111	No	N/A	No	Moderate	None
CV-95-3	Culvert	S		550483	7917613	Probable	Moderate	Probable	Moderate	Marginal - Important
CV-95-4	Culvert	S		550630	7917484	Probable	Moderate	Probable	Low	Marginal
CV-95-5	Culvert	S		550708	7917426	No	Low	No	Low	None
CV-95-5a	Culvert	S		550781	7917371	No	N/A	No	N/A	None
CV-95-6	Culvert	S		550832	7917333	No	Low	No	Low	None
CV-95-7	Culvert	S		550885	7917294	No	Low	No	N/A	None
CV-96-1	Culvert	S		550924	7917265	Yes	N/A	Yes	N/A	Important
CV-96-2	Culvert	S		550964	7917235	No	N/A	No	N/A	None
CV-96-3	Culvert	LP		551117	7917101	No	N/A	No	N/A	None

Table A1-1. - continued -

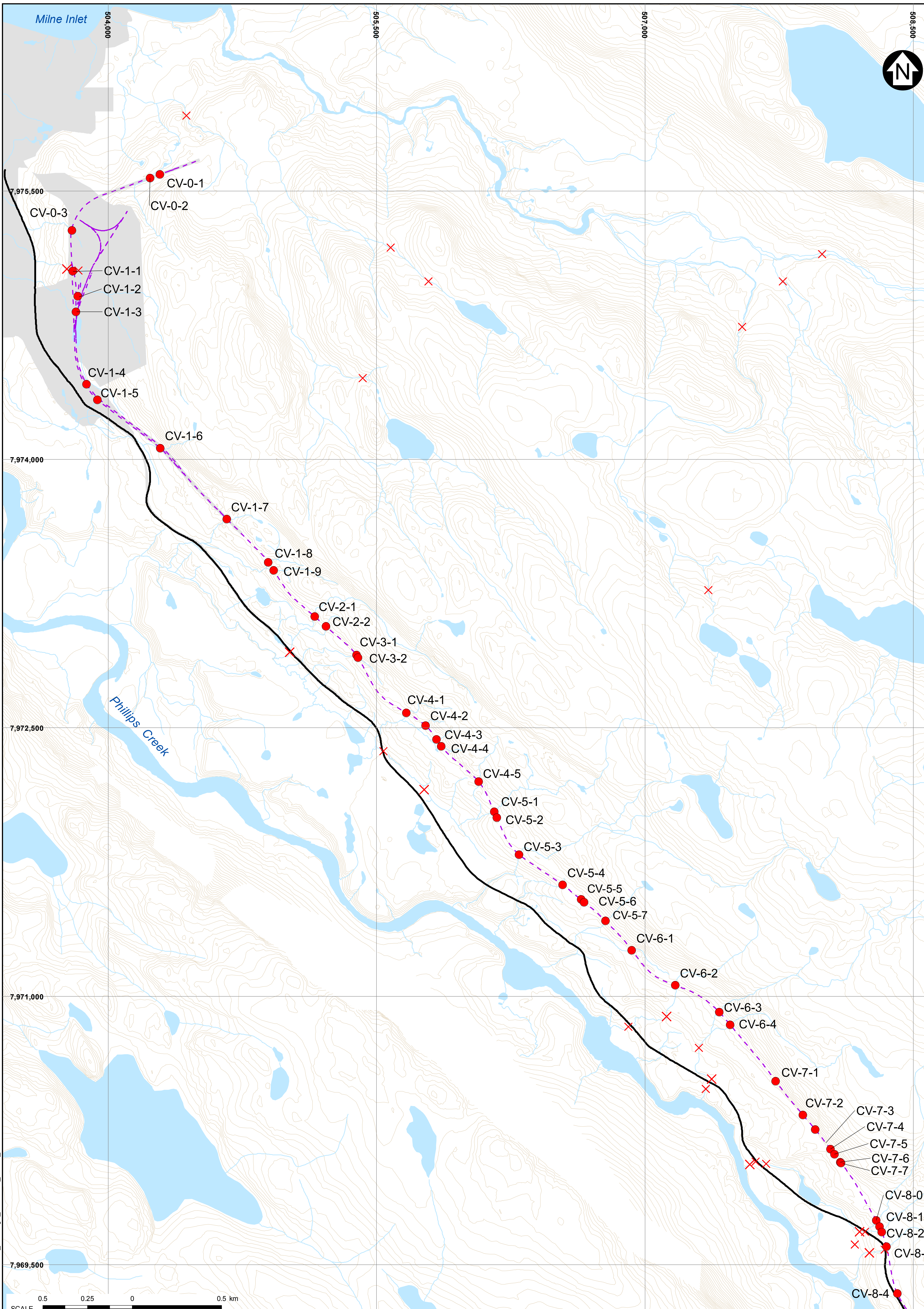
Site ID	Description	Waterbody Type	Diversion to	Current UTM Coordinates		Arctic Char		Ninespine Stickleback		Habitat Quality
				Easting	Northing	Fish Bearing	Classification Uncertainty	Fish Bearing	Classification Uncertainty	
CV-97-1	Culvert	LP		551191	7917013	No	N/A	No	N/A	None
CV-97-2	Culvert	S		551226	7916972	No	N/A	No	N/A	None
CV-97-3	Culvert	S		551254	7916940	No	N/A	No	N/A	None
CV-97-4	Culvert	S		551292	7916898	No	N/A	No	N/A	None
CV-97-5	Culvert	S		551351	7916843	No	N/A	No	N/A	None
CV-97-5b	Culvert	S		551326	7916865	No	N/A	No	N/A	None
CV-97-6	Cut	LP	CV-97-5	551457	7916754	No	N/A	No	N/A	None
CV-97-7	Culvert	S		551576	7916658	No	N/A	No	N/A	None
CV-97-7a	Culvert	S		551560	7916671	No	N/A	No	N/A	None
CV-97-9	Culvert	S		551629	7916614	No	N/A	No	N/A	None
CV-97-10	Culvert	S		551781	7916475	No	N/A	No	N/A	None
CV-97-11	Culvert	LP		551823	7916434	No	N/A	No	N/A	None
CV-97-12	Culvert	LP		551891	7916370	No	N/A	No	N/A	None
CV-98-0	Culvert	LP		552001	7916266	No	N/A	No	N/A	None
CV-98-1	Culvert	LP		552043	7916226	No	N/A	No	High	None
CV-99-1	Culvert/Encroachment	S/P		552464	7915930	No	N/A	Potential	High	None - Marginal
CV-99-2	Culvert	S		552958	7915502	No	N/A	Potential	Low	None - Marginal
CV-99-3	Culvert	S		553253	7915414	Yes	Low	Yes	N/A	Marginal - Important
CV-100-1	Culvert	LP		553579	7915319	No	N/A	No	N/A	None
CV-100-2	Culvert	LP		553862	7915292	No	N/A	No	High	None
CV-100-3	Culvert	LP		554050	7915379	No	N/A	No	N/A	None
CV-100-4	Culvert	S		554185	7915443	Probable	Moderate	Probable	Moderate	Marginal
CV-101-1	Culvert	S		554664	7915456	Probable	Moderate	Probable	Moderate	Marginal
CV-101-1a	Cut	S	CV-101-1	554772	7915455	No	N/A	No	N/A	None
CV-101-1b	Cut	S	CV-101-1	554885	7915454	No	N/A	No	N/A	None
CV-101-2	Culvert	S		555200	7915449	No	N/A	Unlikely	N/A	None - Marginal
CV-102-1	Bridge	S		555728	7915442	Yes	N/A	Yes	N/A	Important
CV-102-1a	Cut	S	CV-102-2	555891	7915441	No	N/A	No	N/A	None
CV-102-2	Culvert	S		556019	7915438	Yes	N/A	Yes	Moderate	Important
CV-102-3	Culvert	S		556373	7915485	Probable	Moderate	Probable	Low	Marginal - Important
CV-102-4	Culvert	S		556461	7915488	Yes	Low	Yes	High	Marginal - Important
CV-102-5	Cut	S	CV-103-1	557111	7915356	No	N/A	No	N/A	None
CV-103-1	Culvert	S		557447	7915244	Yes	N/A	Yes	Moderate	Important
CV-104-1	Culvert	S		557574	7915202	Probable	Moderate	Probable	Low	Marginal
CV-104-2	Culvert	S		557882	7915099	Yes	Low	Yes	N/A	Marginal - Important
CV-104-3	Culvert	S		557996	7915052	Yes	N/A	Yes	N/A	Important
CV-104-4	Culvert	LP		558154	7914976	No	N/A	No	N/A	None
CV-104-5	Culvert	S		558340	7914885	Yes	N/A	Yes	Moderate	Important
CV-105-1	Culvert	S		558521	7914785	Probable	Moderate	Probable	N/A	Marginal
CV-105-2	Culvert	S		558750	7914656	Yes	N/A	Yes	Low	Marginal
CV-105-3	Pond Infilling	P		558875	7914578	Yes	N/A	Yes	N/A	Marginal - Important

Table A1-1. - continued –

Site ID	Description	Waterbody Type	Diversion to	Current UTM Coordinates		Arctic Char		Ninespine Stickleback		Habitat Quality
				Easting	Northing	Fish Bearing	Classification Uncertainty	Fish Bearing	Classification Uncertainty	
CV-105-4	Culvert	S		559196	7914375	Yes	N/A	Yes	N/A	Marginal
CV-106-1	Pond Infilling	P		559334	7914281	Yes	N/A	Yes	N/A	Marginal - Important
CV-106-2	Pond Infilling	P		559615	7914085	Yes	N/A	Yes	Low	Marginal - Important
CV-106-3	Encroachment	P		559980	7913834	Yes	N/A	Yes	Moderate	Marginal - Important
CV-107-1	Encroachment	P		560409	7913682	Probable	Moderate	Probable	High	Marginal - Important
CV-107-2	Encroachment	P		560529	7913655	Potential	High	Potential	Low	None - Marginal
CV-107-3	Encroachment	P		560660	7913555	No	Low	No	N/A	None
CV-107-4	Culvert	S		560706	7913502	Yes	N/A	Yes	N/A	Important
CV-108-1	Culvert	S		560926	7913247	No	N/A	No	N/A	None
CV-108-2	Culvert	S		560963	7913204	No	N/A	No	N/A	None
CV-108-3	Culvert	S		561364	7912739	No	N/A	No	High	None
CV-109-1	Cut	S	CV-109-2	561856	7912346	Unlikely	High	Unlikely	High	None - Marginal
CV-109-2	Culvert	S		561973	7912254	No	Low	No	N/A	None
CV-109-3	Culvert	LP		562024	7912215	No	N/A	No	N/A	None
CV-110-1	Culvert	S		561084	7912910	No	N/A	No	N/A	None
CV-110-2	Culvert/Encroachment	P		561266	7912241	No	N/A	No	N/A	None
CV-110-3	Pond Infilling	P		561445	7912240	No	N/A	No	N/A	None
CV-110-4	Culvert	S		561546	7912425	No	N/A	No	N/A	None

N/A = not applicable; L = lake; LP = low point; P = pond; S = stream; ARCH = Arctic Char; NNST = Ninespine Stickleback.

ATTACHMENT 2. NORTH RAIL CORRIDOR FISH HABITAT CLASSIFICATION MAPS



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LEGEND:

ARCTIC CHAR HABITAT

- NO
- UNLIKELY
- POTENTIAL
- PROBABLE
- YES

- PROPOSED NORTH RAILWAY (JUNE 2018)
- MILNE INLET TOTE ROAD (EXISTING)
- MILNE INLET TOTE ROAD (REALIGNMENT)
- CONTOUR (5M INTERVAL)
- INFRASTRUCTURE

- BARRIER
- FALLS

NOTES:

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4. CONTOUR INTERVAL IS 5 M AND IS IN METRES.

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MARY RIVER PROJECT

FISH HABITAT CLASSIFICATIONS RELEVANT TO THE NORTH RAILWAY (MAP 1 OF 13)

North/South Consultants Inc.
Aquatic Environment Specialists

P/A NO.	REF NO.
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DATE: 13/06/2018

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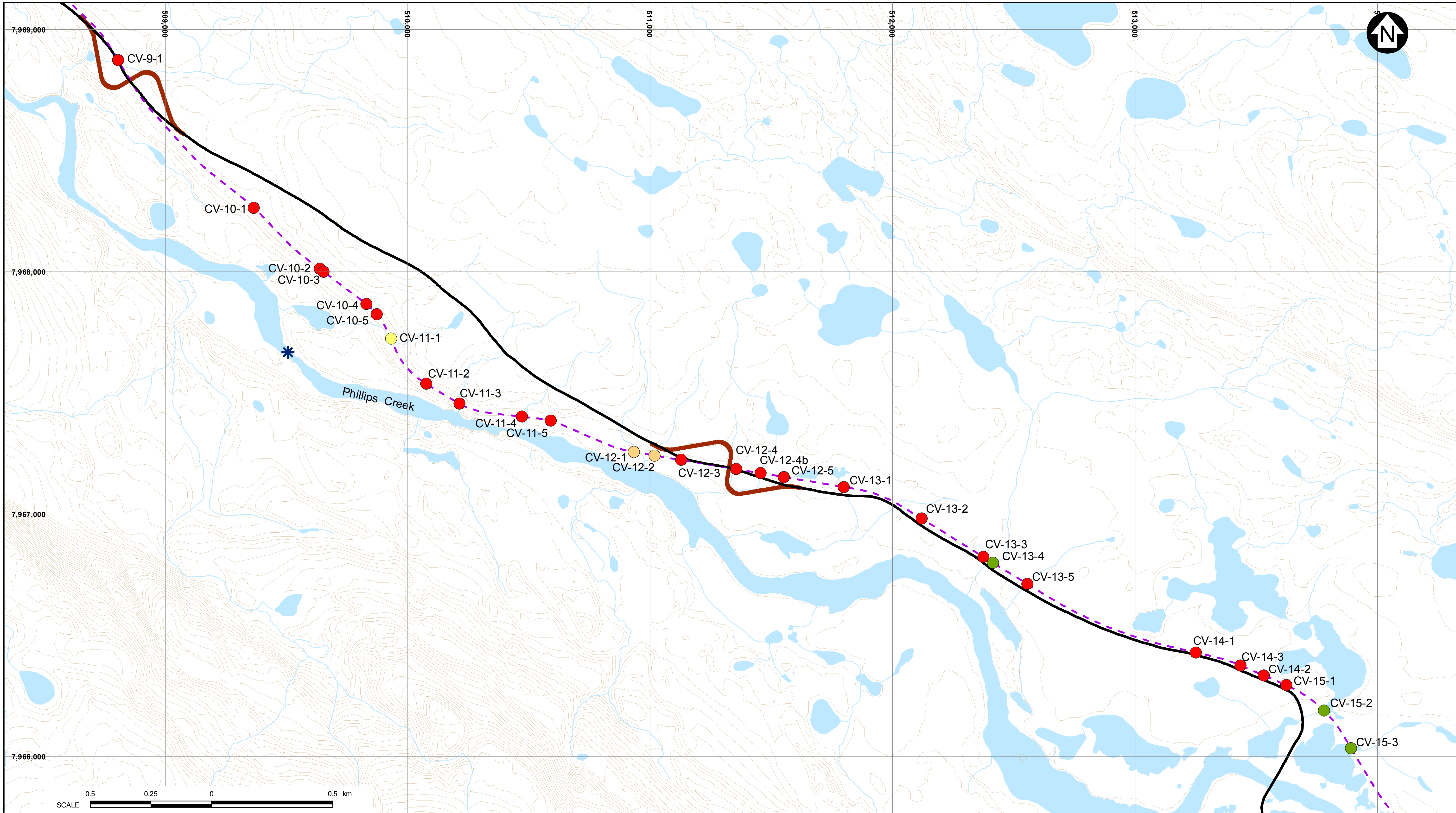

LEGEND:

ARCTIC CHAR HABITAT

- NO
- UNLIKELY
- POTENTIAL
- PROBABLE
- YES

- PROPOSED NORTH RAILWAY (JUNE 2018)
- MILNE INLET TOTE ROAD (EXISTING)
- MILNE INLET TOTE ROAD (REALIGNMENT)
- CONTOUR (5M INTERVAL)
- INFRASTRUCTURE

- BARRIER
- FALLS

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FISH HABITAT CLASSIFICATIONS RELEVANT TO THE NORTH RAILWAY (MAP 2 OF 13)

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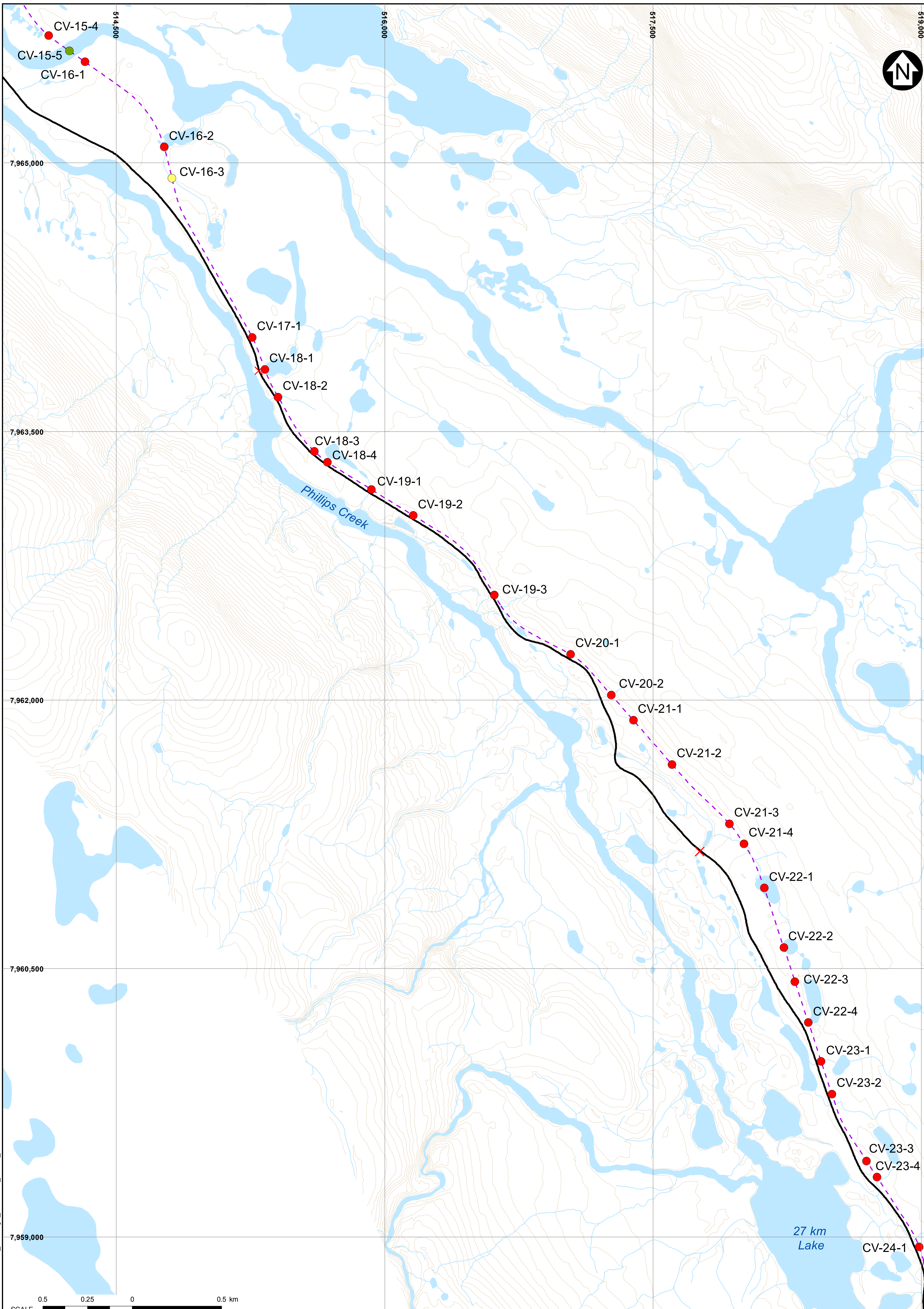

LEGEND:

ARCTIC CHAR HABITAT

- NO
- UNLIKELY
- POTENTIAL
- PROBABLE
- YES

- PROPOSED NORTH RAILWAY (JUNE 2018)
- MILNE INLET TOTE ROAD (EXISTING)
- MILNE INLET TOTE ROAD (REALIGNMENT)
- CONTOUR (5M INTERVAL)
- INFRASTRUCTURE

- BARRIER
- FALLS

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FISH HABITAT CLASSIFICATIONS RELEVANT TO THE NORTH RAILWAY (MAP 3 OF 13)

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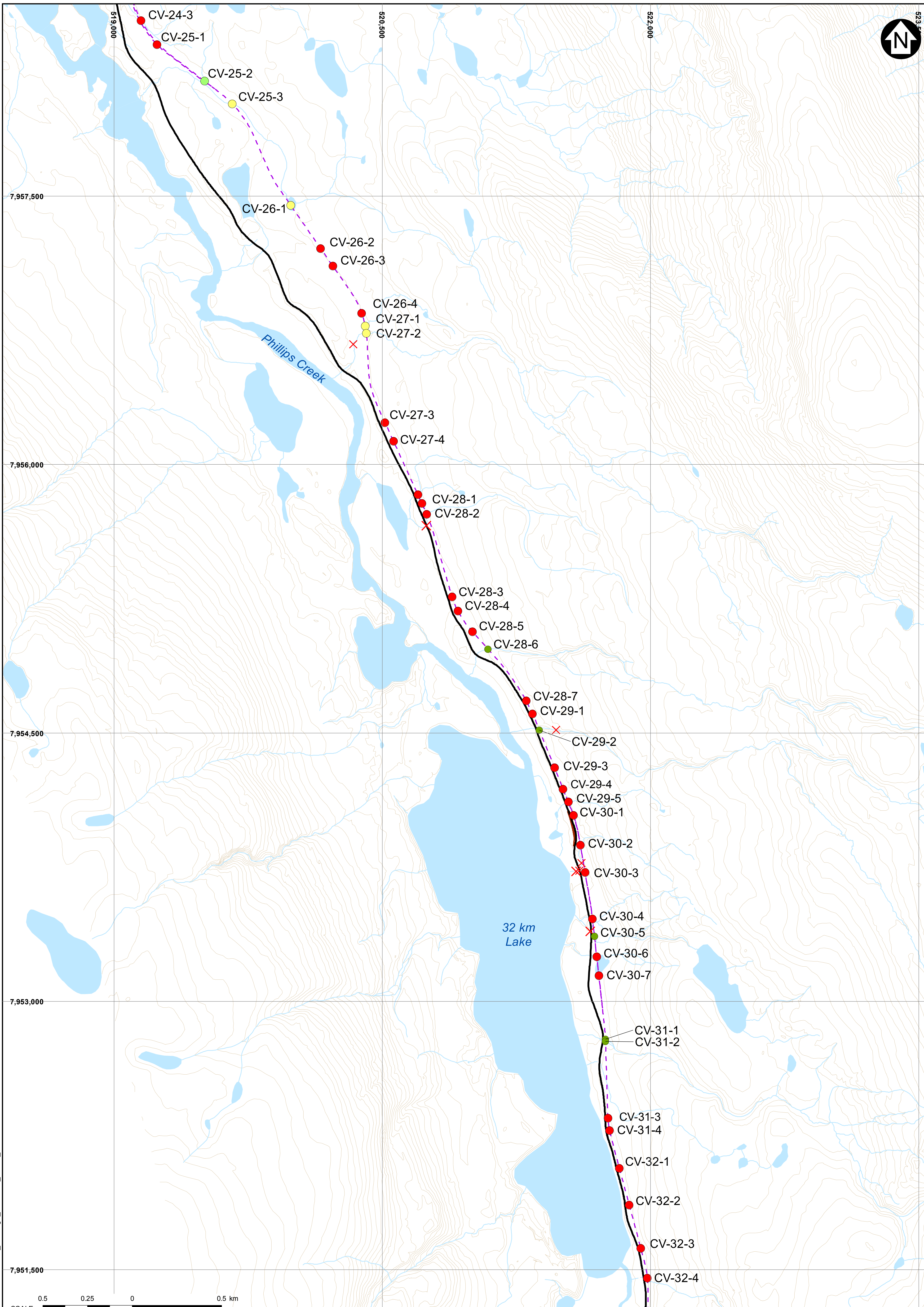

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LEGEND:

ARCTIC CHAR HABITAT

- NO
- UNLIKELY
- POTENTIAL
- PROBABLE
- YES

- PROPOSED NORTH RAILWAY (JUNE 2018)
- MILNE INLET TOTE ROAD (EXISTING)
- MILNE INLET TOTE ROAD (REALIGNMENT)
- CONTOUR (5M INTERVAL)
- INFRASTRUCTURE

- BARRIER
- FALLS

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FISH HABITAT CLASSIFICATIONS RELEVANT TO THE NORTH RAILWAY (MAP 4 OF 13)

North/South Consultants Inc.
Aquatic Environment Specialists

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DATE: 13/06/2018

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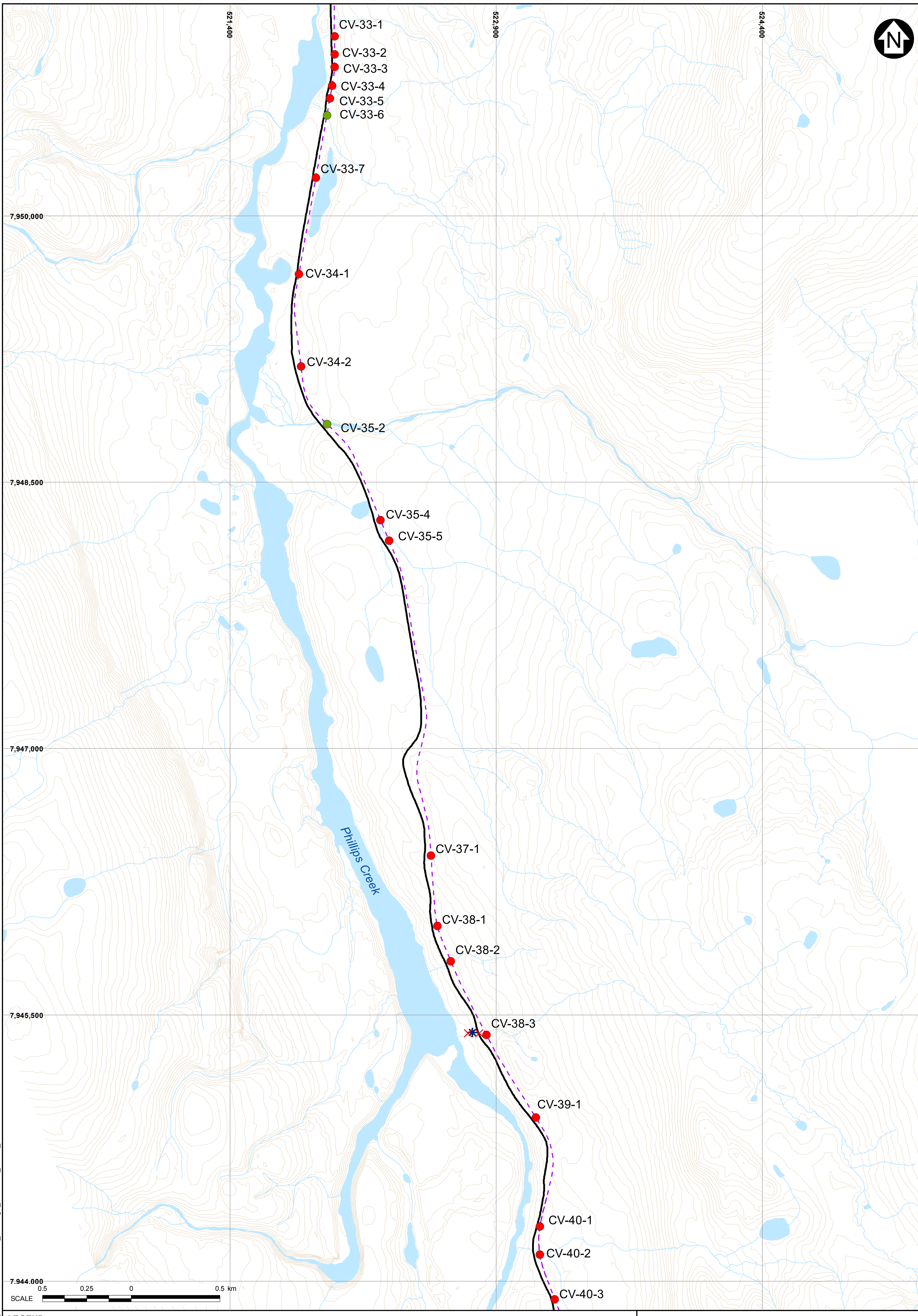

LEGEND:

ARCTIC CHAR HABITAT

- NO
- UNLIKELY
- POTENTIAL
- PROBABLE
- YES

- PROPOSED NORTH RAILWAY (JUNE 2018)
- MILNE INLET TOTE ROAD (EXISTING)
- MILNE INLET TOTE ROAD (REALIGNMENT)
- CONTOUR (5M INTERVAL)
- INFRASTRUCTURE

- BARRIER
- FALLS

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FISH HABITAT CLASSIFICATIONS RELEVANT TO THE NORTH RAILWAY (MAP 5 OF 13)

North/South Consultants Inc.
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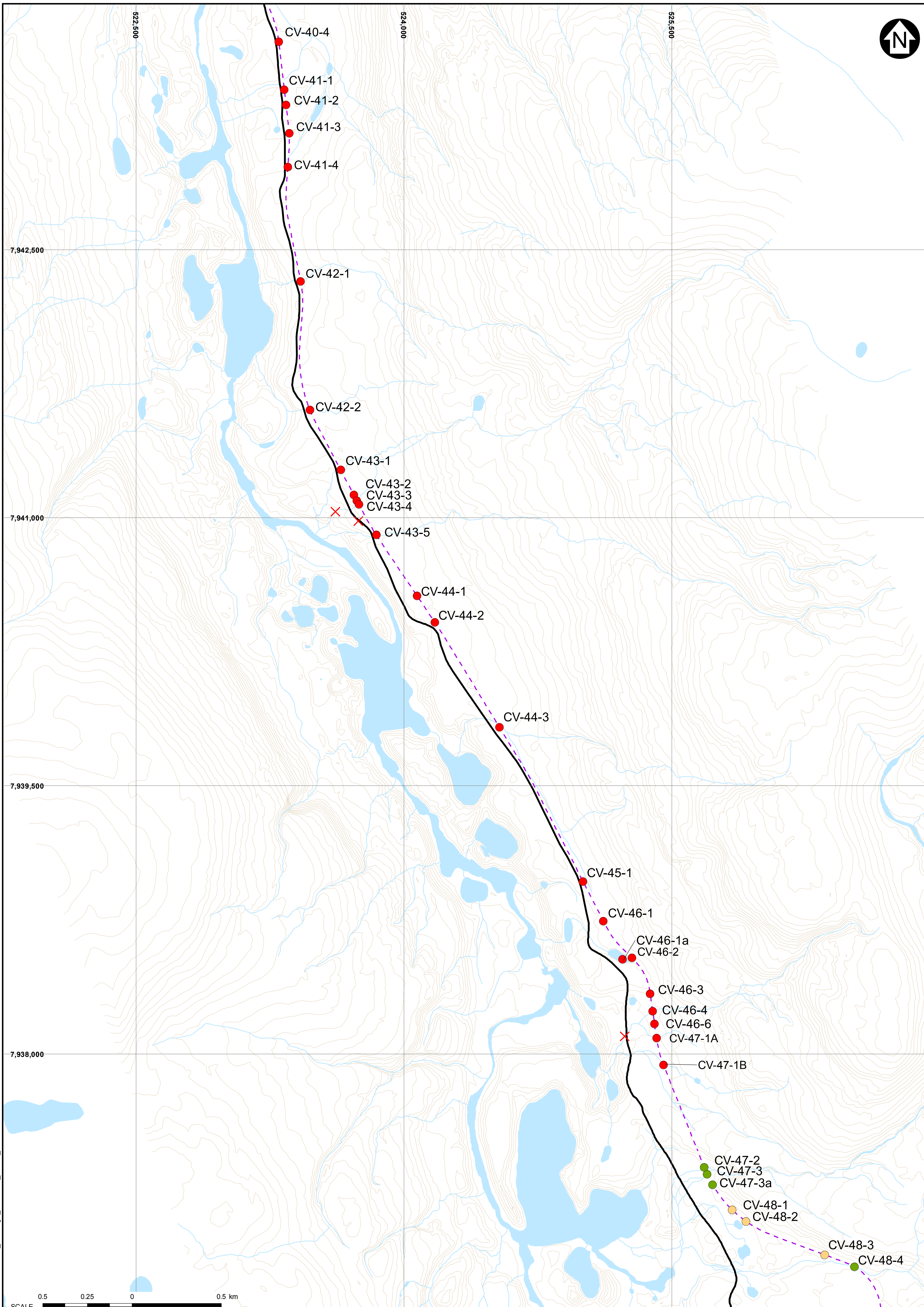

LEGEND:

ARCTIC CHAR HABITAT

- NO
- UNLIKELY
- POTENTIAL
- PROBABLE
- YES

- PROPOSED NORTH RAILWAY (JUNE 2018)
- MILNE INLET TOTE ROAD (EXISTING)
- MILNE INLET TOTE ROAD (REALIGNMENT)
- CONTOUR (5M INTERVAL)
- INFRASTRUCTURE

- BARRIER
- FALLS

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FISH HABITAT CLASSIFICATIONS RELEVANT TO THE NORTH RAILWAY (MAP 6 OF 13)

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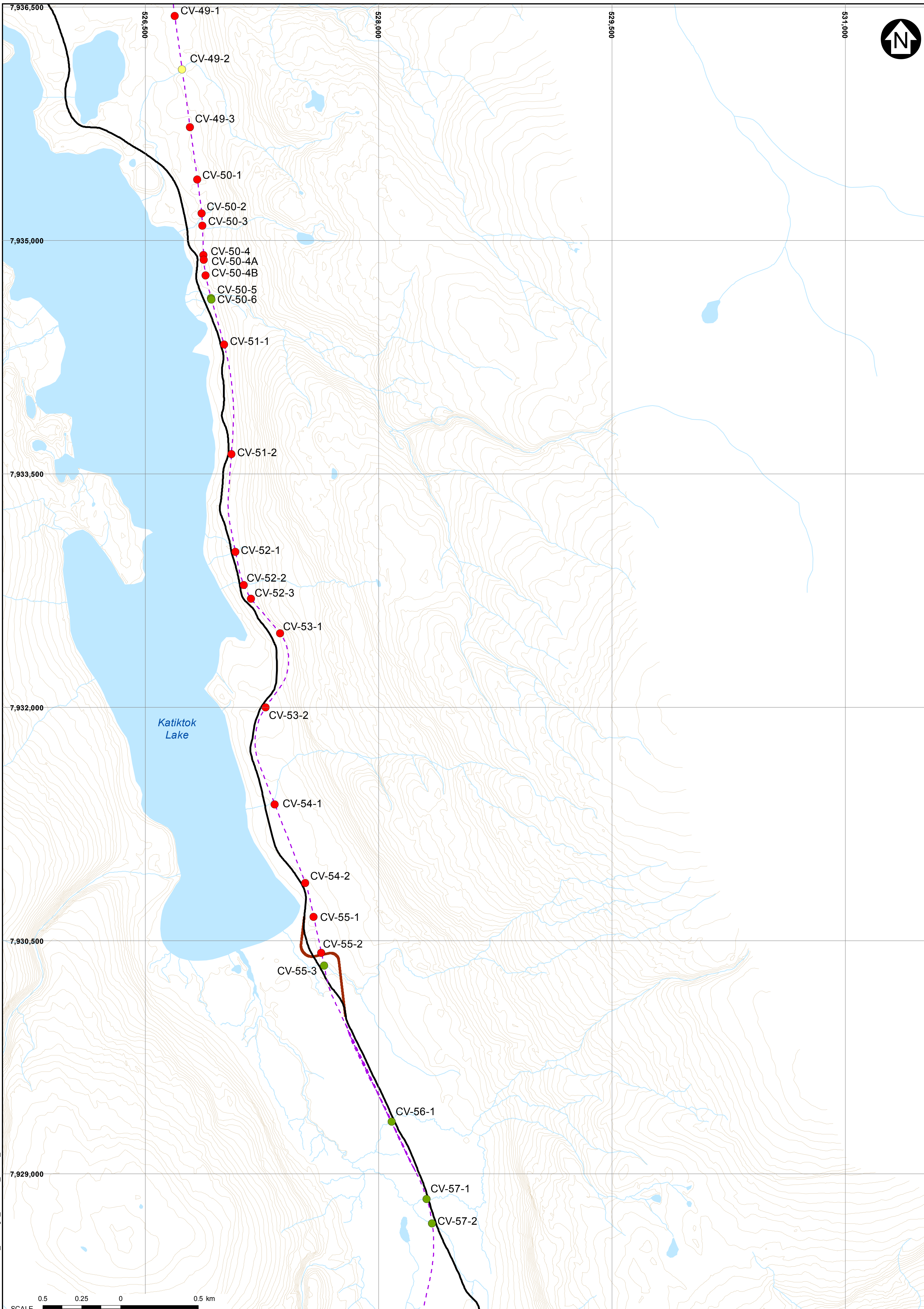

LEGEND:

ARCTIC CHAR HABITAT

- NO
- UNLIKELY
- POTENTIAL
- PROBABLE
- YES

- PROPOSED NORTH RAILWAY (JUNE 2018)
- MILNE INLET TOTE ROAD (EXISTING)
- MILNE INLET TOTE ROAD (REALIGNMENT)
- CONTOUR (5M INTERVAL)
- INFRASTRUCTURE

- BARRIER
- FALLS

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FISH HABITAT CLASSIFICATIONS RELEVANT TO THE NORTH RAILWAY (MAP 7 OF 13)

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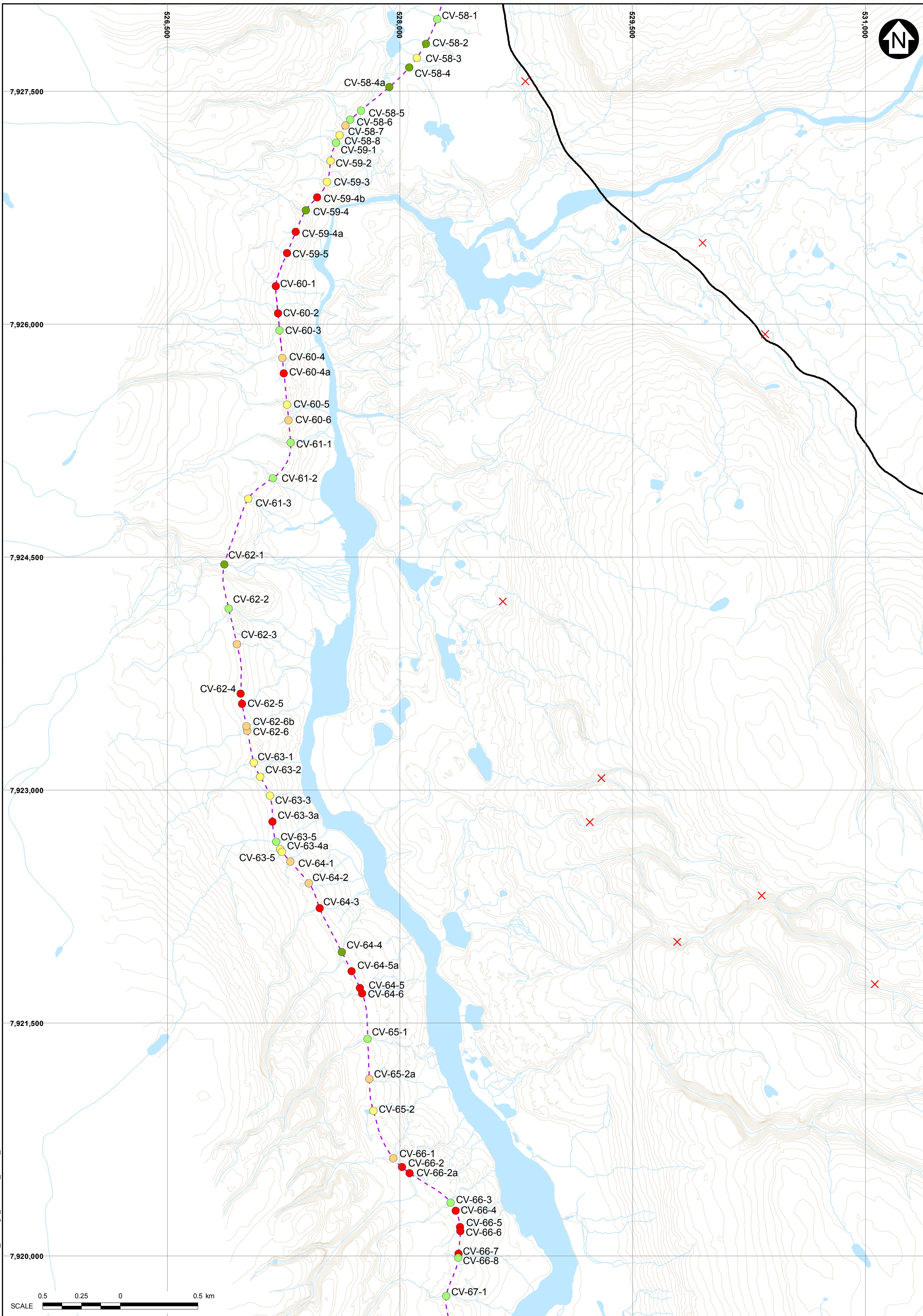

LEGEND:

ARCTIC CHAR HABITAT

- NO
- UNLIKELY
- POTENTIAL
- PROBABLE
- YES

- PROPOSED NORTH RAILWAY (JUNE 2018)
- MILNE INLET TOTE ROAD (EXISTING)
- MILNE INLET TOTE ROAD (REALIGNMENT)
- CONTOUR (5M INTERVAL)
- INFRASTRUCTURE

- BARRIER
- FALLS

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FISH HABITAT CLASSIFICATIONS RELEVANT TO THE NORTH RAILWAY (MAP 8 OF 13)

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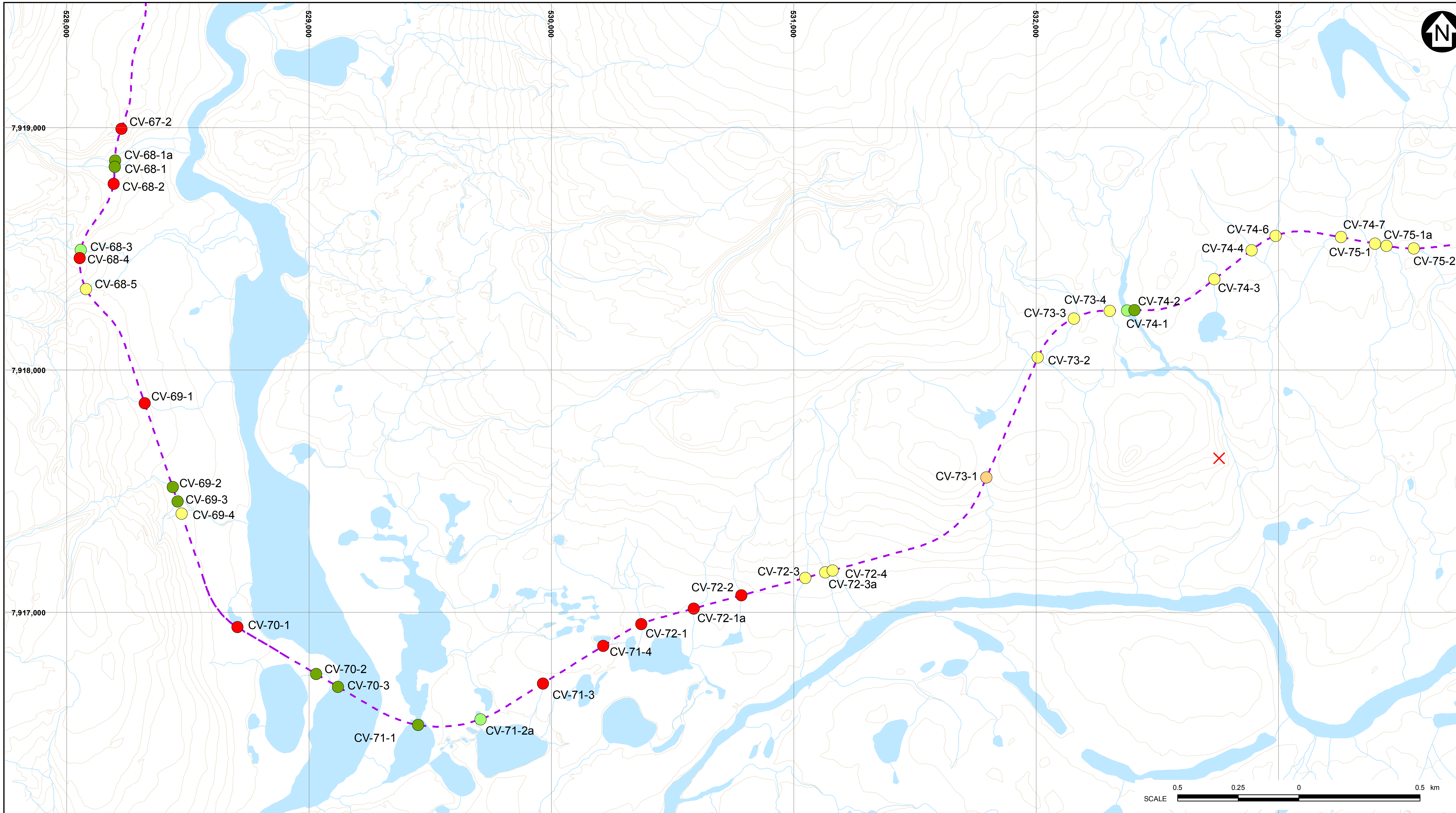

LEGEND:

ARCTIC CHAR HABITAT

- NO
- UNLIKELY
- POTENTIAL
- PROBABLE
- YES

- PROPOSED NORTH RAILWAY (JUNE 2018)
- MILNE INLET TOTE ROAD (EXISTING)
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- INFRASTRUCTURE

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FISH HABITAT CLASSIFICATIONS RELEVANT TO THE NORTH RAILWAY (MAP 9 OF 13)

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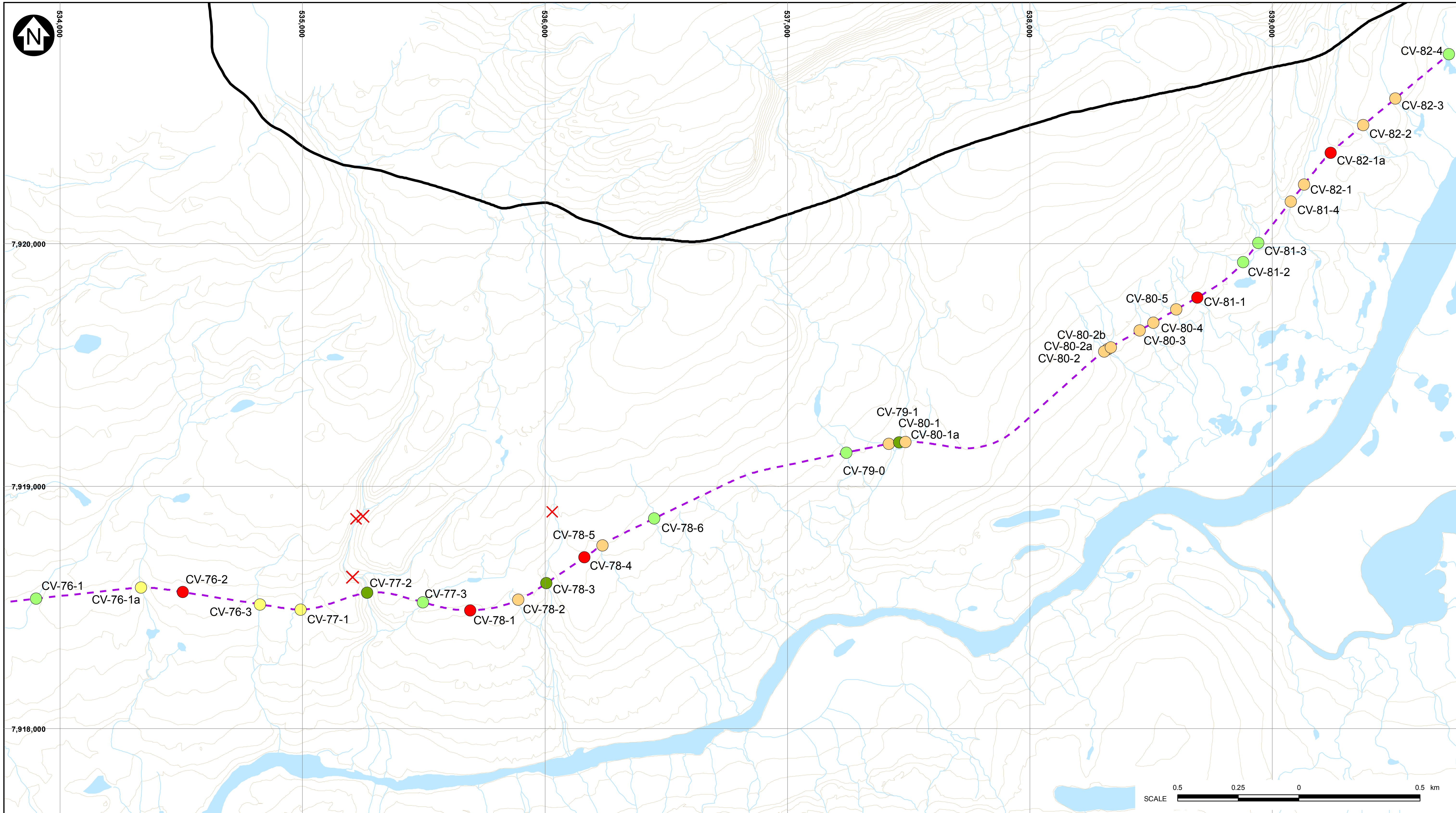

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LEGEND:

ARCTIC CHAR HABITAT

- NO
- UNLIKELY
- POTENTIAL
- PROBABLE
- YES

- PROPOSED NORTH RAILWAY (JUNE 2018)
- MILNE INLET TOTE ROAD (EXISTING)
- MILNE INLET TOTE ROAD (REALIGNMENT)
- CONTOUR (5M INTERVAL)
- INFRASTRUCTURE

- BARRIER
- FALLS

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MARY RIVER PROJECT

FISH HABITAT CLASSIFICATIONS RELEVANT TO THE NORTH RAILWAY (MAP 10 OF 13)

North/South Consultants Inc.
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DATE: 14/06/2018

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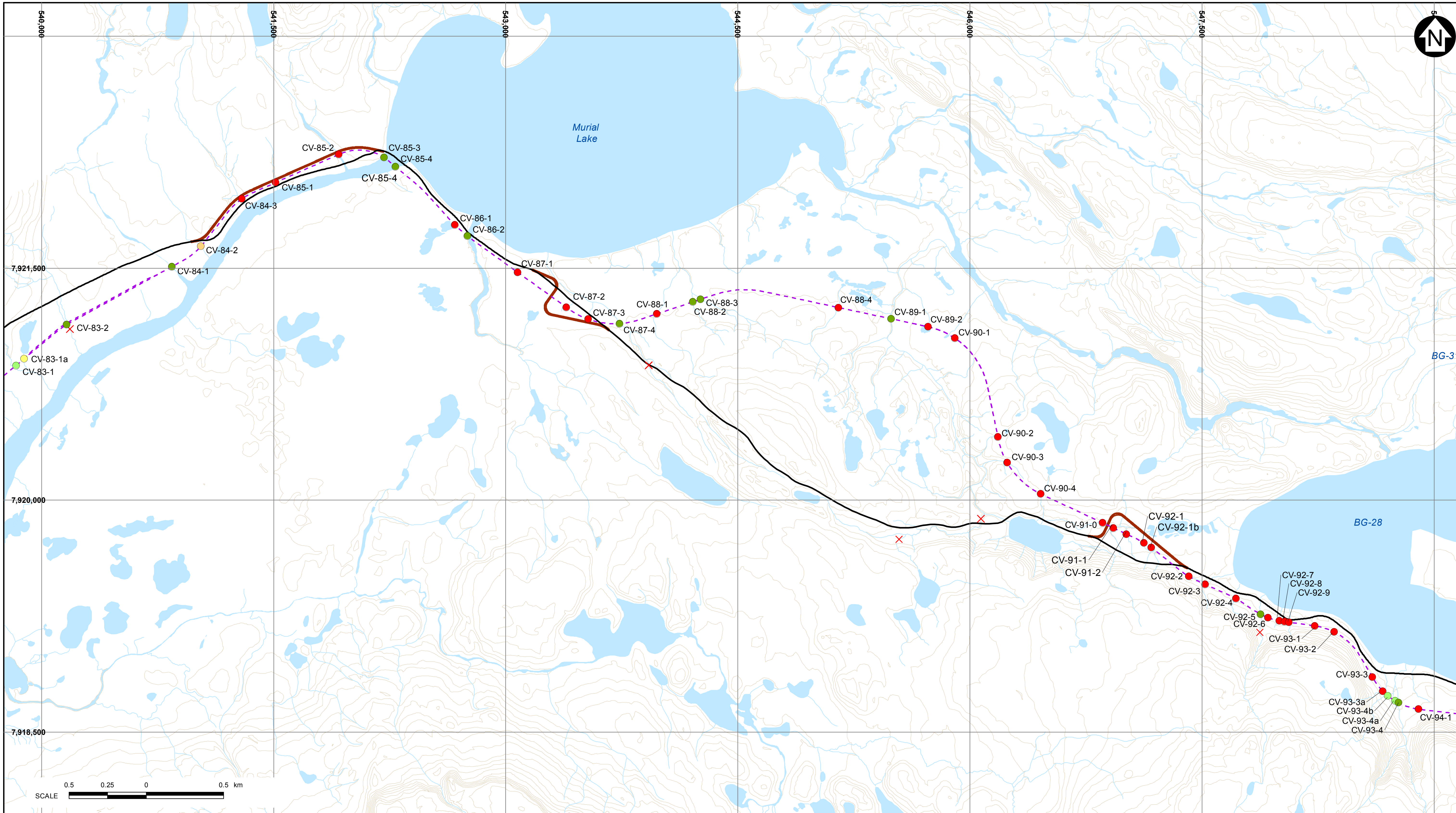

LEGEND:

ARCTIC CHAR HABITAT

- NO
- UNLIKELY
- POTENTIAL
- PROBABLE
- YES

- PROPOSED NORTH RAILWAY (JUNE 2018)
- MILNE INLET TOTE ROAD (EXISTING)
- MILNE INLET TOTE ROAD (REALIGNMENT)
- CONTOUR (5M INTERVAL)
- INFRASTRUCTURE

- BARRIER
- FALLS

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FISH HABITAT CLASSIFICATIONS RELEVANT TO THE NORTH RAILWAY (MAP 11 OF 13)

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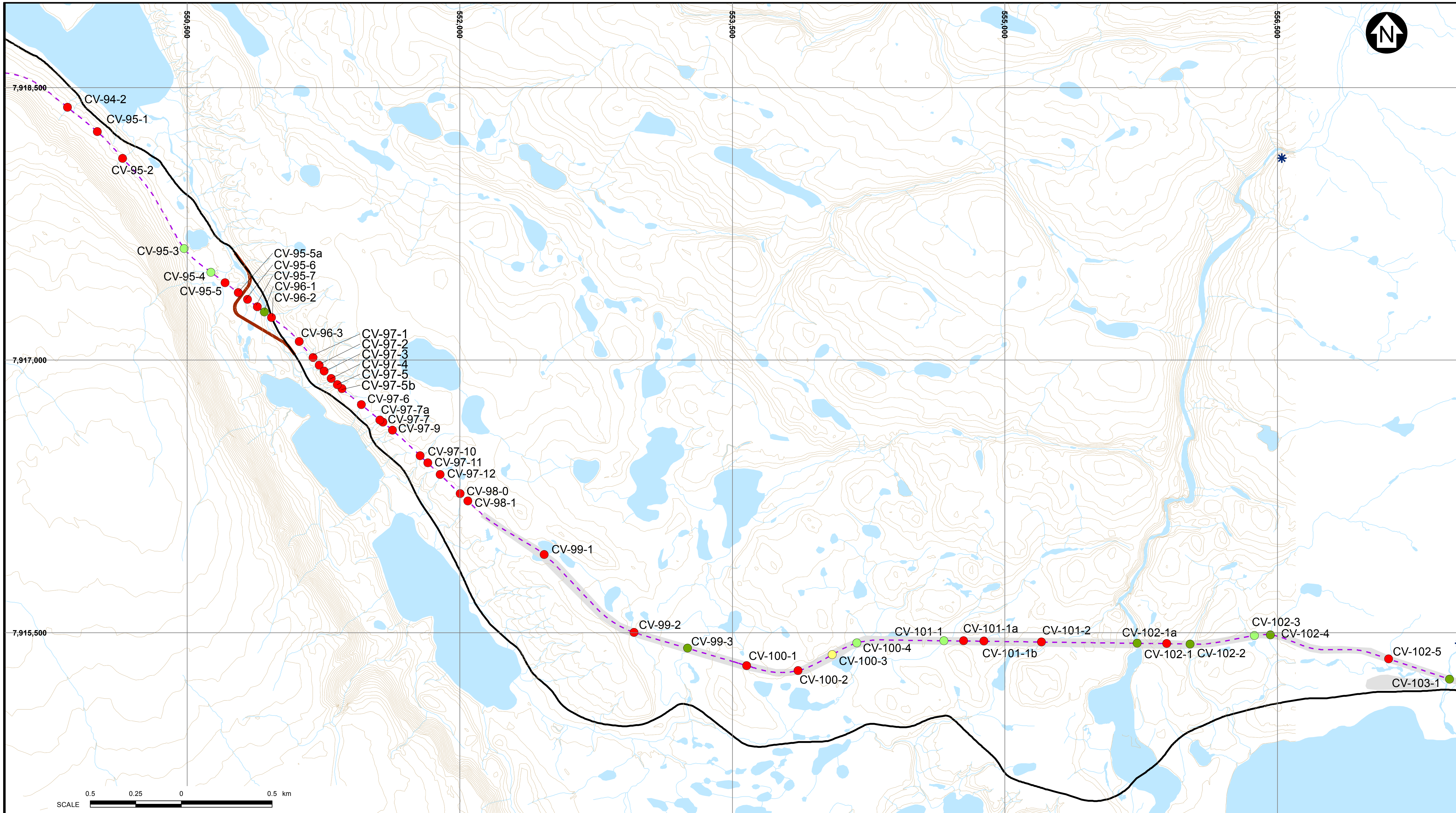

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LEGEND:

ARCTIC CHAR HABITAT

- NO
- UNLIKELY
- POTENTIAL
- PROBABLE
- YES

- PROPOSED NORTH RAILWAY (JUNE 2018)
- MILNE INLET TOTE ROAD (EXISTING)
- MILNE INLET TOTE ROAD (REALIGNMENT)
- CONTOUR (5M INTERVAL)
- INFRASTRUCTURE

- BARRIER
- FALLS

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FISH HABITAT CLASSIFICATIONS RELEVANT TO THE NORTH RAILWAY (MAP 12 OF 13)

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Aquatic Environment Specialists

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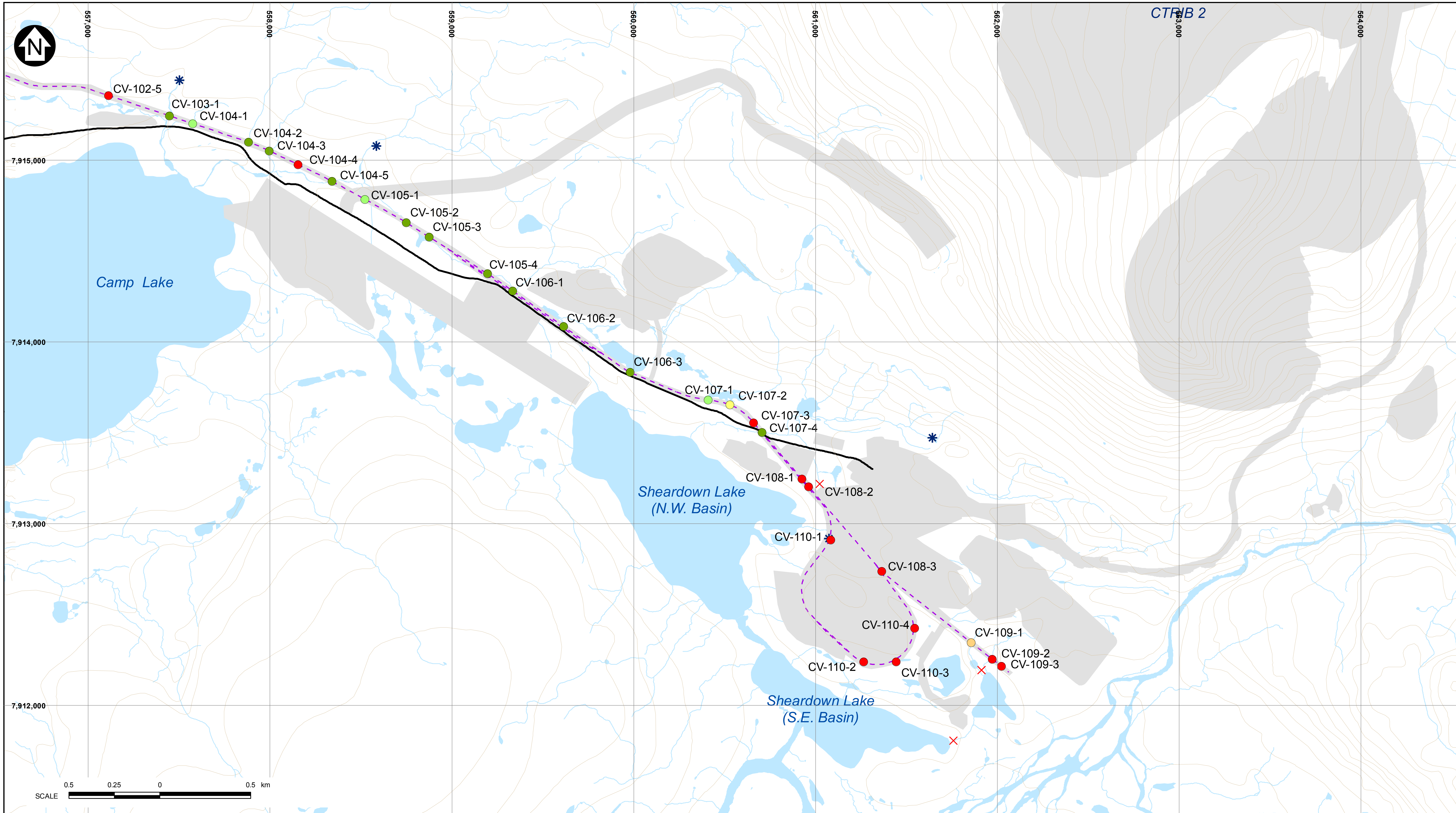
-	-

DATE: 14/06/2018

REV -



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LEGEND:

ARCTIC CHAR HABITAT
- NO
- UNLIKELY
- POTENTIAL
- PROBABLE
- YES

- PROPOSED NORTH RAILWAY (JUNE 2018)
- MILNE INLET TOTE ROAD (EXISTING)
- MILNE INLET TOTE ROAD (REALIGNMENT)
- CONTOUR (5M INTERVAL)
- INFRASTRUCTURE

- BARRIER
- FALLS

NOTES:

1. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA DEPARTMENT OF NATURAL RESOURCES (2009.) ALL RIGHTS RESERVED.
2. TOPOGRAPHY PROVIDED BY EAGLE MAPPING (2005)
3. COORDINATE GRID IS SHOWN IN UTM (NAD83) ZONE 17 AND IS IN METRES.
4. CONTOUR INTERVAL IS 50 M AND IS IN METRES.

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

FISH HABITAT CLASSIFICATIONS RELEVANT TO THE NORTH RAILWAY (MAP 13 OF 13)

North/South Consultants Inc.
Aquatic Environment Specialists

P/A NO. -
REF NO. -
DATE: 14/06/2018
REV -

ATTACHMENT 3. HYDRAULIC MODELING AND FISH PASSAGE ASSESSMENT: NORTH RAIL STREAM CROSSINGS

Table A3-1. Hydraulic modeling results and fish passage assessment for culvert crossings along the North Rail alignment. Hydraulic modeling results from Knight Piésold (2018). *Culvert design details estimated.

Site ID	Description	Waterbody Type	Arctic Char Habitat Classification	No. Barrels	Culvert Length (m)	Culvert Diameter (mm)	Mean Annual Flow		Hydraulic Modeling Results				
							Low Flow Scenario (L/s)	High Flow Scenario (L/s)	Min velocity (m/s)	Max Velocity (m/s)	Min Depth (m)	Max Depth (m)	
CV-11-1	Culvert	S	Potential	1	6.0	900	0.6	1.0	0.21	0.38	0.01	0.02	
CV-12-1	Culvert	S	Unlikely	1	18.0	900	2.5	3.8	0.32	0.59	0.02	0.04	
CV-12-2	Culvert	S	Unlikely	1	18.0	900	0.7	1.0	0.21	0.39	0.01	0.02	
CV-13-4	Culvert	S	Yes	2	18.0	1400	79.2	119.3	0.69	1.27	0.08	0.14	
CV-15-2	Culvert/encroachment	S/P	Yes	1	24.0	1400	7.6	11.4	0.42	0.76	0.04	0.06	
CV-15-3	Culvert/encroachment	S/P	Yes	2	17.5	900	2.4	3.6	0.25	0.47	0.02	0.03	
CV-25-2	Culvert	S	Probable	1	13.6	900	-	-	NM				*
CV-25-3	Culvert	S	Potential	2	20.6	1200	-	-	NM				*
CV-27-1	Culvert	S	Potential	1	13.6	900	-	-	NM				*
CV-27-2	Culvert	S	Potential	1	13.6	900	-	-	NM				*
CV-28-6	Culvert	S	Yes	1	17.5	1400	19.5	29.4	0.56	1.02	0.06	0.10	
CV-29-2	Culvert	S	Yes	1	25.0	1400	19.7	29.7	0.56	1.02	0.06	0.10	
CV-30-5	Culvert	S	Yes	1	7.5	900	7.1	10.7	0.44	0.80	0.04	0.07	
CV-31-1	Culvert	S	Yes	1	20.0	1200	32.0	48.2	0.66	1.21	0.08	0.13	
CV-31-2	Culvert	S	Yes	1	20.0	1200	32.0	48.2	0.66	1.21	0.08	0.13	
CV-33-6	Culvert	S	Yes	4	18.0	1200	12.9	19.5	0.33	0.60	0.03	0.04	
CV-35-2	Culvert	S	Yes	5	22.5	1400	253.5	382.1	0.74	1.36	0.09	0.15	
CV-47-1	Culvert	S	Yes	1	13.6	900	-	-	NM				*
CV-47-2	Culvert	S	Yes	4	15.0	1400	54.4	81.9	0.50	0.91	0.05	0.08	
CV-47-3	Culvert	S	Yes	2	17.5	1400	54.4	81.9	0.62	1.13	0.07	0.11	
CV-48-4	Culvert	S	Yes	2	27.5	1200	-	-	0.02	0.04	0.00	0.00	
CV-49-2	Culvert	S	Potential	1	16.1	900	-	-	NM				*
CV-50-5	Culvert	S	Yes	2	30	1200	58.0	87.4	0.64	1.18	0.07	0.12	
CV-50-6	Culvert	S	Yes	2	30	1200	58.0	87.4	0.64	1.18	0.07	0.12	
CV-55-3	Culvert	S	Yes	5	12.5	900	20.3	30.6	0.37	0.68	0.03	0.05	
CV-56-1	Culvert	S	Yes	2	12.2	1200	19.9	30.0	0.46	0.85	0.04	0.07	
CV-57-1	Culvert	S	Yes	1	12.2	900	11.8	17.8	0.51	0.93	0.05	0.09	
CV-57-2	Culvert	S	Yes	1	12.2	900	6.5	9.8	0.42	0.78	0.04	0.06	
CV-58-1	Culvert	S	Probable	2	9.76	900	0.7	1.0	0.17	0.32	0.01	0.02	
CV-58-2	Culvert	S	Yes	1	9.76	900	0.8	1.3	0.23	0.42	0.01	0.02	
CV-58-3	Culvert	S	Potential	1	9.76	900	0.1	0.1	0.10	0.18	0.00	0.01	
CV-58-4	Culvert	S	Yes	1	12.2	900	1.4	2.1	0.27	0.49	0.02	0.03	
CV-58-4a	Culvert	S	Yes	1	12.2	900	0.5	0.7	0.19	0.35	0.01	0.02	
CV-58-5	Culvert	S	Probable	1	12.2	900	0.1	0.2	0.13	0.24	0.01	0.01	
CV-58-6	Culvert	S	Probable	1	12.2	900	3.1	4.6	0.34	0.62	0.03	0.05	
CV-59-1	Culvert	S	Probable	1	9.76	900	0.7	1.0	0.21	0.39	0.01	0.02	
CV-59-2	Culvert	S	Potential	1	14.64	900	0.4	0.5	0.18	0.32	0.01	0.02	
CV-59-3	Culvert	S	Potential	1	9.76	900	0.3	0.4	0.16	0.30	0.01	0.02	
CV-59-4	Culvert	S	Yes	3	21.96	1200	34.8	52.4	0.49	0.89	0.05	0.08	

Table A3-1. - continued –

Site ID	Description	Waterbody Type	Arctic Char Habitat Classification	No. Barrels	Culvert Length (m)	Culvert Diameter (mm)	Mean Annual Flow		Hydraulic Modeling Results				
							Low Flow Scenario (L/s)	High Flow Scenario (L/s)	Min velocity (m/s)	Max Velocity (m/s)	Min Depth (m)	Max Depth (m)	
CV-60-3	Culvert	S	Probable	1	24.4	900	2.0	3.1	0.30	0.55	0.02	0.04	
CV-60-4	Culvert	S	Unlikely	1	9.76	900	1.8	2.7	0.29	0.53	0.02	0.04	
CV-60-5	Culvert	S	Potential	1	26.84	1200	4.4	6.6	0.36	0.66	0.03	0.05	
CV-60-6	Culvert	S	Unlikely	1	26.84	900	0.1	0.2	0.13	0.23	0.01	0.01	
CV-61-1	Culvert	S	Probable	1	31.72	900	3.6	5.4	0.35	0.65	0.03	0.05	
CV-61-2	Culvert	S	Probable	1	9.76	900	1.0	1.5	0.24	0.44	0.02	0.03	
CV-62-1	Culvert	S	Yes	7	51.24	1800	854.1	1287.1	0.94	1.72	0.13	0.22	
CV-62-2	Culvert	S	Probable	1	12.2	900	2.7	4.1	0.33	0.60	0.03	0.04	
CV-63-1	Culvert	S	Potential	1	14.64	900	0.8	1.2	0.22	0.41	0.01	0.02	
CV-63-2	Culvert	S	Potential	1	12.2	900	2.2	3.3	0.31	0.56	0.02	0.04	
CV-63-3	Culvert	S	Potential	1	14.64	900	0.5	0.8	0.20	0.36	0.01	0.02	
CV-63-4	Culvert	S	Probable	1	12.2	900	8.5	12.8	0.46	0.85	0.04	0.07	
CV-63-4a	Culvert	S	Potential	1	12.2	900	0.2	0.3	0.14	0.25	0.01	0.01	
CV-63-5	Culvert	S	Potential	1	12.2	900	-	-	0.03	0.04	0.00	0.00	
CV-64-1	Culvert	S	Unlikely	1	9.76	900	0.6	0.9	0.21	0.38	0.01	0.02	
CV-64-2	Culvert	S	Unlikely	1	12.2	900	0.1	0.2	0.12	0.22	0.01	0.01	
CV-64-4	Culvert	S	Yes	1	19.52	900	2.3	3.4	0.31	0.57	0.02	0.04	
CV-65-1	Culvert	S	Probable	1	17.08	900	4.5	6.7	0.38	0.70	0.03	0.05	
CV-65-2	Pond Infilling/Culvert	P	Potential	1	21.96	900	0.9	1.4	0.24	0.43	0.02	0.03	
CV-66-1	Culvert	S	Unlikely	1	12.2	900	2.4	3.6	0.31	0.58	0.02	0.04	
CV-66-3	Culvert	S	Probable	1	19.52	900	1.3	2.0	0.26	0.48	0.02	0.03	
CV-66-8	Culvert	S	Probable	1	9.76	900	0.3	0.4	0.16	0.29	0.01	0.01	
CV-67-1	Culvert	S	Probable	1	14.64	900	2.4	3.6	0.31	0.58	0.02	0.04	
CV-68-1a	Culvert	S	Yes	1	33	900	25.9	39.1	0.65	1.18	0.07	0.13	
CV-68-1	Culvert	S	Yes	3	31.72	1400	25.9	39.1	0.43	0.80	0.04	0.07	
CV-68-3	Culvert	S	Probable	1	21.96	1200	7.9	11.8	0.43	0.79	0.04	0.07	
CV-68-5	Culvert	S	Potential	1	26.84	900	4.3	6.5	0.37	0.69	0.03	0.05	
CV-69-2	Culvert	S	Yes	1	14.64	900	3.4	5.2	0.35	0.64	0.03	0.05	
CV-69-3	Culvert	S	Yes	1	14.64	900	0.6	0.9	0.21	0.38	0.01	0.02	
CV-69-4	Culvert	S	Potential	1	12.2	900	-	-	0.03	0.04	0.00	0.00	
CV-70-2	Culvert	S	Yes	1	17.08	900	-	-	0.03	0.04	0.00	0.00	
CV-71-1	Pond Infilling	S/P	Yes	4	17.08	1800	21.6	32.6	0.36	0.66	0.03	0.05	
CV-72-3	Culvert	S	Potential	1	12.2	900	0.1	0.1	0.11	0.19	0.00	0.01	
CV-72-3a	Culvert	S	Potential	1	12.2	900	0.5	0.7	0.19	0.35	0.01	0.02	
CV-72-4	Culvert	S	Potential	2	9.76	900	3.0	4.6	0.27	0.50	0.02	0.03	
CV-73-1	Culvert	S	Unlikely	1	9.76	900	-	-	0.03	0.04	0.00	0.00	
CV-73-2	Culvert	S	Potential	1	16.1	900	-	-	NM				*
CV-73-3	Culvert	S	Potential	1	16.1	900	-	-	NM				*
CV-73-4	Culvert	S	Potential	1	13.6	900	-	-	NM				*
CV-74-1	Culvert	S	Probable	2	20.6	1200	-	-	NM				*

Table A3-1. - continued –

Site ID	Description	Waterbody Type	Arctic Char Habitat Classification	No. Barrels	Culvert Length (m)	Culvert Diameter (mm)	Mean Annual Flow		Hydraulic Modeling Results			
							Low Flow Scenario (L/s)	High Flow Scenario (L/s)	Min velocity (m/s)	Max Velocity (m/s)	Min Depth (m)	Max Depth (m)
CV-74-2	Culvert	S	Yes	2	20.6	1200	-	-	NM			
CV-74-3	Culvert	S	Potential	1	14.64	1800	0.5	0.8	0.18	0.33	0.01	0.02
CV-74-4	Culvert	S	Potential	1	14.64	1800	0.5	0.8	0.18	0.32	0.01	0.02
CV-74-6	Culvert	S	Potential	1	9.76	900	1.5	2.3	0.27	0.50	0.02	0.03
CV-75-1	Culvert	S	Potential	1	12.2	1200	0.1	0.1	0.11	0.20	0.00	0.01
CV-75-1a	Culvert	S	Potential	1	12.2	1200	10.2	15.4	0.47	0.86	0.04	0.07
CV-75-2	Culvert	S	Potential	1	17.08	900	10.2	15.4	0.49	0.89	0.05	0.08
CV-76-1	Culvert	S	Probable	1	19.52	1200	8.5	12.8	0.44	0.81	0.04	0.07
CV-76-1a	Culvert	S	Potential	1	19.52	1200	1.7	2.6	0.27	0.50	0.02	0.03
CV-76-3	Culvert	S	Potential	1	19.52	900	1.9	2.9	0.29	0.53	0.02	0.04
CV-77-1	Culvert	S	Potential	1	19.52	900	0.4	0.6	0.18	0.34	0.01	0.02
CV-77-2	Culvert	S	Yes	3	39.04	1400	81.7	123.2	0.62	1.13	0.07	0.11
CV-77-3	Culvert	S	Probable	1	9.76	900	0.9	1.3	0.23	0.42	0.02	0.03
CV-78-2	Culvert	S	Unlikely	1	14.64	900	0.3	0.4	0.16	0.29	0.01	0.01
CV-78-3	Culvert	S	Yes	1	29.28	900	8.8	13.3	0.47	0.86	0.04	0.07
CV-78-5	Culvert	S	Unlikely	1	9.76	900	-	-	0.03	0.04	0.00	0.00
CV-78-6	Culvert	S	Probable	1	10	900	0.5	0.8	0.20	0.36	0.01	0.02
CV-79-0	Culvert	S	Probable	1	10	900	5.7	8.5	0.41	0.75	0.04	0.06
CV-79-1	Culvert	S	Unlikely	1	17.08	900	-	-	0.03	0.04	0.00	0.00
CV-80-1	Culvert	S	Yes	2	24.4	1200	23.8	35.9	0.49	0.90	0.05	0.08
CV-80-1a	Culvert	S	Unlikely	1	12.2	1200	0.7	1.0	0.20	0.37	0.01	0.02
CV-80-2	Culvert	S	Unlikely	1	10	900	0.0	0.0	0.07	0.13	0.00	0.00
CV-80-2a	Culvert	S	Unlikely	1	10	900	0.2	0.3	0.14	0.26	0.01	0.01
CV-80-2b	Culvert	S	Unlikely	1	10	900	1.2	1.8	0.25	0.46	0.02	0.03
CV-80-3	Culvert	S	Unlikely	1	10	900	0.5	0.8	0.20	0.36	0.01	0.02
CV-80-4	Culvert	S	Unlikely	1	10	900	0.3	0.5	0.17	0.32	0.01	0.02
CV-80-5	Culvert	S	Unlikely	1	10	900	0.3	0.4	0.16	0.30	0.01	0.01
CV-81-2	Culvert	S	Probable	1	12.2	900	1.1	1.6	0.24	0.45	0.02	0.03
CV-81-3	Culvert	S	Probable	1	12.2	900	1.9	2.9	0.29	0.54	0.02	0.04
CV-81-4	Culvert	S	Unlikely	1	12.2	900	1.1	1.6	0.25	0.45	0.02	0.03
CV-82-1	Culvert	S	Unlikely	2	12.2	900	14.9	22.5	0.44	0.81	0.04	0.07
CV-82-2	Culvert	S	Unlikely	1	9.76	900	-	-	0.03	0.04	0.00	0.00
CV-82-3	Culvert	S	Unlikely	1	12.2	900	0.8	1.2	0.22	0.41	0.01	0.02
CV-82-4	Culvert	S	Probable	1	13.2	1200	0.5	0.8	0.19	0.34	0.01	0.02
CV-83-1	Culvert	S	Probable	1	12.2	1200	9.0	13.6	0.45	0.83	0.04	0.07
CV-83-1a	Culvert	S	Potential	1	12.2	1200	0.7	1.0	NM			
CV-83-2	Culvert	S	Yes	4	12.2	1800	23.6	35.6	0.37	0.68	0.03	0.05
CV-84-1	Culvert	S	Yes	1	17.08	1200	83.7	126.2	0.88	1.62	0.12	0.20
CV-84-2	Culvert	S	Unlikely	1	12.2	900	3.5	5.2	0.35	0.64	0.03	0.05
CV-85-4	Culvert	S	Yes	1	17.08	1800	-	-	0.02	0.03	0.00	0.00

*

Table A3-1. - continued –

Site ID	Description	Waterbody Type	Arctic Char Habitat Classification	No. Barrels	Culvert Length (m)	Culvert Diameter (mm)	Mean Annual Flow		Hydraulic Modeling Results			
							Low Flow Scenario (L/s)	High Flow Scenario (L/s)	Min velocity (m/s)	Max Velocity (m/s)	Min Depth (m)	Max Depth (m)
CV-86-2	Culvert	S	Yes	2	19.52	1800	181.1	272.9	0.86	1.57	0.11	0.19
CV-87-4	Culvert	S	Yes	1	9.76	900	3.5	5.3	0.35	0.65	0.03	0.05
CV-88-2	Culvert	S	Yes	1	14.64	900	1.1	1.7	0.25	0.46	0.02	0.03
CV-88-3	Culvert	S	Yes	1	12.2	900	1.2	1.8	0.25	0.46	0.02	0.03
CV-89-1	Culvert	S	Yes	1	24.4	900	28.2	42.5	0.66	1.22	0.08	0.13
CV-92-5	Culvert	S	Yes	1	14.64	900	4.7	7.1	0.39	0.71	0.03	0.06
CV-93-4a	Culvert	S	Probable	1	12.2	900	0.2	0.2	0.14	0.25	0.01	0.01
CV-93-4b	Culvert	S	Probable	1	24.2	1200	3.3	5.0	0.33	0.61	0.03	0.04
CV-93-4	Culvert	S	Yes	3	24.4	1400	39.3	59.2	0.49	0.90	0.05	0.08
CV-95-3	Culvert	S	Probable	1	12.2	900	0.4	0.5	0.18	0.32	0.01	0.02
CV-95-4	Culvert	S	Probable	1	12.2	900	0.2	0.3	0.15	0.28	0.01	0.01
CV-96-1	Culvert	S	Yes	1	26.84	900	119.9	180.7	1.02	1.87	0.15	0.27
CV-99-3	Culvert	S	Yes	5	12.2	900	50.6	76.3	0.49	0.89	0.05	0.08
CV-100-4	Culvert	S	Probable	2	12.2	1200	5.7	8.6	0.32	0.58	0.02	0.04
CV-101-1	Culvert	S	Probable	1	9.76	900	5.7	8.6	0.41	0.75	0.04	0.06
CV-102-2	Culvert	S	Yes	1	21.96	1200	12.2	18.4	0.49	0.91	0.05	0.08
CV-102-3	Culvert	S	Probable	1	14.64	900	0.6	0.9	0.20	0.37	0.01	0.02
CV-102-4	Culvert	S	Yes	3	9.76	900	2.2	3.4	0.22	0.40	0.01	0.02
CV-103-1	Culvert	S	Yes	1	41.48	1800	62.1	93.6	0.76	1.40	0.09	0.16
CV-104-1	Culvert	S	Probable	1	17.08	900	0.9	1.3	0.23	0.42	0.02	0.03
CV-104-2	Culvert	S	Yes	1	21.96	1200	2.6	3.9	0.31	0.56	0.02	0.04
CV-104-3	Culvert	S	Yes	3	26.84	1400	1.4	2.2	0.18	0.33	0.01	0.02
CV-104-5	Culvert	S	Yes	1	21.96	1800	59.1	89.1	0.75	1.38	0.09	0.15
CV-105-1	Culvert	S	Probable	1	9.76	900	-	-	0.03	0.04	0.00	0.00
CV-105-2	Culvert	S	Yes	1	9.76	900	17.2	25.9	0.57	1.05	0.06	0.10
CV-105-4	Culvert	S	Yes	1	14.64	900	17.2	25.9	0.57	1.05	0.06	0.10
CV-107-4	Culvert	S	Yes	1	26.84	1400	13.7	20.7	0.50	0.92	0.05	0.08

S = stream; P = pond; LP = Low point; L = Lake
NM = Not modelled

>95% Passage
<95% Passage
<75% Passage
<50% Passage
<25% Passage
<5% Passage