Baffinland

TECHNICAL SUPPORTING DOCUMENT

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

TSD 13

Surface Water Assessment





SURFACE WATER ASSESSMENT TECHNICAL SUPPORTING DOCUMENT SUMMARY

The Surface Water Assessment Technical Supporting Document provides an assessment of effects of the Phase 2 Proposal on surface water and includes new information collected or published since submission of materials for the Approved Project. 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.

Appended to this assessment are recent hydrology monitoring reports and analyses supporting the effects assessment. Groundwater in the Project area occurs in distinctive shallow and deep systems, with limited connections and interaction between them. The extremely cold temperatures of the region, combined with the permafrost, result in a short period of surface water runoff that typically occurs from June to September.

Activities associated with the Phase 2 Proposal may affect freshwater quantity and quality due to water extraction and consumption, stream diversion at the North Railway, ore dust deposition and transport, and water-rock interactions at quarries and rock cuts along the North Railway. The Phase 2 Proposal will not involve any substantive changes to how water is managed at the Mine Site, as there are no changes to how waste rock will be managed.

During the construction of the North Railway, streams will be permanently diverted to adjacent streams that will cross the railway and flow received in culverts along the Tote Road may change. Planned mitigation includes an adaptive management approach where activities may include potential culvert replacement, channel widening, regrading, channel stabilization, and, where necessary, fish habitat construction. With the planned mitigation, the downstream water quantity increases associated with stream diversions are not expected to affect the watershed as a whole. Baffinland’s streamflow monitoring program provides data that, in conjunction with regional streamflow and climate datasets, can be used to determine design criteria for engineering design, including the sizing of bridges and culverts along the Northern Transportation Corridor. In or near water works associated with the construction of the North Railway have the potential to cause erosion and input sediments into freshwater systems. The effects of construction on water quality will be addressed through implementation of proven erosion and sediment control and dust suppression measures.

The Phase 2 Proposal is not expected to influence the quantity and quality of freshwater at the watershed level due to planned mitigation and the small footprint relative to the available freshwater in the region. Based on the present assessment and planned mitigation, Project activities proposed as part of the Phase 2 Proposal are not predicted to result in significant adverse residual effects on surface water.

RÉSUMÉ DE LA DOCUMENTATION TECHNIQUE COMPLÉMENTAIRE SUR L'ÉVALUATION DES EAUX DE SURFACE

La documentation technique complémentaire sur l'évaluation des eaux de surface comporte une évaluation des impacts de la proposition de la phase 2 sur les eaux de surface et comprend tous nouveaux renseignements recueillis ou publiés depuis la soumission des matériaux pour le projet approuvé. 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.

Des rapports de surveillance hydrologique récents et des analyses à l'appui de l'évaluation des impacts sont annexés à cette évaluation. Les eaux souterraines dans la zone du projet se trouvent dans des systèmes distincts peu profonds et profonds, avec des connexions et des interactions limitées entre elles. Les températures extrêmement froides de la région, combinées au pergélisol, entraînent une courte période de ruissellement des eaux de surface, généralement de juin à septembre.

Les activités associées à la proposition de phase 2 peuvent affecter la quantité et la qualité de l'eau douce en raison de l'extraction et de la consommation d'eau, du détournement des cours d'eau au passage du chemin de fer du Nord, de la déposition et du transport des poussières de minerai et des interactions entre l'eau et la pierre aux carrières et aux coupes rocheuses le long du chemin de fer du Nord. La proposition de la phase 2 n'entraînera aucun changement important à la gestion de l'eau sur le site minier, car il n'y a aucun changement dans la façon dont les stériles rocheux seront gérés.

Pendant la construction du chemin de fer du Nord, les cours d'eau seront détournés en permanence vers les cours d'eau adjacents qui traverseront le chemin de fer. Les flux reçus dans les ponceaux installés long du chemin Tote pourraient changer. Les mesures d'atténuation prévues comprennent une approche de gestion adaptative où les activités peuvent inclure le remplacement potentiel de ponceaux, l'élargissement du chenal, le reclassement, la stabilisation du chenal et, au besoin, la construction d'habitats pour le poisson. Avec les mesures d'atténuation prévues, les augmentations de la quantité d'eau en aval associées aux dérivations de cours d'eau ne devraient pas avoir d'incidence sur le bassin hydrographique dans son ensemble. Le programme de surveillance du débit de Baffinland fournit des données qui, conjointement avec les ensembles de données régionaux sur le débit et le climat, peuvent servir à déterminer les critères de conception, y compris le dimensionnement des ponts et des ponceaux le long du corridor de transport du Nord. Dans les eaux ou à proximité des ouvrages associés à la construction du chemin de fer Nord, il est possible que l'érosion se propage et que les sédiments pénètrent dans les systèmes d'eau douce. Les impacts de la construction sur la qualité de l'eau seront atténués par la mise en œuvre de mesures éprouvées de lutte contre l'érosion et les sédiments et de suppression des poussières.

La proposition de la phase 2 ne devrait pas influer sur la quantité et la qualité de l'eau douce à l'échelle du bassin versant en raison des mesures d'atténuation prévues et de la faible empreinte des travaux relativement à la quantité d'eau douce disponible dans la région. 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 les eaux de surface.

ᓄᓇᐅᑉ ᑕᑎᐅᖑᕆᑦᑐᖅ ᐃᒪᖓ ᕿᒥᕈᔭᐅᓂᐊᓄᑦ ᐱᔭᓇᐊᑐᔪᑦ ᐃᑲᔪᐃᔾᔪᑎᑦ ᑎᑎᖅᑲᑦ ᐅᓂᒃᑳᓚᐊᑦ

ᑖᓐᓇ ᑕᑎᐅᖑᕆᑦᑐᖅ ᐃᒪᖓ ᕿᒥᕈᔭᐅᓂᐊᓄᑦ ᐱᔭᓇᐊᑐᔪᑦ ᐃᑲᔪᐃᔾᔪᑎᑦ ᑎᑎᖅᑲᖅ ᐱᑕᖃᖅᑎᑦᑎᕗᖅ ᕿᒥᕈᐃᓂᕐᒥᒃ ᐊᒃᑐᐃᓂᖏᑕ ᐱᓕᕆᐊᑉ ᒪᕈᕆᓕᖅᑕᖓ ᐅᒃᑑᑎᖓᑕ ᓄᓇᐅᑉ ᑕᑎᐅᖑᕆᑦᑐᖅ ᐃᒪᖓᓄᑦ ᐃᓚᖃᖅᑐᓂᑐ ᓄᑖᓂᒃ ᑐᑭᓯᐅᒪᔾᔪᑎᒃᓴᓂᒃ ᑲᑎᖅᓯᒐᑦ ᑎᑎᕋᐅᓯᐅᔪᓪᓘᓐᓃᑦ ᑕᐃᑲᖓᓂᑦ ᑎᑎᕋᐅᓯᑦ ᓯᕗᓪᓕᖅᐹᑦ ᑐᓐᓂᕆᔭᐅᓚᐅᖅᑎᓪᓗᒋᑦ ᐊᖏᖅᓯᒪᔭᒧᑦ ᐅᔭᕋᓐᓂᐊᕐᓂᕐᒧᑦ. ᐱᓕᕆᐊᑉ ᒪᕈᕆᓕᖅᑕᖓ ᐅᒃᑑᑎᖓ ᐃᓚᒋᐊᕆᔭᖅᖅᑐᖅ ᖄᖓᒍᑦ ᐊᖏᕚᔪᑦ ᑐᙵᕕᑦ ᖃᐅᔨᓴᕕᓃᑦ ᐊᕐᕌᓄᑦ ᑕᒪᓐᓇ ᕿᒥᕈᐃᓂᖅ ᑕᐃᑲᖓᑦ 2011–ᒥ ᑖᓯᒪᖓ ᐃᓗᐃᑦᑑᔪᒧᑦ ᐊᖏᖅᓯᒪᔭᒧᑦ ᐅᔭᕋᓐᓂᐊᕐᓂᕐᒧᑦ ᑕᐃᓖᑦᑐ ᓂᒃᓯᒃᓯᒪᓂᖅᑲᖅᐳᖅ ᑭᖑᓪᓕᖅᐹᑦ ᐅᓂᒃᑳᖏᓄᑦ FEIS ᓯᕗᓂᐊᒍᓪᓗ ᐅᐃᒍᒋᐊᖅᑕᐅᓂᑰᔫᒃᑯᑦ.

ᐅᐃᒍᖅᓯᒪᔪᖅ ᕿᒥᕈᐃᓂᕐᒧᑦ ᓄᑖᖑᓛᑦ ᐃᒪᐅᑉ ᐃᖏᕋᓂᖏᓐᓄᑦ ᖃᐅᔮᓵᖑᔪᑦ ᐅᓂᒃᑳᑦ ᕿᒥᕈᐃᓃᓪᓗ ᐃᑲᔪᐃᔪᑦ ᐊᒃᑐᐃᓂᐊᑕ ᕿᒥᕈᔭᐅᓂᐊᓄᑦ. ᐃᒪᖓ ᓄᓇᐅᑉ ᖄᖓᓂ ᐅᔭᕋᓐᓂᐊᕝᕕᐅᑉ ᐊᕙᑖᓂ ᓴᖅᑭᓲᖅ ᐊᔾᔨᖏᕆᑦᑐᒃᑯᑦ ᐃᒃᑲᑦᑐᑦ ᐃᑎᔫᑎᓪᓗ ᐃᒪᐅᑉ ᐊᐅᓚᓂᕆᔭᖏᑦ, ᑲᑎᖅᓱᖓᓗᐊᕋᑎᒃ ᐃᒪᖓᓗ ᐅᑎᖅᑕᕋᕋᓂ ᐊᑯᓐᓂᐊᒍᑦ. ᓂᓪᓚᓯᒪᔪᓐᓂᖓ, ᐃᓚᕐᖁᓂ ᓄᓇᐅᑉ ᐃᑭᐊᖓ ᖁᐊᖑᐃᓐᓇᓱᒥᒃ, ᓴᖅᑮᓐᓇᔭᖅᑐᖅ ᐊᑯᓂᐅᓗᐊᖏᑦᑐᒥᒃ ᐊᐅᒃᓯᒪᓂᕐᒥᒃ ᑰᓚᐅᑲᒃᑲᓂ ᔫᓂᒥᒃ ᓯᑎᐱᓇᒧᑦ.

ᐱᓕᕆᓃᑦ ᐊᒃᑐᐊᓂᓖᑦ ᐱᓕᕆᐊᑉ ᒪᕈᕆᓕᖅᑕᖓ ᐅᒃᑑᑎᖓᓄᑦ ᐊᒃᑐᐃᔭᓇᖅᑐᑦ ᐃᒪᑦᑎᐊᕙᐅᑉ ᐊᒃᑎᒋᓂᐊᓂᒃ ᐱᐅᓂᖓᓂᓪᓗ ᐱᑦᑐᒍ ᐃᒥᖅᑕᖅᑕᐅᓂᖓᓄᑦ ᐊᑐᖅᑕᐅᓂᖓᓄᓪᓗ, ᑰᑦ ᓴᓂᕝᕙᒃᑕᐅᓂᖏᓐᓄᑦ ᐅᐊᖕᓈᑕ ᓄᓇᓯᐅᑎᑯᑖᕐᕝᕙᐊᓂ, ᓴᕙᕋᔭᒃᓴᐅᑉ ᐳᔪᖓ ᑎᒃᑕᐅᓂᐊᓄᑦ ᐅᓯᒃᖃᖅᑕᐅᓂᐊᓄᓪᓗ, ᐊᒻᒪ ᐃᒥᐅᑉ–ᐅᔭᕋᐅᓪᓗ ᐊᒃᑐᐊᕐᑲᑎᑉᕆᓂᖏᓐᓄᑦ ᑐᐊᐸᒃᑕᕝᕕᖕᓂ ᖄᖅᑎᑕᓂᓪᓗ ᖃᐃᙳᓂᒃ ᐊᖅᑯᑖᒍᑦ ᐅᐊᖕᓈᑕ ᓄᓇᓯᐅᑎᑯᑖᕐᕝᕙᐊᑕ. ᐱᓕᕆᐊᑉ ᒪᕈᕆᓕᖅᑕᖓ ᐅᒃᑑᑎᖓ ᐃᓚᖃᒃᔫᖅᑐᖅ ᐊᖏᔪᐋᓗᖕᒥᒃ ᐊᓯᔾᔨᓂᕐᒥᒃ ᐃᒪᐅᑉ ᐊᑐᖅᑕᐅᓂᐊᓄᑦ ᐊᐅᓚᑕᐅᓂᐊᓄᓪᓗ ᐅᔭᕋᓐᓂᐊᕝᕕᖕᒥ, ᐊᓯᔾᔨᖅᑐᖅᑳᓇᓂᓗ ᖃᓄᖅ ᓴᕙᕋᔭᒃᓴᖅᑲᖅᑐᖅ ᐅᔭᕋᑐᐃᓐᓇᖅ ᑲᒪᒋᔭᐅᖕᒪᖔᑦ.

ᓴᓇᔭᐅᓚᕈᓂ ᐅᐊᖕᓈᑕ ᓄᓇᓯᐅᑎᑯᑖᕐᕝᕙᐊ, ᑰᑦ ᐃᓚᖏᑦ ᓅᑎᖅᑕᐅᓂᐊᖅᑐᑦ ᑰᒍᓐᓇᐃᓪᓚᓗᑎᒃ ᐊᓯᐊᒍᑦ ᑰᕝᕙᓪᓗᒋᑦ ᐃᑳᖅᓯᒪᔪᑦ ᓄᓇᓯᐅᑎᑯᑖᑉ ᐊᖅᑯᑖᓂᒃ ᑰᓐᓂᖏᓪᓗ ᑰᒃᑯᑎᒍᑦ ᕿᙳᐊᓄᑦ ᐊᖅᑯᑖᑕ ᐊᕙᑖᓂ ᐊᔾᔨᐅᑐᐃᓐᓇᕆᐊᓖᑦ. ᐸᕐᓈᕐᔪᔪᑦ ᓄᖅᑲᖓᔾᔪᑏᑦ ᐃᓚᖅᑲᖅᑐᑦ ᓯᖏᕐᐅᑎᓇᓱᒃᑐᒥᒃ ᐊᐅᓚᑦᑎᔾᔪᑦ ᐃᓪᓕᖅᑯᓯᖓ ᐱᓕᕆᐊᑦ ᐃᓚᖅᑭᕈᓇᖅᑐᒍᑦ ᑰᒍᑖ ᑭᖑᕝᕙᕈᑖᓂᒃ, ᑰᖓ ᐃᑭᖅᑐᓯᕆᐊᕆᓂᐊᓂᒃ, ᓯᕙᖓᓂᐊ ᐊᓯᔾᔨᕈᑖᓂᒃ, ᑰᑉ ᑰᑦᑎᐊᕐᓂᖓ, ᐊᑐᕆᐊᖅᑲᕈᑎᓪᓗ, ᐃᖅᑲᓗᐃᑦ ᓇᔪᒐᒃᓴᖓᓂᒃ ᓴᓇᓂᖅ. ᑖᒃᑯᓈ ᐸᕐᓈᕐᔪᔪᑦ ᓄᖅᑲᖓᔾᔪᑏᑦ, ᑕᑎᐅᕐᒨᖓᔪᖅ ᑰᒃᑕᖓ ᐊᖏᓪᓕᕆᐊᓇᔪᑦ ᑰᕈᑦ ᐊᓯᖏᓄᑦ ᑰᓕᖅᑎᑕᐅᓂᖏᓄᑦ ᓂᕆᐅᖓᓂᒃ ᐃᒪᐅᑉ ᑰᖓᓇᓃᖏᑦ ᐊᒃᑐᖅᑕᐅᓇᔭᕐᓂᖏᑦ. ᐸᕐᓈᖓᓐᓇᑯᑦ ᑰᖓᓂᐊᓄᑦ ᖃᐅᔨᓴᕈᑎᖏᑦ ᐱᓕᕆᐊᑦ ᓴᖅᑮᓐᓇᑦ ᓇᓴᐅᑎᓂᒃ, ᑕᒪᓐᓇ ᐃᓚᖅᑲᖅᑐᓂ ᐊᕙᒃᓯᒪᐅᖅᑐᑦ ᑰᑦ ᑰᖓᓂᖏᓐᒥᒃ ᓯᓚᐅᓪᓗ ᐃᓕᖅᑯᓯᕆᓇᓕᐊᒃᑕᖏᓐᓂᒃ, ᐊᑐᓗᒃᓴᐅᕝᕙᑦ ᓴᓇᔪᓇᔪᐊᑦ ᓴᓇᓯᒪᓂᐊᓂᒃ ᑎᑎᕋᐅᓯᐅᔭᖅᑎᓪᓗᒋᑦ, ᐱᖃᓯᐅᑎᔪᑦ ᐃᑳᕝᕚᑦ ᐊᒃᑎᒋᓂᖏᑦ ᑰᒍᑎᖏᓪᓗ ᐅᐊᖕᓈᑕ ᐃᖏᕋᔪᓕᕆᐊᖕᕝᕙ ᓱᓪᓗᖓᒍᑦ. ᐃᓗᐊᒍᑦ ᖃᓂᕐᑳᒍᓪᓗ ᐃᒪᐅᑉ ᓴᓇᔪᑦ ᐊᒃᑐᐊᔪᑦ ᓴᓇᔭᐅᓂᐊᓄᑦ ᐅᐊᖕᓈᑕ ᓄᓇᓯᐅᑎᑯᑖᕐᕝᕙᐊ ᓴᖅᑮᔪᓐᓇᖅᑐᑦ ᓄᖑᓴᐃᓂᕐᒥᒃ ᑰᒃᑐᒧᑦ ᓴᕝᕙᐅᑎᑦᑎᓗᑎᓪᓗ ᓯᐅᕋᓐᓂᒃ ᐊᓯᖏᓄᑦ ᐃᒪᑦᑎᐊᕙᖕᓄᑦ. ᐊᒃᑐᐃᓂᖏᑦ ᓴᓇᔪᑎᓪᓗᒍ ᐃᒪᐅᑉ ᐃᒪᑦᑎᐊᕙᐅᓂᐊᓄᑦ ᓵᙳᔪᐅᓯᒪᕗᑦ ᐊᑐᓕᖅᑎᑦᑎᓪᓗᑎᒃ ᓇᓗᓇᐃᖅᓯᒪᕙᒌᖅᑐᓂᒃ ᓄᖑᓴᐃᑦᑕᐃᓕᒪᔾᔪᑎᑦ ᐊᒻᒪᓗ ᐳᔪᓗᐊᖅᑕᐃᓕᒪᔾᔪᑎᑦ ᓯᐅᖅᑭᓇᓃᑦᑐ.

ᐱᓕᕆᐊᑉ ᒪᕈᕆᓕᖅᑕᖓ ᐅᒃᑑᑎᖓ ᓂᕆᐅᒋᔭᐅᖏᑦᑐᖅ ᐊᒃᑐᐃᓇᔭᕐᓂᐊᓂᒃ ᐃᒪᖅᑐᕐᓂᐊᑕ ᐃᒪᑦᑎᐊᕙᐅᓂᐊᑕᓗ ᐊᕙᑖᑕ ᐃᒪᖏᑕ ᐊᐅᓚᓂᕆᔪᖏᓄᑦ ᐱᑦᑐᒍ ᐸᕐᓈᖑᔪᑦ ᓄᖅᑲᖓᔾᔪᑎᑦ ᓄᓇᓗ ᒥᑭᑦᑑᓂᖓ ᐊᑐᖅᑕᖅ ᓴᓂᕚᒍᑦ ᐃᒪᑦᑎᐊᕙᖅᑲᕐᓂᐊ ᓄᓘᔾᔮᑉ. ᑐᙵᓪᓗᓂ ᐅᓪᓗᒥ ᕿᒥᕈᐃᓂᐅᔪᒧᑦ ᐸᕐᓈᖑᔪᓄᓪᓗ ᓄᖅᑲᖓᔪᑎᑦᑎᔾᔪᑎᕝᓴᓄᑦ, ᐅᔭᕋᓐᓂᐊᖅᑐᑦ ᐱᓕᕆᓂᖏᑦ ᐊᑐᖅᑕᐅᔪᒪᔪᑦ ᐃᓚᒋᔭᐅᔪᑦ ᑖᓯᒪ ᐱᓕᕆᐊᑉ ᒪᕈᕆᓕᖅᑕᖓ □□□□□□ᒍᑦ ᓇᓚᐅᑦᑖᖏᒍᑦ ᓴᖅᑮᓇᔭᖏᑦᑐᖅ ᐊᖏᔪᒥᒃ ᐱᐅᖏᑦᑐᒥᒃ ᓄᓇᐅᑉ ᐃᒪᖓᓄᑦ.

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT - PHASE 2 PROPOSAL



TECHNICAL SUPPORTING DOCUMENT NO. 13
SURFACE WATER ASSESSMENT

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BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT - PHASE 2 PROPOSAL

TECHNICAL SUPPORTING DOCUMENT NO. 13
SURFACE WATER ASSESSMENT
NB102-181/39-8

Rev	Description	Date
3	Added Text on Ice Damming	August 1, 2018
2	Added navigation assessment; incorporated client comments; issued as Surface Water Assessment	July 10, 2018
1	Added water quality assessment; issued as Freshwater Assessment	May 1, 2018
0	Issued in Final as Hydrology Assessment	November 16, 2017

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ABBREVIATIONS

the Project .... Mary River Project
AEMP .... Aquatic Effects Monitoring Program
AMJJAS: .... Average Change over April, May, June, July, August, and September
ARD .... Acid Rock Drainage
AREMA .... American Railway Engineering and Maintenance-of-Way Association
Baffinland .... Iron Mines Corporation
CCME .... Canadian Council of Ministers of the Environment
CWP .... construction water point
DWT .... dead weight tonnage
ECCC .... Environment and Climate Change Canada
EEM .... Environmental Effects Monitoring
ERP .... Early Revenue Phase
FAD .... Fisheries Act Directive
FEIS .... Final Environmental Impact Statement
GCM .... global climate model
Golder .... Associates Ltd.
Hatch .... Hatch Ltd.
INAC .... Indigenous and Northern Affairs Canada
IPCC .... Intergovernmental Panel on Climate Change
KP .... Knight Piésold Ltd.
LSA .... local study area
MAD .... mean annual discharge
Minnow .... Minnow Environmental Inc.
ML .... Metal Leaching
MDMER .... Metal and Diamond Mining Effluent Regulations
MMER .... Metal Mining Effluent Regulations
Mtpa .... million tonnes per annum
NBRLUP .... North Baffin Regional Land Use Plan
NIRB .... Nunavut Impact Review Board
NPA .... Navigation Protection Act
NPP .... Navigation Protection Program
NSC .... North/South Consultants Inc.
NTC .... Northern Transportation Corridor
NTI .... Nunavut Tunngavik, Incorporated
NWB .... Nunavut Water Board
NWPA .... Navigable Waters Protection Act
NWPP .... Navigable Waters Protection Program
ONDJFM.... Average Change over October, November, December, January, February, and March
PAG .... potentially acid generating
PC .... Project Certificate
PDA .... Project Development Area
PEL .... probable effects level
Q2 .... two-year return period peak flow

QIA .... Qikiqtani Inuit Association
RCP .... Representative Concentration Pathway
SDLT .... Sheardown Lake Tributary
SNP .... Surveillance Network Program
Story .... Story Environmental Inc.
TC .... Transport Canada
TSD .... Technical Supporting Document
TSP .... total suspended particulate
TSS .... total suspended solids
VEC .... valued ecosystem component
V_{max} .... high slope, high flow scenario
V_{min} .... low slope, low flow scenario
WRF .... waste rock facility
WQO .... water quality objectives
YOY .... young of year

1 – 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 Mary River Project (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 shown on Figure 1.2.

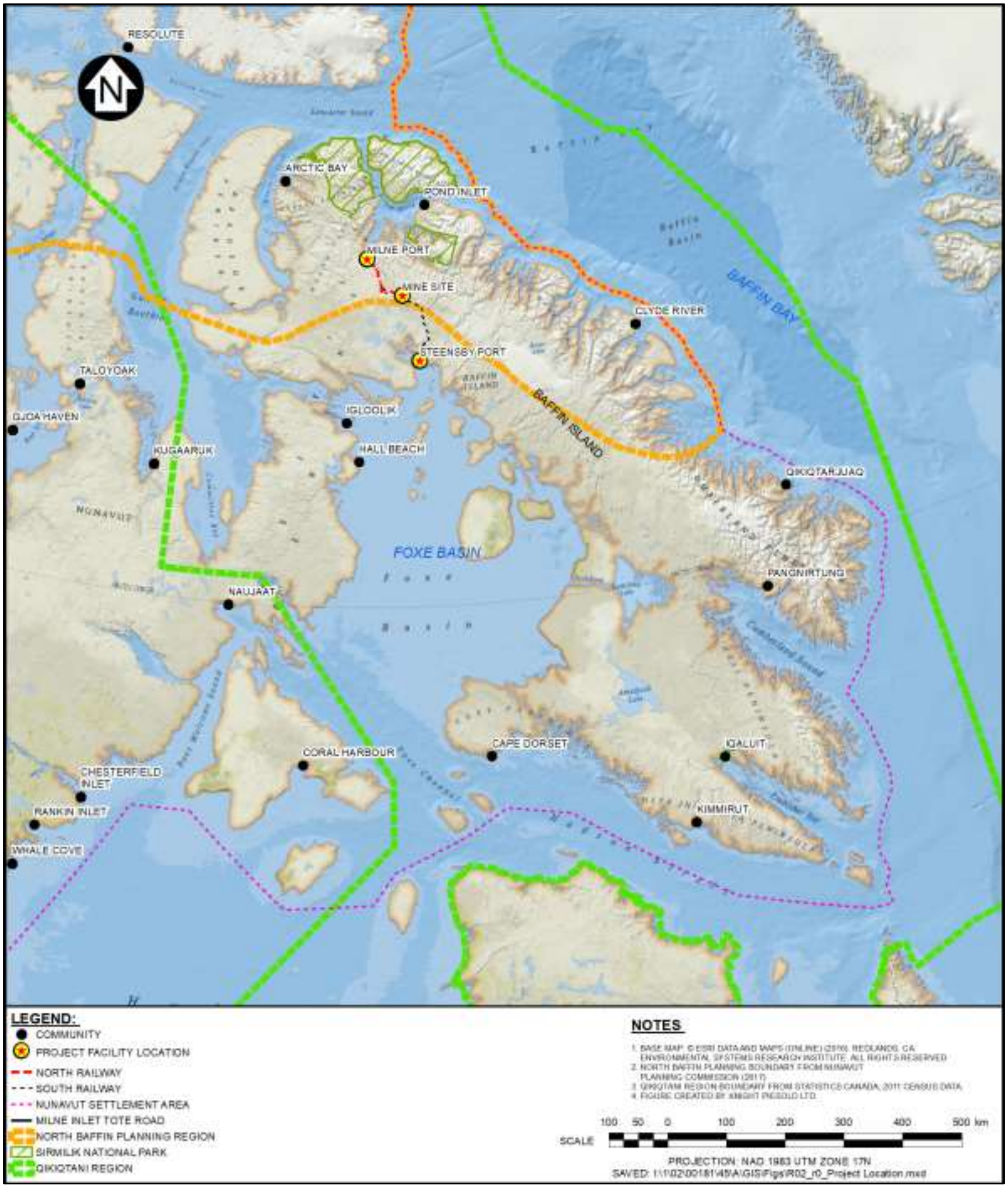

Figure 1.1 Project Location Map

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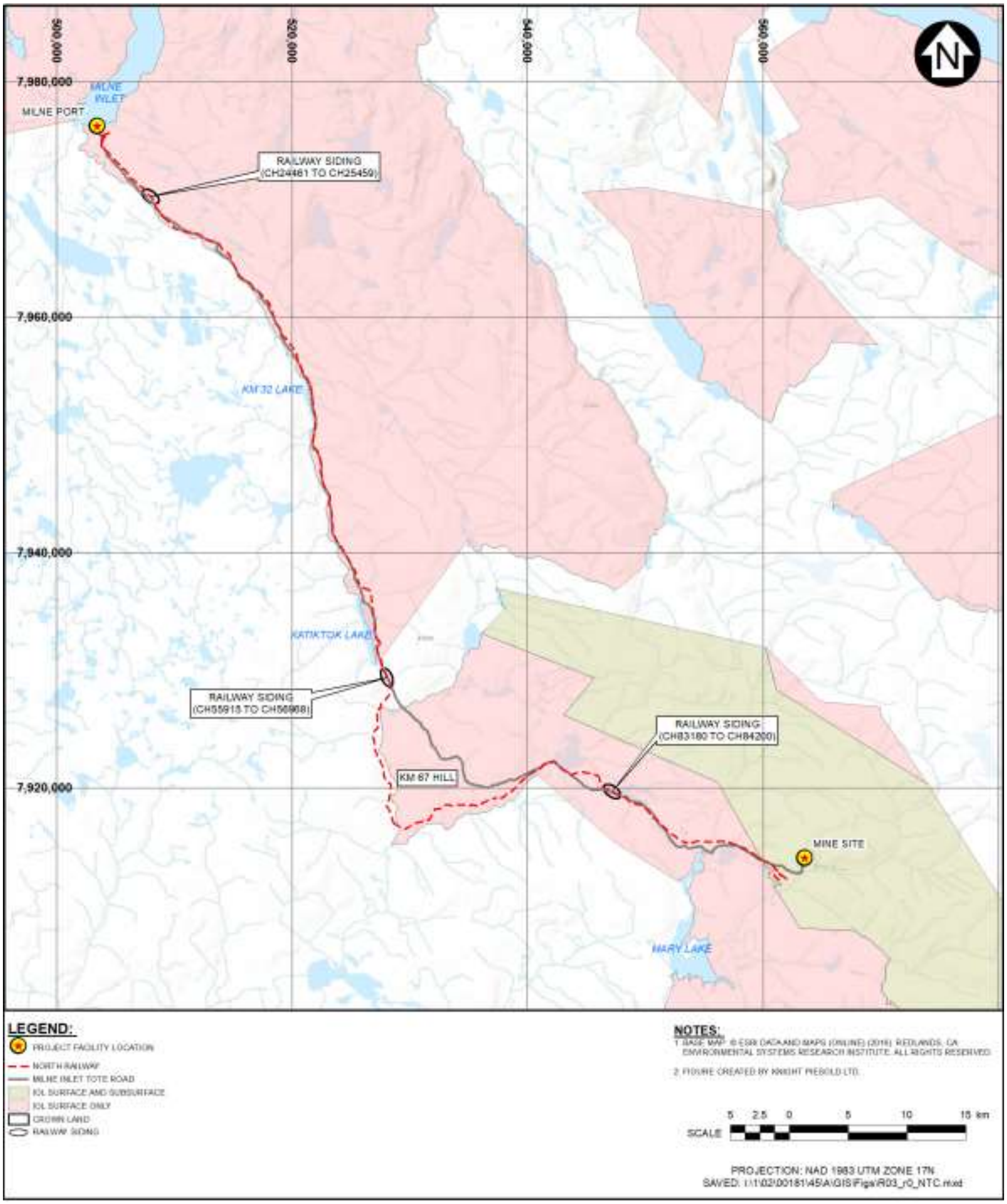


Figure 1.2 Location of Project Activities

1.2 SCOPE

Knight Piésold Ltd. (KP) has prepared this Technical Supporting Document (TSD) assessing the effects of the Phase 2 Proposal on surface water, which is discussed in three parts;

- Water quantity (Section 2)
- Water and sediment quality (Section 3)
- Navigation (Section 4)

The local study areas (LSAs) of the freshwater environment applicable for assessment of the Phase 2 Proposal are presented on Figure 1.3. The Milne Port and Mine Site LSAs presented for the Approved Project (Baffinland, 2012 and 2013) remain unchanged for the Phase 2 Proposal. The Milne Inlet Tote Road LSA, renamed the Northern Transportation Corridor LSA in this assessment, has been expanded to account for a section of the North Railway that deviates away from the Tote Road. The Phase 2 Proposal does not involve any changes to the South Railway and Steensby Port project components, and hence those LSAs remain unchanged from that presented previously by Baffinland (2012 and 2013).

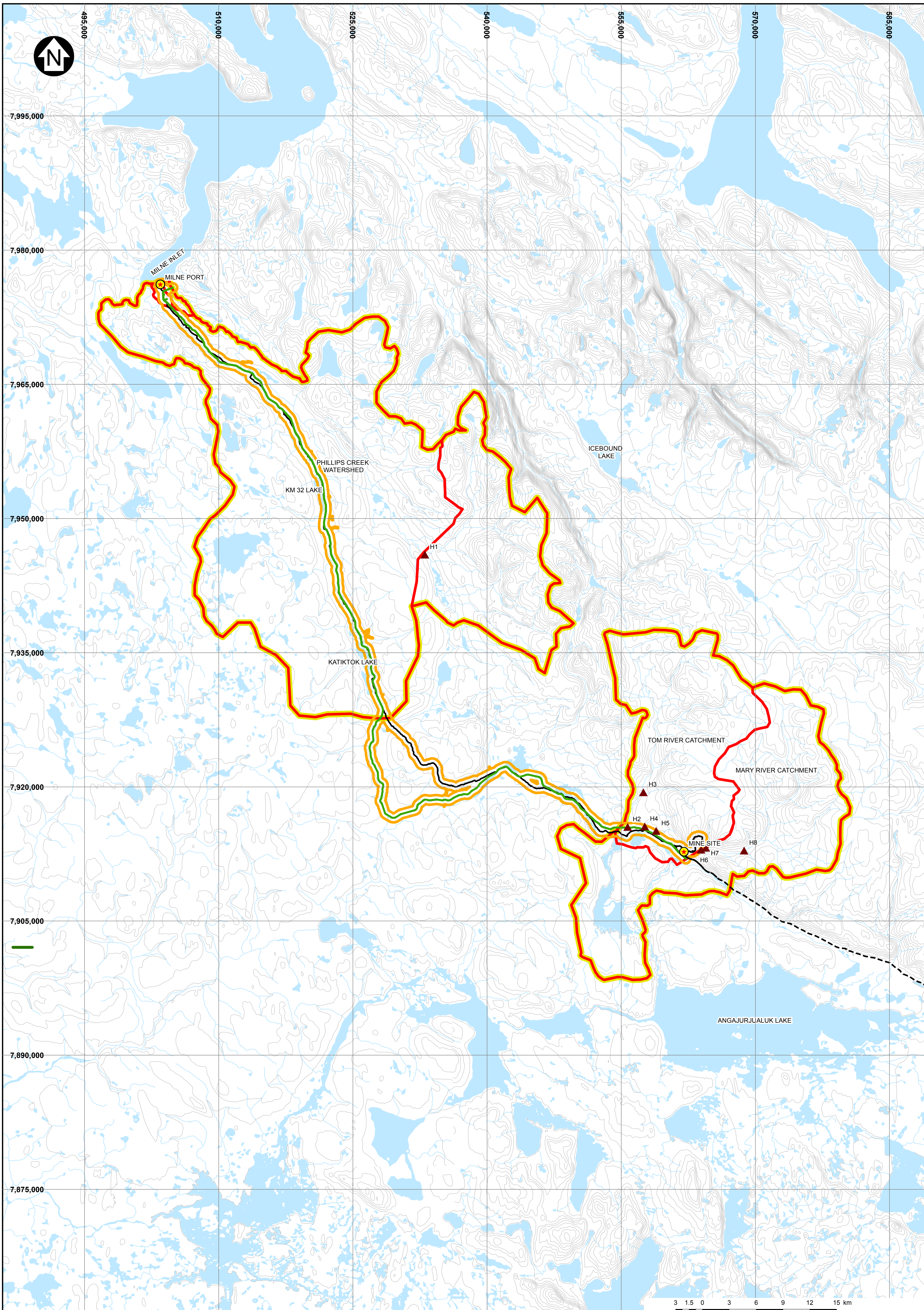
Appended to this TSD are recent hydrology monitoring reports and analyses supporting the water quantity effects assessment, namely:

- **Appendix A -** A hydrological monitoring update presenting updates to hydrometric station hydrographs (Story, 2018).
- **Appendix B -** An updated peak flow analysis completed to support the design of water management structures associated with the Phase 2 Proposal (KP, 2016).
- **Appendix C -** An evaluation of additional water takes for dust suppression purposes during construction of the Phase 2 Proposal (KP, 2017a).
- **Appendix D -** A hydrological modelling study that estimates flow velocities within proposed culverts to be installed along the North Railway, along with an evaluation of the risk of stream diversions associated with the railway resulting in effects to stream morphology (KP, 2017b).

This TSD forms part of an addendum to the FEIS being prepared by Baffinland for the Phase 2 Proposal. Reference is made to other TSDs prepared by Baffinland and other consultants.

1.3 STAKEHOLDER FEEDBACK

A very small proportion of stakeholder concerns recorded during engagement on the Phase 2 Proposal were related to surface water. Comments were received from community members of Arctic Bay, Clyde River, and Pond Inlet. Approximately half the comments raised were related to effluent discharges and Baffinland's wastewater treatment facility; two comments were related to the quality of traditional drinking water locations; and the remaining comments were related to acid rock drainage, surface water quality and quantity monitoring and sediment quality. Minimal feedback was received regarding water quantity (changes in flow).



LEGEND:

- MILNE INLET TOTE ROAD
- SOUTH RAILWAY
- NORTH RAILWAY
- CONTOUR
- RIVER/STREAM/DRAINAGE
- WATER
- CATCHMENT BOUNDARY
- MILNE PORT LOCAL STUDY AREA (LSA)
- TOTE ROAD LOCAL STUDY AREA (LSA)
- HYDROLOGY STATIONS

NOTES:

1. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA, DEPARTMENT OF NATURAL RESOURCES (2004). ALL RIGHTS RESERVED.
2. COORDINATE GRID IS SHOWN IN UTM (NAD83) ZONE 17 AND IS IN METRES.
3. CONTOUR INTERVAL VARIES. CONTOUR INTERVAL IS IN METRES.

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

FRESHWATER LOCAL STUDY AREAS

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P/A NO.	REF NO.
NB102-181/39	8

FIGURE 1.3 REV 0

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
0	10JUL'18	ISSUED WITH REPORT	KT	ASM	KT	RCB

2 – WATER QUANTITY

2.1 BACKGROUND

Surface water quantity is defined as the spatial and temporal variability of water volume within watercourses and waterbodies. The current operating Project affects the quantity (or flow) of lake and stream water across Project areas; previously assessed Project effects on water quantity are described below. Effects of the Approved Project on water quantity were determined to be not significant (Baffinland, 2012 and 2013). Monitoring and observations are consistent with these predictions (Baffinland, 2017a). The nature of the previously assessed effects to water quantity are summarized below.

2.1.1 Water Withdrawal

Water withdrawals reduce the volume of a waterbody as well as downstream flow. In lakes used by Arctic char for spawning, winter water withdrawals that meaningfully lower lake levels can freeze or smother eggs in shallow spawning beds. Large water withdrawals during winter can delay outflows from the lake in the spring, further reduced by the rate of any summer withdrawals. Reduction in summer outflow, whether as a trickle-down effect of winter withdrawal, or due to summer time water use, may affect downstream fish biota or restrict fish passage.

Water withdrawals from Camp Lake (mine site water supply), David Lake (temporary ice strip), and both Phillips Creek and KM32 Lake (Milne Port water supplies) were assessed in the FEIS and/or FEIS Addendum for the Early Revenue Phase (ERP). Subsequently, water withdrawals for dust suppression along the Tote Road were assessed by KP (2014a) in support of an amendment request to Baffinland's Type A Water Licence No. 2AM-MRY1325 (Nunavut Water Board (NWB), 2015).

2.1.2 Water Diversion

Water diversion involves redirecting flows between catchments, resulting in decreased discharge in the redirected catchment and increased flows in the receiving catchment. Decreased discharge in the redirected catchment may result in a loss of fish habitat. Increased discharge may damage or remove fish habitat by altering sediment transport and channel morphology, if the increase in the proportion of flows is high enough, and may impair navigation of the watercourse by fish.

One of the previously assessed water diversions includes the reductions in runoff to local tributaries from the fully developed open pit. The second is associated with stormwater management around the waste rock facility (WRF), and involves the rerouting of runoff from Sheardown Lake Tributary 1 (SDLT-1) to tributaries of Camp Lake. At present, the mining footprint is comparatively small relative to the fully built out project, and as such, the predicted water diversion effects associated with the open pit and WRF have not yet been realized.

2.1.3 Runoff or Effluent Discharges

Discharges of runoff, stormwater effluent from mining/stockpiling areas, and sewage effluent to receiving waters were considered in the assessments of the Approved Project. Increased runoff or effluent discharge to fresh water will increase the amount of water within a watercourse. Effects of runoff and effluent discharges from the Approved Project on affected watercourses were assessed to be not significant (Baffinland, 2012 and 2013).

2.2 PROJECT MONITORING

Baffinland operates six seasonal hydrometric stations as part of its Aquatic Effects Monitoring Program (AEMP). Annual hydrology updates (KP, 2014b, c; Story, 2016, 2017 and 2018) have been presented in the annual report to the Qikiqtani Inuit Association (QIA) and the NWB for operations. The 2017 Hydrometric Program Summary (Story, 2018) is provided in Appendix A.

The streamflow monitoring program provides Project area data that, in conjunction with regional streamflow and climate datasets, can be used to determine design criteria for engineering design. Updated peak flow estimates (Appendix B; KP, 2016) were used to size hydraulic structures associated with the Phase 2 Proposal, including bridges and culverts along the North Railway.

Flows in tributaries of Camp Lake and Sheardown Lake at the Mine Site may be reduced by flow diversions around the open pit, and diversions to manage runoff from the WRF, in the latter part of the mine life. Baffinland's AEMP includes a component that assesses effects of reduced flows from these diversions to fish passage. Since the pit and WRF currently remain small compared to the final build-out at the current mine production rate, limited flow is currently diverted away from these tributaries. As such, current monitoring focuses on establishing the frequency at which barriers to the movement of fish within the tributaries occurs under near baseline conditions (KP, 2014d).

2.3 ASSESSMENT METHODOLOGY

The assessment of water quantity effects relies on the data in the hydrology baseline report presented in the FEIS (Appendix 7A; KP, 2012) as well as ongoing hydrology monitoring undertaken by Baffinland since 2013 (KP, 2014b,c, 2016 and 2017b; Story, 2016, 2017 and 2018).

The methods used herein to assess effects to water quantity is consistent with the FEIS (Volume 7, Section 2.3.1). The freshwater LSAs incorporating the Mine Site and Milne Port remain unchanged from that of the Approved Project. The Northern Transportation Corridor LSA (previously the Milne Inlet Tote Road LSA) incorporates a section of railway that deviates outside of the immediate Tote Road area at approximately km 60 to km 80.

2.4 CLIMATE CHANGE CONSIDERATIONS

Baffinland's Climate Change Assessment (Baffinland, 2018a) summarizes the latest climate change forecasts relevant to the Phase 2 Proposal. 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°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 (Baffinland, 2018a).

Table 2.1 presents the projected precipitation changes in the region most representative for the Project area for the near and mid-term time frames and for the three selected forcing scenarios (as described fully in Baffinland, 2018a). Minimum, maximum, and median projected change for winter (October, November, December, January, February, March), summer (April, May, June, July, August, September) and the whole year are presented.

Accordingly, bridges and culverts on the North Railway are being designed with increased conservatism, by applying a higher return period (the 1 in 200-year storm event) to the design basis, rather than the 1 in 100-year storm event design criteria that would otherwise be applied.

Table 2.1 Projected Changes in Precipitation at High Latitudes

Parameter	Model Scenario [6]	Model Year	Changes in Annual Precipitation (in %) [1,2]		
			Minimum	Maximum	Median
Winter Precipitation (ONDJFM [3])	RCP 2.6	2035	-1	13	5
		2065	-3	18	7
	RCP 4.5 [4]	2035	-2	12	5
		2065	1	21	10
	RCP 8.5	2035	1	13	6
		2065	3	29	15
Summer Precipitation (AMJJAS [5])	RCP 2.6	2035	-1	10	4
		2065	0	13	5
	RCP 4.5 [4]	2035	-2	7	3
		2065	1	14	6
	RCP 8.5	2035	0	11	4
		2065	5	21	9
Precipitation (Annual)	RCP 2.6	2035	-1	10	4
		2065	-2	14	6
	RCP 4.5 [4]	2035	-2	8	4
		2065	2	15	8
	RCP 8.5	2035	1	10	5
		2065	4	22	12

NOTES:

1. SOURCE: IPCC (2014), TABLES 14.SM.1A, B, AND C. HIGH LATITUDES INCLUDES: CANADA/GREENLAND/ICELAND FOR SELECTED SCENARIOS.
2. GLOBAL CLIMATE MODELS (GCMs) PREDICT A RANGE OF VALUES FOR EACH SCENARIO. MINIMUM, MAXIMUM, AND MEDIAN STATISTICS WERE CALCULATED OVER ENSEMBLES OF 25 TO 39 GCM RUNS, DEPENDING ON SCENARIO.
3. ONDJFM: AVERAGE CHANGE OVER OCTOBER, NOVEMBER, DECEMBER, JANUARY, FEBRUARY, AND MARCH.
4. RESULTS SHOWN ARE FOR RCP6.0 SCENARIO BUT ARE SIMILAR TO RCP 4.5 FOR 2035 AND 2065.
5. AMJJAS: AVERAGE CHANGE OVER APRIL, MAY, JUNE, JULY, AUGUST, AND SEPTEMBER.
6. RCP SCENARIOS: REPRESENTATIVE CONCENTRATION PATHWAY SCENARIOS.

2.5 EFFECTS ASSESSMENT

Potential interactions of the Phase 2 Proposal with water quantity are identified in Table 2.2.

Table 2.2 Phase 2 Proposal Interactions with Water Quantity

Project Infrastructure or Activity	Level of Interaction
Mine Site	
Minor changes to site drainage (no meaningful new diversions)	1
Tote Road	
Replacement of Tote Road culverts downstream of select North Railway crossings that will receive diverted flows from other streams	2
Increased downstream flows at upsized Tote Road culverts located downstream of North Railway crossings with diverted flows	2
Short-term traffic increase associated with increased ore haulage to 6 Mtpa and to support rail construction	1
Increased water takes for dust suppression	2
North Railway	
Construct temporary and permanent culvert crossings	2
Construct bridges with piers at four large crossings	1

NOTES:
1. INTERACTIONS ARE RATED AS FOLLOWS:
   0 - NO INTERACTION.
   1 - MINOR INTERACTION POST-MITIGATION, DISCUSSION ASSESSMENT.
   2 - MAJOR INTERACTION SUBJECT TO DETAILED ASSESSMENT.

Table 2.3 presents the effects pathways and nature of the effects to water quantity at each project area affected by the Phase 2 Proposal. Effects to water quantity resulting from the South Railway and Steensby Port remain unchanged from what was assessed in the FEIS (Baffinland, 2012).

Table 2.3 Effects to Water Quantity Due to the Phase 2 Proposal

Effect Pathway	Milne Port	Northern Transportation Corridor	Mine Site
Water Withdrawal	No change	Additional construction water sources	No change
Water Diversion	Minor alterations to local drainage	Railway crossings and stream diversions	No change
Runoff or Effluent Discharge	No change[1]	No change	Minor increase in volume of mine effluent discharged to Mary River

NOTES:
1. EFFLUENT FROM THE ORE STOCKPILES AND THE SEWAGE TREATMENT PLANT ARE DISCHARGED TO THE MARINE ENVIRONMENT.

At Milne Port, minor alterations to local drainage will occur as a result of additional infrastructure within a larger PDA; however, there are no drainages of meaningful size within the Milne Port PDA, and nearly all site runoff reports to the ocean. Though an increase in the volume of mine effluent will be generated from larger ore stockpiles, this effluent is discharged to the ocean. Therefore, no meaningful effects to freshwater water quantity will occur at Milne Port.

Additional water sources will be required along the Northern Transportation Corridor during the construction phase to support dust suppression efforts, both along the Tote Road as well as along the rail alignment and at quarries. These effects are assessed in the subsections below.

The Phase 2 Proposal will not involve any meaningful changes to how water is managed at the Mine Site, as there are no changes to the mine plan or how waste rock will be managed. The volume of mine effluent stormwater to be discharged from the ore crusher pad at the Mine Site will increase because the size of the crusher pad and stockpiles will increase. The ore crusher pad will increase in area by approximately 40%. Under the Approved Project, the ore crusher pad runoff represents 0.17% of the mean annual flow volume in the Mary River. With the Phase 2 Proposal, this will increase to 0.24% of the mean annual flow volume in the Mary River (Section 3.5.1.1). This change is not meaningful relative to the flows in the Mary River; under mean flow conditions.

There are no changes to the previously assessed South Rail component of the Project (South Railway and Steensby Port).

2.5.1 Water Withdrawals along the Northern Transportation Corridor

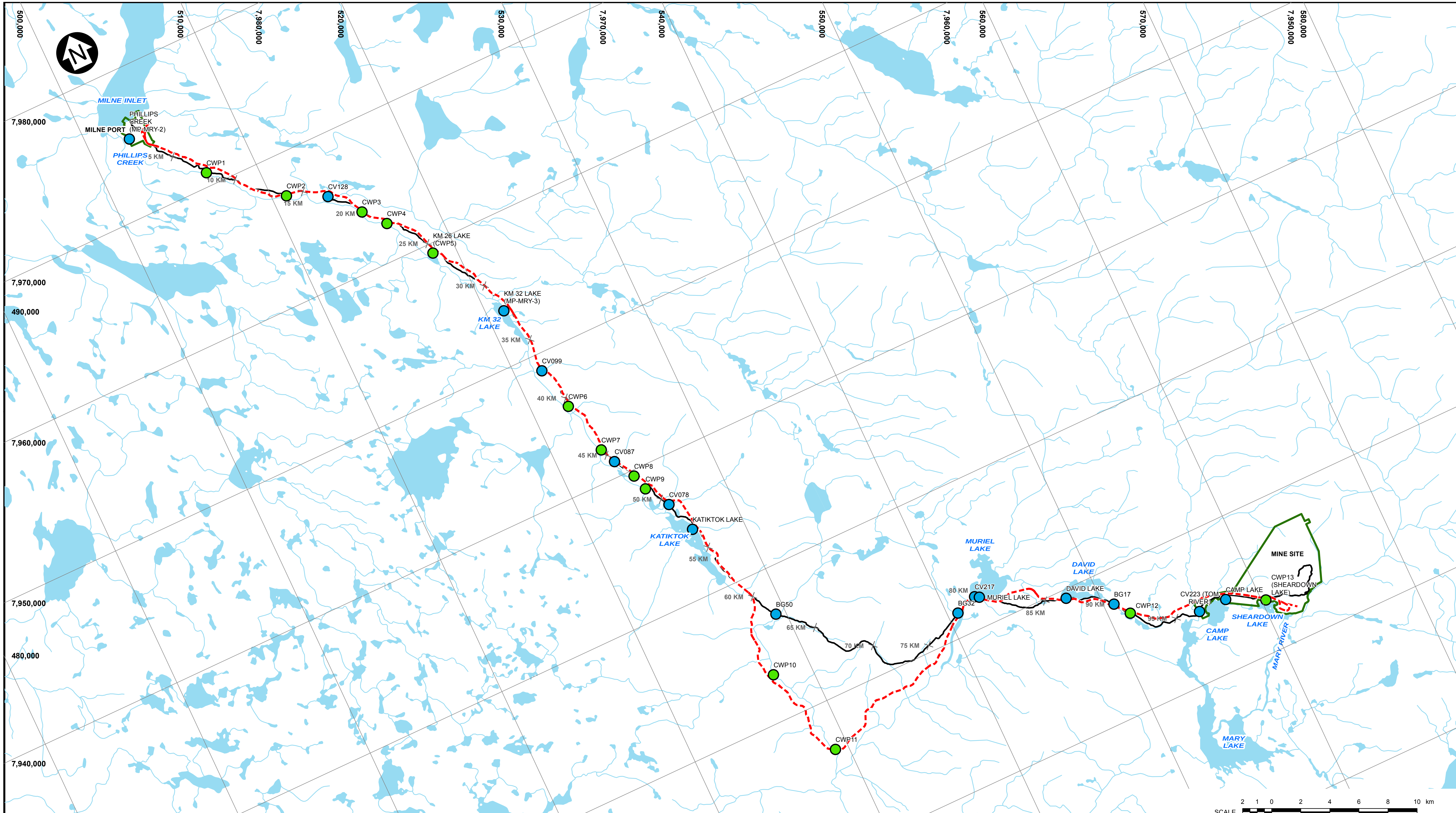
Fifteen sources along the Tote Road are currently approved under Baffinland's Type A Water Licence (NWB, 2015) for extraction of water for dust suppression. These sources will not provide sufficient water supply for dust suppression efforts along the Tote Road or the North Railway during its construction. An additional 13 construction water points (CWPs) have been identified based on their proximity to the railroad construction and quarrying activities. The additional and approved water source locations and their proximity to the Northern Transportation Corridor and quarry locations are shown on Figure 2.1. 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, with the exception of CWP10 and CWP11, albeit at reduced quantities.

Increased withdrawals from approved water sources and from additional water sources are identified and assessed in the Water Take Assessment (Appendix C). The outcome of this assessment on lake and stream water sources is described below.

2.5.1.1 Water Withdrawals from Lakes

Water take assessments were completed for five lakes that are currently approved for use under the Type A Water Licence (KM32 Lake, Katiktok Lake, Muriel Lake, David Lake, and Camp Lake) and two lakes not previously targeted as water sources (KM26 Lake and Sheardown Lake). The methodology used to assess the water takes is presented in Appendix C.

The effect of a single water take from a lake is not measurable. However, repeated water takes have the potential to lower lake levels and reduce lake outflows. The initial screening threshold allows for a monthly withdrawal of up to 10% of the mean monthly outflow from the lake without further evaluation. The estimated reductions in monthly lake outflows of the seven lake water sources are presented in Table 2.4. The proposed water withdrawal volumes are below 10% reduction of outflow threshold under all flow conditions including 10-year return period low flow conditions, with the exception of Camp Lake.



LEGEND:

- APPROVED WATER SOURCE
- PROPOSED WATER SOURCE
- MILNE INLET TOTE ROAD
- WATER
- PROJECT DEVELOPMENT AREA

NOTES:

1. BASE MAP: HER MAJESTY THE QUEEN IN RIGHTS OF CANADA, DEPARTMENT OF NATURAL RESOURCES, (2004).
2. COORDINATE GRID IS UTM (NAD83) ZONE 17 AND IS IN METRES.
3. FIGURE CREATED BY KNIGHT PIESOLD LIMITED.

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
1	20JUN'18	CHANGED SYMBOLOGY AND LABELLED MAJOR WATER BODIES	RAC	SBF	RAC
0	20JUN'18	ISSUED WITH REPORT	RAC	RF	RAC

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BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

NORTHERN TRANSPORTATION CORRIDOR SHOWING WATER WITHDRAWAL LOCATIONS

Knight Piésold CONSULTING

P/A NO. NB102-181/39 | REF NO. 8

FIGURE 2.1 | REV 1

Camp Lake meets the 10% reduction of outflow threshold under mean flow conditions in June, July and August, but not in September or under low flow conditions. The proposed Camp Lake water withdrawal will potentially result in a 26.5% and 30% reduction in the monthly outflow in September and under the 10-year low flow condition, respectively. The outflow stream of Camp Lake reports to Mary Lake, and it is broad and shallow and has been observed on multiple occasions (and various flow conditions) to lack connectivity.

Table 2.4 Estimated Reductions in Lake Outflows Due to Water Withdrawals

Water Source	Catchment Area	Daily Withdrawal Volume	Monthly Withdrawal Volume	Reduction in Mean Monthly Discharge (%)				Reduction Under Low Flow Conditions
	(km^2)	(m^3/day)	(m^3)	June	July	Aug	Sept	(%)
CWP 5 (KM26 Lake)	540.8	119.0	3,688	0.0%	0.0%	0.1%	0.2%	0.2%
MP-MRY-3 (KM32 Lake)	456.6	125.6	3,893	0.0%	0.0%	0.1%	0.3%	0.3%
Katiktok Lake	90.8	103.4	3,205	0.1%	0.1%	0.4%	1.1%	1.3%
Muriel Lake	219.5	82.6	2,561	0.0%	0.0%	0.1%	0.4%	0.4%
David Lake	49.7	116.6	3,615	0.2%	0.2%	0.8%	2.3%	2.6%
Camp Lake(1)	25.9	691.5	21,437	2.0%	2.6%	8.5%	26.5%	30.0%
CWP13 (Sheardown Lake)	8.5	10.4	323	0.1%	0.1%	0.4%	1.2%	1.4%

NOTES:
1. DAILY AND MONTHLY WITHDRAWAL VOLUMES INCLUDE DOMESTIC WATER TAKING.
2. METHODOLOGY FOR ESTIMATING REDUCTION IN LAKE OUTFLOWS PRESENTED IN APPENDIX C.

The proposed water withdrawal can be expected to increase the frequency at which natural lack of connectivity occurs between the two lakes. Limited movement of adult arctic char occurs through this stream, and consequently, this stream was not identified as critical fish habitat by North/South Consultants Inc. (NSC, 2012).

NSC has determined that a reduction in flow of 30% is unlikely to cause fish stranding 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 (NSC, 2018).

2.5.1.2 Water Withdrawals from Streams

Ten streams are approved as water sources for dust suppression under the Type A Water Licence. An additional 11 streams have been identified as proposed additional water sources. Additionally, increased water takes are proposed at three of the 10 approved water stations.

Unlike lakes, water withdrawals from streams need to consider the instantaneous rate of water withdrawal relative to flow within the stream under various flow conditions, to ensure that the water withdrawal does not negatively effect the local section of stream. The thresholds applied in the assessment presented in Appendix C are based on an earlier assessment undertaken to support an amendment to the Type A Water Licence (KP, 2014a). For streams known or potentially fish-bearing, the removal of 20% of run-off during a 10-year dry monthly flow condition was identified as an environmentally protective threshold.

Streams confirmed to not support fish habitat typically feed a downstream reach or collecting stream that is fish habitat. In these instances, the subject stream is only one contributor to the flow in the downstream fish habitat. Therefore, a higher threshold of 40% of the 10-year dry monthly flow was used. Based on these thresholds, fish-bearing streams with a catchment area of at least 71.4 km^2, and non-fish bearing streams with a catchment area of at least 35.7 km^2, are suitable for water withdrawal under all flow conditions. Table 2.5 presents the parameters and means of calculating the minimum catchment sizes.

Table 2.5 Calculation of Minimum Catchment Areas to Support Water Takes

Parameter	Unit	Quantity	Comment/Data Source
Water Withdrawal Rate	USG/min	233	Bowie 3300 pump @ 400 RPM
	L/s	14.7	
10-year Monthly Low Flow Estimate	L/s/km^2	1.03	FEIS Appendix 7A (KP, 2012)
Fish-bearing Streams			If the pump rate of 14.7 L/s is to represent 20% of the mean flow, then the streamflow must be 5 x 14.7 L/s or 73.5 L/s. Based on the 10-year low flow unit runoff estimate of 1.03 L/s/km^2, a catchment size of 71.36 km^2 would be required to provide a streamflow rate of 73.5 L/s.
Threshold	%	20	
Minimum Flow	L/s	73.5	
Minimum Catchment	km^2	71.4	
Non Fish-bearing Streams			If the pump rate of 14.7 L/s is to represent 40% of the mean flow, then the streamflow must be 2.5 x 14.7 L/s or 36.75 L/s. Based on the 10-year low flow unit runoff estimate of 1.03 L/s/km^2, a catchment size of 35.68 km^2 would be required to provide a streamflow rate of 36.75 L/s.
Threshold	%	40	
Minimum Flow	L/s	36.7	
Minimum Catchment	km^2	35.7	

A total of 21 stream water sources were assessed based on screening criteria, and 16 of the 21 water sources meet the catchment area thresholds discussed above under all flow conditions (Table 2.6; note that new water sources on the Phillips Creek mainstem (CWP1 to CWP4 and CWP-6 to CWP9) are grouped as a one row in the table). New water sources are identified as CWPs, distinguishing them from water sources that are already approved under Baffinland's Type A Water Licence (NWB, 2015). The proposed daily water withdrawals volumes in Table 2.6 will be extracted at an instantaneous rate of 14.7 L/s until the volume is achieved. In all cases the proposed daily water withdrawals are much less than the maximum daily water withdrawal (1,270 m^3/day, if the pump was operated continuously for 24 hours).

Table 2.6 Streams Meeting Water Take Criteria under Any Flow Conditions

Water Take Station (Waterbody, if named)	Chainage (Along Railway) (km+m)	Catchment Area (km^2)	Proposed Water Withdrawal (m^3/day)	Fish Habitat Classification
MP-MRY-2 (Phillips Creek)[1]	1+000	1,192.6	462.4	Likely
CWP1 to CWP4; CWP6 to CWP9 (Phillip's Creek)	6+500 to 51+000	90.8 - 1,168.7	582	Likely/ Important
CV128[1]	15+500	543.3	70.1	Important
CV078[1]	48+400	110.3	89.2	Important
BG50[1]	59+500	181.1	211	Important
CWP10	63+500	549.2	53.1	Important
CWP11	70+750	587.8	98	Important
CV217[1]	85+750	219.5	26	Important
CV223[1] (Tom River)	102+250	247.0	65.4	Important

NOTES:
1. APPROVED WATER SOURCES UNDER THE TYPE A WATER LICENCE.
2. SEE APPENDIX C FOR COORDINATES.

Table 2.7 lists the five water take locations where the source streams may not meet the thresholds under low flow conditions (i.e., during September), or in conditions resembling the 10-year low flow unit runoff. However, these streams will have sufficient water from June through August, in the modelled 10-year dry conditions. Even in the 10-year dry conditions scenario, stream flows in June and July are typically 400% of the annual runoff. Assuming 10-year dry conditions, the mean monthly reductions in stream flow were calculated to assess the magnitude of the impacts caused by water taking.

Table 2.7 Streams Meeting Water Take Criteria under Most Flow Conditions

Water Take Location	Chainage Along Railway[(2)] (km+m)	Contributing Catchment Area (km^2)	Proposed Water Withdrawal (m^3/day)	Fish Habitat Classification
CV099[(1)]	35+250	33.8	90.6	Important
CV087[(1)]	43+500	3.8	33.3	Marginal
BG32[(1)]	84+250	13.2	176.6	Important
BG17[(1)]	96+250	17.1	55.5	Important
CWP12	97+500	15.2	75.1	Important

NOTES:
1. APPROVED WATER SOURCES UNDER THE TYPE A WATER LICENCE (NWB, 2015).
2. SEE APPENDIX C FOR COORDINATES.

Table 2.8 shows the mean monthly reductions in stream flow for the five locations listed in Table 2.7. Out of these five locations, only BG32 will experience flow reductions greater than 10%, and only in the month of September, and in the 10-year monthly low flow scenario. It is recommended that an environmental coordinator visually inspect the streams listed in Tables 2.7 and 2.8, and refer to ongoing stream gauging data (as necessary) to determine if flows are representative of wet, mean (i.e., typical), or dry conditions. If stream flows are averaging less than mean flows for the year, this signals a drier year where caution should be taken. In these cases, the streams should be inspected and their use as a water take location confirmed by the environmental coordinator before water withdrawals are made in August and September.

Table 2.8 Estimated Reductions in Monthly Discharge in Streams with Smaller Catchment Areas

Water Take Location	Monthly Withdrawal Volume (m^3/month)	Reduction in 10-year Monthly Low Flow Discharge[(2)]				Flow Reductions Under the 10-Year Monthly Low Flow Scenario (%)
		June (%)	July (%)	August (%)	September (%)	
CV099[(1)]	2810	0.2%	0.3%	0.9%	2.7%	3.0%
CV087[(1)]	1032	0.7%	0.8%	2.8%	8.8%	9.9%
BG32[(1)]	5473	1.0%	1.3%	4.3%	13.3%	15.1%
BG17[(1)]	1720	0.2%	0.3%	1.0%	3.2%	3.6%
CWP12[(1)]	2327	0.4%	0.5%	1.6%	4.9%	5.6%

NOTES:
1. APPROVED WATER SOURCES UNDER THE TYPE A WATER LICENCE.
2. BASED ON MONTHLY DISCHARGE RATES FOR 10-YEAR DRY MONTHLY FLOW CONDITIONS (KP, 2014c).

Ten water take stations are located on Phillip's Creek, so the cumulative water withdrawal from the Creek was evaluated. The cumulative water withdrawal was assessed at the following locations within the Phillip's Creek catchment:

- At CWP7, the cumulative water take includes water extracted at CWP7 and four additional upstream locations: CWP8, CWP9, CV078 and Katiktok Lake.
- At MP-MRY-2, the cumulative water take includes the water extracted at the MP-MRY-2 and 9 upstream locations.

The proposed daily maximum water withdrawn from all upstream locations would represent <5% of the available water under a 10-year dry monthly unit flow condition (Table 2.9). The 10-year dry monthly unit flow represents the minimum value from the open water season (June to September) and typically occurs in September as pluvial (rainfall) generated runoff diminishes.

Table 2.9 Cumulative Water Withdrawal Assessment in Phillip's Creek

Assessed Station	Catchment Area (km^2)	Number of Water Withdrawal Stations	Cumulative Daily Water Withdrawal (m^3)	Proportion of 10-year Dry Monthly (September) Unit Flow (%)
CWP7	180	5	324.6	4.8
MP-MRY-2	1,192.6	10	1,481.6	3.4

The effects of cumulative water withdrawals in the Muriel Lake catchment were assessed at the mouth of Muriel Lake, which includes water extracted at 4 upstream locations: CWP12, BG17, David Lake, and Muriel Lake. The proposed daily maximum water withdrawal from all upstream locations would represent <2% of the available water under 10-year monthly low flow conditions (Table 2.10).

Table 2.10 Cumulative Water Withdrawal Assessment in the Muriel Lake Catchment

Assessed Station	Catchment Area (km^2)	Number of Stations	Cumulative Daily Water Withdrawal (m^3)	Proportion of Daily 10-Year Dry Flow (%)
CV217	219.5	4	355.7	1.8

Key mitigation measures applied in the establishment of additional water take stations can be summarized as follows:

- Monthly cumulative withdrawals from lakes represent less than 10% of the monthly outflow, unless site-specific conditions indicate that a greater water withdrawal will not be significant in the context of fish habitat (i.e., Camp Lake).
- Stream water take stations are selected to be sufficiently large such that the instantaneous water withdrawal rate does not exceed 20% of the 10-year monthly low flow condition if a stream is fish-bearing, or 40% of the 10-year monthly low flow condition if the stream is not fish-bearing.
- At select streams where the water take exceeds than the applicable threshold under mean flow conditions but not under the 10-year low flow, water withdrawals are permitted only during the months of June and July.

The proposed water withdrawals are not expected to significantly affect water quantity (Section 2.5.4).

2.5.2 Increased Flow Velocity at North Railway Watercourse Crossings

Culverts and bridges will result in changes to stream flow; the channelization of flow will result in increased flow velocities. Such increases in streamflow velocity can affect the ability of fish to successfully move upstream through the culvert or bridge.

A hydrology assessment was conducted to estimate flow velocities at proposed railway culvert crossings (Appendix D). The effects of these changes to flow velocity at proposed crossings at known or potentially fish-bearing streams on fish passage are assessed in the freshwater fisheries assessment (NSC, 2018).

Hydraulic modeling was conducted to determine water depth and velocity for each culvert crossing under the mean annual discharge (MAD) condition. Due to uncertainty in the estimated MAD and in the culvert slope, two scenarios were assessed: low slope, low flow (referred to hereafter as "V_{min}"); and high slope, high flow (referred to hereafter as "V_{max}"). V_{min} is based on the lower bound flow and culvert slope estimate, while V_{max} is based on the upper bound estimates. Of 145 stream crossings in known or potential Arctic char habitat, 21 crossings will have flow velocities deemed acceptable for fish passage, for the V_{min} and V_{max} scenarios, respectively. The remaining 124 crossings may present barriers to fish passage. Of these, 70 crossings do not meet the V_{max} 50% fish passage criterion, and 15 of the 70 crossings do not meet the V_{max} 5% fish passage criterion (NSC, 2018). Fish-bearing culverts that have been identified as potential fish passage barriers will be assessed on a case-by-case basis during the final detailed engineering design phase of the Project to include appropriate fish passing promoting measures.

There are a number of ways that streamflow velocities can be reduced:

- Install culverts at the same slope as the existing stream, where feasible
- Increase barrel roughness of the culvert
- Install additional culverts, if the channel width allows for this
- Insert boulders, baffles, baffle inserts, or weirs to increase friction in the culvert and mimic stream bed conditions

Baffinland commits to incorporating additional measures to reduce streamflow velocities during detailed engineering design at 124 fish-bearing crossings that have been identified in NSC (2018) as expected to have flow velocities exceeding the applicable threshold for fish passage. It is expected that with additional engineering design, flow velocities that currently exceed fish passage thresholds will be able to be reduced below the thresholds.

2.5.3 Flow Diversions at Stream Crossings along the North Railway

Where construction of the North Railway will involve rock cuts that intersect existing streams, it is not feasible to direct water across or through the cut to the downstream watercourse. In these locations, the stream will be diverted to an adjacent stream that will cross the railway. Twenty-six streams will be affected by rock cuts (the assessment in Appendix D assessed 27 streams, but ay stream diversion at CV-49-5a was subsequently eliminated with a small realignment of the railway). Once constructed, the diversions will be permanent. Table 2.11 lists the streams that will be diverted due to rock cuts, and the estimated increase in flows within the streams that will receive the diversion. The estimated flow increases are directly proportional to catchment area.

Table 2.11 Estimated Increases in Flows in Streams Receiving Diverted Flows along the North Railway

Ref	Diverted Stream ID	Receiving Stream ID	Diverted Stream Catchment Area (km^2)	Receiving Stream Catchment Area (km^2)	Increased Flow in Receiving Stream[(1)] (%)	Comment
1	CV-0-2	CV-0-1	0.14	0.01	1,227%	Low point (no stream) at CV-0-1
2	CV-8-0	CV-8-1 and CV-8-2	0.8	0.4	194%	No apparent surface flow at CV-8-0, CV-8-1, and CV-8-2; all located on the same sub-catchment
3	CV-12-4b	CV-12-5 and CV-13-1	0.49	0.03	1648%	CV-12-5 and CV-13-1 are located on the same catchment
4	CV-20-2	CV-20-1	0.13	0.03	433%	CV-20-1 has no apparent surface flow
5	CV-35-5	CV-35-4	2.76	0.04	7332%	CV-35-4 is not located on a waterbody

Ref	Diverted Stream ID	Receiving Stream ID	Diverted Stream Catchment Area (km^2)	Receiving Stream Catchment Area (km^2)	Increased Flow in Receiving Stream(1) (%)	Comment
6	CV-46-1a	CV-46-3	0.06	0.92	7%	CV-46-3 has no apparent surface flow
7	CV-58-7 and -8	CV-59-1	0.11	0.22	50%	
8	CV-59-4a and -4b	CV-59-4	1.45	3.32	44%	
9	CV-60-4a	CV-60-5	0.03	0.57	6%	
10	CV-61-3	CV-61-2	0.08	0.07	114%	
11	CV-62-3	CV-62-4	0.18	0.06	300%	CV-62-4 is not located on a waterbody
12	CV-62-6 CV-62-6b	CV-62-5	0.31	0.08	388%	CV-62-5 is not located on a waterbody; CV-62-5 and CV-62-6 are located within the same catchment
13	CV-63-3a	CV-63-3	0.07	0.05	149%	CV-63-3a and CV-63-3 are located on the same catchment
14	CV-64-5a	CV-64-5	0.01	0.01	100%	No surface flow observed; CV-64-5a and CV-64-5 are located on the same catchment
15	CV-65-2a	CV-65-2	0.05	0.08	63%	No surface flow at CV-65-2a; CV-65-2a and CV-65-2 are located on the same catchment
16	CV-66-2a	CV-66-2	0.01	0.60	2%	No surface flow observed
17	CV-74-7	CV-74-6	0.09	0.12	75%	CV-74-7 and CV-74-6 are on the same catchment
18	CV-82-1a	CV-82-1	0.01	2.03	0%	No surface flow at CV-82-1
19	CV-90-2, CV-90-4	CV-90-3	0.09	0.05	171%	No surface flow observed
20	CV-92-1b	CV-92-1	0.01	0.01	100%	CV-92-1b and CV-92-1 are on the same catchment. CV-92-1 is located at the edge of a small, shallow pond, unconnected to other waterbodies; when wet, CV92-1b may connect pond at CV-92-1 with upstream ponds.
21	CV-95-1	CV-94-2	0.14	0.18	78%	No waterbody at CV-95-1
22	CV-97-6	CV-97-5	0.02	0.02	112%	

Ref	Diverted Stream ID	Receiving Stream ID	Diverted Stream Catchment Area (km^2)	Receiving Stream Catchment Area (km^2)	Increased Flow in Receiving Stream[1] (%)	Comment
23	CV-101-1a CV-101-1b	CV-101-1	0.09	0.52	17%	CV-101-1a, CV-101-1b and CV-101-1 located on same catchment - channel realignment
24	CV-102-1a	CV-102-2	0.03	1.68	2%	CV-102-1a may lack surface flow; Tote Road culvert CV-224 is located downstream, but is unlikely to require modification based on negligible additional flows
25	CV-102-5	CV-103-1	0.30	8.20	4%	CV-102-5 and CV-103-1 on the same sub-catchment
26	CV-109-1	CV-109-2	0.01	0.14	6%	

NOTES:

1. INCREASES IN FLOW IN THE RECEIVING STREAM ARE CALCULATED BASED ON RELATIVE CATCHMENT AREAS OF THE DIVERTED AND RECEIVING STREAMS.

Previously, in the FEIS (Volume 7, Section 2.3; Baffinland, 2012), it was established that greater than a 10% change in downstream monthly flow values would trigger further review. The 10% increase in flow threshold will be exceeded at 19 of the 26 diversion locations (Table 2.11).

Table 2.12 identifies Tote Road culvert crossings that are located downstream of rail crossings that will receive surface flows.

Table 2.12 Tote Road Culverts Possibly Affected by Rail Stream Diversions

Receiving Stream ID	% increase in Flow in Receiving Stream	Downstream Tote Road Crossing
CV-8-1 and CV-8-2	194%	CV-152
CV-12-5 and CV-13-1	1648%	CV-131 and CV-195
CV-35-4	7332%	CV-098
CV-49-5	1%	CV-076
CV-97-5	112%	CV-006
CV-102-2	2%	CV-224
CV-103-1	4%	CV-225

Baffinland will need to review the design flows for these culverts and upsize the culverts as required to meet the higher flows.

Depending on the increase in flows and the size of the receiving channel, erosion of the receiving stream channel and changes to stream morphology may occur. An assessment of the effects of the additional flows on the morphology of the receiving stream was completed to evaluate the relative risk of effects to stream morphology, fish habitat and other considerations such as the

Tote Road (Appendix D). This assessment focuses on the effect of increased flow in the receiving stream, with potential effects including:

- *Exceedance of channel capacity and flooding.* If flow increases are modest, flooding may be infrequent. Where flow increases are larger, the channel banks may be overtopped each year during freshet (nival runoff) or during rainfall driven runoff events. Given the lack of vegetation and shallow frozen soils, rainfall runoff is rapid, causing sudden pronounced and relatively large increases in flow. If the channel is within a well defined valley, the flooded extent may be modest, but in flat terrain flooding may be extensive or follow low terrain (e.g. ice wedges) into other drainages.
- *Changes in permafrost and frozen soil*. Flooding and higher water levels may affect permafrost and frozen soil conditions proximal to the channel, causing subsidence or slope instability.
- *Fluvial geomorphic change*. Increased flows may cause channel bed scour or bank erosion. Additionally, overbank flows may erode surficial soils. These eroded materials would be deposited downstream where the watercourse meets the diverted channel, larger river or lake.

In order to realize these potential effects, the magnitude of flow change must be sufficient and the channel morphology sensitive to flow changes. Each of the 27 diversion locations were assessed, based on available desktop information, and were screened with consideration of the following:

- *Change in flow.* If the predicted increase in flow in the receiving stream is less 10% (i.e. less than 10% change in contributing catchment area), it is unlikely that measurable changes in channel morphology or flood conditions would be detected. These diversions were rated as low risk.
- *Channel morphology.* For catchments less than 0.5 km^2, mean annual discharge and 2-year peak flow were estimated to be less than 5 l/s and 0.4 m^3/s respectively. In these locations, the channels are small and channel morphology is dominated by ice, frozen soil and non-fluvial processes. If the combined catchment area (baseline plus diverted catchments) is less than 0.5 km^2, it is unlikely that measurable changes in channel morphology or flood conditions would be detected. These diversions were rated as low risk.

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.

Catchment area, MAD and two-year return peak flow (Q2) and length of stream channel with affected flows were estimated for each diverted and receiving stream, as shown in Appendix D. Of the 27 diversions, 23 are considered low risk. The remaining four diversions are considered medium or high risk and are summarized in Table 2.13.

Site specific assessments will be undertaken at these diversions during detailed engineering design of the railway. The assessments will consider fish use and length of impacted channel.

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 having any unexpected effects. Adaptive management can be used to address any 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. Options for mitigation may include:

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

Monitoring and adaptive management will also be conducted, if deemed necessary.

Table 2.13 Summary of Diversions with Medium/High Risk to Geomorphic Change

Diverted Stream(s)	Receiving Stream	% flow increase from Baseline	Fish Bearing at Crossing?
CV-8-0			No
CV-8-1			No
	CV-8-2	194%	No
CV-12-4b			No
CV-12-5			No
	CV-13-1	1648%	No
CV-35-5			No
	CV-35-4	7332%	No
CV-59-4b			No
CV-59-4a			No
	CV-59-4	44%	Probable

2.5.4 Significance of Residual Water Quantity Effects

The assessment of significance of residual effects to water quantity is presented in Table 2.14. The effects are predicted to be not significant. This assessment of significance is based on the forward-referenced commitment to undertake further engineering review and design of mitigation measures as follows:

- Undertake an engineering review at the 124 fish crossings identified in NSC (2018) in which flow velocities are expected to exceed fish passage thresholds, to identify appropriate mitigation measures to reduce flow velocities to levels that maintain fish passage.
- Undertake an engineering review at four (4) streams receiving diverted flow from adjacent streams affected by rock cuts to identify appropriate mitigation measures to minimize erosion and sedimentation and resultant effects to water quality and aquatic life.

Satisfactory completion of the additional study and design of mitigation measures can be verified through submission of an application for an authorization under the *Fisheries Act* to Fisheries and Oceans Canada.

Table 2.14 Significance of Residual Effects to Water Quantity

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)
Water withdrawals along the Northern Transportation Corridor affecting flow in streams and at lake outlets	**Level I:** effect expected to result in a change greater than threshold value(s)	**Level I:** confined to the LSA	**Level II:** intermittent	**Level II:** life of Project	**Level I:** effect reversible	Not Significant	Effect will occur	High
Increased flow velocities at crossings in streams Along the North Railway	**Level I:** effects are expected to be within threshold value	**Level I:** confined to the LSA	**Level III:** continuous	**Level II:** life of Project	**Level I:** effect reversible	Not Significant	Effect will occur	High
Increased flow in streams receiving diverted flows from streams affected by rock cuts along the North Railway	**Level I:** effect is expected to be low magnitude	**Level I:** confined to the LSA	**Level III:** continuous	**Level III:** beyond life of Project	**Level III:** effect is permanent	Not Significant	Effect will occur	High

2.6 MITIGATION AND MONITORING PLAN UPDATES

A key mitigation measure already implemented by Baffinland with respect to water quantity includes updating its design criteria for watercourse crossings with the latest available hydrology data for the Phase 2 Proposal. Though updated peak flow estimates (Appendix B) do not vary significantly from previous estimates, the latest return period flow estimates are being used to size bridges and culverts along the North Railway, and will be used to size new water management facilities, such as stormwater ponds.

Three of Baffinland's existing management plans are relevant to water quantity; proposed additions or revisions to these plans to address the outcome of the water quantity effects assessment for the Phase 2 Proposal are presented in Table 2.15.

Table 2.15 Proposed Management Plan Updates

Management Plan	Required Update for the Phase 2 Proposal
Surface Water, Aquatic Ecosystems, Fish and Fish Habitat 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.

No modifications to the water quantity (hydrology) program are contemplated. Baffinland's long-term hydrometric monitoring program and the stream diversion barrier monitoring program will both continue to be implemented in their current forms.

Baffinland expects that an authorization under the *Fisheries Act* will be required for construction of in-water works associated with the North Railway that are located in fish habitat; this is discussed further by others.

3 – WATER QUALITY

3.1 BACKGROUND

The Project is situated in the Northern Arctic Ecozone with a semi-arid climate and continuous permafrost that is deep, typically in the 400–700 m depth range (KP, 2010). Due to the combination of low temperatures and the low capacity of the soil to hold moisture, vegetation is minimal and surface water is abundant. The region is dotted with thousands of small waterbodies (i.e., lakes, ponds) and watercourses (i.e., rivers, streams). The extremely cold temperatures of the region, combined with the permafrost, result in a short period of surface water runoff that typically occurs from June to September. Most streams freeze completely during the winter months.

Groundwater in the Project area occurs in distinctive shallow and deep systems, with limited connections and interaction between them. The shallow groundwater system occurs in the thin active layer (1 to 2 m) and is considered surface water. The deep groundwater system is isolated by the thick zone of continuous permafrost and is not expected to interact substantively with the Project activities (Baffinland, 2012 and 2013). Taliks likely exist beneath lakes over a certain size, though taliks in the Project area have not been studied because the Approved Project does not involve major interactions with lakes (i.e., such as lake dewatering and/or mining beneath lakes). As with the Approved Project, the Phase 2 Proposal does not meaningfully interact with groundwater. As such, groundwater has not been carried forward in the assessment of water quality.

Article 20 of the Inuit Water Rights of the Nunavut Agreement (Indigenous and Northern Affairs Canada (INAC) and Nunavut Tunngavik, Incorporated (NTI), 2010) formally recognizes the importance of water quality to the Inuit, and Baffinland established a Water Compensation Agreement in 2013 under this article (QIA and Baffinland, 2013). Water quality's formal recognition and well-understood potential interactions between mining projects and water quality provide the basis for selecting water quality as a valued ecosystem component (VEC).

Eleven (11) Project Certificate (PC) conditions (PC conditions 20 to 30) relate to the potential impacts of the Project on groundwater and surface water. There is overlap in the scope of these PC conditions with PC Conditions 16 to 19 for hydrology and hydrogeology. Several of the conditions require the development of management plans. These conditions also overlap with aspects of the Project that are regulated under Baffinland's Type A Water Licence 2AM-MRY-1325 for mining (NWB, 2015) and Type B Water Licence 2BE-MRY1421 for mineral exploration (NWB, 2014).

The Approved Project was assessed for the following effects to water quality:

- **Effluent Discharges -** Mining and stockpiling areas (i.e., the ore and waste rock stockpiles and the open pit) have the potential to introduce adverse quality effluent into natural watercourses, and reduce the water quality therein. Similarly, treated sewage effluent has the potential to add oxygen-consuming material and other contaminants into local watercourses, thereby offsetting the natural ecosystem of these waterbodies. The effects of effluent discharges to relevant watercourses (Camp Lake, Sheardown Lake, and their associated tributaries) were assessed.
- **Deposition of Ore Dust -** Crushing and screening activities at the Mine Site result in the deposition of ore dust, and its subsequent run-off into local waterbodies. The effects of dust deposition on biota in Camp Lake and Sheardown Lake were assessed.

- **Erosion and Sedimentation -** Construction activities including the development of new aggregate sources, as well as ground preparation activities, were assessed for their potential to increase erosion and deposition into waterbodies.
- **Quarries and Rock Cuts -** Construction activities typically involve the establishment of new quarries, and rock cuts. The quarries and rock cuts expose fresh rock surfaces to weathering and oxidation processes. These materials have the potential to leach metals and/or generate acid rock drainage (ARD/ML).
- **Fuel Storage and Handling Facilities -** Accidental releases of fuel have the potential to negatively effect water quality if the spills reach local watercourses.
- **Wastewater Treatment Plants -** Various runoff and wastewater streams will be discharged to the Mary River or its tributaries, all of which have the potential to affect species' health and condition through effects on water and/or sediment quality.
- **Blasting and Chemical Leaching -** 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.
- **Construction and Operation of Camps -** Camp areas may increase erosion rates and sediment runoff.
- **Road Traffic -** Can result in an increase in dust emissions.
- **Rail -** Trains travelling between the mine site and Milne Port will emit products of combustion and have the potential to produce airborne dust from blow-off from the open rail cars.
- **Surface Disturbances -** Typical ground preparation activities include vegetation removal and stripping, resulting in ground surface conditions that are prone to potential erosion and liberation of potential contaminants of concern.

3.2 PROJECT MONITORING

Water and sediment quality monitoring at the Project consists of the following components:

- A Surveillance Network Program (SNP)
- An Aquatic Effects Monitoring Program
- An EEM Program under the Metal and Diamond Mining Effluent Regulations (MDMER); formerly the Metal Mining Effluent Regulations (MMER)

Each of these are described below.

3.2.1 Surveillance Network Program (SNP)

The SNP is a requirement of Baffinland's Type A Water Licence that consists of the following:

- **Mine Effluent Monitoring -** Mine effluent from ore stockpiles and the WRF is sampled and monitored prior to discharge (currently overland flow to a tributary of the Mary River).
- **Sewage Effluent Monitoring -** Treated sewage effluent reporting to the freshwater environment is sampled and tested prior to land discharge, eventually reporting to the Mary River.
- **Local Receiving Waters Monitoring -** Local receiving waters immediately downstream effluent discharges or construction areas are monitored during periods of flow.

SNP sampling is reported to the NWB monthly, and an annual report to the NWB and the QIA presents the results of both monitoring programs. Baffinland has generally been in compliance with the discharge limits specified in its Type A Water Licence, with two exceptions:

- Several instances of high total suspended solids (TSS) runoff from project areas occurred in 2016
- An unauthorized discharge occurred from the WRF stormwater pond in 2017

Immediate corrective action has been undertaken in both instances.

3.2.2 Aquatic Effects Monitoring Program

The AEMP, also established under the Type A Water Licence, monitors various components of the Mine Site aquatic environment (water and sediment quality, benthic invertebrates and fish) within entire waterbodies, including Camp Lake and its Project-affected tributaries, Sheardown Lake and its Project-affected tributaries, and the Mary River / Mary Lake system (Baffinland, 2015a). The AEMP is intended to detect mine-related changes to the Mine Site aquatic environment over time that may result from all Project influences, including effluent discharges, potential sedimentation, and the deposition of ore dust.

The results from the latest (2017) monitoring of water and sediment quality is summarized for each Mine Site lake system in Table 3.1 (Minnow, 2018a).

Table 3.1 Summary of 2017 AEMP Monitoring of Water and Sediment Quality

Lake System	Water Quality	Sediment Quality
Camp Lake	Tributaries: Mine-related effects were apparent, with some elevated metals and other parameters. Quarry QMR2 and fugitive road dust appear to be contributing sources. Copper exceeded AEMP benchmark in north branch of CLT1, which is unaffected by mining. Camp Lake: Shows continuous increases over baseline of conductivity and several metals, all well below WQOs and AEMP benchmarks.	Tributaries: Mine related effects apparent with elevated metals that are below sediment quality guidelines (SQGs). Littoral (near-shore) lake sediment closest to the outflow of CLT1 showed elevated metals, some of which exceed SQGs (Iron, manganese and nickel) and AEMP benchmarks (arsenic, iron, nickel and phosphorus) were above AEMP benchmarks. Camp Lake: Iron and manganese in profundal sediment were above respective SQG but also in Reference Lake, indicating naturally high concentrations of these metals in the study area. Arsenic was above AEMP benchmark in 2017.

Lake System	Water Quality	Sediment Quality
Sheardown Lake	Tributaries: Mine-related effects were apparent only at Sheardown Lake Tributary 1 (SDLT1), where aqueous concentrations of nitrate, sodium, and sulphate were elevated compared to concentrations at reference areas and during applicable baseline studies. Copper exceeded the AEMP benchmarks at SDLT1, but copper concentrations are consistent with baseline concentrations and are likely not mine-related. Sheardown Lake NW: several metals were elevated. Elevated total aluminum and manganese were attributed to backwater influences from the Mary River. Molybdenum and uranium were attributed to a possible mine-related effect, though concentrations were well below applicable WQG and AEMP benchmarks. Sheardown Lake SE: AEMP benchmarks for water quality were consistently met.	Tributaries: Mine-related effects were apparent in SDLT 1 and 12. A number of metals were elevated (aluminum, arsenic, barium, chromium, cobalt, copper, iron, lead, magnesium, manganese, molybdenum, nickel, uranium, and zinc), with iron was above SQG in both SDLT1 and SDLT12. Mine-related sedimentation was observed at these locations. Sheardown Lake NW: sediment iron concentrations appeared to be highest at stations situated closest to the outlets of SDLT1 and SDLT12. Iron concentrations in deposited sediment at SDLT1 and SDLT12 were considerably higher than sediment of Sheardown Lake NW, indicating that these tributaries were a source of iron loadings to the lake. Sheardown Lake SE: AEMP benchmarks for sediment quality were exceeded for iron and manganese for both littoral and profundal habitat stations.
Mary River / Lake	Elevated concentrations of ammonia, nitrate, and sulphate were detected within a tributary of Mary River (MRTF) that receives treated mine effluent.	Mine-related effects on sediment quality only included slight elevation of manganese concentrations at Mary Lake.

Mine-related effects are detected in each lake/river system, though in most cases concentrations of metals are below applicable water quality objectives (WQOs), sediment quality objectives (SQOs), and AEMP benchmarks for either water or sediment as applicable.

Quarry QMR2 and the tote road are influencing water and sediment quality in Camp Lake and its tributaries. Ore dust deposition appears to be influencing tributaries of Sheardown Lake, as well as sediment in Sheardown Lake. The tributary of the Mary River that receives effluent from the WRF pond contained elevated nitrogen compounds but concentrations are well below AEMP benchmarks.

3.2.3 Environmental Effects Monitoring (EEM)

The Mary River Project became subject to the MDMER (previously the MMER) under the *Fisheries Act* on July 10, 2015. Baffinland registered two mine effluent Final Discharge Points with ECCC in accordance with MDMER requirements:

- MS-06 - The outlet of the Mine Site stormwater pond collecting runoff from the crusher pad
- MS-08 - The outlet of the waste rock stormwater pond

The MDMER requires the following monitoring of the volume, chemical characteristics and acute toxicity of mine effluent, along with monitoring of the receiving aquatic environment with respect to water and sediment quality, benthic invertebrates and fish. The EEM Program under the MDMER focuses on the receiving environment downstream of mine effluent discharges, and therefore overlaps with the more comprehensive AEMP. Monitoring and reporting under the MDMER is reported to Environment and Climate Change Canada. Monitoring to date has generally demonstrated compliance with MDMER requirements, with the exception of pH and TSS levels documented in August and September of 2017.

3.3 ASSESSMENT METHODOLOGY

The assessment of water quality effects arising from the Phase 2 Proposal relies on the following:

- Additional dust modelling of the Phase 2 Proposal for the Mine Site and Milne Port; estimates of fugitive dust generated at the Mine Site and Milne Port have been utilized to establish updated estimates of dust accumulation in sediment accumulation in lakes, increase in TSS within rivers, and subsequent increased metal concentrations in waterbodies.
- Hydrology data to estimate flow in waterbodies receiving dust deposition, so that loadings to surface waterbodies may be estimated.
- Geochemistry evaluations of materials representative of quarries and exposed rock cuts, to assess potential impacts of quarrying and rock excavation and backfilling activities on water quality.

The specific methods used to assess water quality are consistent with the FEIS.

3.4 CLIMATE CHANGE CONSIDERATIONS

As indicated in Section 2.4, and described in detail in Baffinland (2017b), 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°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 according to the Intergovernmental Panel on Climate Change (IPCC, 2014).

A climate change assessment completed for the Phase 2 Proposal provides a description of the anticipated permafrost warming. Warmer air temperatures and thawing permafrost have implications on the long-term storage of waste rock on site. Currently, the plan requires Baffinland to encapsulate potentially acid generating (PAG) waste rock in permafrost by capping the final WRF with non-acid generating materials. This is described in the FEIS (Baffinland, 2012) and the Life of Mine Waste Rock Management Plan (Baffinland, 2014a). The proposed non-acid generating waste rock cap will be sufficiently thick (50 m) to ensure the active layer will remain within the non-acid generating material, and accounts for predicted increases in the active layer thickness due to long-term climate warming.

With respect to an increase in the mean precipitation to the Project area, an increase in precipitation may result in greater surface runoff, and larger discharge volumes within creeks and rivers, especially during the freshet period. An increase in precipitation, along with melting of thaw-sensitive permafrost soils, may result in increased erosion and sediment loadings in streams. Conversely, higher flows could provide for slightly higher dilution rates for Project discharges.

3.5 EFFECTS ASSESSMENT

The following Potential interactions of the Phase 2 Proposal with water quality are identified in Table 3.2.

Table 3.2 Phase 2 Proposal Interactions with Water Quality

Project Infrastructure or Activity	Level of Interaction
Mine Site	
Minor changes to site drainage	1
Expansion of crusher pad, installation of rail loading facilities; expanded settling pond	1
Tote Road	
Replace Tote Road culverts downstream of select North Railway crossings that will receive diverted flows from other streams	1
Short-term traffic increase associated with increased ore haulage by truck and temporary ore transfer area, and traffic supporting rail construction	1
North Railway	
Prepare site area and construct access trail	1
Quarry, crush, screen, haul and place aggregate	2
Construct permanent culvert and bridge crossings, relocate existing culvert crossings due to minor Tote Road realignments	1
Operate temporary ore transfer area including ore stockpiles and settling ponds	2
Transport 12 Mtpa of ore over the railway	1

NOTES:

1. INTERACTIONS ARE RATED AS FOLLOWS:
   0 - NO INTERACTION.
   1 - MINOR INTERACTION POST-MITIGATION, DISCUSSION ASSESSMENT.
   2 - MAJOR INTERACTION SUBJECT TO DETAILED ASSESSMENT.

Table 3.3 presents the effects pathways and nature of the effects to water quality at each project site. These effects pathways are discussed further below.

Table 3.3 Incremental Effects to Water Quality Due to the Phase 2 Proposal

Effect Pathway	Milne Port	Northern Transportation Corridor	Mine Site
Mine effluent discharges to local surface waters	No change; mine effluent will continue to be discharged to the marine environment.	A stormwater pond at the temporary ore transfer area over a 1 to 2 year period; effluent to be used for dust suppression.	A larger ore stockpile area will result in a greater volume of mine effluent to Mary River.
Ore dust deposition and sedimentation effects to water quality	Earthworks during construction; increases in dust deposition due to increased ore stockpiling and traffic.	Increased dust generation due to construction activities, increased traffic and temporary ore transfer activities.	Decreased dust generation due to relocation of secondary crushing and screening. Increases in ore extraction,
Effects of quarries and rock cuts to water quality	Additional quarries and rock cuts	Additional quarries and rock cuts	Additional quarries and rock cuts

3.5.1 Mine Effluent Discharges

Runoff from ore stockpiles, the WRF and the active mining area is collected and discharged to local watercourses in accordance with the discharge limits in the Type A Water Licence and the MDMER. Potential effects of these discharges on local receiving waters at the Mine Site were assessed in the FEIS (Volume 7, Section 3).

Mine effluent discharges associated with the Approved Project include the SNP Stations listed in Table 3.4. The Phase 2 Proposal will involve replacing the current crusher pad stormwater pond at the Mine Site with a new pond sized appropriate to the new 12 Mtpa North Rail crusher pad; the final discharge location to the Mary River, however, will not change. In addition, five new stormwater ponds will be constructed (Table 3.4). The effluent will either discharge to the ocean via approved final discharge points, or will be applied to roads as part of dust suppression efforts. Each of these discharges must meet the effluent quality limits in Table 10 (Part F, Item 25) of the Type A Water Licence.

Other SNP stations listed in Schedule I of the Water Licence that are not listed in Table 3.4 are related to historic ore stockpiles associated with the 2007-2008 bulk sample program that have been removed and are no longer applicable.

Unrelated to the Phase 2 Proposal, non-compliant discharges occurred in 2017 from the existing WRF stormwater pond (final discharge point MS-08). These non-compliant discharges were reported to the NT-NU Spill Line (Spill Reports 17-289, 17-312, 17-328 and 17-361). The pH of the effluent dropped below the mine effluent MDMER and Type A Water Licence discharge limits, possibly due to the unexpected onset of weakly acidic conditions in the WRF. Batch treatment in the pond using sodium carbonate was undertaken in August 2017, and an Interim Waste Rock Management Plan was prepared (Golder, 2018a). A modification request has been submitted to the NWB to upgrade the WRF pond in 2018 to address seepage and expand its capacity.

Table 3.4 Proposed Changes to Existing Mine Effluent Discharges

SNP Station	Description	Status and Proposed Changes for Phase 2 Proposal
Mine Site		
MS-06	Ore stockpile (crusher pad) pond stormwater	Operational; new stormwater pond will replace new pond, with no changes to final discharge point
MS-07	Run of Mine (ROM) Ore Stockpile Pond Stormwater	Not yet constructed; no changes proposed
MS-08	Waste Rock Stockpile West Pond	Operational, but discharges to the Mary River as the east pond intended
MS-09	Waste Rock Stockpile East Pond	Not yet constructed; no changes proposed
Milne Port		
MP-05	Milne Port Ore Stockpile Sedimentation Pond - East (Stormwater Pond No. 2)	Operational; a second adjacent pond will be constructed
MP-06	Milne Port Ore Stockpile Sedimentation Pond – West (Stormwater Pond No. 1)	Operational; a second adjacent pond will be constructed in 2018 as part of ongoing operations under a separate modification to the current water Licence 2AM-MRY-1325.
(new)	Stormwater Pond No. 3	Ore fines stockpile runoff. Final discharge will be to Milne Inlet via Stormwater Ponds 1/1a or 2/2a, or for use in dust suppression on roads.
(new)	Stormwater Pond No.4	Crusher feed stockpile runoff. Final discharge will be to Milne Inlet via Stormwater Ponds 1/1a or 2/2a, or for use in dust suppression on roads.
(new)	Lump ore stockpile perimeter ditching East	Lump ore stockpile runoff on the east perimeter. Final discharge will be Milne Inlet by pumping.
(new)	Lump ore stockpile perimeter ditching West	Lump ore stockpile runoff on the west perimeter. Final discharge will be Milne Inlet by pumping.
Northern Transportation Corridor		
(new)	Temporary Ore Transfer Area Stormwater Pond	Temporary ore transfer area runoff, for 1 to 2 years during rail construction/commissioning. Final discharge will be to use the effluent for dust suppression on Tote Road. Pond will operate for 1-2 years during rail construction/commissioning.

A further revised Waste Rock Management Plan is under preparation to address waste rock management over the next five years and recent waste rock geochemistry and WRF pond monitoring results. Because no changes to waste rock management are required to undertake the Phase 2 Proposal and this work is ongoing as part of current operations, it is not assessed herein.

Mine effluent discharges associated with the Phase 2 Proposal are described and assessed below.

3.5.1.1 MS-06 - Ore Stockpile Pond Stormwater – Increased Pond Size

The surface area of the mine site ore stockpile area will increase by approximately 40% to support the Phase 2 Proposal. Hence, the quantity of runoff from the stockpile and crusher pad area will increase by approximately the same proportion. Runoff from the ore crusher pad area is discharged to the Mary River. The FEIS presented a mass balance water quality model that estimated the mixed water quality of the Mary River after receiving effluent discharges from this source as well as the ROM stockpile and east WRF stormwater pond (FEIS Volume 7, Section 3.4.2.2). The quality and quantity of the mine effluent from this source is evaluated briefly below to determine if the increased flows/loading into the Mary River will represent a material change relative to the water quality modelling presented in the FEIS.

Table 3.5 presents the source terms for ore stockpile runoff used in the FEIS water quality modelling, and compares these values to monitoring undertaken in 2016 and 2017 as part of the SNP monitoring program (Baffinland, 2017b and 2018a). The 2008 lysimeter data was from a stockpile of manganese-rich ore. For most parameters for which there is a corresponding water quality objective (WQO) for the protection of aquatic life, the mean value of two years of monitoring (2016 and 2017) is at or below the mean lysimeter data from 2008 that was adopted as the source term values in FEIS water quality modelling (FEIS Volume 7, Section 3). Exceptions include aluminum, iron, mercury, for which the mean effluent quality in 2016/2017 is still less than the 90th percentile value applied in the water quality model. The 2016/2017 mean effluent quality value for uranium (0.0020 mg/L) exceeded the 90th percentile source term in the FEIS water quality model (0.0010 mg/L). The conclusion of this review is that the previous modelling was substantially representative of the effluent quality monitoring conducted at site to date.

The annual volume of water generated from the FEIS ore stockpile under mean flow conditions is 143,489 m^3, which represents 0.17% of the mean annual flow volume in the Mary River upstream of the point of discharge. The surface area of the crusher pad will increase by approximately 40% to support the 12 Mtpa North Railway operation, relative to the 18 Mtpa Approved Project. The crusher pad stormwater runoff volume will consequently represent 0.24% of the mean annual flow volume in the Mary River. Given that the effluent quality is better or consistent with the source terms used in the FEIS water quality model, and the increase in volume represents a negligible (0.24% minus 0.17% equals 0.07%) increase relative to the mean flows of the Mary River, the incremental increase in annual stormwater runoff associated with the Phase 2 Proposal will not result in adverse impacts to downstream water quality in the Mary River.

3.5.1.2 MS-08 and MS-09 - WRF West Pond

The Phase 2 Proposal does not involve changes to the mine plan or waste rock management plan. As such, no modification to the MS-08 mine effluent discharge from the WRF stormwater pond will occur as a result of the Phase 2 Proposal.

Table 3.5 Comparison of Monitoring Results to FEIS Ore Stockpile Runoff Source Terms

Parameter	Effluent Quality Discharge Limits (Water Licence Table 10)	2008 Source Terms Mean Lysimeter Data (*n = 4*)	2016/2017 Mean Effluent Quality (*n = 8*)
pH		7.7	7.6
Total Suspended Solids	15	-	12.2
Aluminum		0.044	0.29
Arsenic	0.50	0.00063	0.00013
Beryllium		0.0031	0.00010
Boron		0.21	0.030
Cadmium		0.00027	0.000034
Chromium		0.0031	0.00051
Copper	0.30	0.0023	0.0017
Iron		0.24	0.51
Lead	0.20	0.00054	0.00075
Manganese		54.4	0.78
Mercury		0.000014	0.000023
Molybdenum		0.00049	0.0018
Nickel	0.50	0.088	0.0057
Selenium		0.0069	0.00061
Silver		0.000063	0.000050
Thallium		0.00063	0.000028
Uranium		0.000081	0.0020
Vanadium		0.0063	0.00050
Zinc	0.50	0.013	0.0035

NOTES:
1. METALS PARAMETERS ARE TOTAL METALS; RESULTS IN MG/L.

3.5.1.3 MP-05 and MP-06 - Milne Port Mine Effluent Stormwater

The volume of stormwater generated from ore stockpiles at the port will increase as noted in Table 3.4. Mine effluent discharges at Milne Port will continue to be discharged to the marine environment; this is assessed in TSD-17 (Golder, 2018b).

3.5.1.4 MS-07 - Run of Mine Ore Stockpile Stormwater

The ROM stockpile has not yet been constructed, and no changes to the stockpile are proposed as part of the Phase 2 Proposal.

3.5.1.5 New Stormwater Pond at Temporary Ore Transfer Area

The temporary ore transfer area at km 57 of the North Railway will operate for 1 to 2 years during rail construction. Runoff from the ore stockpiles at this facility will be directed to a settling pond. The volume of water collected by this pond is small; less than 1,000 m^3 under mean annual flow conditions.

Effluent collected in this pond will be sampled to ensure it meets discharge criteria before applying the water to the Tote Road as part of dust suppression efforts. Dispersion of this effluent, meeting discharge criteria, over a large surface area for one to two summer periods is not expected to have an effect on local surface waters.

3.5.2 Dust Deposition and Sedimentation Effects

A portion of dust emissions falling on land can be transported by surface runoff into nearby waters, thereby potentially increasing TSS and metals concentrations in water and sediment. Resultant changes in water and sediment are a potential concern to freshwater biota through increased TSS and metals concentrations, and sedimentation of fish habitat, including incubating fish eggs. The following effects pathways for water and sediment quality were assessed for the Approved Project:

- Increased TSS in local waterbodies from sedimentation and the runoff of deposited dust
- Increased metals concentrations in water and sediment arising from increased TSS
- Increased sediment accumulation in Mine Site Lakes

The Phase 2 Proposal will involve the following changes with respect to the generation of ore dust and consequent potential effects on water and sediment quality:

- **Mine Site -** The production rate will increase from 22.2 Mtpa to 30 Mtpa. Secondary crushing, however, will be relocated to Milne Port and indoors. The net result a reduction in particulate matter emission and dust deposition rates compared to the Approved Project. Effects of dust deposition to water quality will also be reduced (Sections 3.5.2.1 to 3.5.2.4).
- **Milne Port -** The quantity of ore delivered to Milne Port, stockpiled, and loaded into ore carriers will increase to 12 Mtpa. Secondary crushing will be relocated from the Mine Site to indoors in a crusher building. Particulate matter emissions and dust deposition rates will increase, resulting in increased TSS loading to Phillips Creek (Section 3.5.2.6).
- **Northern Transportation Corridor -** Substantial dust is generated by truck traffic along the Tote Road. Most of the dust is generated by the entrainment of dust particles by truck tires, with little generated by wind-blown dust or losses of ore from the ore truck haul boxes (Golder, 2016a). Dust emissions will increase considerably over the short-term (i.e., construction phase) when: (1) truck haulage of ore will temporarily increase; (2) a temporary ore transfer area will be operated at approximately km 57 for 1 to 2 years; and (3) construction of the railway will be underway and will involve quarrying (drilling and blasting), crushing and screening of aggregate, and transport of aggregate and other materials for placement at work fronts. 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 (Section 3.5.2.5).

Sedimentation may occur because of earthworks including in-water works during construction, and due to erosion and mass wasting following construction. The Phase 2 Proposal will introduce a second construction phase.

Effects of sedimentation and dust deposition on water and sediment quality at the Mine Site and Milne Port are assessed below.

3.5.2.1 Comparison of Dust Deposition Rates from the Phase 2 Proposal to the Approved Project

As described in Section 1.1, the Phase 2 Proposal will involve an increase in the production rate at the Mine Site from the current 4.2 Mtpa to 12 Mtpa and eventually to 30 Mtpa. The maximum production rate of the Approved Project is 22.2 Mtpa. Although the total amount of ore to be mined in Deposit No. 1 will not change, the rate of extraction will increase even beyond the maximum production rate of the Approved Project. An increase in fugitive dust can be expected as the production rate increases. However, the Phase 2 Proposal also involves relocation of secondary crushing and screening from the Mine Site to an indoor facility at Milne Port.

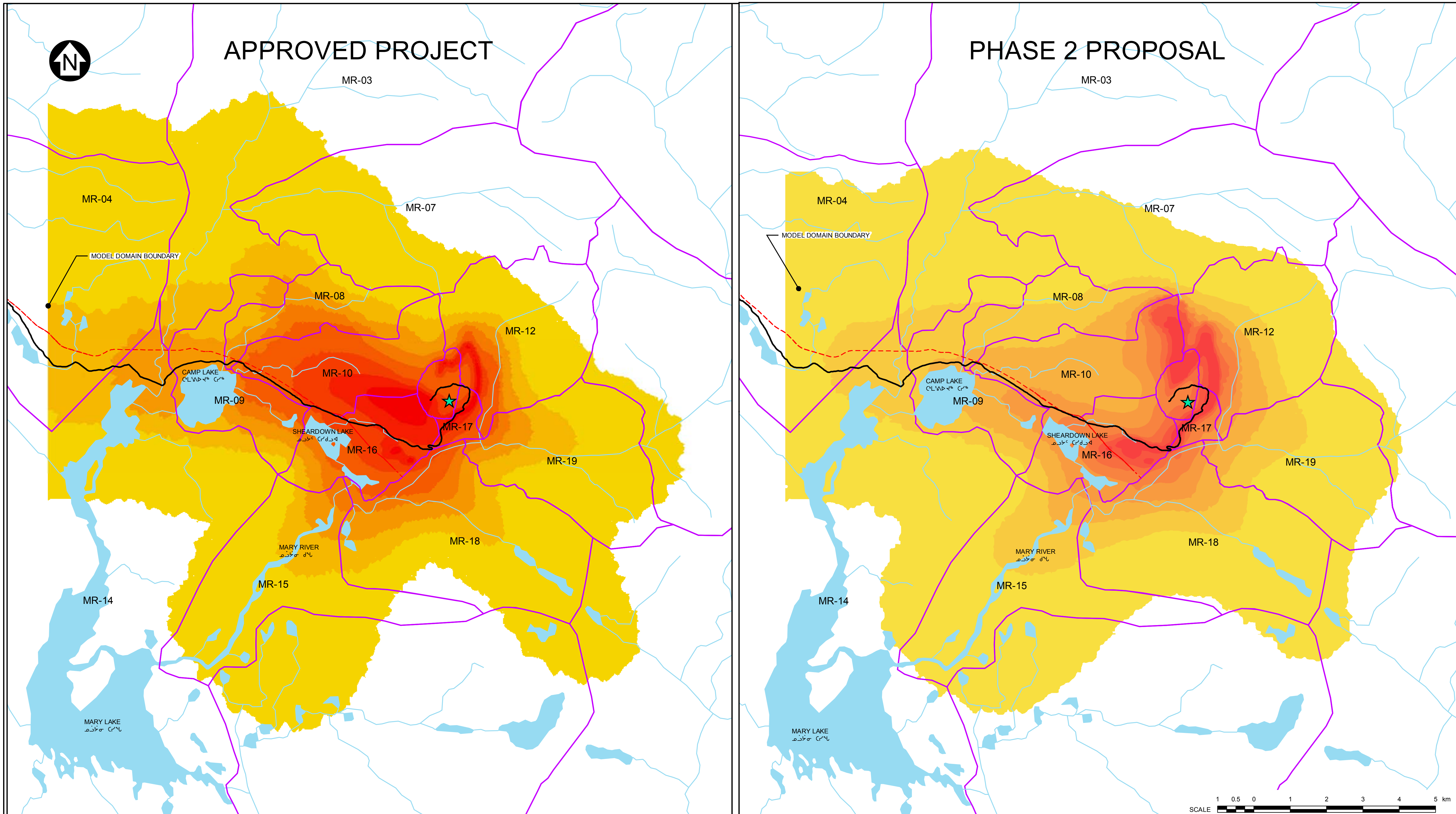
To establish the net effect of these changes on dust generation at the Mine Site, updated air quality dispersion modelling was undertaken based on the plans for the Phase 2 Proposal (RWDI AIR Inc., 2018a,b).

Figure 3.1 compares the contour plots for annual dust deposition completed for the Approved Project (based on the annual production rate of 21.5 Mtpa assessed in the FEIS Addendum; Baffinland, 2013) to that of the 30 Mtpa production rate associated with the Phase 2 Proposal (RWDI AIR Inc., 2018a). A meaningful reduction in the annual dust deposition rate is apparent from the comparison of contour plots. In terms of total suspended particulate (TSP) emissions, the increased emissions expected with the higher production rate of the Phase 2 Proposal is more than offset by the reduction in TSP emissions that will result from moving secondary crushing and screening to Milne Port.

As indicated in Section 3.1, the concern with ore dust generation is the effect to freshwater biota within local waterbodies. Both Sheardown Lake and Camp Lake are located near to the Mine Site, and are expected to be most influenced by dust generated at the mine. To illustrate the estimated changes in annual dust deposition rates of the Phase 2 Proposal as compared to the FEIS, dust deposition rates and sediment loading within the catchments of both Camp Lake and Sheardown Lake was quantified.

Relative to the Approved Project, the annual TSP deposition within the contributing catchments of Camp Lake and Sheardown Lake will be reduced by an estimated 31% and 25%, respectively, with the implementation of the Phase 2 Proposal. The annual TSP deposition rates used for the Phase 2 Proposal are based on air quality modelling of the highest production year of 30 Mtpa.

The reduction in dust deposition within the immediate Mine Site area will result in a corresponding reduction in the quantity of ore dust that is potentially available to runoff into local watercourses.



LEGEND :

- PROJECT FACILITY LOCATION
- MILNE INLET TOTE ROAD
- PROPOSED NORTH RAILWAY
- CATCHMENT BOUNDARY

ANNUAL DUST DEPOSITION (g/m ^{2}/year)

- <2
- 2 - 7.5
- 7.5 - 15
- 15 - 30
- 30 - 55
- 55 - 120
- 120 - 240
- 240 - 480
- > 480

NOTES :

1. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA DEPARTMENT OF NATURAL RESOURCES (2009). ALL RIGHTS RESERVED.
2. ANNUAL DUST DEPOSITION CONTOURS PROVIDED BY RWDI AIR INC. (APRIL 16, 2013). THRESHOLD = 60 µg/m³.

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
1	10JUL'18	CHANGED HEADING TITLES ON FIGURES	RAC	SBF	RAC
0	20JUN'18	ISSUED WITH REPORT	RAC	RF	RAC

SAVED: I:\1102\0018\1139\A\GIS\Figs\B49_r1 - air quality modelling.mxd; Jul 13, 2018 11:25 AM; sfoster

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

AIR QUALITY MODELLING
MINE SITE DUST DEPOSITION RATES

Baffinland

P/A NO.	REF NO.	REV
NB102-181/39	8	1

FIGURE 3.1

3.5.2.2 Sediment Releases to Mine Site Streams and Lakes

The following are considered potential activities or sources that have the ability to increase sediment releases at the Mine Site as a result of implementing the Phase 2 Proposal:

- **Fugitive Dust -** The mine production rate will increase from 22.2 Mtpa to 30 Mtpa, which would be expected to increase the quantity of fugitive dust being released within the Mine Site area. As presented on Section 3.5.2.1, dust emission rates associated with the Phase 2 Proposal are predicted to decrease relative to the estimated emissions of the Approved Project (KP, 2018a; RWDI, 2018a,b; Baffinland, 2012 and 2013). This decrease in modelled emissions is due in large part to the relocation of the secondary crushing at the Mine site to Milne Port and indoors.
- **Additional Sources of Sediment-laden Water -** The Phase 2 Proposal may temporarily introduce new sources of sedimentation at the Mine Site due to construction activities associated with the Phase 2 Proposal (new crusher pad, storm water ponds, railway within mine site area). The Mine Site also currently has ongoing sedimentation issues with cut-slope instability, low quality fills, and sediment contaminated snow. These sedimentation sources are currently being mitigated through ongoing remedial work including the implementation of Baffinland's Sedimentation Mitigation Action Plan (Golder, 2016b) and the Tote Road Earthworks Execution Plan and Design Report (TREEP; Golder, 2017). Baffinland's Surface Water and Aquatic Ecosystems Management Plan (Baffinland, 2016a) describes the standard mitigation measures implemented at the site.

Both dustfall and erosion and sedimentation are potential contributing sources of total suspended solids (TSS) in waterbodies within the Mine Site. Baffinland's experience with the ERP has brought a better understanding of the contributing factors to sedimentation at the Project, and hence the effects to water and sediment quality that are likely to arise from the Phase 2 Proposal. Unauthorized releases of sediment into local watercourses occurred the 2016 freshet, which resulted in additional study and the implementation of remedial measures to reduce the potential for additional sediment releases.

On May 7, 2016, a snowmelt event resulted in the release of runoff containing sediments and discoloured water entering two tributaries of Sheardown Lake (Baffinland, 2016b). Baffinland self-reported this unauthorized release of sediment to ECCC, INAC, and the NT-NU Spill Line (Spill #16-158). The source of the sediment was dirty snow located downwind of the crusher pad. Baffinland responded to the event by installing check dams and silt fences downstream of the crusher pad, and deploying flocculent and treated jute to settle solids prior to discharge. Daily monitoring of water quality and flow was undertaken, including aquatic toxicity testing which was non-lethal (Baffinland, 2016c).

The release of ore dust sediment laden water along with general erosion and sedimentation issues that occurred in early June of the same year along the haul road and Tote Road prompted ECCC to issue Baffinland a Directive under the Section 38 (7.1) of the *Fisheries Act* (ECCC, 2016). INAC also issued a Letter of Non-Compliance to Baffinland on June 16, 2017 (INAC, 2016). The Directive outlined measures to be taken to protect fish and fish habitat, all of which were completed by Baffinland within the specified deadlines. Baffinland submitted a report detailing the completion of the measures assigned by ECCC (Baffinland, 2016d), and thereby fulfilling the requirements of the Directive. Additional information is provided in Baffinland's 2016 and 2017 annual reports to the QIA and the NWB (Baffinland, 2017b; 2018a).

An outcome of this was to develop and implement the following action plans:

- Dust Mitigation Action Plan (Golder Association Ltd. (Golder), 2016a)
- Sedimentation Mitigation Action Plan (Golder, 2016b)
- Tote Road Earthworks Execution Plan (TREEP; Golder, 2017)

Additionally, the Snow Management Plan (Baffinland, 2018b) was revised with a focus on improving the locations of snow dumps and stockpiles to prevent any future spill associated with snowmelt.

The main mechanism for dust generation at the Mine Site (haul road, crusher, and associated facilities) includes wheel entrainment and wind-blown dust; however, dust generation is considered to be the least likely mechanism to lead to inappropriate levels of TSS within water bodies (Golder, 2016a). The primary sources of sediment water runoff at the Mine Site into local watercourses across the Project are identified in Baffinland's Sedimentation Mitigation Action Plan (Golder, 2016b) as follows:

- Site wide:
    - o Sediment-contaminated snow melt; snow management practices have resulted in sediment-laden meltwater from snow clearing activities
- At the crusher area:
    - o Sediment-contaminated snow from wind-blown dust generated during ore and aggregate crushing and loading
- On roads (mine haul road and tote road):
    - o Sediment from low quality fills used in previous road embankment construction are prone to erosion
    - o Cut-slope instability resulting from permafrost degradation; ice-rich permafrost and fine-grained soils, upon thawing, result in sediment-laden flows to ditches, culverts, the road surface, and directly to the receiving environment
- Other site-specific sources of sediment

To assess the relationship of mining activity to sedimentation near the Mine Site, KP reviewed TSS monitoring data and dustfall data from the period of 2013 to 2017 from monitoring stations closest to the main sources of activity with the highest levels of dustfall at the Mine Site. Figure 3.2 shows the location of several surface water and dustfall monitoring locations across the Mine Site. Figure 3.3 presents a graphic summary of the TSS measurements from four key Surveillance Network Program (SNP) monitoring locations: MS-C-C, MS-C-D, MS-C-E, MS-C-F, and two recently established freshet monitoring stations measuring sediment discharge into Sheardown Lake NW: SDLT-OUT, and LDFG-OUT. Figure 3.3 also presents annual dustfall results for four Mine Site dustfall monitoring stations (DF-M-01 to DF-M-03 and DF-M-07) over the same period of 2013 to 2017.

SNP stations MS-C-D and MS-C-E are located on the same non-fish bearing stream that drains to Sheardown Lake Tributary, the main surface drainage near to the existing ore crusher pad (Figure 3.2). In May 2016, two rock check dams were installed along this drainage feature to reduce sediment loading into this tributary. SNP station MS-C-C is located in a small contributing drainage upstream of MS-C-D.

LEGEND:

- WATER QUALITY SAMPLE LOCATION
- CULVERT LOCATION
- DUSTFALL MONITORING SITE
- FLOW DIRECTION

NOTES:

1. COORDINATE GRID IS UTM NAD83 ZONE 17N.
2. PLAN BASED ON INFORMATION PROVIDED BY HATCH, DATED (JAN 13, 2015).
3. IMAGERY BASED ON INFORMATION PROVIDED BY BAFFINLAND IRON MINES CORPORATION, DATED AUGUST 2016.
4. CHECK DAMS #1 AND # 2 WERE CONSTRUCTED IN 2016.

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

FRESHET MONITORING LOCATIONS AT THE MINE SITE

Knight Piésold CONSULTING

P/A NO.	REF NO.
NB102-181/39	8

FIGURE 3.2 REV 0

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
0	10JUL'18	ISSUED WITH TRANSMITTAL	AV	CJV	RAC

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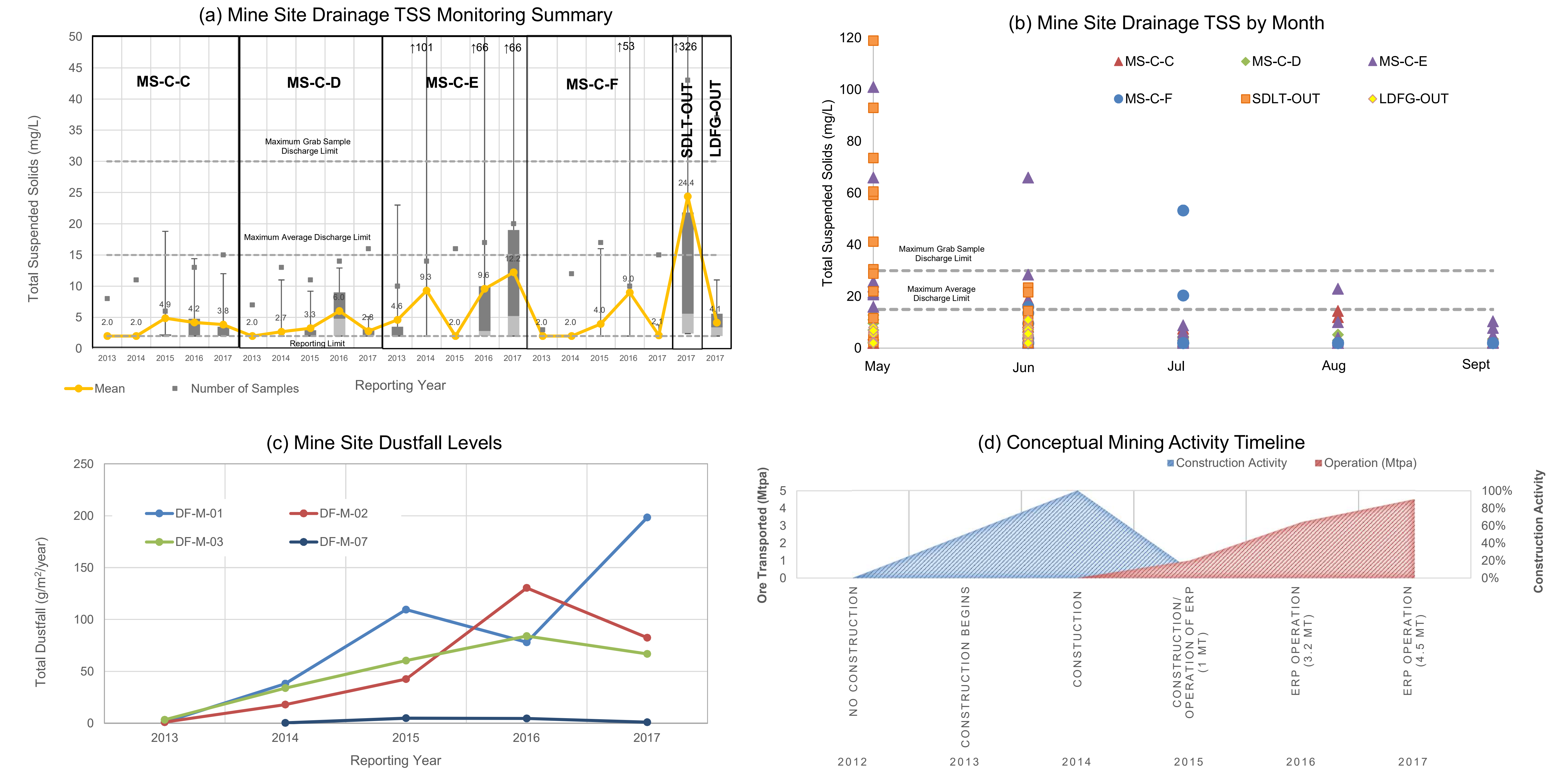

NOTES:

1. NON-DETECT TSS DATA (<2 mg/l) USES DETECTION LIMIT (2 mg/L) FOR STATISTICS.
2. MINE SITE DUSTFALL MONITORING STATIONS DF-M-4, 5, 6, 8 AND 9 OMITTED DUE TO DISTANCE FROM MINE SITE

0	10JULY'18	ISSUED WITH REPORT	SBF	RAC
REV	DATE	DESCRIPTION	PREP'D	RVW'D

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

MINE SITE DRAINAGE TSS AND DUSTFALL MONITORING SUMMARY

Knight Piésold CONSULTING

P/A NO. NB102-181/39 | REF. NO. 8

FIGURE 3.3 | REV 0

SNP Station MS-C-F is at a small pond located behind the mine services buildings north of the ore crusher pad. Dustfall stations DF-M-01 is located at the exploration camp and near to the airstrip. DF-M-02 is closest to the ore crusher pad, approximately 700 m to the south. DF-M-03 is located approximately 1.2 km east of the crusher pad and less than 200 m south of the mine haul road. Dustfall station DF-M-07 is located to the east and beyond the main dust deposition area.

TSS sample data (grab sample results) are being presented using simple box plot statistics (chart a) (quartiles, median, mean, and maximum values) indicating yearly trends for each TSS monitoring station. TSS sample data is also being presented as a scatter plot (chart b) to represent seasonal TSS concentrations. The majority of TSS results are found to be less than the reporting limit of 2 milligrams per litre (mg/L). For sample results that are below the reporting limit, statistical analysis used the reporting limit value (2 mg/L).

As indicated on Figure 3.3 (a), the data suggests that there has been an overall increasing trend in TSS in mine site drainages and dustfall over the periods of construction (2013-2014), early operations (2015), and full mine production (2016-2017) (Figure 3.3 (d)). The data also indicates a reduction in both TSS and dustfall from 2016 to 2017, with the exception of SNP station MS-C-E and dustfall monitoring location DF-M-01 (exploration camp and airstrip). The reduction in TSS and dustfall is likely due to improved mitigation measures, which have included improved dust mitigation and snow management. Climatic factors likely also influence monitoring results: wet years may result in greater erosion where low qualify fills or permafrost degradation exist; dry years may result in greater dust emissions. Mean TSS concentrations are lowest at SNP station MS-C-C and freshet monitoring station LDFG-OUT, both located closest to the ore crusher pad and highest at the stations closest to the road (SNP station MS-C-E and freshet monitoring station SDLT-OUT. This suggests that dust deposition is not the main contributor to TSS in local streams at the Mine Site.

The high TSS concentrations at SNP station MS-C-E and freshet station SDLT-OUT and are suspected to be influenced by loading effects from vehicle traffic, and mass wasting at or near culverts CV186 and CV187 (which were replaced in 2017 as part of prioritized work identified in the TREEP).

Figure 3.3 (b) indicates that the majority of TSS exceedances (concentrations above maximum discharge limits) occur during freshet (May and June). In fact, most of the elevated TSS concentrations are in May when snow is melting but the ground is still frozen. Our evaluation agrees with Golder's assessment (Golder, 2016a,b) that sediment-contaminated snowmelt and mass-wasting related sediment transport are the major contributors to TSS in surface water near the Mine Site. Mass wasting does occur as a natural process in the area, particularly in areas with silty and ice-rich soils.

The sources of dust deposition and sedimentation associated with the Phase 2 Proposal are identified at the beginning of Section 3.5.2. Dust deposition at the Mine Site will likely increase over the short-term with construction and a higher level of mine production and ore haulage by truck. Monitoring to date suggests that wheel entrainment of dust is the largest contributor to dust deposition, and also that dust deposition is not a significant contributor to TSS in local watercourses. Therefore, increased dust deposition during the construction phase is not predicted to contribute to a meaningful increase in TSS concentrations in local watercourses.

Earthworks activities at the Mine Site during the construction phase will be relatively limited. The new crusher pad, stormwater pond and discharge pipeline will be constructed. Railway construction and Tote Road realignments will occur within the Mine Site area, and this is assessed in Section 3.5.2.5.

It will be necessary to continue to implement improved snow clearing practices at the Mine Site to minimize the uptake of sediment for later release as meltwater. Implementation of Baffinland's dust and sedimentation action plans and the earthworks execution plan will continue to further reduce sediment releases to local watercourses, independent of the Phase 2 Proposal. Baffinland's Surface Water and Aquatic Ecosystems Management Plan (Baffinland, 2016a) describes the standard mitigation measures implemented at the site. This management plan will be updated by the end of 2018 to address the freshet monitoring programs that have been underway the past couple of years.

During the operation phase, dust deposition at the Mine Site is expected to be reduced compared to the Approved Project, as described in Section 3.5.2.1. The risk of TSS entering local watercourses during the operation phase due to additional infrastructure and activities associated with the Phase 2 Proposal should be low. As mentioned above, current sedimentation issues will be managed through implementation of existing action, execution and management plans.

3.5.2.3 Sediment Accumulation in Mine Site Lakes

The FEIS assessed the potential for increased sediment deposition in Mine Site lakes. Significant dust emissions may result in accumulations of dust that can has the potential to affect salmonid egg hatch success. A threshold of 1 mm of sediment deposition for effects on salmonid egg hatch success was identified in the FEIS Volume 7, Section 4.5.1 (Fudge and Bodaly, 1984). The FEIS calculated the annual thickness of sediment from airborne emissions under a worst-case scenario. The estimated thickness of annual sediment accumulation was estimated to be 0.54 mm and 0.24 mm in Sheardown Lake and Camp Lake, respectively (FEIS Volume 7, Section 4.5.5.1). The estimated thickness of annual sediment accumulation associated with the Phase 2 Proposal was estimated using updated air quality modelling results and using the methodology used in the FEIS. The annual sediment accumulation in Sheardown Lake and Camp Lake due to the Phase 2 Proposal is estimated to be 0.4 mm and 0.2 mm, respectively. This is a reduction compared to the estimate for the Approved Project mentioned above.

Under the assumption that most of the sediment accumulating in the Mine area lakes is ore dust, a dry bulk density for the ore was applied in calculating the deposition thicknesses referred to above for the Approved Project and Phase 2 Proposal. This is likely an overestimate of the actual dry bulk density of sediment in the Mine Site lakes, which would underestimate the sediment accumulation thickness. This is offset, however, by highly conservative assumptions applied in relating the maximum amount of annual dust deposition based on contour plots to the amount of sediment that would report to the Mine Site lakes (i.e., all dust falling within a given lake catchment reporting to that lake). From the analysis provided in Section 3.5.2.2, it is understood that the meltwater of sediment entrained snow and mass wasting are significant contributors of TSS in local watercourses and therefore sedimentation in lakes, and that dust deposition plays a comparatively minor role.

Lake sedimentation monitoring in Sheardown Lake NW is a component of the Aquatic Effects Monitoring Plan (NSC, 2014 in Baffinland, 2015a). Sediment accumulation in Sheardown Lake NW has been measured over the periods of 2013-2014 (baseline), 2014-2015 (early operations), and 2015-2016 (current operations) (NSC, 2014; Minnow Environmental Inc. (Minnow), 2016; 2017b and 2018b). The following is a summary of the annualized sedimentation rates:

- 2013-2014 Baseline Period - 14.3 to 21.2 $mg/cm^2/year$
- 2014-2015 Early Operations - 15.5 to 24.5 $mg/cm^2/year$

- 2015-2016 Current Operations - 27.1 to 39.5 mg/cm^2/year
- 2016-2017 Current Operations - 26.9 to 44.7 mg/cm^2/year

The results of the sediment accumulation in Sheardown Lake NW indicates a degree of influence from mine activities, with an approximate doubling in the sediment rates between 2013-2014 (pre-mining) and 2016-2017 (mining).

Despite the increase over time, the annual rates measured in Sheardown Lake NW remain within the range of those observed at other Canadian Arctic lakes (i.e., 7 to 50 mg/cm^2/year; Lockhart et al. 1998) and much lower than at proglacial lakes in south-east Greenland (i.e., mean of 790 mg/cm^2/year; Hasholt et al. 2000).

To convert the measured sedimentation rates to an annual sediment accumulation thickness, Minnow (2016 and 2017b) initially used a dry bulk density assumption derived from sediment accumulations in pristine lakes in northern Ontario during the summer period. The calculated sedimentation thicknesses in some sediment traps in Sheardown Lake NW, based on the Ontario bulk dry density value, exceeded the 1 mm threshold. However, because a relatively high abundance of healthy Arctic char young of year (YOY) was observed at Sheardown Lake NW each year since 2015, Minnow (2018b) concluded that the derived accumulation thicknesses based on bulk density data from temperate latitudes likely overestimates the actual sediment accumulations for Sheardown Lake NW. This is a reasonable conclusion since summer period biological productivity in northern Ontario lakes is higher than Arctic lakes, and a higher proportion of organic materials will accumulate in the sediment. The dry bulk density of sediment in northern Ontario lakes would therefore typically be lower than the dry bulk density of sediment in Arctic lakes.

A site-specific dry bulk density measurement of sediment from Sheardown Lake NW will allow sedimentation rates to be accurately correlated to a sediment accumulation thickness. The sediment traps are not deployed for sufficient duration to collect an adequate sediment sample to measure its dry bulk density. In 2018, Baffinland intends to obtain sufficient recently deposited sediment from the upper 1 to 2 mm of sediment cores in Sheardown Lake NW, so that dry bulk density measurements can be obtained. The dry bulk density measurement can be used to more accurately calculate annual accumulated sediment thicknesses in its lake sedimentation monitoring program. The same data can be used to support more accurate effects assessments at the Project in the future.

3.5.2.4 Increased Metals Concentrations in Mine Site Water and Sediment

The next step in the FEIS water quality assessment was to estimate the resultant concentration of metals in ore dust runoff. At a threshold TSS concentration of 15 mg/L, cadmium and iron concentrations are expected to exceed their respective water quality objectives (WQOs), resulting in a Level I magnitude effect. Additionally, arsenic, cadmium, and iron concentrations in sediment may exceed the Probable Effects Level (PEL) criteria set out in the Canadian Council of Ministers of the Environment (CCME) Sediment Quality Guidelines for the Protection of Freshwater Aquatic Life (CCME, 1999), under highly conservative assumptions of how much dust runs off into local watercourses, resulting in Level I, Level II, and Level III magnitude effects, respectively. However, given the conservative methodology used in the assessment, it was postulated that in reality, all effects would be Level II magnitude or lower. Aquatic effects monitoring in Camp Lake, Sheardown Lake and Mary River / Mary Lake systems in the third year of mine operation suggest that the FEIS predictions regarding increased metals in Mine Site water and sediment remain valid (Section 3.2; Minnow, 2018a).

As discussed in Section 3.5.2.1, given the decrease in the total amount of dust produced with the Phase 2 Proposal relative to the Approved Project, the potential effects to water and sediment quality from metals in ore dust runoff can be expected to also decrease, or at least be within previous predictions.

3.5.2.5 Sediment Releases into Waterbodies within the Northern Transportation Corridor

The Northern Transportation Corridor (NTC) currently consists of the Milne Inlet Tote Road, a gravel surface road which supports ore transportation haulage from the Mine Site to Milne Port (a distance of approximately 100 km). The North Railway will be located within the same transportation corridor. The NTC encompasses the passage over many surface water drainage features such as ditches, ponded water, streams and rivers, some of which drain to larger lakes.

During the 3-year construction phase associated with the Phase 2 Proposal, the following activities will generate dust and have the potential to result in sedimentation of local watercourses:

- **Railway construction -** including quarrying (drilling, blasting, crushing, screening), haulage and placement of a substantial quantities of rockfill within the railway embankment; the installation of culvert and bridge crossings, and the excavation of soil spoils requiring local disposal.
- **Tote road realignments and ongoing maintenance -** Select sections of the Tote Road will require realignments to accommodate the railway, and the road will require ongoing maintenance (grading, watering, repair).
- **Truck transport of ore -** 6 to 12 Mtpa of ore will be transported over the road by truck; this is an increase from the current 4.2 Mtpa transported over the road as part of the ERP.
- **Temporary ore transfer facility -** For one to two years of the construction phase, when the railway has been constructed to km 57, a temporary ore transfer facility will operate to unload up to 12 Mtpa of ore from trucks arriving from the Mine Site, and rail ore cars will be loaded to deliver the ore the remainder of the distance to Milne Port. The temporary ore transfer facility will include stockpiles, the runoff from which will be managed as described in Section 3.5.1.5. The temporary ore transfer facility will also generate additional dust during ore handling.

The activities associated with the construction phase of the Phase 2 Proposal have the potential to increase TSS concentrations in waterbodies within the NTC. Both dustfall and erosion and sedimentation are potential contributing sources of TSS. These sources are discussed further below.

Once the railway is operational, there will be no major earthworks underway and traffic on the Tote Road will be substantially reduced compared to current traffic levels. Minimal windblown dust emissions are expected from rail cars in transit (FEIS Volume 5, Section 2.6.3.2).

Baffinland's recent experience with exceedances of TSS in local watercourses at the Mine Site is analyzed and discussed in Section 3.5.2.2. The FAD and Letter of Non-Compliance received in 2016 applied to locations along the Tote Road, and spills (sediment releases) at crossings along the Tote Road were reported in 2017. Since 2016, Baffinland has been implementing a number of mitigation measures including culvert replacements as identified in the dust and sedimentation action plans (Golder, 2016a,b) and the TREEP (Golder, 2017).

Work completed by Baffinland in response to the FAD has helped the Company develop a better understanding of the contributing sources of TSS and their management, and to predict the potential effects of the Phase 2 Proposal on TSS in waterbodies along the NTC. The Dust Mitigation Action Plan (Golder, 2016a) suggests that the main mechanism for dust generation along the Tote Road includes: wheel entrainment, wind-blown dust, and losses of ore from ore haul trucks with wheel-entrained dust being the most important source of dust (Golder, 2016a). Dust generation is considered to be the least likely mechanism to lead to inappropriate levels of TSS within water bodies, however, and the primary sources of TSS include sediment entrainment in snowbanks and mass wasting at crossings (Golder, 2016a,b). Golder's conclusions on supported by risk assessment work on ore dusting recently completed by Intrinsik Corporation (TSD-11; Intrinsik, 2018). Intrinsik compared the chemistry of dustfall monitoring data collected at the Mine Site, along the Tote Road, and at Milne Port and established that dustfall at the Mine Site can be distinguished from the dustfall collected along the Tote Road. Mine Site dustfall contains comparably high proportions of ore-related parameters such as iron, aluminum and manganese, relative to dustfall collected adjacent the Tote Road. This supports the conclusion that the dust along the Tote Road is being primarily generated from non-ore sources such as wheel entrainment, and not from wind-blown ore dust.

Earthworks activities and watercourse crossing installations within the Northern Transportation Corridor associated with the Phase 2 Proposal present a risk of erosion and sedimentation during the construction phase. It will be necessary to implement snow clearing practices at construction areas that minimize the uptake of sediment for later release as meltwater. The railway embankment will be constructed primarily of rockfill, which will be resistant to erosion, and little to no sand and gravel. Several sections of the Tote Road will be realigned to accommodate the railway. These sections of road will be constructed using surfacing materials that are resistant to erosion. Culverts installed along the North Railway and realigned sections of the Tote Road will be constructed using appropriate armouring to minimize erosion and sedimentation issues encountered along the mine haul road and Tote Road.

Ongoing implementation of Baffinland's dust and sedimentation action plans and earthworks execution plans will continue to further reduce sediment releases to local watercourses, independent of the Phase 2 Proposal. The Sedimentation Mitigation Action Plan (Golder, 2016b) was developed to specifically address sediment runoff into Lakes and Rivers from the Tote Road and the mine haul road. As indicated in the report, the primary sources of sediment water runoff from the Tote Road into culverts, ditches, creeks, and streams are the following:

- sediment-contaminated snow melt
- road embankment erosion at some culvert locations
- insufficient drainage of the running surface
- insufficient sizing and armouring of ditches
- cut-slope instability resulting from permafrost degradation

Sedimentation issues along the Tote Road are being addressed through the implementation of the TREEP (Golder, 2017) and the Surface Water and Aquatic Ecosystems Management Plan (Baffinland, 2016a). The Surface Water and Aquatic Ecosystems Management Plan will be revised by the end of 2018 to incorporate Baffinland's freshet monitoring program. This or a subsequent revision should specifically address the management of soil spoils generated during railway construction, as this is expected to be significant potential source of sedimentation from rail construction, if not appropriately managed.

By implementing standard best management practices (BMPs) during ground preparation activities, water quality effects can be avoided or reduced to the point where only incidental minor to moderate adverse short-term effects are anticipated.

A number of quarries will be established within the NTC. Potential effects to water quality from quarrying is discussed separately in Section 3.5.3.

Culverts and bridges will be designed, constructed and operated in compliance with *Fisheries Act* authorizations designed to protect water quality as an integral component of fish habitat. Adherence to the conditions of the *Fisheries Act* Authorizations and standard BMPs are anticipated to result in minor adverse residual effects.

The quantity of dust generated during the construction phase will increase relative to current operations (TSD-7; KP, 2018a). Dust also has the potential to contribute to TSS loading in nearby waterbodies. Based on Baffinland's experiences described above, however, dust emissions have been a minor contributor of TSS to surface water bodies along the NTC. As indicated in the Sedimentation Mitigation Plan (Golder, 2016b), elevated levels of TSS in local waterbodies within the NTC has been associated with the entrainment of sediment into snow, and the erosion of site features and surface water channels (ditches) and crossings. However, increases in dust emissions (related to the Phase 2 Proposal) are expected to increase over the short-term (construction phase) from increased truck haulage (wheel entrainment) for 1 to 2 years prior to the finished construction of the North Railway, and from construction works such as drilling and blasting (quarrying) to construct the Railway.

Once the North Railway is operational, the dust generated from wheel entrainment is expected to decrease as transportation of the ore is shifted to from truck to rail, and the volume of truck traffic on the Tote Road decreases substantially. The FEIS established that minimal windblown dust emissions can be expected while the rail cars are in transit (FEIS Volume 5, Section 2.6.3.2).

Provided the realigned sections of Tote Road and culvert installations on both the road and the railway are installed with appropriate armouring to minimize the potential for erosion, potential for mass wasting and the risk of TSS entering local watercourses along the Northern Transportation Corridor during the operation phase should be low. Ongoing sedimentation issues along the Tote Road will continue through implementation of the TREEP, as part of ongoing operations.

Ice damming occurs naturally during spring freshet, when meltwater runs off and stream channels are still filled with ice. This can be seen each freshet on the Phillips Creek. In some instances, such natural events can result in significant mass wasting and sedimentation of waterbodies. Baffinland witnessed such an event in 2014 on Phillips Creek, unrelated to the Project. Ice damming also occurs as a result of the Project, at culvert crossings along the Tote Road and mine haul road. Ice damming has the potential to result in mass wasting of stream banks and erosion of the roadbed, causing sedimentation downstream, with potential effects to fish and fish habitat. As a reoccurring event at the same location, there is the potential to change the stream morphology through changes in erosion and deposition within the stream channel, which could create a barrier to fish passage. To mitigate these effects, Baffinland conducts a culvert maintenance program each spring involving inspection and steaming of culverts. With the Phase 2 Proposal, culverts have been oversized to account for ice accumulation, and the current culvert maintenance program will be implemented along the North Railway.

3.5.2.6 Sediment Releases to Phillips Creek at Milne Port

As detailed in Section 1.1, several developments are being proposed at or near the Milne Port area. These developments include the construction of a rail maintenance facility, freight dock, rail terminal, and second ore dock, and are expected to contribute the generation of dust at the Milne Port area. To evaluate the potential effects of the dust generation on the local waterbodies in this area, an assessment was completed.

Phillips Creek is the major fresh waterbody in the area which is potentially influenced by dust generation. While the potential effects of this dust are largely mitigated through erosion and sediment control and dust suppression measures, TSS concentrations in Philips Creek, may increase. This increase is estimated to be the highest during the spring runoff, when ore dust has accumulated on the snow east of the ore stockpiles.

To calculate the expected contribution of dust to TSS within Phillips Creek, the following information was utilized:

- Modelled dust deposition rates
- Estimated area of the Phillips Creek catchment meaningfully affected by dust deposition
- Mean monthly discharge of Phillips Creek during freshet

The deposition of dust produced from mining activities within the Milne Port Area has been modelled as part of the air quality assessment, (RWDI Air Inc., 2018a). As modelled, the dust deposition is estimated to range from 60 to 500 g/m^2/year on land throughout the Milne Port area. The total land catchment reporting to Phillips Creek is approximately 1.3 km^2 (Figure 3.4), and the mean monthly spring freshet discharge rate within Phillips Creek is estimated at approximately 43 m^3/s. Conservatively assuming that the quantity of dust deposited in snow during the winter reported to the creek over the freshet period, increases in TSS from mining activities would range from 1 to 9 mg/L. The short-term (<24-hour period) CCME guideline is 25 mg/L over background concentrations, and the long-term CCME guideline is +5 mg/L (CCME, 2002). It is possible that the long-term CCME guideline could be exceeded during the freshet period. Limited baseline monitoring of TSS has shown that TSS levels during the freshet period can be high; the maximum TSS concentration measured in Phillips Creek near the mouth was 51 mg/L in the second week of June. In July and August, concentrations are between non-detect (<2 mg/L) and 4 mg/L (KP, 2011). In consideration of the conservative nature of the TSS calculation relative to background concentrations and CCME guidelines, no adverse effects on water quality in Phillips Creek from dust generated at Milne Port are anticipated. Additional mitigation measures (sediment traps, etc.) described in the Surface Water and Aquatic Ecosystems Management Plan (Baffinland, 2016a) are available to manage this issue.

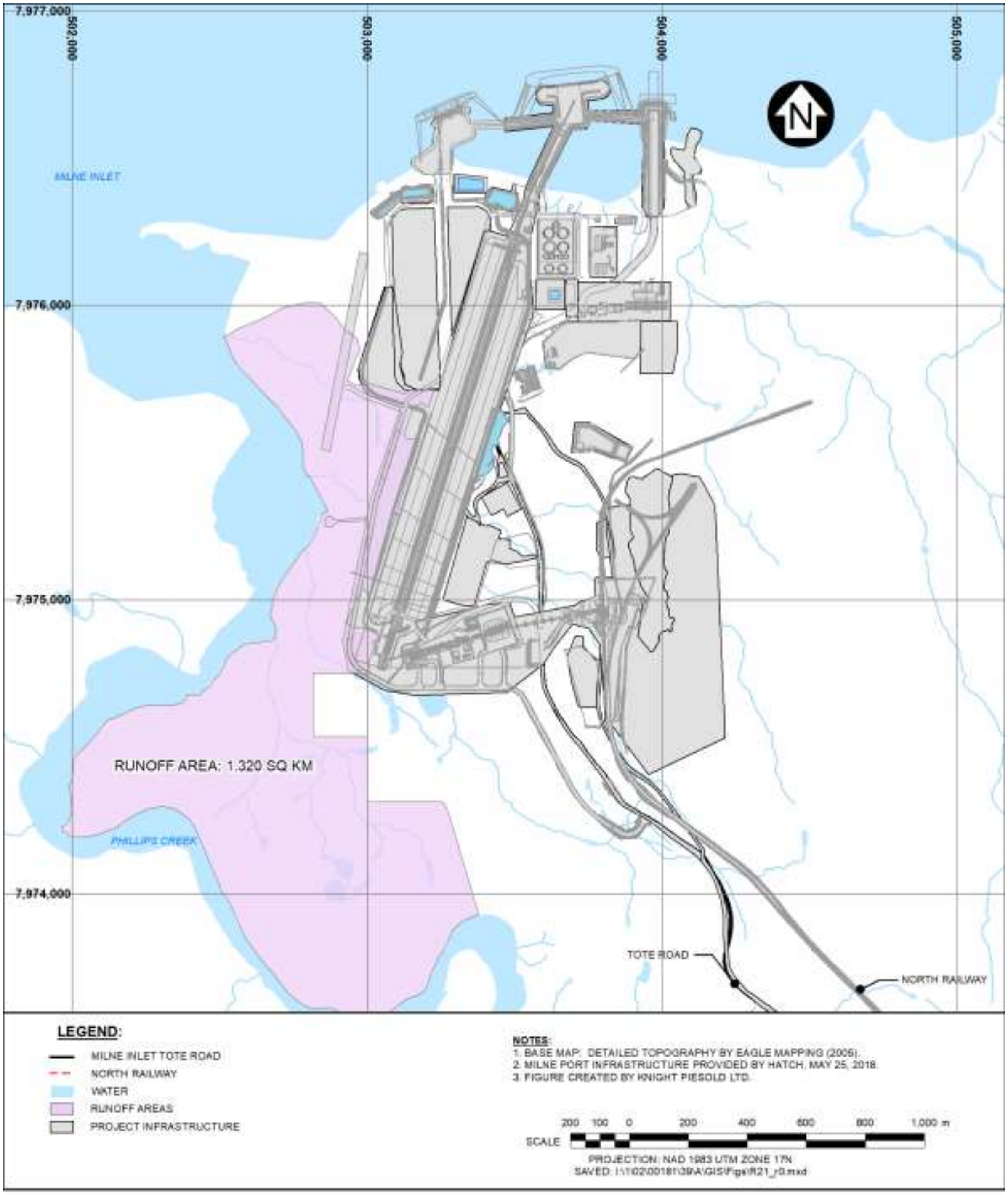

Figure 3.4 Milne Port Phase 2 Project Infrastructure and Phillips Creek Catchment Area

3.5.3 Water Quality Effects from Quarries and Rock Cuts

Potential effects of quarries and rock cuts on water quality were assessed previously in the FEIS, and include:

- Potential releases of nitrogen-containing compounds (nitrate, ammonia), TSS and hydrocarbons from drilling, blasting, extraction and hauling activities
- Potential risk of acid rock drainage (ARD) and/or metal leaching (ML)

These risks are managed through the implementation of the Borrow Pit and Quarry Management Plan (Baffinland, 2014b) and future quarry-specific management plans. The potential for ARD/ML at quarries to be developed as part of the Phase 2 Proposal is discussed further below.

Construction of the North Railway involve the establishment of 36 new quarries. Out of 36 planned quarries, 24 are located in sedimentary rocks (limestone or sandstone), which as mentioned do not present any ARD risk. The remaining 12 quarries are located in granitic gneiss or diorite. A total of 38 rock cuts measuring approximately 25 km in length are also required along the railway right-of-way. Details on quarry locations and extraction quantities are provided in TSD-2 Detailed Project Description prepared by Baffinland, including an application to amend the Type A Water Licence presented in Appendix D of TSD-2 (KP, 2018b).

Based on geochemical testing completed to date, the risk of these activities generating ARD/ML within the sedimentary rocks is negligible, and within the granitic and diabase rocks the risk is low but not negligible. Baffinland's Borrow Pit and Quarry Management Plan (Baffinland, 2014b) prescribes site-specific geochemical testing of rocks prior to quarrying. As a precautionary measure, quarries and rock cuts within the granitic and diabase rock materials will be subject to geochemical testing to confirm that the material is geochemically suitable.

In the unlikely instance that ARD/ML issues are identified at a quarry, Baffinland will avoid using the quarry. There may be less flexibility if ARD/ML issues are identified at rock cuts. If rock cut areas are found to be acid generating through testing, avoidance will be considered where practical. Alternatively, rock cuts may be managed in consideration of site conditions (e.g., use of non-acid generating materials (non-PAG) over the acid generating material; limestone placement; disposal management. Options may range from do-nothing (if exposed faces are limited and/or runoff from the faces is not of adverse quality) to covering the exposed faces with non-PAG/ML material to placing limestone within seepage paths to increase pH of the runoff and precipitate metals.

3.5.4 Potential Effects from Fuel Storage and Handling

Accidental releases of fuel have the potential to negatively effect water quality if the spills reach local watercourses. The Phase 2 Proposal will require additional fuel storage within the current tank farm at Milne Port, as well as dispensing facilities for the North Railway. The potential for fuel spills was assessed previously in the FEIS (Volume 7, Section 3). Accordingly, mitigation measures and response plans have been put into place (Section 43). The additional fuel storage and handling activities and corresponding spill response equipment associated with the Phase 2 Proposal will require an update to the Spill Contingency Plan.

3.5.5 Potential Effects from Camps and Sewage Treatment Plants

The Mine Site camp accommodations are being expanded as part of current operations. The number of beds, anticipated water use and volume of treated sewage to be generated will remain within the parameters assessed in the FEIS (Baffinland, 2012 and 2013).

The Milne Port camp accommodations are being expanded as part of the Phase 2 Proposal. Treated sewage effluent from this camp will continue to be discharged to the marine environment of Milne Inlet, and is therefore assessed in TSD-17 (Golder, 2018b).

3.5.6 Significance of Residual Water Quality Effects

The Phase 2 Proposal will result in effects to water quality that do not meaningfully differ from the Approved Project. The following effects pathways were revisited in Sections 3.5.1 to 3.5.5 of this assessment:

- Mine effluent discharges
- Sediment releases to local watercourses due to sedimentation and dust deposition
- Water quality effects from quarries and rock cuts along the North Railway
- Accidental releases of fuel
- Camps and wastewater discharges

A discussion of the significance of each effect is provided below. The assessment of significance of residual effects to water quality is presented in Table 3.6.

Mine Effluent Discharges

The Phase 2 Proposal will not involve any changes to the mine plan or how waste rock will be managed. A larger crusher pad will generate larger volumes of ore stockpile runoff, but the increased volume of mine effluent from this source will be inconsequential relative to flows in the receiving Mary River. Stormwater collected from a temporary ore transfer area to be operated for 1 to 2 years at km 57 during rail construction and commissioning will be applied to roads in dust suppression efforts provided discharge limits are met as expected. The potential effects of mine effluent discharges associated with the Phase 2 Proposal are consistent with the FEIS and are not significant.

Sediment Releases to Mine Site Streams and Lakes from Dust Deposition and Sedimentation

Dust deposition at the Mine Site is predicted to decrease relative to the Approved Project, mainly due to the relocation of secondary crushing indoors at Milne Port (Section 3.5.2.1). Therefore, the contributions of dust to TSS in local watercourses can be expected to decrease relative to the Approved Project.

Dust deposition will temporarily increase along the Northern Transportation Corridor through the construction phase, and will improve during the subsequent operation phase relative to the Approved Project, due to the substantial reduction in truck traffic along the road and resultant fugitive dust emissions once the rail is operational. The FEIS established that blowing of dust from the rail cars in transit will be minimal.

Dust deposition rates at Milne Port will increase during the construction and operation phases, and a portion of this dust will runoff into the lower reach of Phillips Creek. The bulk of this is likely to occur during freshet, when TSS levels are relatively high. No adverse effects to water quality in Phillips Creek from dust generated at Milne Port are anticipated, and additional mitigation measures (sediment traps, etc.) described in the Surface Water and Aquatic Ecosystems Management Plan (Baffinland, 2016a) are available to manage this issue.

The above potential effects of dust deposition notwithstanding, various analyses indicate that dust deposition is typically only a minor contributor to TSS in local watercourses, and sedimentation due to mainly the entrainment of sediment in snow and mass wasting are the primary sources of TSS in local waterbodies (Section 3.5.2.2). Mitigation of sedimentation into local watercourses is a key focus of the current operation. To minimize sedimentation effects associated with the Phase 2 Proposal, the Snow Management Plan will be updated to identify additional approved snow stockpile locations and possibly other considerations. Culverts and bridges installed as part of the Phase 2 Proposal will be appropriately armoured to minimize the erosion and mass wasting and consequent sedimentation issues that have been experienced with the existing Tote Road.

The assessment in Section 3.5.2.3 considered the effects of the Phase 2 Proposal on lake sedimentation rates. As dust emissions are expected to be reduced relative to the Approved Project, potential effects to lake sedimentation can be expected to be reduced.

Releases of sediment containing ore dust have the potential to increase metals concentrations in water and sediment to local watercourses (Section 3.5.2.4). Aquatic effects monitoring in Camp Lake, Sheardown Lake and Mary River / Mary Lake systems in the third year of mine operation suggest that the FEIS predictions regarding increased metals in Mine Site water and sediment remain valid (Section 3.2; Minnow, 2018a). Given the decrease in the total amount of dust produced with the Phase 2 Proposal relative to the Approved Project, the potential effects to water and sediment quality from metals in ore dust runoff can be expected to also decrease, or at least be within previous predictions.

The effects of dust deposition and sedimentation on water and sediment quality due to the Phase 2 Proposal are consistent with that assessed for the FEIS and are not significant.

Water Quality Effects from Quarries and Rock Cuts

A number of new quarries will be established to support construction of additional components associated with the Phase 2 Proposal. Geochemical evaluations to date suggest that the potential for ARD/ML is low, and quarrying operations to date have not resulted in significant effects to water quality. Proposed mitigation includes the continued implementation of the Borrow Pit and Quarry Management Plan which includes an ARD/ML testing protocol, and the development and implementation of quarry-specific management plans. Cuts through rock that are potentially ARD/ML will be managed by applying the mitigation measures described in Section 3.5.3. With mitigation, the effects of quarries and rock cuts on surface water quality are expected to be consistent with that assessed for the FEIS and are not significant.

Fuel Storage and Handling

The Phase 2 Proposal will involve additional fuel storage added to the existing Milne Port tank farm, construction of a second tank farm at the Mine Site, and the use of mobile double-walled fuel storage tanks during construction. There will be no material change in how fuel is stored and handled with the Phase 2 Proposal that will result in new effects to water quality. The potential effects of fuel storage and handling on surface water quality will not be significant.

Camps and Sewage Treatment Plants

The quality and volume of treated sewage to be discharged to the freshwater environment remains unchanged from that assessed in the FEIS (Baffinland, 2012 and 2013).

Summary Conclusion

Based on this assessment, the effect of the Phase 2 Proposal on surface water quality is assessed to be not significant (Table 3.6).

Table 3.6 Significance of Residual Effects to Water Quality

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)
Construction phase fugitive dust emissions causing elevated TSS in local watercourses (site-wide)	**Level I:** effect may result in a change within one order of magnitude above threshold	**Level I:** confined to the LSA	**Level II:** intermittent	**Level I:** short-term (construct. phase)	**Level I:** effect is reversible	Not Significant	Effect will occur	High
Construction phase erosion and sedimentation causing elevated TSS in local watercourses (site-wide)	**Level I:** effect may result in a change within one order of magnitude above threshold	**Level I:** confined to the LSA	**Level I:** infrequent	**Level I:** short-term (construct. phase)	**Level I:** effect is reversible	Not Significant	Effect will occur	High
Mine Effluent Discharges – increased loading to the Mary River	**Level I:** effect may result in a change within one order of magnitude above threshold	**Level I:** confined to the LSA	**Level II:** intermittent	**Level II:** medium term (life of Project)	**Level I:** effect is reversible	Not Significant	Effect will occur	High
Operation phase dust deposition and sedimentation causing elevated TSS in Mine Site waterbodies	**Level I:** effect may result in a change within one order of magnitude above threshold	**Level I:** confined to the LSA	**Level II:** intermittent	**Level II:** medium term (life of Project)	**Level I:** effect is reversible	Not Significant	Effect will occur	High
Dust deposition resulting in increased sedimentation in Mine Site lakes	**Level I:** low magnitude effect	**Level I:** confined to the LSA	**Level III:** continuous	**Level II:** medium term (life of Project)	**Level III:** effect is not reversible	Not Significant	Effect will occur	High

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)
Increase in metal concentrations in Mine Site water and sediment due to dust deposition	**Level II:** effect may result in a change that exceeds threshold values by more than an order of magnitude	**Level I:** Confined to the LSA	**Level II:** intermittent	**Level II:** medium term (life of Project)	**Level III:** Effect is permanent	Not Significant	Effect will occur	High
Dust Deposition and TSS increases in Phillips Creek	**Level I:** indicator concentrations predicted to exceed threshold value	**Level I:** confined to the LSA	**Level II:** intermittent	**Level II:** medium term (life of Project)	**Level I:** effect is reversible	Not Significant	Effect will occur	High
ARD/ML and water quality effects to water quality from quarries	**Level I:** Effect is expected to result in a change greater than threshold value(s)	**Level I:** confined to the LSA	**Level I:** Infrequent	**Level III:** long term (beyond Project life)	**Level II:** partially reversible with cost/effort	Not Significant	Effect will occur	High
Fuel Storage and Handling	**Level I:** effect is expected to be less than threshold values	**Level I:** confined to the LSA	**Level II:** intermittent	**Level II:** medium term (life of Project)	**Level II:** partially reversible with cost/effort	Not Significant	Effect will occur	High
Camps and Sewage Treatment Plants	**Level I:** effect below threshold values	**Level I:** confined to the LSA	**Level III:** continuous	**Level II:** medium term (life of the Project)	**Level I:** effect is reversible	Not Significant	Effect will occur	High

3.6 MITIGATION AND MONITORING PLAN UPDATES

Four of Baffinland's existing management plans are relevant to water quality of which two will require updates for the Phase 2 Proposal. The proposed additions or revisions to these plans to address the outcome of the water quality effects assessment for the Phase 2 Proposal are presented in Table 3.7.

Table 3.7 Water Quality Related Proposed Management Plan Updates

Management Plan	Required Update for the Phase 2 Proposal
Spill Contingency Plan	Minor update to account for new fuel storage and handling facilities
Snow Management Plan	Update to identify revised and additional snow stockpile locations and other snow management guidelines
Surface Water and Aquatic Ecosystem Management Plan	Update to address rail construction including the disposal of soil spoils
Borrow Pit and Quarry Management Plan	No changes required; additional quarry-specific management plans will need to be developed and approved under the Type A Water Licence

As noted in Sections 3.5.1 and 3.5.6, an update to the Waste Rock Management Plan will be prepared by the end of 2018, unrelated to the Phase 2 Proposal.

Baffinland's AEMP (Baffinland, 2015a) will not require an update to address changes due to the Phase 2 Proposal. Sediment samples will be collected in 2018 to obtain an accurate measurement of dry bulk density to apply to the lake sedimentation monitoring program (Section 3.5.2.3).

4 – NAVIGATION

4.1 BACKGROUND

4.1.1 Purpose

This section assesses the effects of the Phase 2 Proposal on surface water navigation as required by the federal *Navigation Protection Act* (NPA), administered by the Navigation Protection Program (NPP) of Transport Canada. The scope of the assessment includes any proposed Phase 2 Proposal infrastructure or activities that directly affect both marine and freshwater waterways within the Nunavut Settlement Area. The infrastructure or activities include:

- A second ore dock at Milne Port
- Proposed watercourse crossings on new sections of the Milne Inlet Tote Road
- Proposed watercourse crossings on the North Railway

The EIS Guidelines (NIRB, 2015) require Baffinland to assess the potential impacts to the navigability of watercourses from proposed water crossings.

4.1.2 Legislation and Regulatory Framework

Navigation in Canada is regulated under the NPA administered by the NPP of Transport Canada. The current NPA came into force in April 2014, and replaced the former *Navigable Waters Protection Act* (NWPA). The NPA authorizes and regulates interferences with the public right of navigation. The public has a right of navigation, which is generally the right to free and unobstructed passage over navigable waters.

A list of navigable waters is one of the most significant changes introduced in the NPA; 100 oceans and lakes and 62 rivers appear in a list of navigable waters in a schedule of the NPA, having already been deemed navigable by Transport Canada because these waters support busy commercial or recreation-related navigation. These are referred to as "scheduled waters," and waterbodies not appearing in the schedule are referred to as "non-scheduled waters." The public right of navigation, the right to use navigable waters as a highway, is protected in Canada irrespective of whether the navigable water is listed on the schedule to the NPA or not.

For purposes of the NPA, a navigable water includes a canal and any other body of water created or altered as a result of the construction of any work and are those waterways where the public has a right to navigate the water as a highway. Criteria used to assess if a waterway is navigable include:

- The physical characteristics of the waterway support carrying (floating and traversing) a vessel of any size (e.g., canoe/kayak) from one point to another
- There is evidence of current or past use by the public of the waterway as an aqueous route for navigation purposes either as a self contained route or as part of a navigation network extending beyond the boundaries of the specific waterway
- There a reasonable likelihood of use by the public of the waterway as an aqueous highway

The NPA requires proponents to provide Notice to the Minister (of Transport) about certain works on navigable waters in Canada. For purposes of the NPP, the Notice must include a "Notice of Works" form and all required attachments and additional information. The detailed information submitted in a

Notice to the Minister is required for the NPP to identify likely interferences with shipping and boating activities. Minor works may proceed without Notice to the Minister as long as they meet the criteria for the applicable class of minor works, as well as specific terms and conditions for construction.

4.1.3 Previous NWPA Assessments and Approvals

Transport Canada, Navigable Waters Protection Program (NWPP) staff visited the Mary River Project site during the summer of 2008 and provided preliminary feedback concerning the requirements for NWPA approval based on the level of Project design information provided at the time. In 2014, NWPA approvals were issued for four bridges (BG-50, CV-128, CV-217, and CV-223) and four culverts (BG-017, CV-040, CV-072, and CV-099) as part of Tote Road construction upgrades to support the ERP. NWPA approval was issued for the existing ore dock at Milne Port in 2014.

Under Related Provisions of the NPA, these existing approvals constitute “designated works,” in which works permitted under the former NWPA are deemed to be validly constructed in accordance with Section 10 of the NPA.

4.2 ASSESSMENT METHODOLOGY

The methodology to assess the effects of the Phase 2 Proposal on surface water navigation was developed in consideration of previous assessments of components of the Mary River Project under the NWPA, and in consideration of recent NPP policy guidance (TC, 2018). The steps in the assessment included:

- Identify the proposed Phase 2 Proposal infrastructure or activities that directly affect both marine and freshwater waterways within the Nunavut Settlement Area
- Identify affected waterways that are listed as “scheduled waters” under the NPA List of Scheduled Waters
- Identify waterways previously identified as navigable waters under the NWPA, if the Phase 2 Proposal affects these same waterways
- Consider the size and location of affected waterways to support vessels of any size
- Consider historical, past, existing, and future use of affected waterways for navigation
- Develop a list of affected waterways that are navigable
- Identify mitigation to reduce potential impacts and requirements for monitoring
- Identify affected waterways that will potentially require a Notice to the Minister of Transport or an Approval

The results of the navigation assessment are presented in the following sections.

4.3 NAVIGATION ASSESSMENT

4.3.1 Marine Infrastructure at Milne Port

4.3.1.1 Baseline Conditions

Baseline conditions related to navigation at Milne Port were previously assessed by Baffinland to support the environmental assessments for the Approved Project.

Milne Inlet is part of the Arctic Ocean, a “scheduled water” under the NPA. Milne Inlet is an 80 km long fjord originating to the south of Eclipse Sound, and is characterized by deep waters (generally >100 m depth) and steep surrounding headlands. The width of Milne Inlet ranges from 2 km nears its head to 15 km at it mouth, with an irregular shape as the result of several bays, islands, and small inlets. Milne Port is located at the southern tip of Milne Inlet on a fjord-head delta. The final 15 km of Milne Inlet nears its head is approximately 15 km long by 2 km wide. Shorelines within Milne Inlet include a mix of rock cliffs, alluvial fans, and raised beach ridges. The Inlet is ice-covered most of the year, with a short three to four month open-water season. Icebergs are common and often become grounded in shallow, nearshore areas.

Existing marine infrastructure at Milne Port includes an ore dock and barge landing ramp. A freight dock will also be constructed at Milne Port during the 2018 open water season. The freight dock is a component of the Approved Project, assessed in the FEIS. Baffinland is currently seeking both an authorization under the *Fisheries Act* and an approval under the NPA for the freight dock.

Marine traffic at the head of Milne Inlet includes shipping activities and port operations by Baffinland, Inuit hunters in small boats, and to lesser extent, Arctic cruises and other tourism activities (often supported by Inuit small craft). The nearshore distance from Pond Inlet (the closest community) to Milne Port by boat is approximately 180 km, and is too far to support day trips from Pond Inlet. Nonetheless, hunters do travel regularly to Milne Inlet during the open water season to hunt narwhal within Milne Inlet and to use Milne Port and the Milne Inlet Tote Road as a means to access inland areas for mainly caribou hunting (FEIS Volume 4, Section 10; Baffinland, 2012). For public safety, Baffinland has published a Hunter and Visitor Site Access Procedure (Baffinland, 2015b), which details the safe way to travel near the docks and to visit the site and access the inland.

4.3.1.2 Proposed Works

Proposed marine infrastructure at Milne Port is described in detail in the Project Description (TSD-2). This section summarizes proposed marine infrastructure.

A second ore dock capable of berthing Cape size ore carriers will be required to be able to deliver 12 Mtpa of ore to market via Milne Port. Cape size vessels are up to 230,000 dead weight tonnage (DWT), with a length of approximately 316 m, and a draft of about 19 m.

The orientation of the ore dock is optimized to allow a clear approach for vessels parallel to the berth face and clearing the existing dock. Position of the new dock relative to the existing dock also considered the spacing requirements for vessels when both docks are in use. Based on the optimum angle for mooring lines the position chosen allows for a minimum clear spacing of greater than 150 m. This then ensures mooring lines from vessels at the adjacent docks will not be crossed, something which is desirable from a safety and operations aspect.

4.3.1.3 Potential Effects and Mitigation

Potential effects and mitigation related to navigation at the head of Milne Inlet route were previously assessed by Baffinland to support the environmental assessments for the Approved Project. The potential effects of port infrastructure and operations on coastline navigation include:

- Increased navigation risk to small vessels by having to alter their normal course around ports
- Increased navigation risk to small vessels resulting from port induced alterations to current, wind, and ice conditions
- Risk of collision between small vessels and cargo ships and tugs
- Risk of collision between small vessels and port infrastructure

Mitigation of these potential effects is best achieved by adopting best industry practices and undertaking appropriate consultation with user groups to communicate potential risks. Navigation aids are not expected to be required, but might be specified by Transport Canada.

Baffinland intends to submit a Notice of Works to the NPP for the proposed port infrastructure with the understanding that an Approval under the NPA is a likely requirement, prior to construction.

4.3.2 Access Road Culverts

4.3.2.1 Baseline Conditions

The Milne Inlet Tote Road was first constructed to support mineral exploration at Mary River in the early 1960s. In 2007, Baffinland undertook the first modern upgrades to bring the road back into use as a year-round road to support a bulk sample program. In 2014, the North Baffin Regional Land Use Plan (NBRLUP) was amended to establish the Tote Road as a transportation corridor. The road is currently a vital transportation link for the Project, and as such, upgrades to the road have been ongoing since 2013. The Milne Inlet Tote Road is currently used to transport iron ore from the Mine Site to Milne Port. It is also used to move supplies arriving by sealift to the Mine Site.

The Tote Road includes approximately 249 watercourse crossings, although 174 of these are drainage culverts on small streams. In 2014, NWPA approvals were issued for the largest crossings: four bridges (BG-50, CV-128, CV-217, and CV-223) and four culverts (BG-017, CV-040, CV-072, and CV-099) as part of Tote Road construction upgrades to support the ERP.

Other roads include the Haul Road between Deposit No. 1 and the primary crusher, and secondary roads to access quarries, borrows, Mile Port facilities, and Mine Site facilities.

There is no existing navigation use on freshwater streams, rivers, and lakes within the PDAs for the Mine Site, Northern Transportation Corridor, or Milne Port, other than to support aquatic studies undertaken by Baffinland on lakes. This is largely due to the climate, terrain, remoteness, and large distance from communities. Large streams, lakes, and rivers are potentially navigable and were previously identified as navigable waters under the NWPA.

4.3.2.2 Proposed Works

Minor realignments of the Tote Road are required to support construction of the North Railway, while new secondary roads are required to access new borrows. These roads sections will require 17 new or relocated culverts on small streams.

4.3.2.3 Potential Effects and Mitigation

Potential effects and mitigation related to navigation at road crossings were previously assessed by Baffinland to support the environmental assessments for the Approved Project. None of the 17 streams were previously identified as requiring NWPA approvals. No new adverse effects to navigation are expected to occur, and therefore no additional mitigation is proposed.

There are no freshwater streams, lakes, and rivers in the RSA included as “scheduled waters” under the NPA List of Scheduled Waters.

4.3.3 North Railway Bridges, Culverts, and Diversions

4.3.3.1 Baseline Conditions

The Northern Transportation Corridor generally follow a northwest-southeast oriented glacial valley between Milne Port and the Mine Site. Surficial deposits along this alignment include till veneer or blankets on the higher elevations with some drumlins and moraines. Glaciofluvial outwash sediments (gravel and sand) forming braided floodplains, terraces and fans or stratified glacial drift (gravel and sand) are typically found in the valley floors.

The Northern Transportation Corridor passes through the Phillips Creek Valley, an inland travel route for Inuit hunters and people travelling between communities. Most travel occurs in winter by snowmobile, but some hunters travel up the valley, including along the road, by ATV in summer. No navigation of Phillips Creek or the surrounding waterways is known to occur.

4.3.3.2 Proposed Works

Proposed bridges, culverts, and diversions for the North Railway are described in detail in the Project Description (TSD-2). This section summarizes proposed rail crossing infrastructure.

The North Railway will cross an estimated 443 watercourse and drainage crossings along the North Railway. The railway will not encroach on any lakes although there are encroachments on small ponds less than 1 ha in size.

Bridges will be installed at four railway water crossings on the same rivers where bridges are currently installed on the Tote Road. A rail bridge is proposed at CV-70-3 in the rail section that deviates from the Tote Road alignment, on the same river crossed by the Tote Road at BG-50. Bridge spans are based on the existing normal flow riverbank and the adjacent Tote Road bridges. Bridge designs will be based on the 1:200 year 24-hour storm, sufficiently conservative to account for climate change induced increases in precipitation and runoff.

Culverts will be installed at other water crossings along the railway. Culverts will be designed in accordance with AREMA (2010) guidelines. Culvert diameters will range from 0.6 m to 1.8 m, and will be covered with a minimum of 1 m of fill.

Due to the construction of the North Railway, 32 stream diversions will be required on small streams. As a result of these diversions, four culverts on the Tote Road will be upgraded to accommodate higher flows.

There is no existing navigation use on freshwater streams, rivers, and lakes within the PDA for the Northern Transportation Corridor. This is largely due to the climate, terrain, remoteness, and distance from communities. Large streams, lakes, and rivers are potentially navigable and were previously identified as navigable waters under the NWPA in relation to Tote Road upgrades for the ERP. The navigable waters at watercourse crossings on the Tote Road and proposed North Railway are summarized in Table 4.1.

Table 4.1 Navigable Waters at Watercourse Crossings

Watercourse Type	NWPA Assessment	Structure	Tote Road Crossing	Proposed North Railway Crossing	Proposed Designation
River	Navigable	bridge	CV-223	CV-102-1 (Bridge 4)	Navigable
River	Navigable	bridge	CV-217	CV-85-3 (Bridge 3)	Navigable
River	Navigable	bridge	CV-128	CV-15-5 (Bridge 1)	Navigable
River	Navigable	bridge	BG-50	CV-70-3 (Bridge 2)	Navigable
Stream	Navigable	culvert	CV-099	CV-35-2	Navigable
Stream	Navigable	culvert	CV-072	CV-50-5/6	Navigable
Stream	Navigable	culvert	CV-040	CV-77-2	Navigable
Stream	Navigable	culvert	BG-017	not applicable	not applicable

4.3.3.3 Potential Effects and Mitigation

The North Railway crosses seven of the eight waterways previously identified as navigable under the NWPA related to construction of the Tote Road under the ERP. Four rail bridges are required on the same rivers that require bridges on the Tote Road. These four bridges on the North Railway are at large crossings but are not expected to impede navigation in the unlikely event that a person attempts to navigate these waterways.

Baffinland intends to submit a Notice of Works to the NPP for the eight proposed rail crossings on navigable waters with the understanding that an Approval under the NPA is a likely requirement, prior to construction. Detailed bridge drawings will be formally submitted to NPP for review. Drawings will include the watercourse name and number (if applicable), crossing width, height to the bridge measured from the high water mark, bankfull depth, longitude and latitude.

Temporary closures of watercourses would occur due to potential safety concerns associated with operation of heavy equipment and other construction activities. During these periods, navigability would be limited or prohibited.

4.3.4 Significance of Residual Effects to Navigation

Baffinland will seek approval for works that will be located in scheduled waters (the ore dock in the Arctic Ocean) and for works along the North Railway that were previously deemed navigable. The second ore dock is located in a navigable water frequently used by small craft operated by hunters, and therefore there will be residual effects to navigation. Given its location between two approved docks (the existing ore dock and the approved freight dock to be constructed prior to the Phase 2 Proposal), the second ore dock is not likely to meaningfully interfere with navigation by others.

The railway crossings, while potentially navigable, are isolated and are unlikely to meaningfully interfere with navigation.

The effects of the Phase 2 Proposal will be not significant.

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Transport Canada (TC). 2018. Navigation Protection Program. Website address: https://www.tc.gc.ca/eng/programs-621.html

6 – CERTIFICATION

This report was prepared and reviewed by the undersigned.

Prepared: ______________________

Simon Foster, M.Sc., P.Geo.
Project Scientist

Reviewed: ______________________

Richard Cook, P.Geo.(Ltd.)
Specialist Environmental Scientist | Associate

Approval that this document adheres to Knight Piésold Quality Systems:

APPENDIX A

2017 HYDROMETRIC MONITORING REPORT

(Pages A-1 to A-19)

STORY environmental inc

MEMO

To:	Jim Millard Environmental Manager Baffinland Iron Mines	**From:**	Andrew Rees, Ph.D., EP Senior Environmental Scientist
Re:	2016 Hydrometric Monitoring Program	**Date:**	28 February 2017
		Proj No:	199-03-09

1 Introduction

The 2016 Mary River Hydrometric Monitoring Program was initiated in late June around the onset of the spring melt period. Site visits were conducted by Story Environmental Inc. ("SEI") to re-install pressure transducers and conduct flow measurements at the six previously established monitoring stations (Table 1.1). The hydrometric stations are a part of the streamflow monitoring program supporting the Aquatic Effects Monitoring Plan ("AEMP").

Table 1.1 2016 Hydrometric Monitoring Stations

Station ID	Station Name	Period of Record	Drainage Area (km^2)	Coordinates (UTM)	
				Easting	Northing
H01	Phillips Creek Tributary	2006-2008, 2011-2016	250	532831	7946247
H02	Tom River near outlet to Mary Lake	2006-2008, 2010-2016	210	555712	7915514
H04	Camp Lake Tributary (CLT-2)	2006-2008, 2010-2016	8.3	557639	7915579
H05	Camp Lake Tributary (CLT-1)	2006-2008, 2010-2016	5.3	558906	7915079
H06	Mary River	2006-2008, 2010-2016	240	563922	7912984
H11	Sheardown Lake Tributary (SDLT-1)	2011-2016	3.6	560503	7913545

During the June site visit, benchmark and water level surveys were conducted and pressure transducers were installed. Discharge was measured using the velocity-area technique and a wading current meter where lower flows permitted safe access to the channel and using dilution gauging where higher flows were present. Final site visits were made by Baffinland Iron Mines ("BIM") staff between 3 and 7 September to remove the stations prior to winter freeze-up.

2 Stage-Discharge Measurements

The stage-discharge data obtained in 2016 were compared to the existing rating curves summarized in the 2015 Hydrometric Monitoring Program Summary (SEI, 2016). The rating curves for each station, inclusive of the 2016 measurements, are provided on Figures 1 to 6. A discussion and interpretation of the fit of the current data to the existing rating curves is provided in the following sections:

- **H01 (Phillip's Creek Tributary)** - A stage-discharge measurement was recorded at H01 during the June site visit using dilution gauging and is consistent with the existing rating curve (Figure 1). As such, the existing rating curve was used for the development of the 2016 streamflow record.
- **H02 (Tom River)** - A stage-discharge measurement was recorded at H02 during the June site visit using dilution gauging and the flow measured plots lower than the previous rating curve (Figure 2). As noted in SEI, 2015, the data from 2013 to 2015 suggested that there has been a shift in the rating curve. The 2016 discharge measurement also supports this shift in the rating curve and an updated rating curve has been developed and was used for the development of the 2016 flow record. Additional high flow measurements are recommended to verify the upper half of the rating curve
- **H04 (Camp Lake Tributary CLT-2)** - A stage-discharge measurement was recorded at H04 during the June site visit and is consistent with the updated rating curve proposed in SEI, 2016 (Figure 3). The June measurement was during higher flow than previous measurements and helps validate the upper half of the rating curve. There is less confidence in the accuracy of the rating curve for flows above 0.7 m^3/s. Additional high flow measurements are recommended to further validate the updated rating curve at H04. The updated rating curve was used for the development of the 2016 flow record.
- **H05 (Camp Lake Tributary CLT-1)** – The stage-discharge measurement recorded at H05 during the June site visit was consistent with the existing rating curve (Figure 4). The rating curve was used for the development of the 2016 flow record.
- **H06 (Mary River)** – A stage-discharge measurement was recorded at H06 during the June site visit using dilution gauging and is generally consistent with the existing rating curve (Figure 5). The discharge measurement demonstrates that the rating curve for H06 remains valid and that the channel appears to be stable. The existing rating curve was used for the development of the 2016 flow record.
- **H11 (Sheardown Lake Tributary SDLT-1)** – A stage-discharge measurements was recorded at H11 during the June site visit and is consistent with the rating curve updated in 2014 (Figure 6). There remains some uncertainty around higher stage-discharge conditions at H11 due to the lack of field measurements for validation. In future years, higher flow measurements should be obtained at H11 to validate the updated rating curve. The updated rating curve was used for the development of the 2016 flow record.

3 Streamflow Hydrographs

Streamflow records were developed for each station by applying the water level records to the corresponding rating curves. The discharge hydrographs for H01, H02, H04, H05, H06, and H11 are presented on Figures 7 to 12. Each water level record underwent a quality review and periods affected by channel ice or other anomalies were removed from the record.

The discharge records were converted to equivalent unit runoff (discharge per unit area) and are compared to the daily precipitation records on Figure 13. The records of unit runoff generally agree well with each other, exhibiting similar timing and magnitude of runoff events and similar patterns to previous years. As during previous years, the station at H11, with a generally lower elevation catchment, exhibited a much smaller freshet and muted response to precipitation events.

A strong diurnal melt pattern is evident through the end of June and first half of July. The snowmelt at lower elevations and the peak of freshet flows occurred earlier than normal at the stations with smaller and lower elevation catchment areas (H04, H05, and H11) and was not captured in the data. The peak freshet flows at the stations with larger catchments (H01, H02, and H06) occurred in late June. The peak flows at H01, H02, and H06 were similar to 2015 but lower than previous years and occurred over a typical duration. A summary of flows at H05 from 2006 to 2016 is shown on Figure 14. The total annual runoff in 2016 at the H05 station was greater than in 2015 but the third lowest recorded from 2006 to 2016. Both 2015 and 2016 had lower than normal flows in mid-July and from mid-August to early September. The estimated mean monthly discharge and unit runoff for each station in 2016 are summarized in Table 3.1.

Table 3.1 Summary of 2016 Mean Monthly Estimated Discharge and Unit Runoff

STATION	Estimated Mean Monthly Discharge (m^3/s)				Period of Record
	June	July	August	September	
H01	18.1*	8.3	5.7	1.7*	June 25 to September 5
H02	25.5*	6.7	3.9	0.5*	June 26 to September 5
H04	0.59*	0.17	0.23	0.09*	June 23 to September 4
H05	0.17*	0.05	0.13	0.03*	June 23 to September 4
H06	36.5*	13.1	7.2	1.7*	June 26 to September 4
H11	0.03*	0.04	0.13	0.04*	June 24 to September 3

STATION	Estimated Mean Monthly Unit Runoff ($l/s/km^2$)				Period of Record
	June	July	August	September	
H01	72.6*	33.2	22.9	6.8*	June 25 to September 5
H02	121.4*	31.9	18.9	2.4*	June 26 to September 5
H04	71.9*	20.4	27.8	11.6*	June 23 to September 4
H05	32.5*	10.5	26.2	6.3*	June 23 to September 4
H06	152.1*	54.7	30.2	7.2*	June 26 to September 4
H11	8.7*	11.0	38.2	10.6*	June 24 to September 3

Note:

1. Months with incomplete data records are indicated with an asterix.

4 Summary

The 2016 Hydrometric Monitoring Program allowed for the continued monitoring of streamflow at the AEMP hydrometric stations. The data collected confirmed the rating curves at all stations. It is recommended that future hydrometric monitoring includes more frequent site visits during the season to ensure the proper operation of data loggers and to confirm or improve rating curves, especially during summer high flow events.

5 References

Story Environmental Inc. (SEI), 2016. Memorandum to Jim Millard, Baffinland Iron Mines Corporation. Re: *2015 Hydrometric Monitoring Program*. February 2. Haileybury, Ontario. Ref. No. 199-01-09.

Prepared by: Andrew Rees, Ph.D., EP
Senior Environmental Scientist

Reviewed by: Maria Story, P.Eng.
President

Attachments:

Figure 1	H01 - Phillip's Creek Tributary Rating Curve
Figure 2	H02 - Tom River Rating Curve
Figure 3	H04 - Camp Lake Tributary (CLT-2) Rating Curve
Figure 4	H05 - Camp Lake Tributary (CLT-1) Rating Curve
Figure 5	H06 - Mary River Rating Curve
Figure 6	H11 - Sheardown Lake Tributary (SLDT-1) Rating Curve
Figure 7	H01 – Phillip's Creek Tributary 2016 Streamflow Record
Figure 8	H02 - Tom River 2016 Streamflow Record
Figure 9	H04 - Camp Lake Tributary (CLT-2) 2016 Streamflow Record
Figure 10	H05 - Camp Lake Tributary (CLT-1) 2016 Streamflow Record
Figure 11	H06 - Mary River 2016 Streamflow Record
Figure 12	H11 - Sheardown Lake Tributary (SLDT-1) 2016 Streamflow Record
Figure 13	2016 Unit Runoff and Daily Precipitation
Figure 14	H05 - Measured Streamflow Hydrographs 2006-2016

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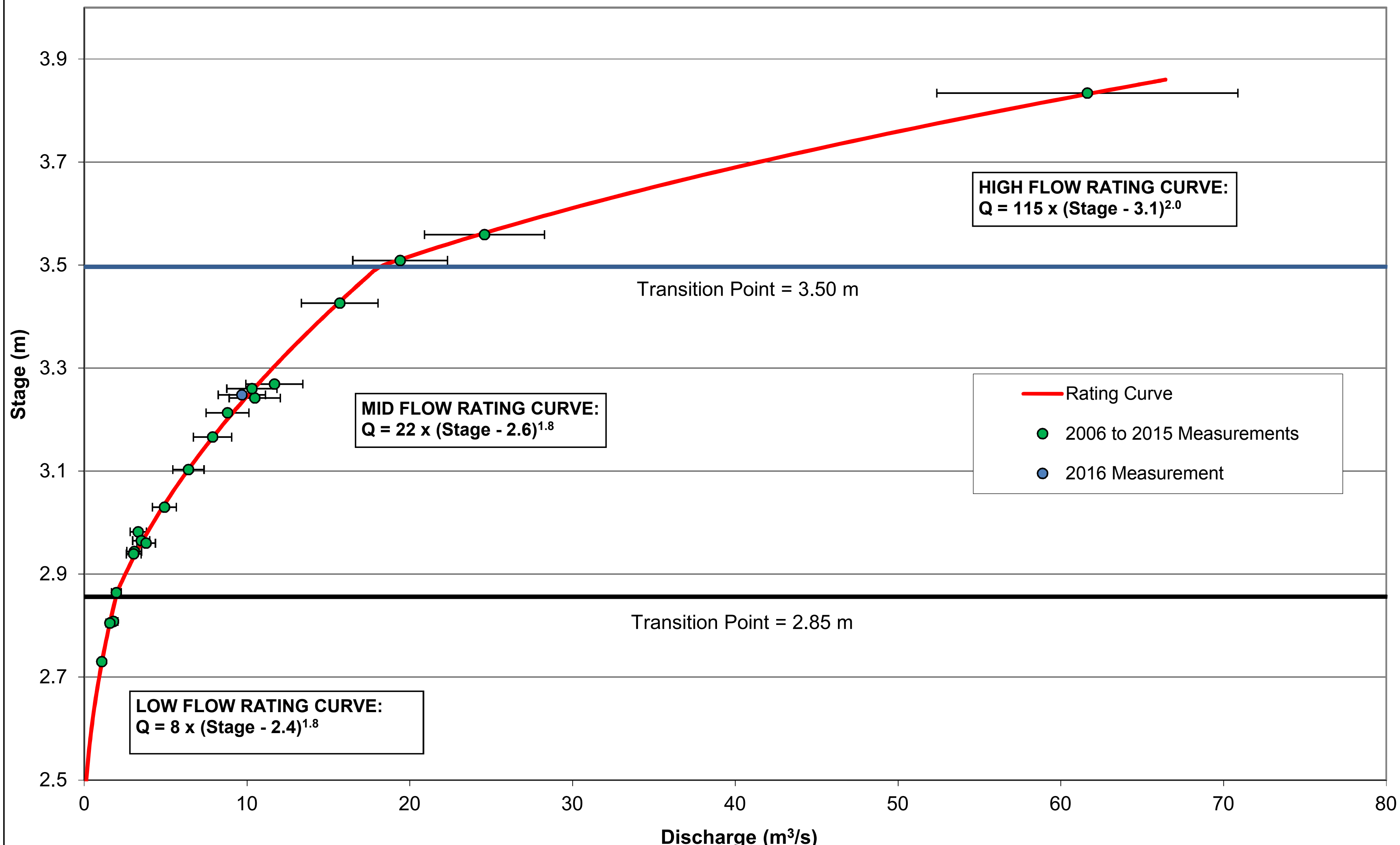
Attachments



NOTE:
1. RATING CURVE SHOWN TO MAXIMUM RECORDED STAGE.

Figure 1 H01 - Philips Creek Tributary Rating Curve

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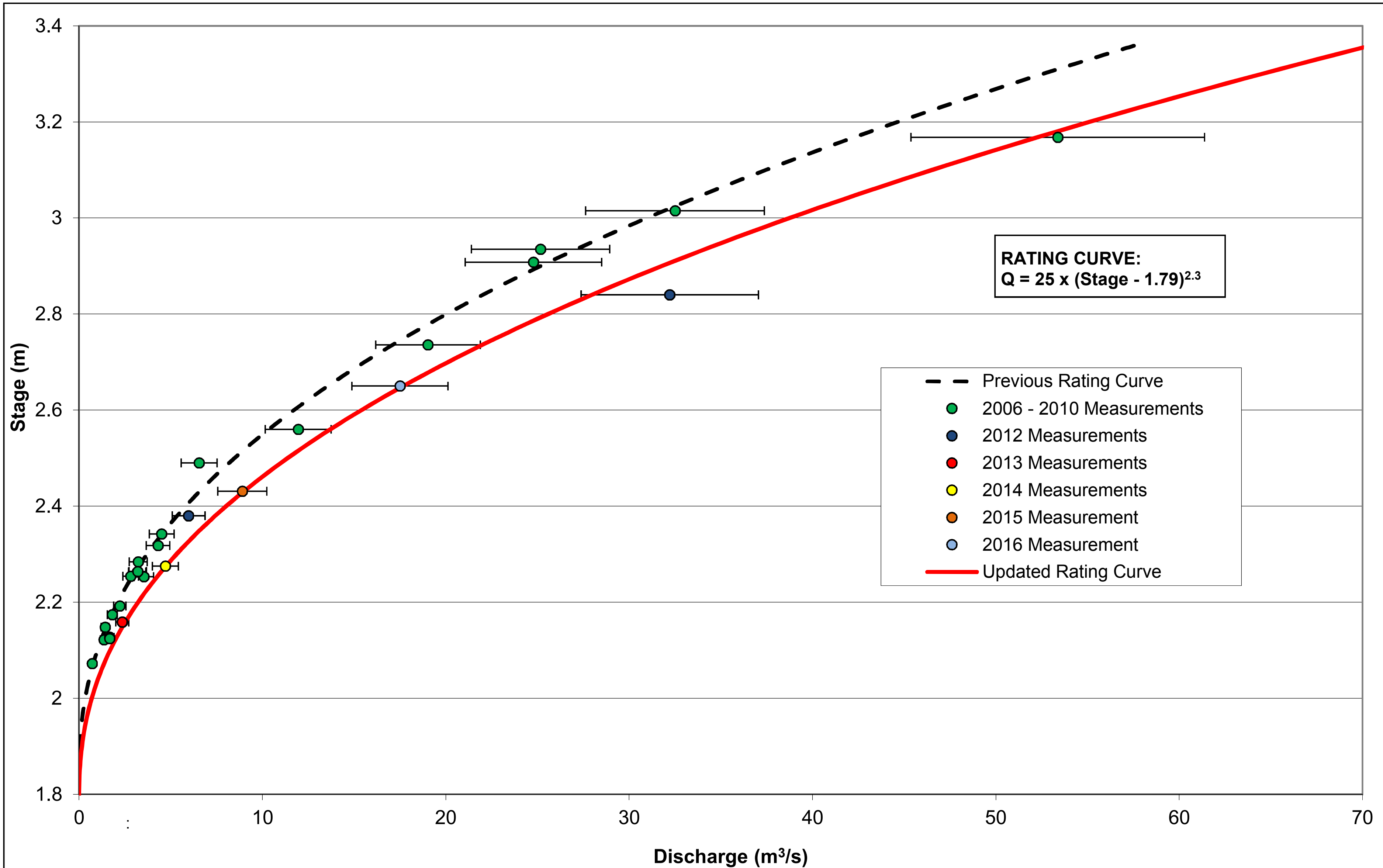

NOTE:
1. RATING CURVE SHOWN TO MAXIMUM RECORDED STAGE.

Figure 2 **H02 - Tom River Rating Curve**

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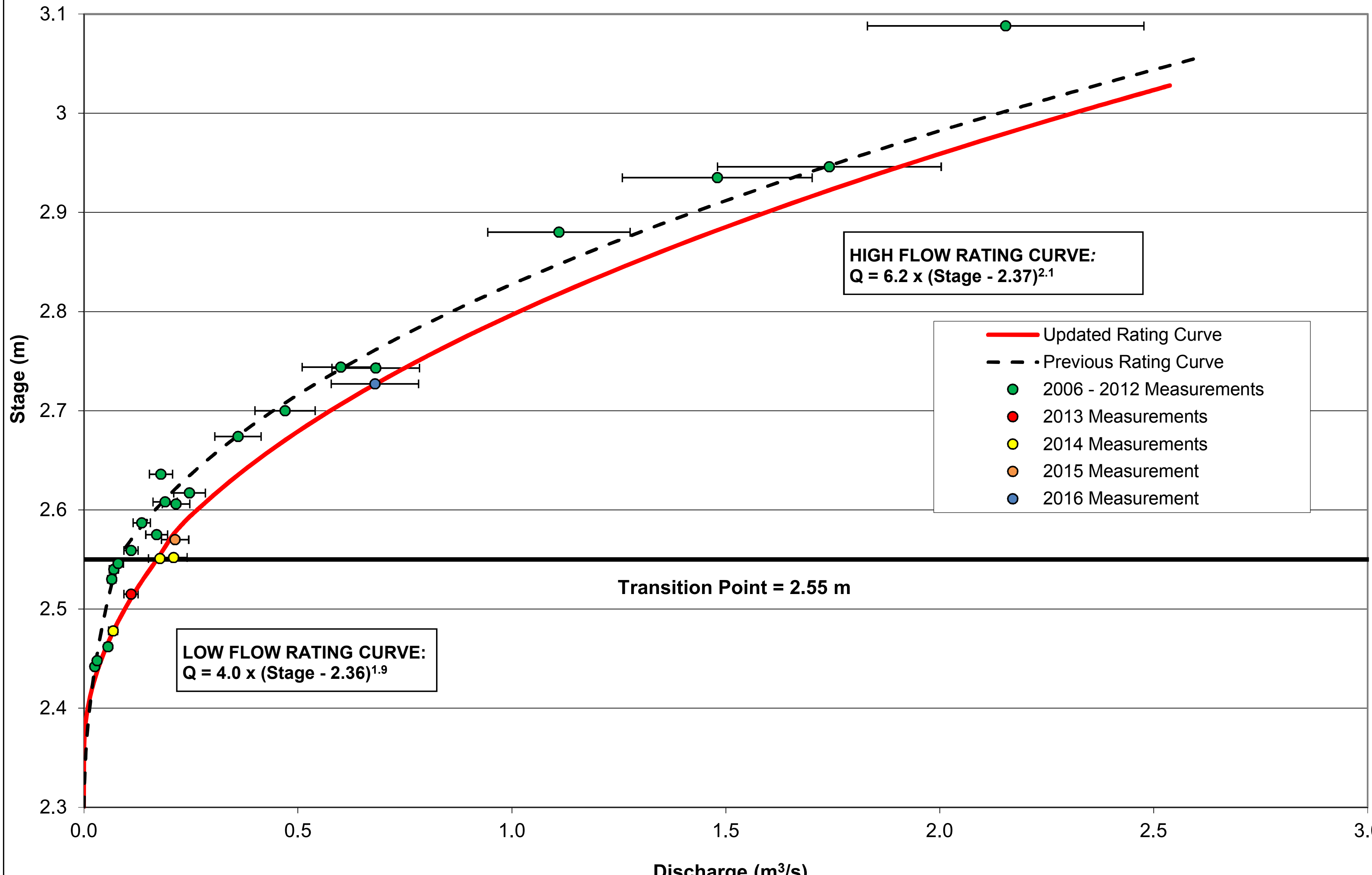

NOTE:
1. RATING CURVE SHOWN TO MAXIMUM RECORDED STAGE.

Figure 3 **H04 - Camp Lake Tributary (CLT-2) Rating Curve**

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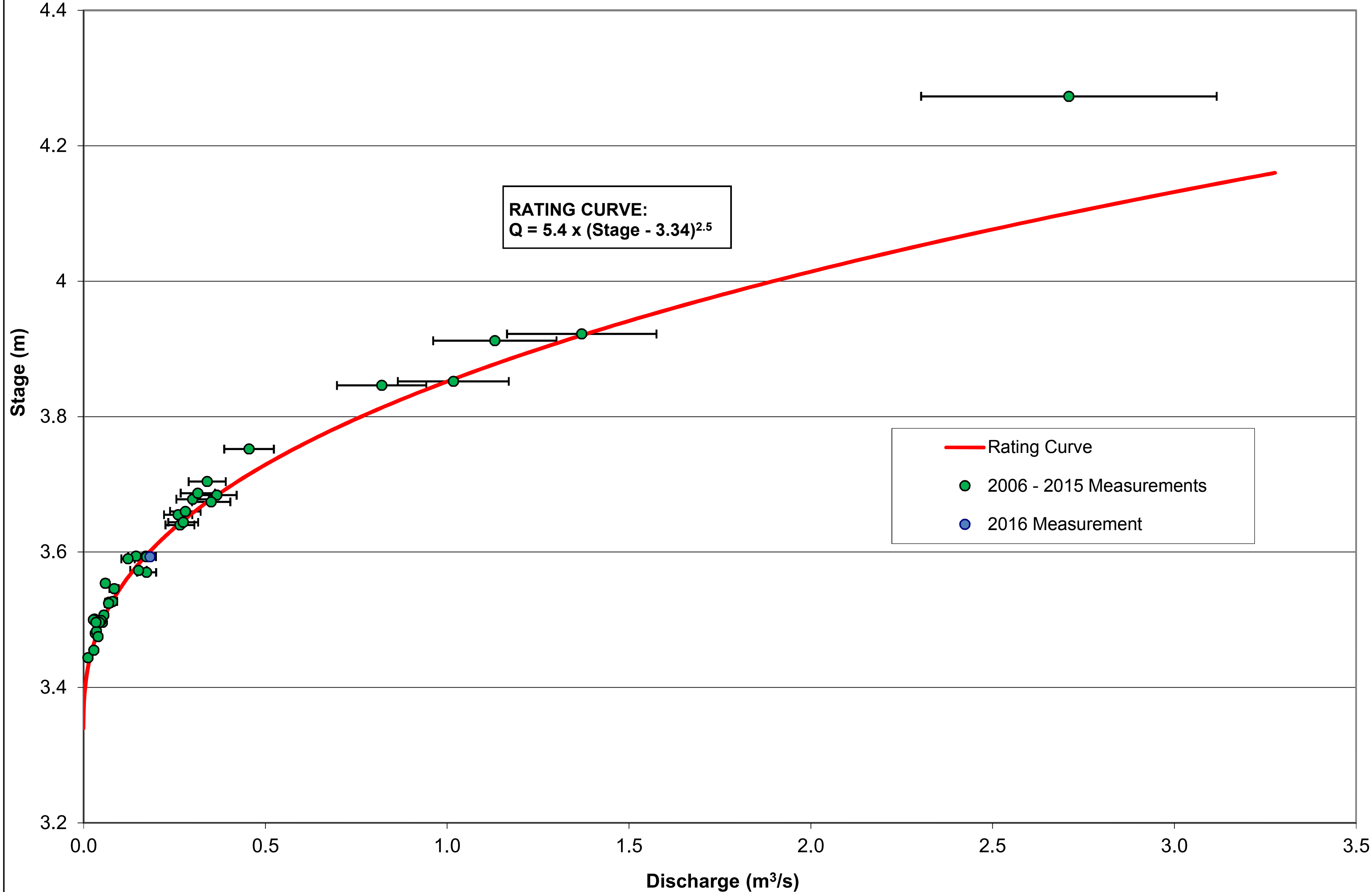

NOTE:
1. RATING CURVE SHOWN TO MAXIMUM RECORDED STAGE.

Figure 4 **H05 - Camp Lake Tributary (CLT-1) Rating Curve**

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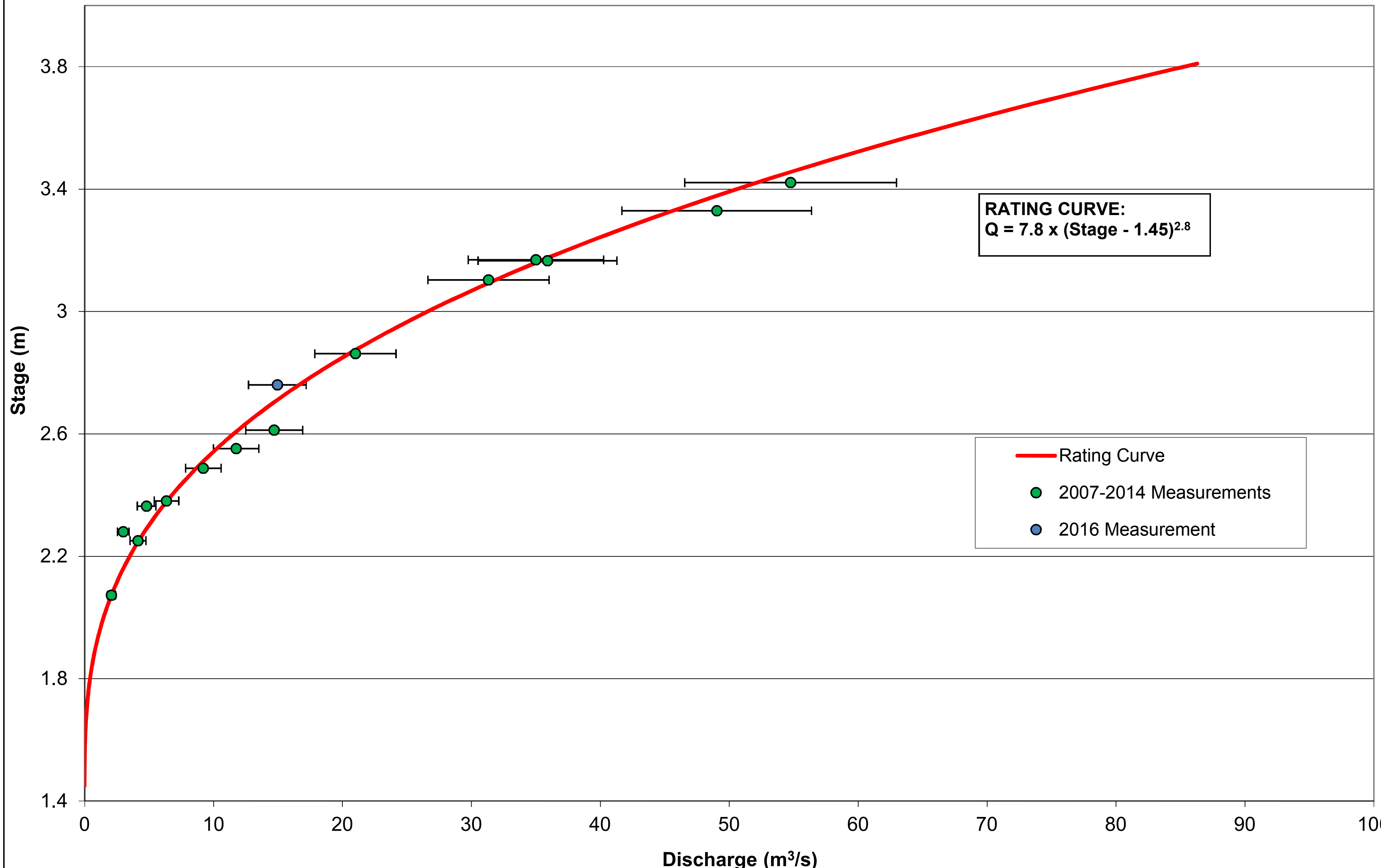
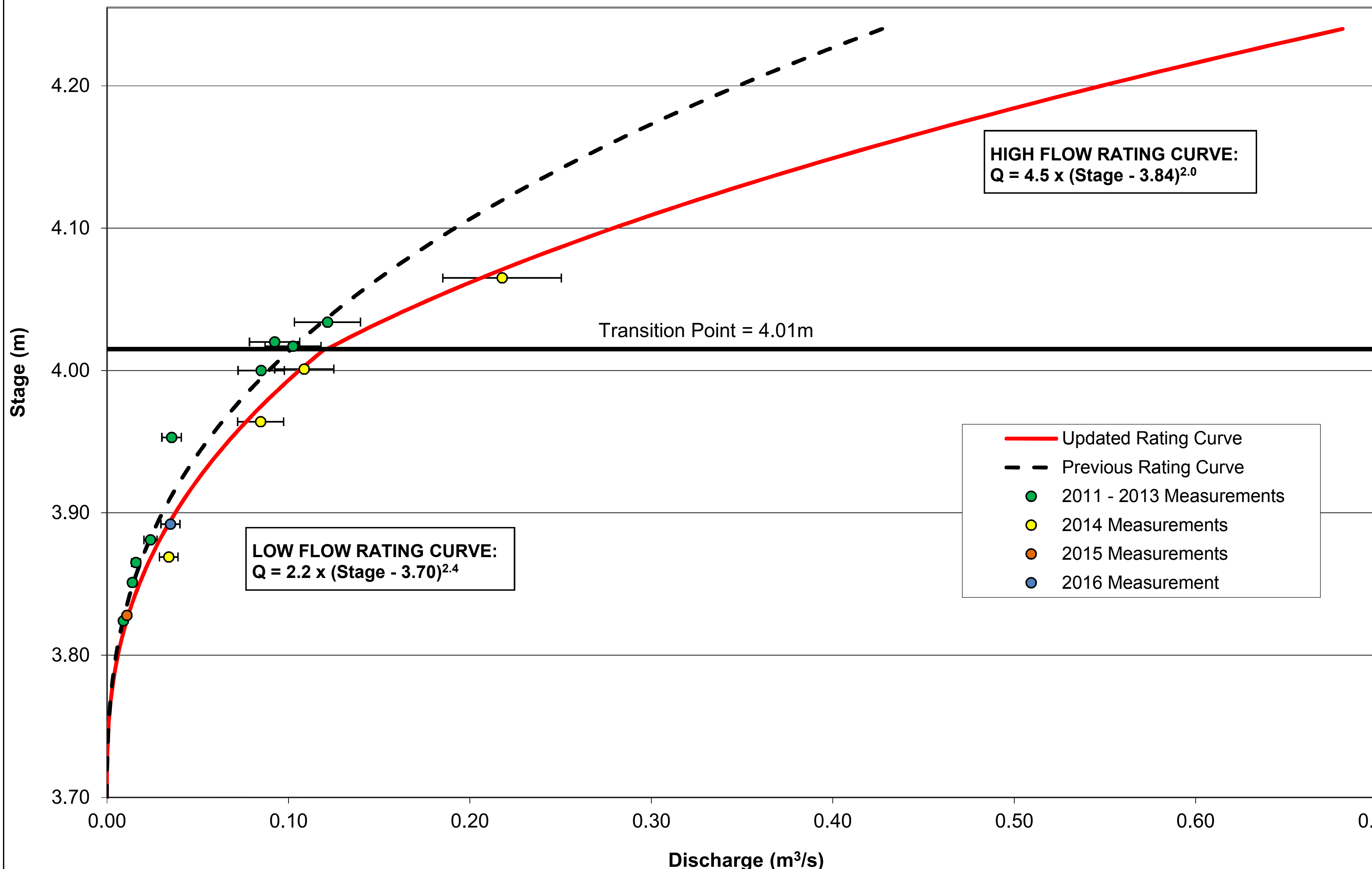


NOTES:
1. RATING CURVE SHOWN TO MAXIMUM RECORDED STAGE.

Figure 5 H06 - Mary River Rating Curve

R:\SEI\199 Baffinland\03 - 2016 Hydrology\Report\2016 AEMP Hydrology Site Report\Figures and Tables\H06 - 2016_FINALFigure 5



NOTE:
1. RATING CURVE SHOWN TO MAXIMUM RECORDED STAGE.

Figure 6 **H11 - Sheardown Lake Tributary (SDLT-1) Rating Curve**

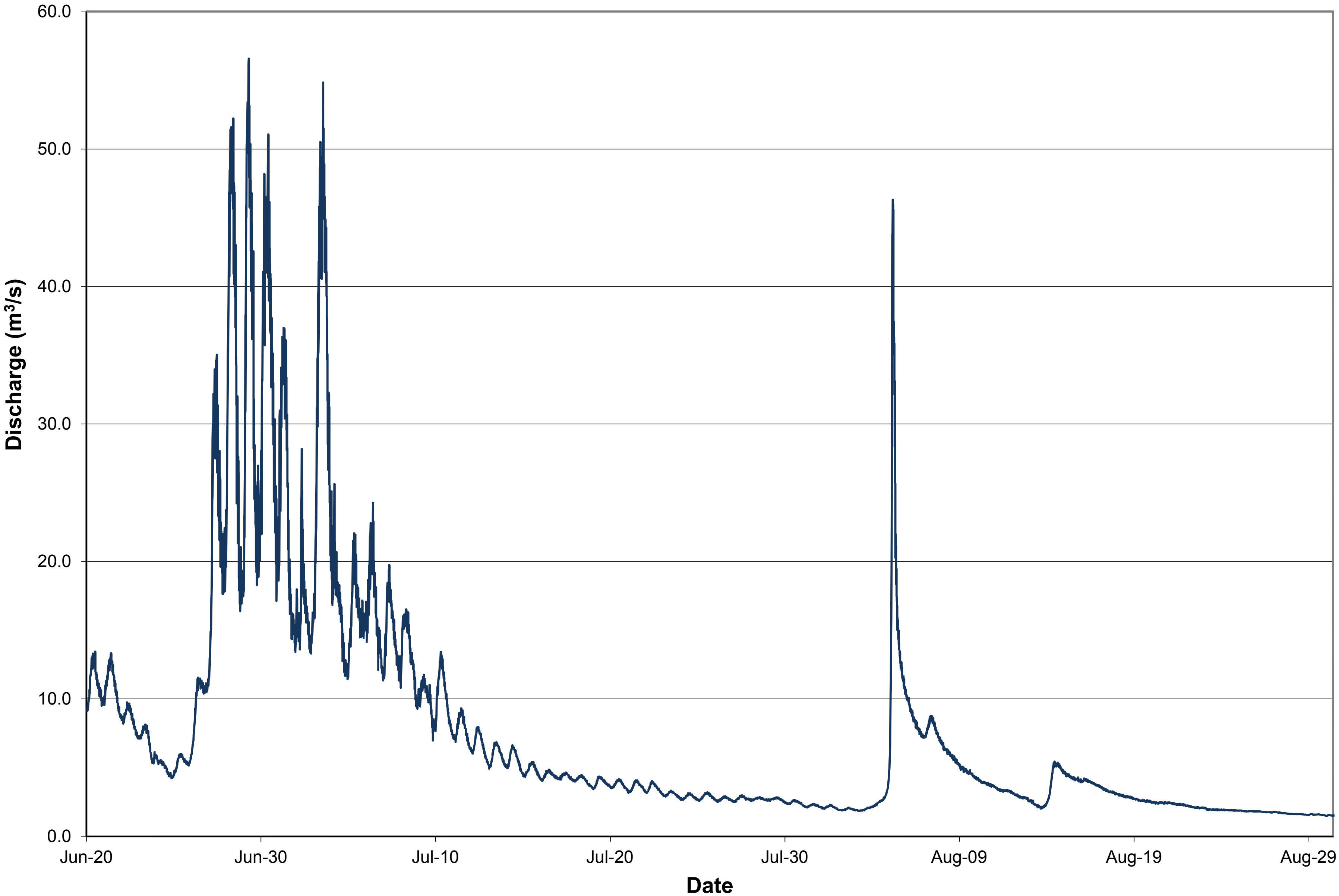


Figure 7 **H01 - Philips Creek Tributary 2016 Streamflow Record**

R:\SEI\199 Baffinland\03 - 2016 Hydrology\Report\2016 AEMP Hydrology Site Report\Figures and Tables\H01 - 2016_FINALFigure 7

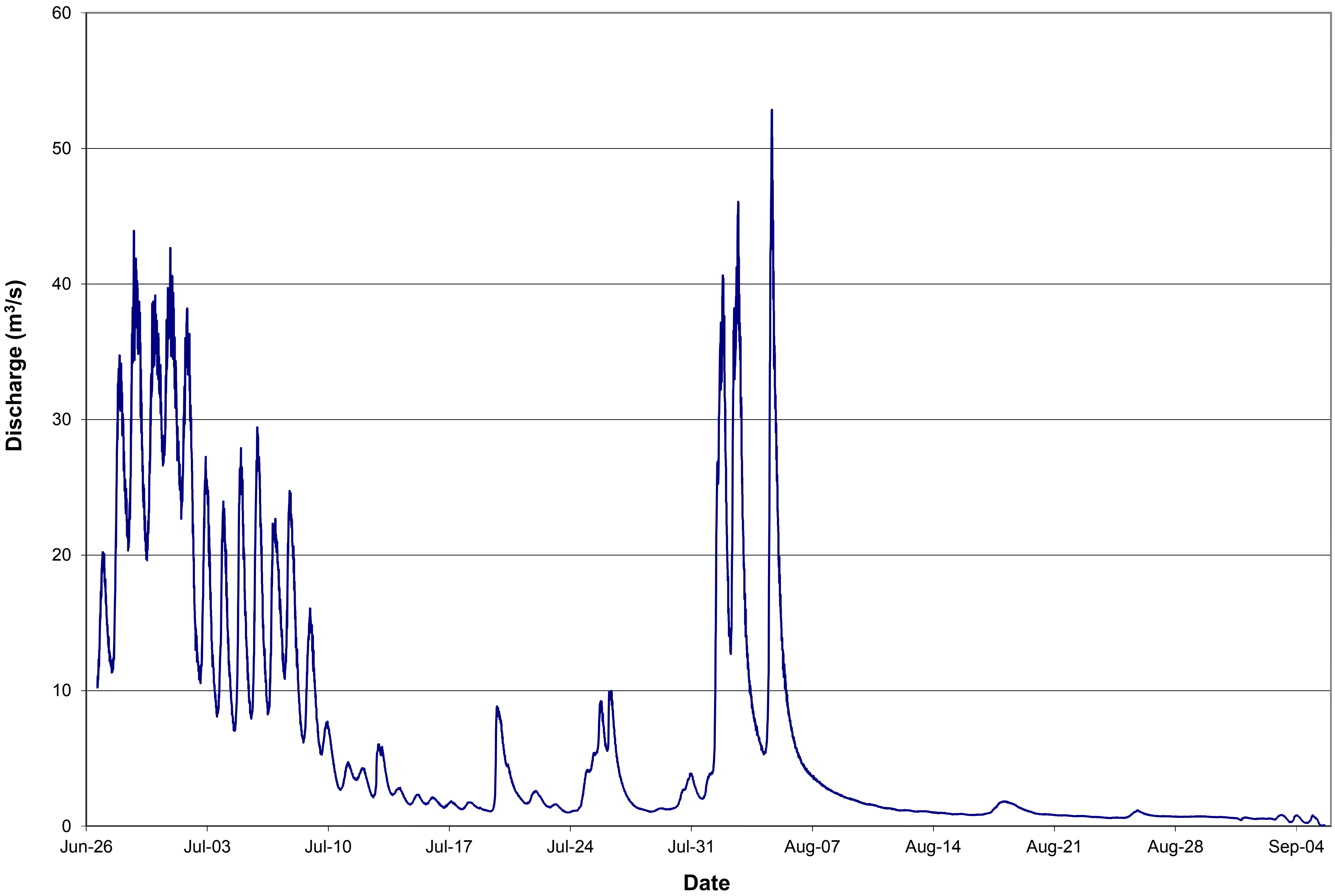


Figure 8 **H02 - Tom River 2016 Streamflow Record**

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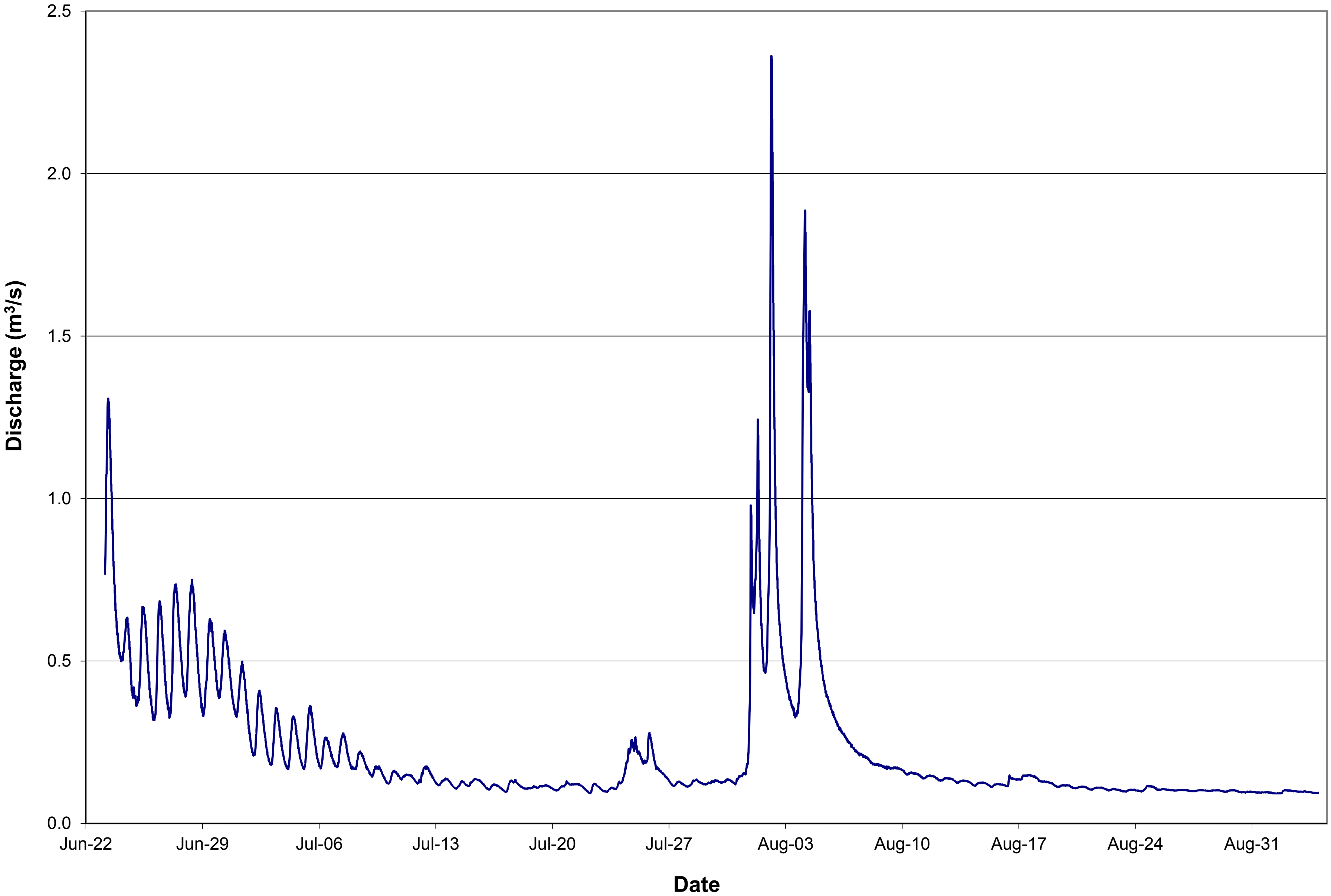

Figure 9 **H04 - Camp Lake Tributary (CLT-2) 2016 Flow Record**

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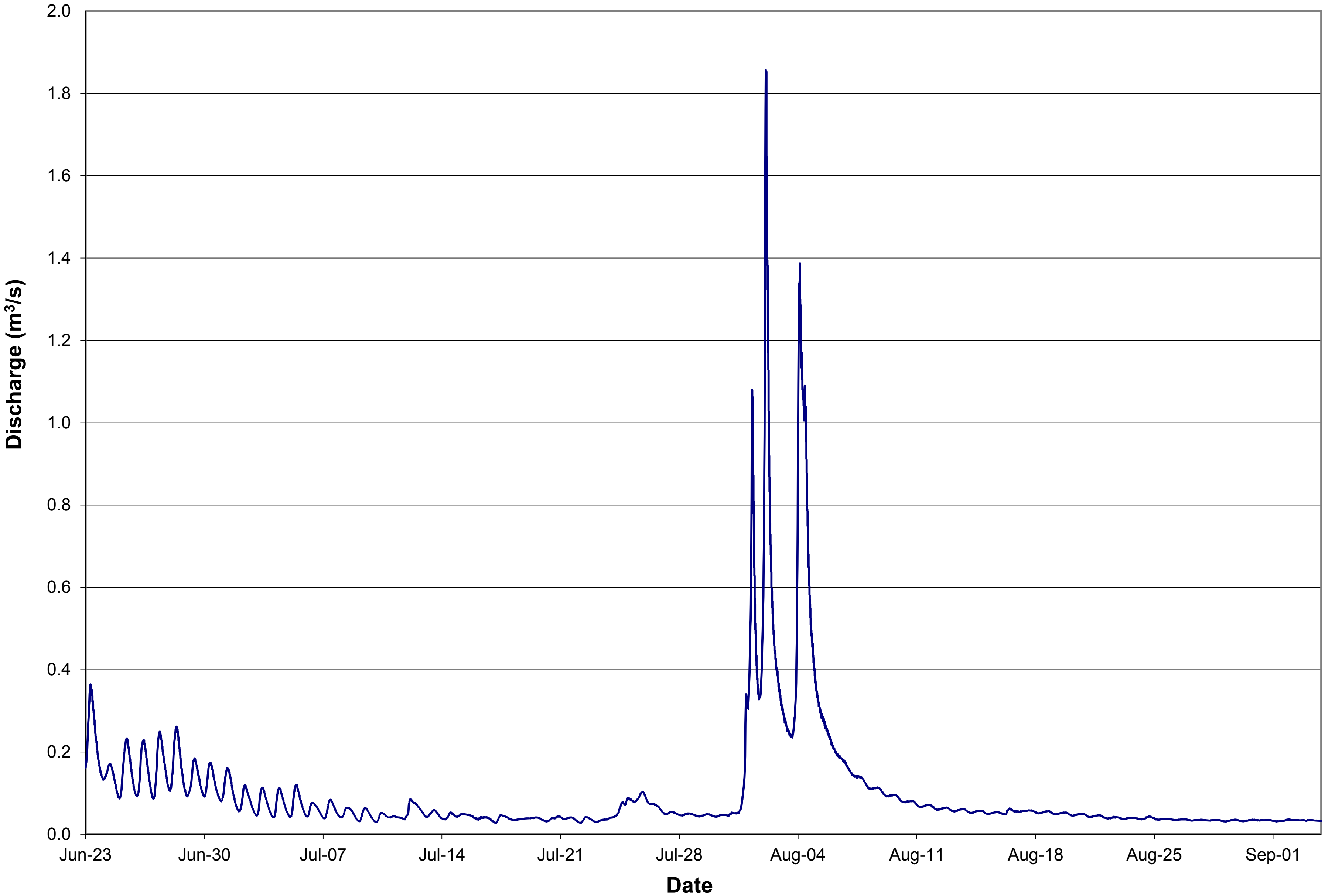

Figure 10 **H05 - Camp Lake Tributary (CLT-1) 2016 Flow Record**

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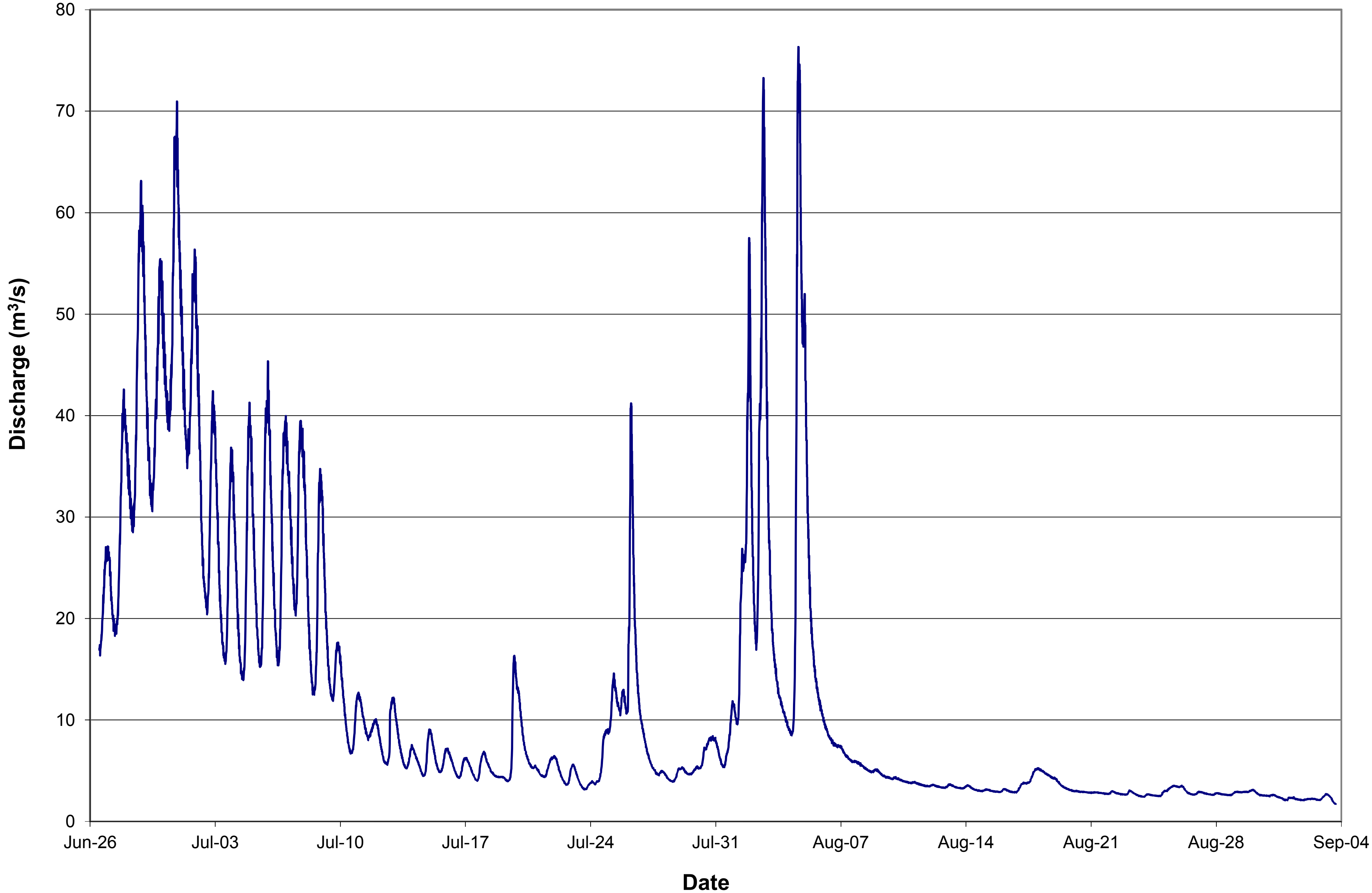


Figure 11 **H06 - Mary River 2016 Flow Record**

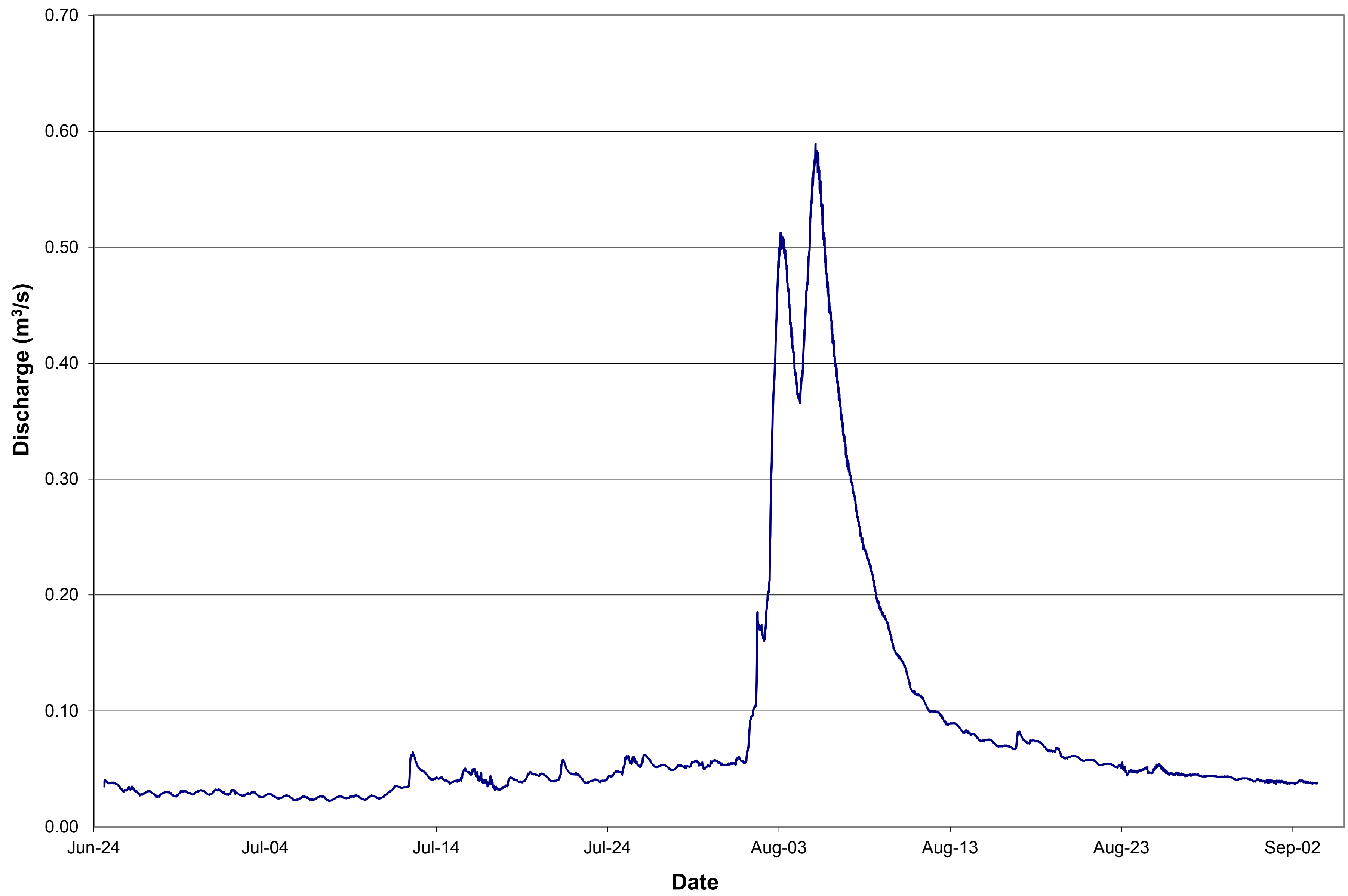


Figure 12 **H11 - Sheardown Lake Tributary (SDLT-1) 2016 Streamflow Record**

R:\SEI\199 Baffinland\03 - 2016 Hydrology\Report\2016 AEMP Hydrology Site Report\Figures and Tables\H11 - 2016_FINALFigure 12

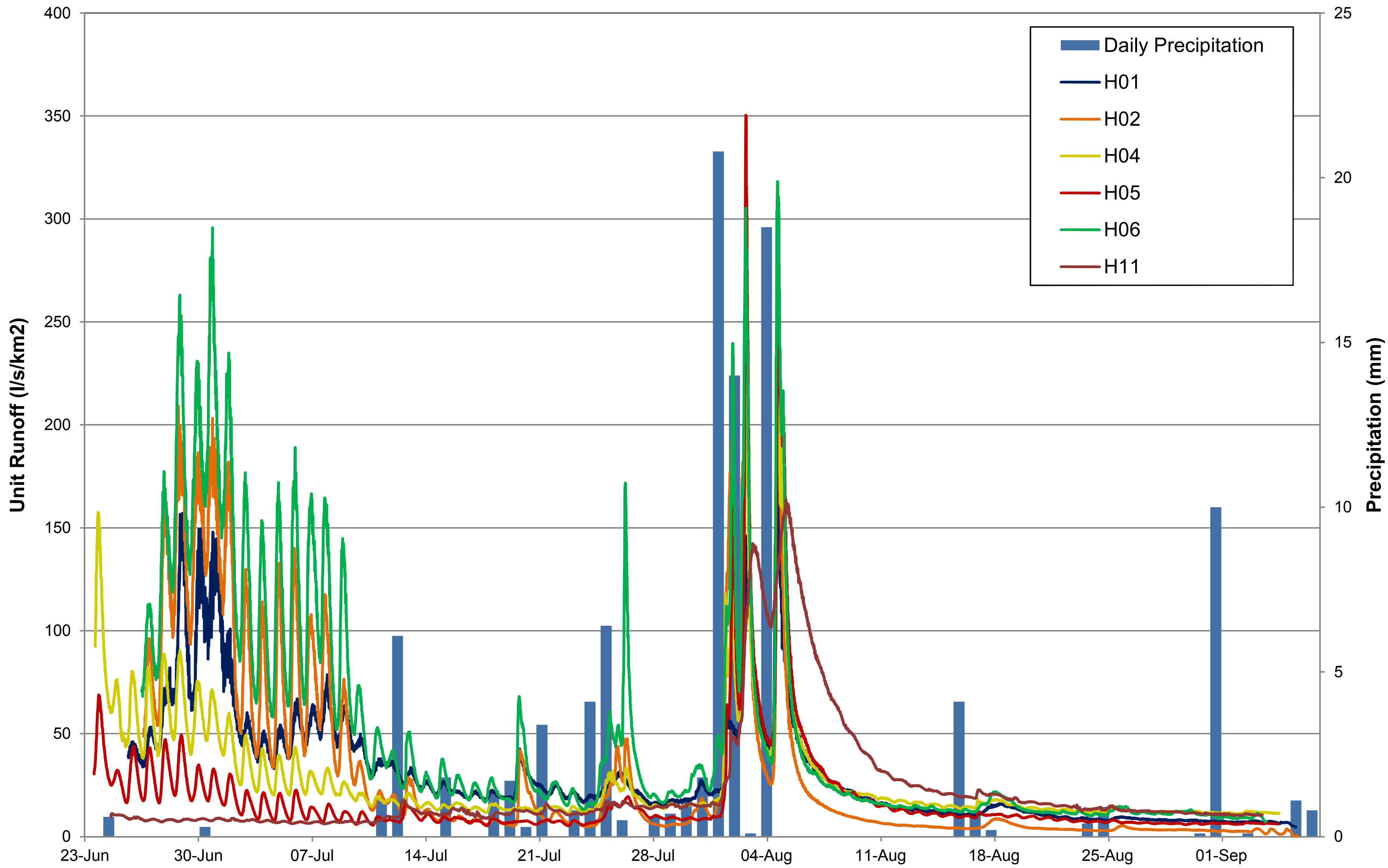


Figure 13 **2016 Unit Runoff and Daily Precipitation**

R:\SEI\199 Baffinland\03 - 2016 Hydrology\Report\2016 AEMP Hydrology Site Report\Figures and Tables\Figure 13 - Unit Hydrographs 2016 FINAL

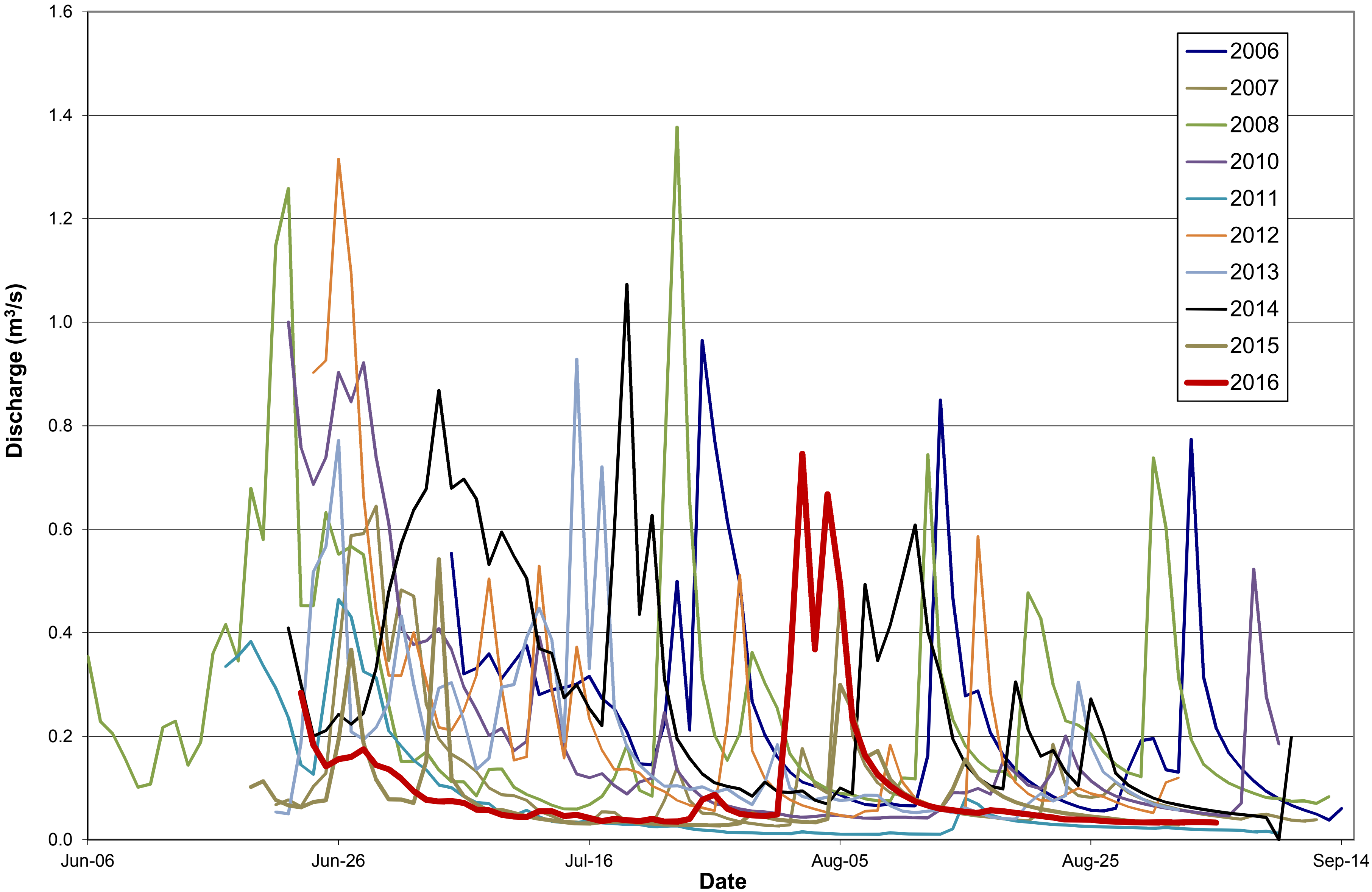


Figure 14 **H05 - Measured Streamflow Hydrographs 2006 - 2016**

R:\SEI\199 Baffinland\03 - 2016 Hydrology\Report\2016 AEMP Hydrology Site Report\Figures and Tables\Figure 14 - H5 Flow Record 2006-2016Figure 14

APPENDIX B

UPDATED DESIGN PEAK FLOW ASSESSMENT

(Pages B-1 to B-13)

December 13, 2016

File No.:NB102-00181/39-A.01
Cont. No.:VA16-01950

FS 64925
EMS 550121
OHS 550122

Mr. Matt Weaver
Project Director
Baffinland Iron Mines Corporation
#300 - 2275 Upper Middle Road East
Oakville, Ontario
Canada, L6H 0C3

Dear Matt,

Re: Updated Design Peak Flow Assessment

Baffinland Iron Mines Corporation (Baffinland) has requested that Knight Piésold Ltd. (KP) update the design peak flow analysis for the Mary River Project to incorporate recent streamflow data.

The previous peak flow analysis completed by KP (2012) was based on limited streamflow data collected by KP over the period of 2006 to 2011, along with longer term regional Water Survey of Canada data. Updated return period flow estimates incorporating streamflow data collected since 2011 will be used by Baffinland to support the design of water crossings along its north railway connecting Milne Port to the Mine Site.

BACKGROUND

A long-term hydrological record does not exist for the North Baffin Region. Stream flow has been monitored at the Mary River Project since 2006, with up to 16 seasonal stream gauges on smaller river/creek systems and four (4) year-round hydrometric stations on larger systems (Water Survey of Canada) operated at various times. Table 1 and Figure 1 present the six (6) seasonal hydrometric stations that continue to be operated by Baffinland.

Table 1 Active Hydrometric Stations

Station	Location	Catchment Area (km^2)
H1	Tributary of Phillip's Creek	250
H2	Tom River	210
H4	Camp Lake Tributary 2 (CLT-2)	8.3
H5	Camp Lake Tributary 1, branch L1 (CLT-1, L1)	5.3
H6	Mary River	240
H11	Sheardown Lake Tributary 1 (SDLT-1)	3.6

ANALYSIS

Annual peak instantaneous flow records are now available from the six active hydrometric stations listed in Table 1, for periods ranging from 6 to 10 years, as summarized in Table 2.

Table 2 Annual Peak Instantaneous Flow Records (m^3/s)

	Station					
Year	H1	H2	H4	H5	H6	H11
2006	35.1	69.9	5.3	3.2	100.3	
2007	35.0	46.7	2.0	1.4	40.2	
2008	41.6		3.1	2.8	76.8	
2009						
2010		51.3		1.7	56.6	
2011	25.0		1.5	0.7	76.5	0.10
2012	67.3	61.0	2.2	1.9	86.5	0.17
2013	18.0	77.0	1.3	2.2	77.7	0.33
2014		59.9	2.5	2.1	129.8	0.59
2015	56.6	48.6	3.6	1.4	90.1	0.27
2016	29.4	33.8	1.1	0.7	50.8	0.52
Mean	38.5	56.0	2.5	1.8	78.5	0.33
St. Dev.	16.4	13.8	1.3	0.8	25.9	0.2
CV	0.43	0.25	0.53	0.45	0.33	0.58
Skew	0.78	-0.02	1.21	0.22	0.47	0.31
Count	8	8	9	10	10	6

These datasets and their associated statistics were used to develop frequency distributions based on an Extreme Value Type I distribution, from which return period flood flow values were determined, as summarized in Table 3.

Table 3 Return Period Flow Estimates (m^3/s)

Return Period	Station					
	H1	H2	H4	H5	H6	H11
2 Year	38	56	2.5	1.8	79	0.33
5 Year	54	69	3.8	2.6	104	0.52
10 Year	66	80	4.8	3.2	123	0.66
25 Year	82	92	6.0	3.9	147	0.84
100 Year	104	111	7.8	5.0	182	1.10
200 Year	115	121	8.7	5.6	200	1.23

These flood values were then plotted against drainage area to develop upper envelope scaling relationships, which were compared to the regionally based scaling relationships generated in 2006. These plots, as shown on Figures 2 to 7, indicate that the 2006 scaling relationships provide a very good basis for estimating peak flows for drainage basins greater than approximately 100 km^2, but tend to substantially overestimate flows for smaller watersheds. However, given the limited length of the site records, and that the measured peak flow datasets involved the considerable extrapolation of their respective rating curves, it should be recognized that there is considerably uncertainty in the estimated flows, particularly for return periods greater than approximately 20 years and for smaller basins since they are not supported by regional data.

Accordingly, and given that it is prudent to err on the side of caution when determining design peak flows, it is recommended that an intermediate curve, as indicated by the solid black line on the plots, be adopted for determining design flows. These curves also provide some contingency to account for potential increases in future peak flows that may be influenced by a possibly changing climate. The recommended scaling equations for determining return period peak design flows are summarized as follows:

$$Q_2 = 0.72 \times A^{0.86}$$

$$Q_5 = 1.10 \times A^{0.84}$$

$$Q_{10} = 1.32 \times A^{0.83}$$

$$Q_{25} = 1.70 \times A^{0.82}$$

$$Q_{100} = 2.27 \times A^{0.80}$$

$$Q_{200} = 2.53 \times A^{0.80}$$

Where, Q = peak instantaneous flow in m^3/s

A = drainage area in km^2

It should be noted that site and regional peak flow data are not available for very small watersheds, and therefore a reassessment of the rainfall-runoff approach previously recommended for very small watersheds is not possible. As a result, it is recommended that this approach, as outlined in Appendix B of the 2011 Mary River Hydrology Report, continue to be used for basins with areas less than 0.5 km^2. This approach will generally produce higher peak flow estimates than would be generated with the equations listed above.

The question has been raised as to whether the annual peak flows are primarily due to snowmelt, rainfall, or rain on snow? The dates of the annual peak flow events, as summarized in Table 4, indicate that the majority of annual peak flows are likely due to snowmelt, or snowmelt combined with rain, since the largest annual runoff events primarily occur during the freshet period in June and July. The dates for the largest events on record for each station are indicated by the yellow highlighting in Table 4, and these all occur in June and July.

Table 4 Timing of Annual Peak Flow Events (m^3/s)

Month of Maximum Annual Flow						
	Station					
Year	H1	H2	H4	H5	H6	H11
2006	Sep	Sep	Jul	Jul	Sep	
2007	Jun	Jun	Jul	Jul	Jul	
2008	Jul		Jul	Jul	Aug	
2009						
2010		Jun		Jun	Jun	
2011	Jun		Jun	Jun	Jun	Jun
2012	Jun	Jun	Aug	Jun	Aug	Aug
2013	Jun	Jul	Aug	Jul	Jul	Jul
2014		Jul	Jul	Jul	Jul	Jun
2015	Jun	Jul	Jul	Jul	Jul	Jul
2016	Jun	Jun	Jun	Aug	Jun	Aug
Area (km^2)	250	210	8.3	5.3	240	3.6

It is worth noting, however, that in some years the largest flows occur in September and August due to intense rainfall, such as in 2006 when the annual peak flows occurred in September (green shading) at stations H1, H2 and H6. Furthermore, in some years very large flow events occur in the spring, summer and fall periods, as demonstrated by the hydrograph plots for 2006, as shown on Figures 8 and 9. Interestingly, in this year the largest events in the small watersheds were due to snowmelt, while those in the large watersheds were due to rainfall.

CULVERT SIZING

Sizing culverts simply on the basis of the design flows may not be adequate because of the potential for partial culvert blockage due to ice formation over the winter, particularly in culverts situated in low lying areas with standing water. Accordingly, consideration should be given to increasing culvert sizes to account for a partial blockage due to ice.

CLOSURE

We trust this meets your current requirements. Please do not hesitate to contact the undersigned with any questions.

PROFESSIONAL PROVINCE OF J. G. CATHCART BRITISH COLUMBIA ENGINEER Dec 13, 2016

Prepared: ______________________ Reviewed: ______________________

Jaime Cathcart, Ph.D., P.Eng.
Specialist Hydrotechnical Engineer | Associate

Richard Cook, P.Geo. (Ltd.)
Senior Environmental Scientist | Associate

Approval that this document adheres to Knight Piésold Quality Systems:

Attachments:

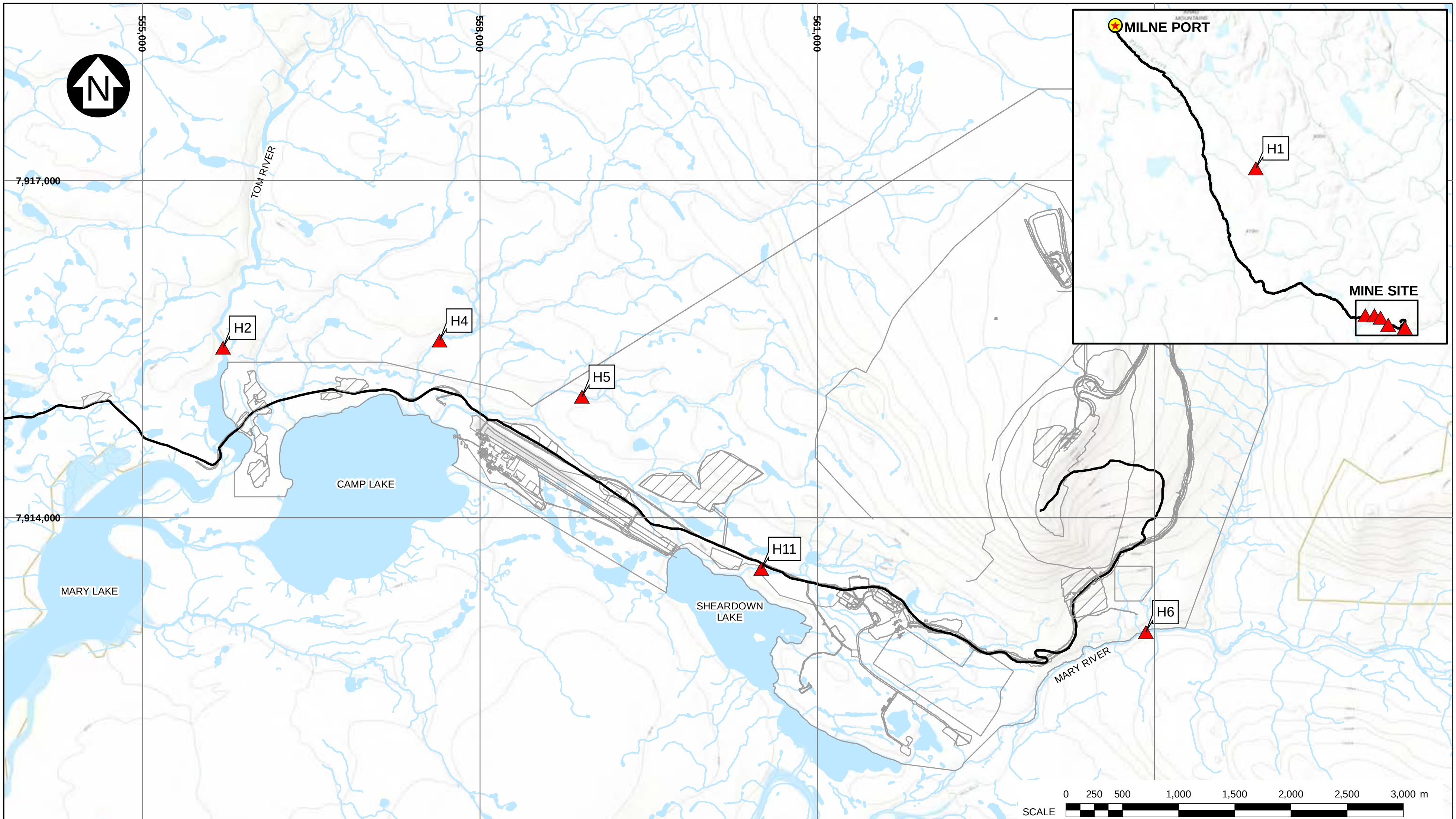
Figure 1 Rev 0	Active Hydrometric Stations
Figure 2 Rev 1	Scaling Plots for Q2 Recommended Design Flows
Figure 3 Rev 1	Scaling Plots for Q5 Recommended Design Flows
Figure 4 Rev 1	Scaling Plots for Q10 Recommended Design Flows
Figure 5 Rev 1	Scaling Plots for Q25 Recommended Design Flows
Figure 6 Rev 1	Scaling Plots for Q100 Recommended Design Flows
Figure 7 Rev 1	Scaling Plots for Q200 Recommended Design Flows
Figure 8 Rev 0	2006 Hydrographs for H1, H2 and H6
Figure 9 Rev 0	2006 Hydrographs for H4 and H5

Copy To: Wayne McPhee

REFERENCES:

Knight Piésold Ltd. (KP), 2012. *Baseline Hydrology Report*. January 4. North Bay, Ontario. Ref. No. NB102-181/30-7, Rev. 1.

/jc



LEGEND:

- ACTIVE HYDROMETRIC STATION
- MILNE INLET TOTE ROAD
- EXISTING INFRASTRUCTURE
- RIVER/STREAM/DRAINAGE
- WATER

NOTES:

1. BASE MAP: © ESRI DATA AND MAPS (ONLINE) (2016). REDLANDS, CA: ENVIRONMENTAL SYSTEMS RESEARCH INSTITUTE. ALL RIGHTS RESERVED.
2. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

ACTIVE HYDROMETRIC STATIONS

Knight Piésold CONSULTING

P/A NO.	REF NO.
NB102-181/39	VA16-01950

FIGURE 1 REV 0

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
0	13DEC'16	ISSUED WITH LETTER	RAC	AS	JC

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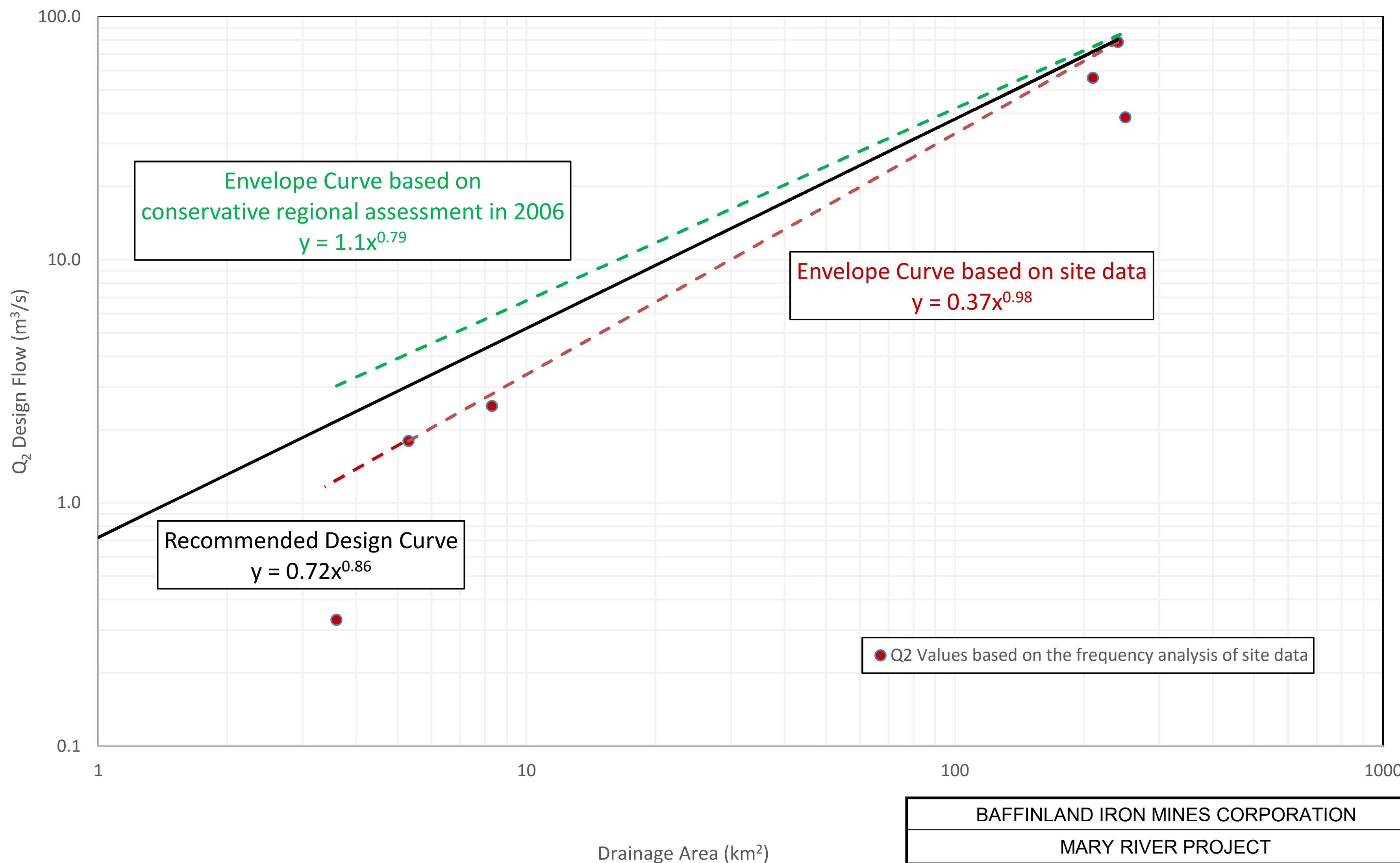


1	06DEC16	ISSUED FOR INFORMATION	JGC	RC
REV	DATE	DESCRIPTION	PREP'D	RVWD

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

SCALING PLOTS FOR Q2 RECOMMENDED DESIGN FLOWS

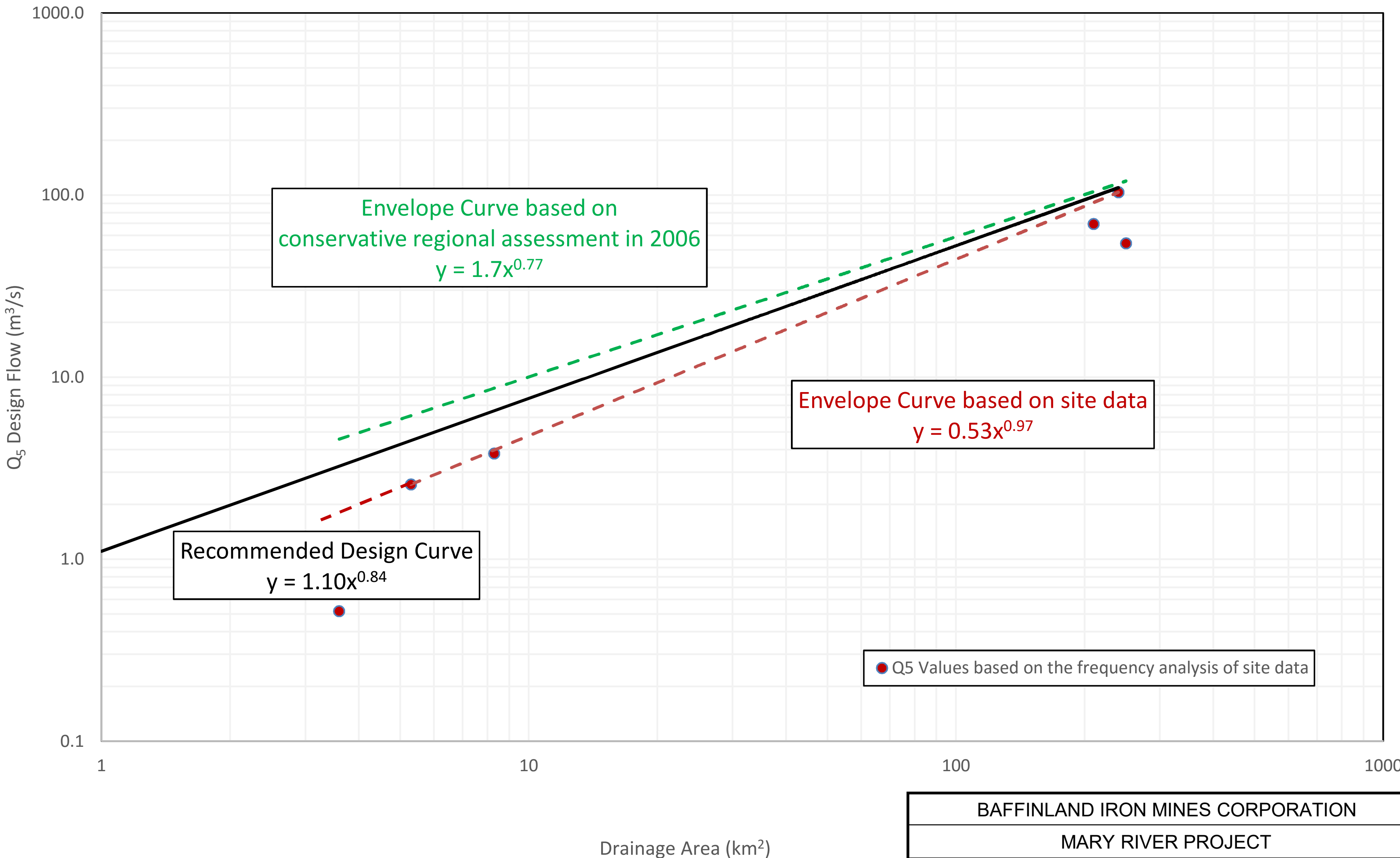
Knight Piésold CONSULTING

P/A NO. NB102-181/30

REF NO. VA16-01950

FIGURE 2

REV 1



BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

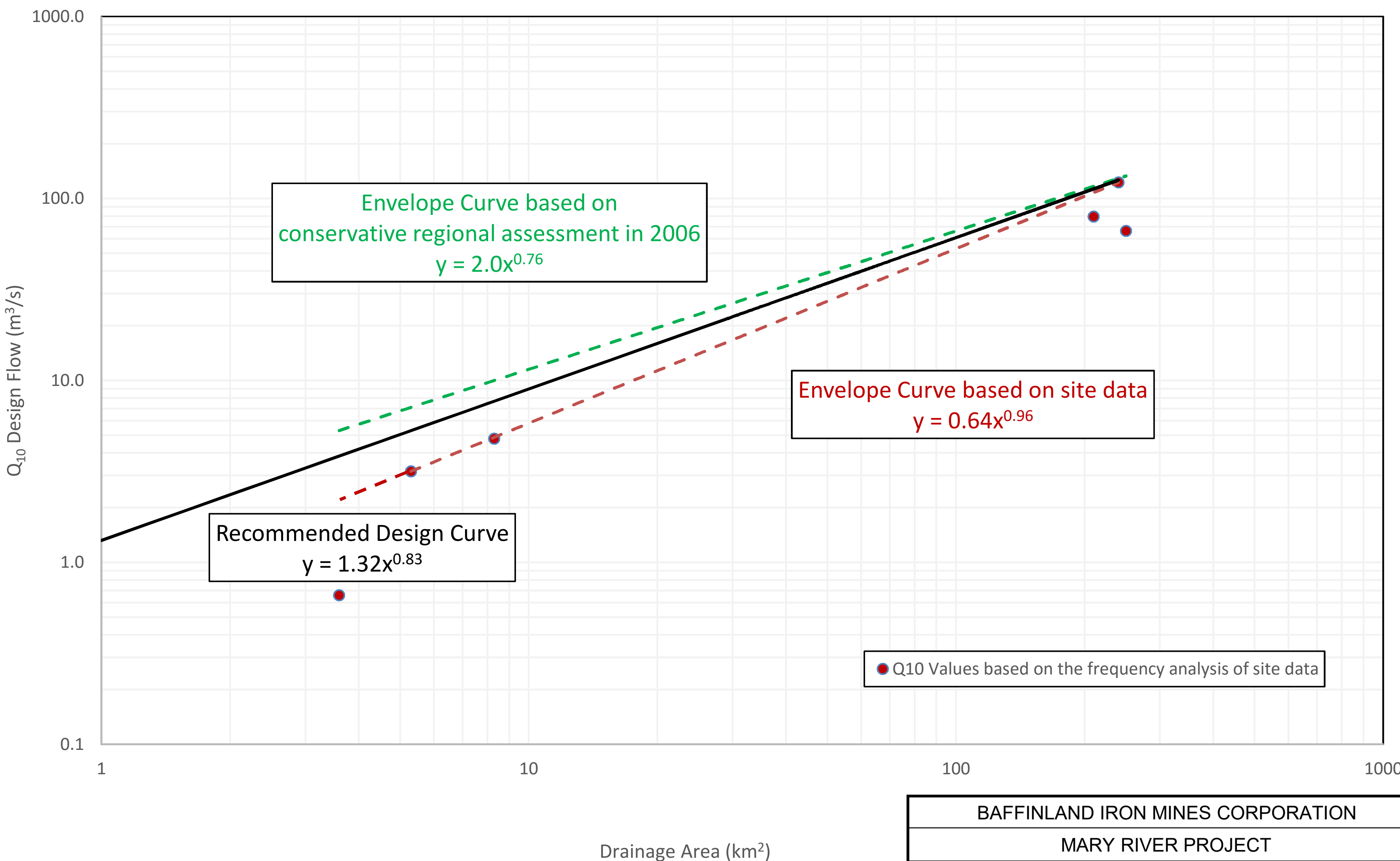
SCALING PLOT FOR Q5
RECOMMENDED DESIGN FLOWS

Knight Piésold CONSULTING

P/A NO.	REF NO.
NB102-181/30	VA16-01950

FIGURE 3 REV 1

1	06DEC16	ISSUED FOR INFORMATION	JGC	RC
REV	DATE	DESCRIPTION	PREP'D	RVWD



1	06DEC16	ISSUED FOR INFORMATION	JGC	RC
REV	DATE	DESCRIPTION	PREP'D	RVWD

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

SCALING PLOT FOR Q10
RECOMMENDED DESIGN FLOWS

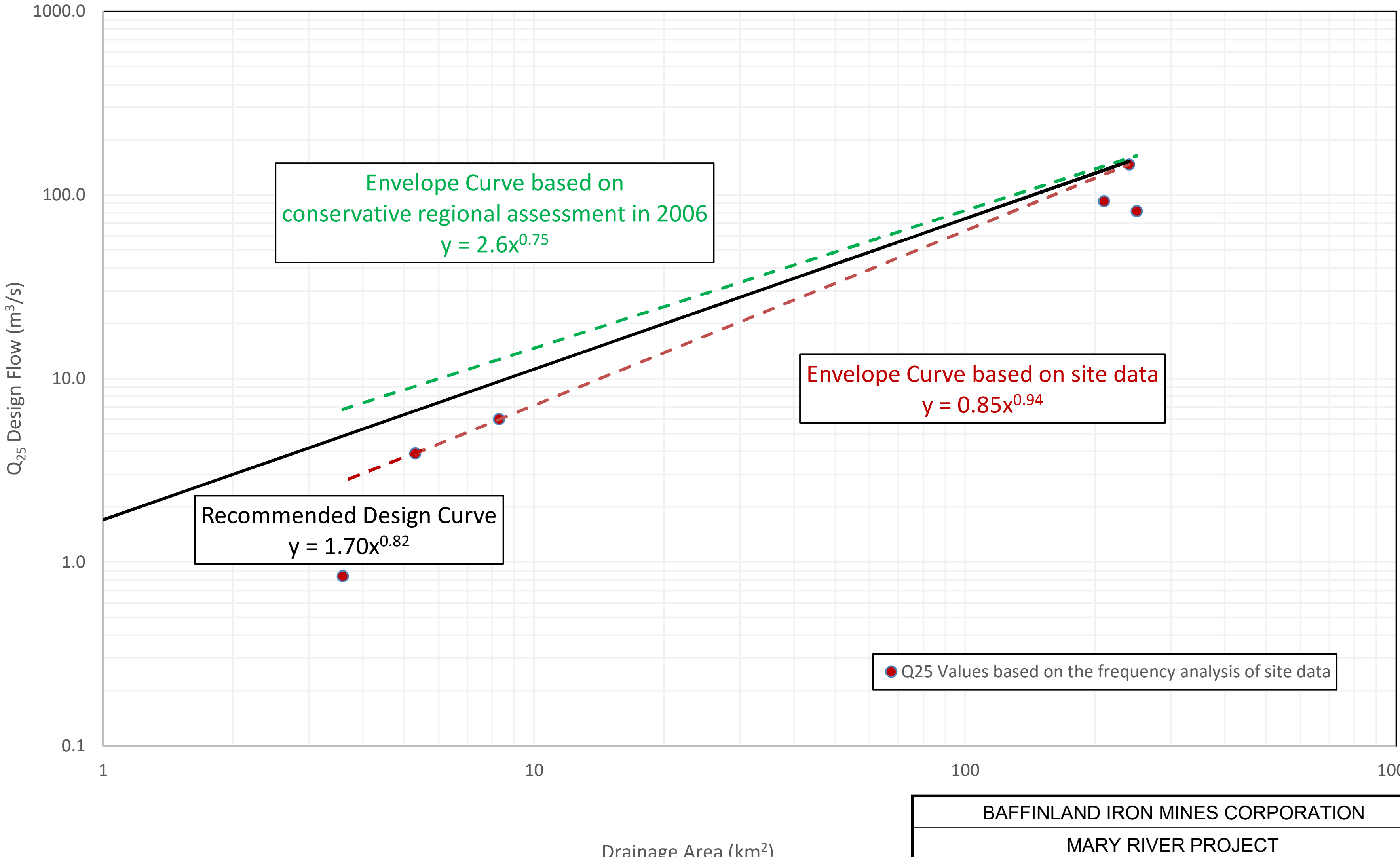
Knight Piésold CONSULTING

P/A NO. NB102-181/30

REF NO. VA16-01950

FIGURE 4

REV 1



BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

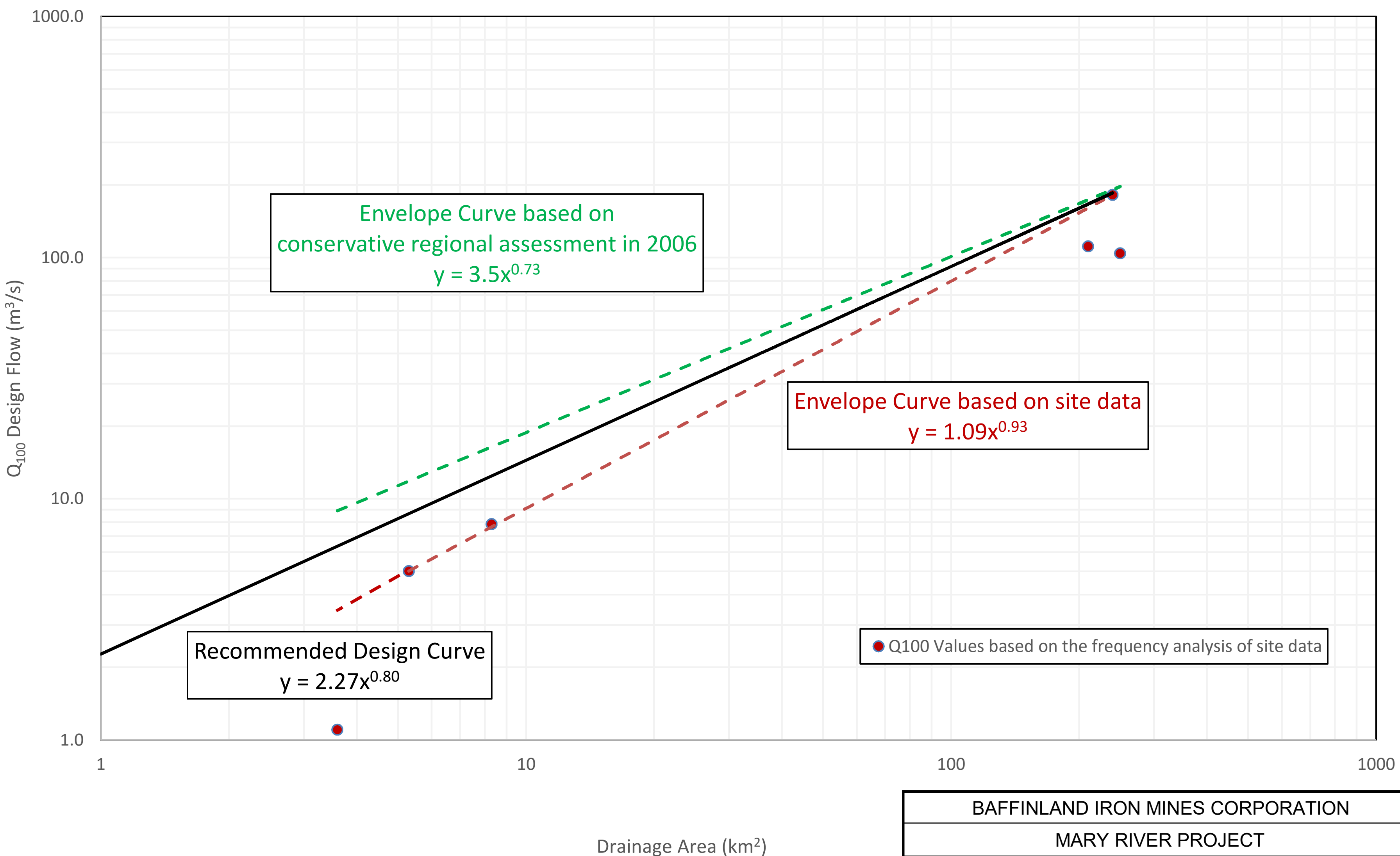
SCALING PLOT FOR Q25
RECOMMENDED DESIGN FLOWS

Knight Piésold CONSULTING

P/A NO.	REF NO.
NB102-181/30	VA16-01950

FIGURE 5 REV 1

1	06DEC16	ISSUED FOR INFORMATION	JGC	RC
REV	DATE	DESCRIPTION	PREP'D	RVWD



BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

SCALING PLOT FOR Q100
RECOMMENDED DESIGN FLOWS

Knight Piésold CONSULTING

P/A NO. NB102-181/30

REF NO. VA16-01950

FIGURE 6

REV 1

REV	DATE	DESCRIPTION	PREP'D	RVWD
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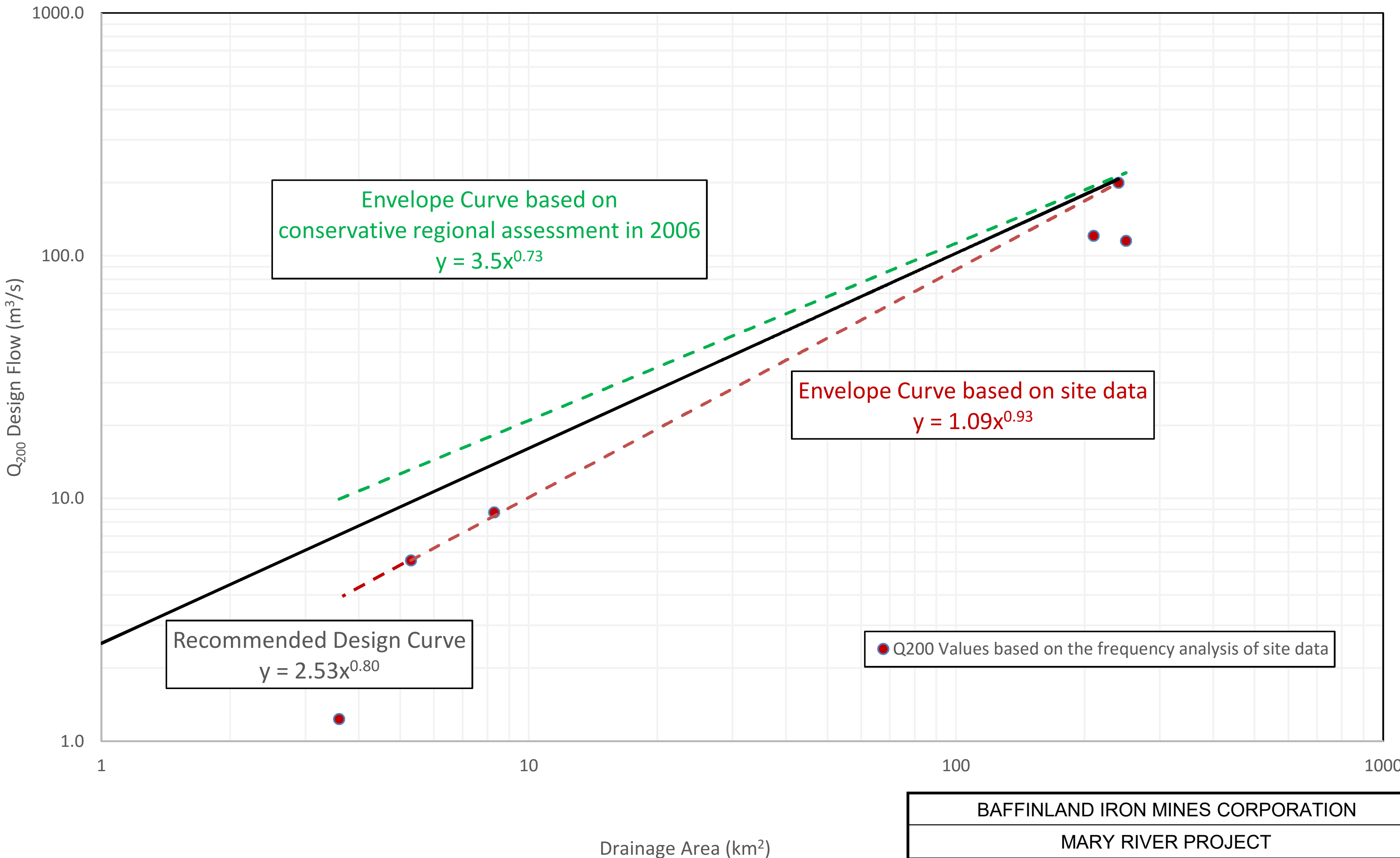


REV	DATE	DESCRIPTION	PREP'D	RVWD
1	06DEC16	ISSUED FOR INFORMATION	JGC	RC

BAFFINLAND IRON MINES CORPORATION

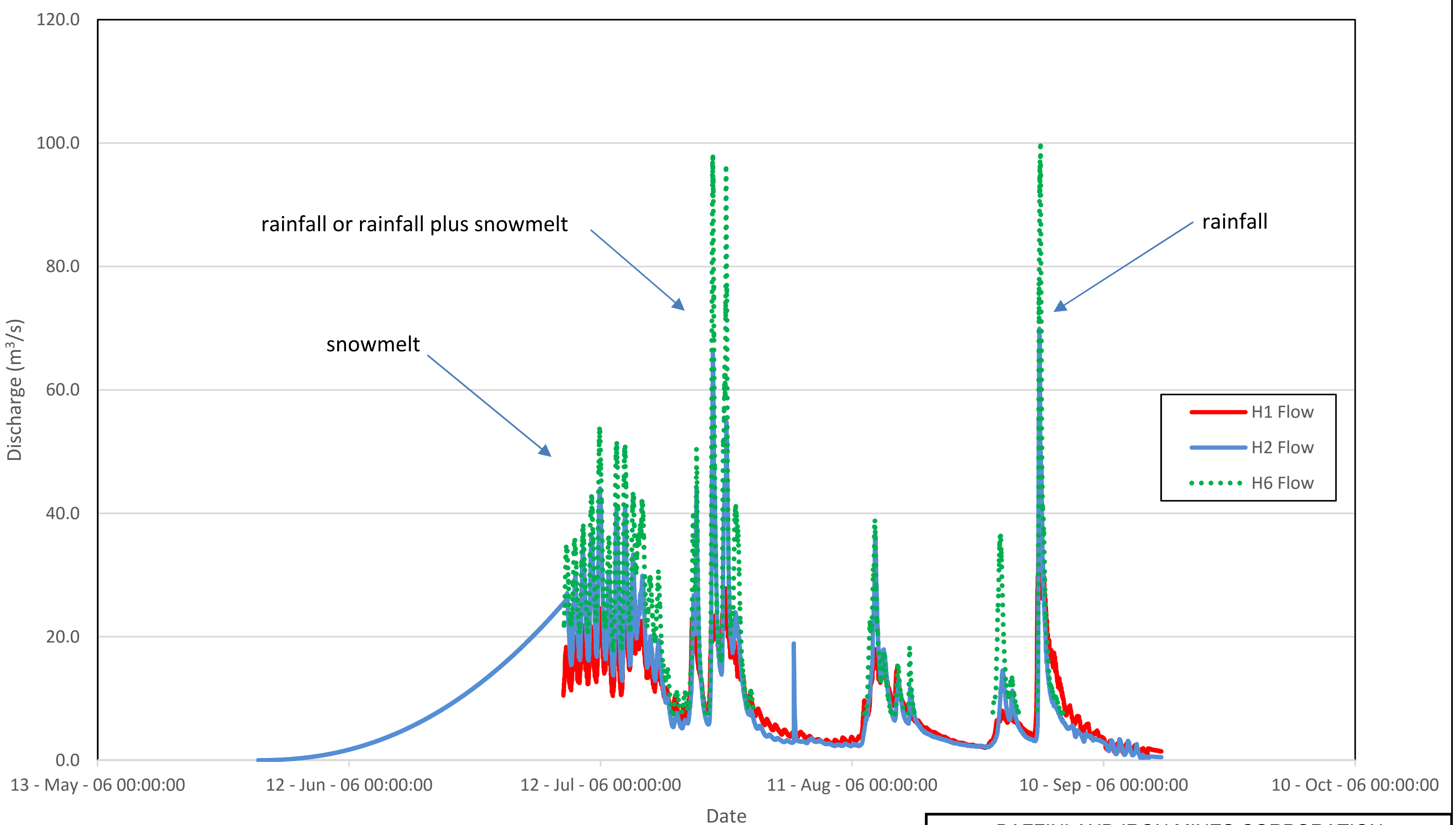
MARY RIVER PROJECT

SCALING PLOT FOR Q200
RECOMMENDED DESIGN FLOWS

Knight Piésold CONSULTING

P/A NO. NB102-181/30 | REF NO. VA16-01950

FIGURE 7 | REV 1



Basin Areas : H1: 250 km^2
H2: 210 km^2
H6: 240 km^2

0	06DEC16	ISSUED FOR INFORMATION	JGC	RC
REV	DATE	DESCRIPTION	PREP'D	RVWD

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

2006 HYDROGRAPHS FOR H1,H2 and H6

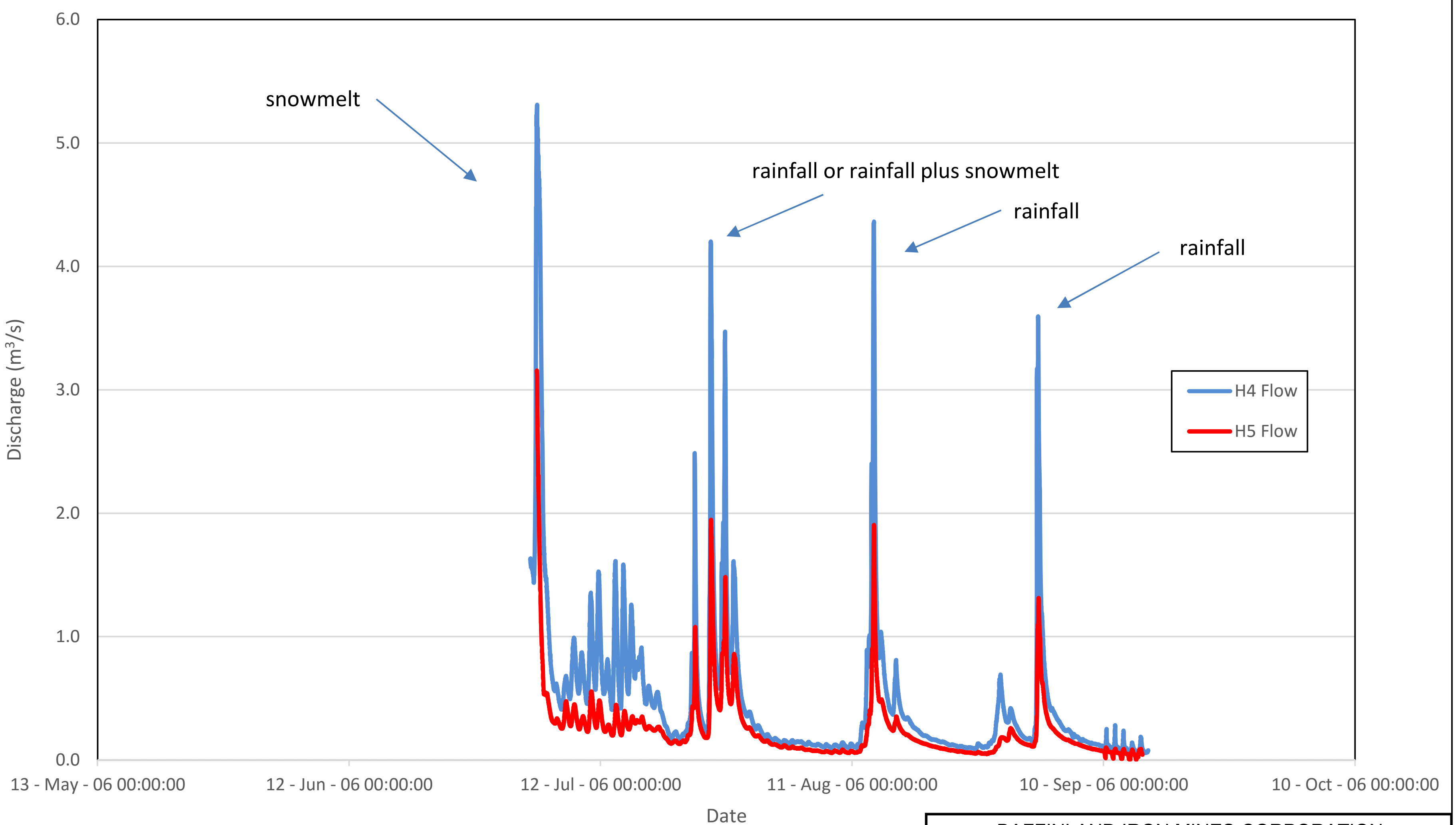
Knight Piésold CONSULTING

P/A NO. NB102-181/30

REF NO. VA16-01950

FIGURE 8

REV 0



Basin Areas : H4: 8.3 km²
H5: 5.3 km²

0	06DEC16	ISSUED FOR INFORMATION	JGC	RC
REV	DATE	DESCRIPTION	PREP'D	RVWD

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

2006 HYDROGRAPHS FOR H4 AND H5

Knight Piésold CONSULTING

P/A NO. NB102-181/30

REF NO. VA16-01950

FIGURE 9

REV 0

APPENDIX C

WATER TAKE ASSESSMENT

(Pages C-1 to C-11)

November 16, 2017

File No.:NB102-00181/39-A.01
Cont. No.:NB17-00728

Ms. Megan Lord-Hoyle
Sustainability Manager
Baffinland Iron Mines Corporation
#300 - 2275 Upper Middle Road East
Oakville, Ontario
Canada, L6H 0C3

Dear Megan,

Re: Hydrology Assessment of Water Sources for Dust Suppression along the Tote Road and North Railway - Mary River Project - Phase 2 Proposal

1 – INTRODUCTION

Baffinland Iron Mines Corporation (Baffinland) has requested that Knight Piésold Ltd. (KP) identify suitable additional water sources for dust suppression along the Milne Inlet Tote Road (Tote Road), and along an adjacent North Railway to be constructed as part of the Phase 2 Proposal. This assessment will be used to support an Addendum to the Final Environmental Impact Statement (FEIS) under preparation for the Phase 2 Proposal.

Baffinland's Type A Water Licence includes 15 water take stations for use in dust suppression efforts on the Tote Road (Nunavut Water Board, 2014). The currently approved stations were assessed previously (KP, 2014).

Additional water take locations will be required during the Phase 2 Proposal to support improved dust suppression efforts along the Tote Road and the railway construction right-of-way (ROW). Using the additional stations identified in this assessment, water trucks will be able to spend more time applying water and less time shuttling between the water source and the section of road and rail construction area being watered. In general terms, the more often the fleet of water trucks can apply water to the road, the more effective the dust suppression efforts will be. In addition to shortening the time required to coat the entire road surface and rail construction area, more water take locations will reduce the intensity of traffic along the road, and reduce fuel consumption and greenhouse gas (GHG) emissions.

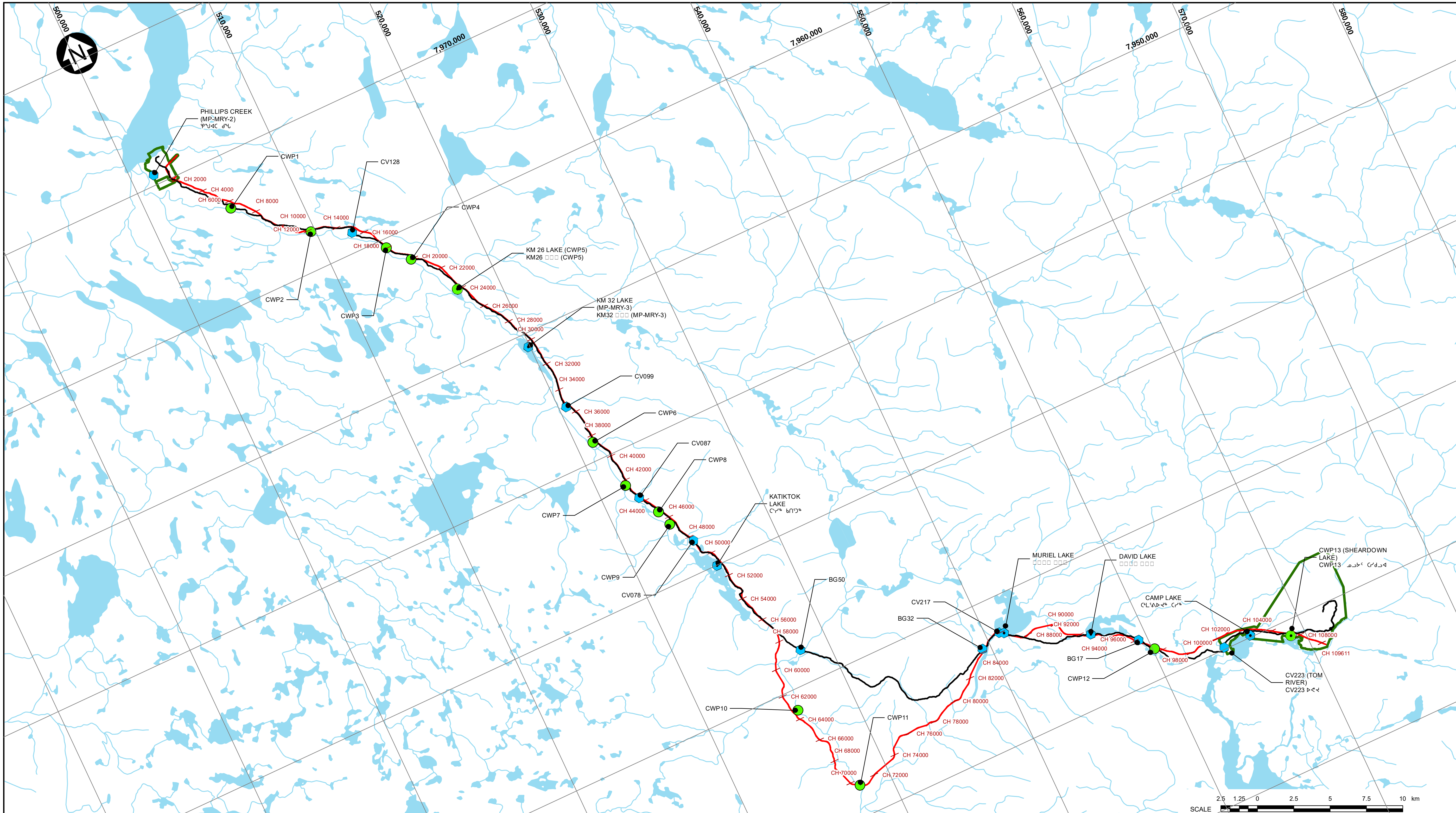
This updated assessment identifies an additional 13 viable water sources (lakes and streams) located within 250 m of the Tote Road and/or the proposed Railway ROW (Figure 1). This assessment applies the same thresholds as the previous assessment (KP, 2014) in identifying water sources that are of sufficient size to support the instantaneous water withdrawal rate during all or most flow conditions. Where applicable, the cumulative withdrawal of water from multiple stations in the same stream has been considered.

2 – METHODOLOGY AND ASSUMPTIONS

2.1 WATER TRUCK DETAILS AND DUST SUPPRESSION REQUIREMENTS

Water trucks will continue to be used to draw water from local watercourses and apply the water to the road and rail construction areas. The water trucks are equipped with onboard water pumps (Bowie 3300 pumps) powered by the trucks' engines. The intake hose on each truck is equipped with a fish screen in accordance with Department of Fisheries and Oceans requirements (DFO, 1995).

The maximum operating rate of the water pumps on the water trucks is 233 US gpm, equivalent to 14.7 L/s. Each truck has a capacity of 8,000 US gallons, equivalent to 30,000 L (Baffinland, 2017). At a maximum pumping rate of 14.7 L/s and a truck capacity of 30,000 L, each truck will be filled in approximately 34 minutes.



LEGEND

- NORTH RAILWAY CHAINAGE (m)
- APPROVED WATER SOURCES, LAKE
- APPROVED WATER SOURCES, STREAM
- CONSTRUCTION WATER SOURCE, LAKE
- CONSTRUCTION WATER SOURCE, STREAM
- MILNE INLET TOTE ROAD
- PROPOSED NORTH RAILWAY
- POTENTIAL DEVELOPMENT AREA
- MILNE PORT- REVISED PDA FOR PHASE 2 PROPOSAL MILNE
- RIVER/STREAM/DRAINAGE
- WATER

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.

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
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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	NB17-00728	0

FIGURE 1

Each load of water will be applied over approximately 15,870 m^2 of road/railway access trail. This equates to approximately 2.27 km of Tote Road (based on an average width of 7 m) and approximately 3.17 km of Railway access trail (based on an assumed width of 5 m). On this basis, approximately 91 truckloads will be required to apply water over the entire road and trail surfaces.

The assumptions and inputs used in the water withdrawal calculations are listed in Table 1. A number of conservative assumptions have been made with regard to the cycle time of trucks and the maximum number of truckloads that can occur in a given day.

Table 1 Assumptions and Inputs into Calculations of Water Withdrawal

Variables and Inputs	Assumption/Estimate
Tote Road	
Length (km)	100
Average width (m)	7
Total area requiring dust suppression (m^2)	700,000
Trail Alongside Railway	
Length (km)	110
Width (m)	5
Total area requiring dust suppression (m^2)	550,000
Water Requirements	
Water required per m^2 of road (L)	1.89
Water required per single application on entire road and trail (m^3)	2,312
Number of truck loads required to complete single application	91
Average cycle time per load - fill, travel, apply and return (min.)	40 to 80
Assumed application frequency	Continuous; 24 hr/day
Average number of truck loads applied per day (incl. all 4 trucks)	91
Assumed max. number of truck loads per day (incl. 20% contingency)	110
Daily maximum water consumption - based on assumed max. number of trucks (m^3/d)	3,300

Currently, there are four water trucks, although more trucks will be brought into service by Baffinland's contractors constructing the Railway. We have assumed in this assessment that these vehicles, working continuously 24 hours per day, could conceivably apply water to the entire road and trail surfaces in one 24-hour period. This estimate does not consider downtime for maintenance and repair. It is more likely in practice that one application over the entire road surface will occur over a week-long period. The estimated maximum daily water consumption for dust suppression has been calculated to be 2,312 m^3 from all sources along the Tote Road and Railway construction access trail, during dust suppression season from mid-June to about mid-September.

2.2 HYDROLOGICAL INPUTS

A series of streamflow monitoring stations were installed along the Tote Road as part of a hydrometric monitoring program to help characterize the regional hydrology (KP, 2012). The previous water take assessment summarized discharge data from hydrometric stations relevant to assessing hydrology along the Tote Road, including minimum, mean and maximum measured discharges, and the 10-year wet and dry monthly unit runoff estimates (KP, 2014). The previous assessment applied mean monthly and 10-year dry monthly unit runoff estimates from stream gauging Station H4, located on a tributary of Camp Lake, as it provided the most conservative flow estimates (i.e. the lowest unit runoff) of 10 stream gauging stations presented in the Baseline Hydrology Report

(FEIS Appendix 6A; KP, 2012). The minimum measured flows at Station H4, for September, closely match the estimate for the 10-year dry return period, that is 1.03 L/s/km^2.

Catchments were delineated for each water take location. Using the monthly mean discharge values and 10-year dry monthly unit runoff for Station H4, flow at each water take location was estimated based on catchment size.

2.3 METHOD OF ASSESSING LAKES FOR WATER WITHDRAWAL

The effect of a single water take from a lake is not measurable. However, repeated water takes have the potential to lower lake levels and reduce lake outflows. The assessment methodology and thresholds applied in the FEIS (Volume 7, Page 19; Baffinland, 2012) as well as the previous water take assessment (KP, 2014) have been applied in the current assessment. The methodology used is as follows:

- Identify all lakes within 250 m of the Tote Road or the North Railway
- Establish the section of road and railway construction ROW which will be watered using the resources from a given water take location - i.e. from the take location to the mid-points between itself and adjacent water take locations (on either side)
- Determine the volume of water required from each water take location for dust suppression along the section of road outlined above
- Assess the impacts of extracting the above-mentioned volume of water on the lake's mean monthly outflows, and on the 10-year dry monthly outflow

The initial screening threshold allows for a monthly withdrawal of up to 10% of the mean monthly outflow from the lake without further evaluation. The mean monthly outflow is calculated based on the lake catchment area, the mean monthly flows, and the calculated 1 in 10-year dry monthly flow (KP, 2014).

2.4 METHOD OF ASSESSING STREAMS FOR WATER WITHDRAWAL

Streams were screened to determine which have adequate flow such that water withdrawals for dust suppression would not affect local fisheries. Given the relatively short duration of truck water withdrawals, the instantaneous water take is the main potential concern. Water trucks will extract water from the stream at a maximum pumping rate of 14.7 L/s for just over 30 minutes, during which flow will be reduced in the stream. Within streams that provide fish habitat, this may result in a temporary reduction in the amount of fish habitat available, and if the temporary flow reduction is considerable, temporary stranding of fish could occur.

Thresholds were identified and applied for fish-bearing and non-fish-bearing waters (KP, 2014). For fish-bearing streams, the removal of 20% of the 10-year dry unit runoff (1.03 L/s/km^2) was identified as an environmentally protective threshold.

Streams confirmed not to be fish habitat typically feed a downstream reach or collecting stream that is fish habitat. In these instances, the subject stream is only one contributor to the flow in the downstream fish habitat stream. Therefore, a higher threshold of 40% of the 10-year dry unit runoff (1.03 L/s/km^2) was used.

Based on these thresholds, streams that have suitably large catchment areas were identified as follows:

- Fish bearing streams with a catchment area of at least 71.4 km^2
- Non-fish bearing streams with a catchment area of at least 35.7 km^2

These thresholds were then applied to validate the water take sources located on the streams identified on Figure 1. Table 2 presents the inputs and approach to calculating the minimum catchment sizes.

Table 2 Calculation of Minimum Catchment Areas to Support Water Takes

Parameter	Unit	Quantity	Comment/Data Source
Water withdrawal rate	US gpm	233	Bowie 3300 pump @ 400 RPM
	L/s	14.7	
10-year dry monthly unit runoff	L/s/km^2	1.03	FEIS Appendix 7A (KP, 2012)
Fish-Bearing Streams			If the pump rate of 14.7 L/s is to represent 20% of the mean flow, then the streamflow must be 5 x 14.7 L/s or 73.5 L/s. Based on the 10-year low flow unit runoff estimate of 1.03 L/s/km^2, a catchment size of 71.4 km^2 would be required to provide a streamflow rate of 73.5 L/s.
Threshold	%	20	
Minimum flow	L/s	73.5	
Minimum catchment	km^2	71.4	
Non Fish-Bearing Streams			If the pump rate of 14.7 L/s is to represent 40% of the mean flow, then the streamflow must be 2.5 x 14.7 L/s or 36.8 L/s. Based on the 10-year low flow unit runoff estimate of 1.03 L/s/km^2, a catchment size of 35.7 km^2 would be required to provide a streamflow rate of 36.8 L/s.
Threshold	%	40	
Minimum flow	L/s	36.8	
Minimum catchment	km^2	35.7	

3 – RESULTS

3.1 LAKE WATER SOURCES

Seven lake water sources are included in the assessment based on screening criteria. Five of these sources have been previously approved by the Nunavut Water Board (NWB), and we propose moderate increases in water withdrawals at these locations. Two new sources have also been identified: KM26 Lake (CWP5) and Sheardown Lake (CWP13). Construction water points (CWPs) distinguish new water sources from those already approved under Baffinland's Type A Water Licence (NWB, 2015).

Table 3 presents the proposed lake water takes for all seven locations along with conservative estimates in monthly flow reductions from June through September.

Table 3 Estimated Reductions in Lake Outflows Due to Water Withdrawals

Water Take Location	Catchment Area (km^2)	Daily Withdrawal Volume (m^3/day)	Monthly Withdrawal Volume (m^3)	Reduction in Monthly Discharge[(2)] (%)				Flow Reductions Under the 10-Year Low Flow Scenario (%)
				June	July	Aug	Sept	
CWP5 (KM26 Lake)	540.8	119.0	3,688	0.0%	0.0%	0.1%	0.2%	0.3%
MP-MRY-3 (KM32 Lake)	456.6	125.6	3,893	0.0%	0.0%	0.1%	0.3%	0.3%
Katiktok Lake	90.8	103.4	3,205	0.1%	0.1%	0.4%	1.1%	1.3%
Muriel Lake	219.5	82.6	2,561	0.0%	0.0%	0.1%	0.4%	0.4%
David Lake	49.7	116.6	3,615	0.2%	0.2%	0.8%	2.3%	2.6%
Camp Lake[(1)]	25.9	691.5	21,437	2.0%	2.6%	8.6%	26.5%	30.0%
CWP13 (Sheardown Lake)	8.5	10.4	323	0.1%	0.1%	0.4%	1.2%	1.4%

NOTES:

1. DAILY AND MONTHLY WITHDRAWAL VOLUMES INCLUDE DOMESTIC WATER TAKING.
2. BASED ON MONTHLY DISCHARGE RATES FOR 10-YEAR DRY CONDITIONS (KP, 2014).

Water takes from each of the identified lakes will be below the 10% reduction of outflow threshold from June through September, as well as the 10-year return period low flow (1.03 L/s/km^2), which most closely resembles 10-year dry conditions in the month of September.

The only exception to this is water taking from Camp Lake, which meets the 10% reduction of outflow threshold each month except in September or under low flow conditions. In September and under the 10-year low flow condition, a reduction of up to 30% of lake outflow could occur (Table 3), warranting further evaluation and consideration of potential effects to fish and fish habitat. While the proposed water withdrawal in Camp Lake will exceed the 10% lake outflow reduction threshold under those conditions, there are site specific conditions to be considered. The outflow stream of Camp Lake reports to Mary Lake. The stream is broad and shallow and has been observed on multiple occasions (and various flow conditions) to lack connectivity. The proposed water withdrawal can be expected to increase the frequency at which natural lack of connectivity occurs between the two lakes. Limited movement of adult Arctic Char occurs through this stream, and consequently, this stream was not identified as critical fish habitat by North/South Consultants Inc. (NSC, 2012). NSC has determined that a reduction in flow of 30% is unlikely to cause fish stranding 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 (NSC, 2017).

3.2 STREAM WATER SOURCES

A total of 21 stream water sources were assessed based on screening criteria. Table 4 lists 16 of the 21 water sources that meet the catchment area thresholds discussed in Section 2.4 under all flow conditions. Eight new water sources on the Phillips Creek mainstem (CWP1 to CWP4; CWP6 to CWP9) are grouped as one row in Table 4. As noted in Section 3.1, new water sources are identified as CWPs, distinguishing them from water sources that are already approved under Baffinland's Type A Water Licence (NWB, 2015).

Table 4 Streams Meeting Water Take Criteria Under Any Flow Conditions

Water Take Location	Coordinates		Chainage (Along Railway)	Contributing Catchment Area	Fish Habitat Classification
	Northing (m)	Easting (m)	(m)	(km^2)	
MP-MRY-2 (Phillips Creek)(1)	7,975,254	502,829	1+000	1,192.6	Likely
CWP1 to CWP4; CWP6 to CWP9 (eight locations on the Phillips Creek Mainstem)	Various(2)	Various(2)	Various	156.0 - 1,168.7	Likely/ Important
CV128(1)	7,965,895	513,545	15+500	543.3	Important
BG50(1)	7,926,846	529,334	59+500	181.1	Important
CWP10	7,923,139	527,413	63+500	549.2	Important
CWP11	7,916,686	529,119	70+750	587.8	Important
CV217(1)	7,922,158	542,219	85+750	219.5	Important
CV223(1) (Tom River)	7,914,691	555,818	102+250	247.0	Important

NOTES:

1. APPROVED WATER SOURCES UNDER THE TYPE A WATER LICENCE.
2. SEE TABLES 7 AND 8 FOR COORDINATES.

Table 5 lists the five water take locations where the source streams may not meet the thresholds under low flow conditions, i.e. during September, or in conditions resembling the 10-year low flow unit runoff. However, these streams will have sufficient water from June through August, in the modelled 10-year dry conditions. Even in the 10-year dry conditions scenario, stream flows in June and July are typically 400% of the annual runoff. Assuming 10-year dry conditions, the mean monthly reductions in stream flow were calculated to assess the magnitude of the impacts caused by water taking. Table 6 shows the mean monthly reductions in stream flow for the five locations listed in Table 5. Out of these five locations, only BG32 will experience flow reductions greater than 10%, and only in the month of September, and in the 10-year low flow scenario. It is recommended that an environmental coordinator visually inspect the streams listed in Tables 5 and 6, and refer to ongoing stream gauging data (as necessary) to determine if flows are representative of wet, mean (i.e. typical), or dry conditions. If stream flows are averaging less than mean flows for the year, this signals a drier year where caution should be taken. In these cases, the streams should be inspected and their use as a water take location confirmed by the environmental coordinator before water withdrawals are made in August and September.

Table 5 Streams Meeting Water Take Criteria Under Most Flow Conditions

Water Take Location	Coordinates		Chainage (Along Railway)	Contributing Catchment Area	Fish Habitat Classification
	Northing (m)	Easting (m)	(m)	(km^2)	
CV099[1]	7,948,820	521,811	35+250	33.8	Important
CV087[1]	7,941,040	523,704	43+500	3.8	Marginal
BG32[1]	7,921,622	540,706	84+250	13.2	Important
BG17[1]	7,917,643	550,703	96+250	17.1	Important
CWP12	7,916,606	551,452	97+500	15.2	Important

NOTES:
1. APPROVED WATER SOURCES UNDER THE TYPE A WATER LICENCE.

Table 6 Estimated Reductions in Monthly Discharge in Streams with Smaller Catchment Areas

Water Take Location	Monthly Withdrawal Volume (m^3/month)	Reduction in Monthly Discharge[2]				
		June (%)	July (%)	August (%)	September (%)	Flow Reductions Under the 10-Year Monthly Low Flow Scenario (%)
CV099[1]	2810	0.2%	0.3%	0.9%	2.7%	3.0%
CV087[1]	1032	0.7%	0.8%	2.8%	8.8%	9.9%
BG32[1]	5473	1.0%	1.3%	4.3%	13.3%	15.1%
BG17[1]	1720	0.2%	0.3%	1.0%	3.2%	3.6%
CWP12[1]	2327	0.4%	0.5%	1.6%	4.9%	5.6%

NOTES:
1. APPROVED WATER SOURCES UNDER THE TYPE A WATER LICENCE.
2. BASED ON MONTHLY DISCHARGE RATES FOR 10-YEAR DRY CONDITIONS (KP, 2014).

The effects of combined water takes at multiple locations in the same watershed were assessed at two key locations within Phillips Creek, and at the mouth of Muriel Lake (CV217). For the former, the cumulative effects of water taking were assessed at CWP7 in the upper part of the Phillips Creek catchment and at MP-MRY-2 at the mouth of Phillips Creek (see Figure 1).

At CWP7, the cumulative water take includes water extracted at CWP7 and four additional upstream locations: CWP8, CWP9, CV078 and Katiktok Lake. The total catchment area contributing flow to CWP7 is 180 km^2. The cumulative proposed daily water take is 357.8 m^3 while the mean daily volume reporting to CWP7 under the low flow conditions is 16,023 m^3. As such, the cumulative water take represents 2% of the available water during low flow conditions.

At MP-MRY-2, the cumulative water take includes the water extracted at the MP-MRY-2 and 12 upstream locations on the Phillips Creek mainstem. The total catchment area contributing flow at MP-MRY-2 is 1,192.6 km^2. The cumulative proposed water take for dust suppression and domestic use is 1,482 m^3, which represents 1.4% of the available water at MP-MRY-2 under low flow conditions (i.e., 106,128 m^3).

In the Muriel Lake watershed, the water extracted at CV217 includes water take at this location, in addition to four upstream locations (CWP12, BG17, David Lake and Muriel Lake). The total area of the contributing catchments is 219.5 km^2, and the cumulative proposed water take is 355.7 m^3, which represents less than 2% of the total available water in the catchment.

Therefore, the cumulative water takes along Phillips Creek represent a 1% to 2% reduction in the overall flow along the creek, and the cumulative water takes in the Muriel Lake watershed represent a 2% reduction in the overall flow in that system. Therefore, the multiple water takes from Phillips Creek and from Muriel Lake will have minimal impact on stream flows, and on fish and fish habitat.

4 – CONCLUSIONS

This assessment identifies a total of 28 water take stations along the Tote Road and North Railway construction ROW. Fifteen of these stations are approved under the Type A Water Licence (NWB, 2015). An additional 13 water take stations are proposed, including two lakes and 11 streams. Each have been assessed as viable water sources.

Table 7 lists the 15 approved water take stations. Increases in daily water takes are proposed at three stations (CV078, BG50 and BG32).

Table 7 Proposed Water Takes at Previously Approved Water Sources

Water Take Station	Coordinates		Additional Water Take Requested for Dust Suppression	Currently Authorized Water Take(3)	Phase 2 Proposal Maximum Water Take
	Northing (m)	Easting (m)	(m³/day)	(m³/day)	(m³/day)
MP-MRY-2 (Phillips Creek)	7,975,254	502,829	-	579.5(4)	579.5
CV128	7,965,895	513,545	-	579.5	579.5
MP-MRY-3 (KM32 Lake)	7,953,660	521,189	-	364(1) / 367.5(5)	364 / 367.5
CV099(2)	7,948,820	521,811	-	110	110
CV087(2)	7,941,040	523,704	-	90	90
CV078	7,936,787	525,852	15	75	**90**
Katiktok Lake	7,934,552	526,600	-	318	318
BG50	7,926,846	529,334	60	150	**215**
BG32	7,921,622	540,706	60	120	**180**
CV217	7,922,158	542,219	-	130	130
Muriel Lake	7,921,987	542,508	-	212	212
David Lake	7,919,396	547,885	-	132	132
BG17(2)	7,917,643	550,703	-	75	75
CV223 (Tom River)	7,914,691	555,818	-	135	135
Camp Lake	7,914,684	557,793	-	888.7(6) / 441.4(7)	888.7 / 441.4

NOTES:
1. WATER TAKING FOR DUST SUPPRESSION IS ONLY AUTHORIZED DURING SUMMER MONTHS.
2. RETAIN PREVIOUS RESTRICTION THAT WATER TAKING IS ONLY PERMITTED DURING JUNE AND JULY DURING LOW FLOW (< MEAN FLOW) YEARS.
3. AUTHORIZED WATER USE WAS RETRIEVED FROM THE NUNAVUT WATER BOARD WATER LICENCE NO. 2AM-MRY1325, AMENDMENT NO. 1 (NWB, 2015).
4. PHILLIPS CREEK APPROVED WATER TAKE - SUMMER ONLY = 579.5 m^3/day (212 m^3/day FOR DUST SUPPRESSION + 367.5 m^3/day FOR INDUSTRIAL/DOMESTIC USE).
5. KM32 LAKE APPROVED WATER TAKE = 364 m^3/day (SUMMER - DUST SUPPRESSION) OR 367.5 m^3/day (WINTER - DOMESTIC USE).
6. CAMP LAKE APPROVED WATER TAKE - CONSTRUCTION = 888.7 m^3/day (86 m^3/day FOR DUST SUPPRESSION + 657.5 m^3/day FOR MINE SITE INDUSTRIAL/DOMESTIC USE + 145.2 m^3/day FOR RAVN RIVER CONSTRUCTION CAMP).
7. CAMP LAKE APPROVED WATER TAKE - OPERATIONS = 441.4 m^3/day (86 m^3/day FOR DUST SUPPRESSION + 355.4 m^3/day FOR MINE SITE INDUSTRIAL/DOMESTIC USE).

Table 8 lists the 13 new water take locations that have been identified in this assessment. Of the 13 new locations, only one (CWP12) will require the same restriction to be applied as other stations with catchment areas below the thresholds estimated in Section 2.4.

Table 8 Proposed Water Takes at New Water Sources

Water Take Station	Coordinates		Phase 2 Proposal Maximum Water Take	Restrictions
	Northing (m)	Easting (m)	(m^3/day)	
CWP1[(1)]	7,970,914	506,663	140	None
CWP2[(1)]	7,967,146	510,978	110	
CWP3[(1)]	7,963,947	515,215	55	
CWP4[(1)]	7,962,497	516,439	75	
CWP5 (KM26 Lake)[(1)]	7,958,592	518,839	120	
CWP6[(1)]	7,945,826	522,434	80	
CWP7[(1)]	7,942,153	523,218	60	
CWP8[(1)]	7,939,580	524,497	35	
CWP9[(1)]	7,938,445	524,839	45	
CWP10	7,923,139	527,413	55	
CWP11	7,916,686	529,119	100	
CWP12	7,916,606	551,452	80	June - July only during low flow (less than mean flow) years
CWP13 (Sheardown Lake)	7,913,489	560,288	10	None

NOTES:
1. LOCATED ON PHILLIPS CREEK.

5 – REFERENCES

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CLOSURE

We trust this water take assessment document meets your present requirements. Feel free to contact the undersigned should you have any questions or require additional information.

Yours truly,
KNIGHT PIÉSOLD LTD.

Prepared: Rabeea Fatima, GIT
Junior Geoscientist

Reviewed: Deena Duff, P.Eng.
Senior Engineer

Approval that this document adheres to Knight Piésold Quality Systems:

/rf

APPENDIX D

STREAM MORPHOLOGY ASSESSMENT

(Pages D-1 to D-52)

September 1, 2017

File No.:NB102-00181/39-A.01
Cont. No.:VA17-01009

Mr. Adam Grzegorczyk
Approvals Manager
Baffinland Iron Mines Corporation
#300 - 2275 Upper Middle Road East
Oakville, Ontario
Canada, L6H 0C3

Dear Adam,

Re: Hydrologic Assessment for Water Crossings – Proposed North Railway – Phase 2 Proposal - Mary River Project

1 – INTRODUCTION

In support of an amendment to Baffinland Iron Mines Corporation's (Baffinland's) Addendum to its Final Environmental Impact Statement (FEIS) for the Phase 2 Proposal of the Mary River Project, Knight Piésold Ltd. (KP) conducted a hydrologic and hydraulic assessment to determine water depths and velocities at culvert crossings along the proposed North Railway. This assessment will be used to support a fish passage assessment being completed by North/South Consultants Inc. (North/South).

The key steps in this assessment include:

1. Review previous hydrologic estimates generated for the FEIS (Baffinland, 2012), and update estimates with consideration of subsequent streamflow data collected during the period of 2012 to 2016
2. With consideration of available hydrology and climate datasets, and arctic hydrologic processes, develop a model for determining mean annual discharge at each crossing, and
3. Determine water depth and average velocity at each culvert stream crossing.

Additionally, hydrologic and geomorphic assessment of the proposed stream diversions were assessed. The key steps in this assessment include:

1. Determine the magnitude of flow and flow changes due to the diversions
2. Identify the length of affected stream channel, and
3. Assess potential physical effects of these changes.

Details of these assessments are presented in the following sections.

2 – HYDROLOGIC ESTIMATES

A hydrologic analysis has been completed to determine mean annual discharge at the rail alignment crossings.

A hydrology baseline analysis for the Mary River Project was completed previously (KP, 2012). The analysis used the Project streamflow data collected over the period of 2006 to 2011, which included data from up to 16 stations on smaller river/creek systems and from four stations on larger systems. The 16 stations on smaller river/creek systems were managed by KP and operated during the open water season. The four stations on larger systems were operated year-round by the Water Survey of Canada (WSC). Long-term regional WSC streamflow data were also used in the analysis. Streamflow stations are shown on Figures 1 and 2.

Since the 2012 analysis was completed, Baffinland collected data from 2012 to 2016 at six of the seasonal hydrometric stations. These stations are identified in Table 1 and highlighted on Figures 1 and 2.

Table 1 Active Hydrometric Stations

Station	Location	Catchment Area (km²)
H1	Tributary of Phillip's Creek	250
H2	Tom River	210
H4	Camp Lake Tributary 2 (CLT-2)	8.3
H5	Camp Lake Tributary 1, branch L1 (CLT-1, L1)	5.3
H6	Mary River	240
H11	Sheardown Lake Tributary 1 (SDLT-1)	3.6

In the previous hydrology analysis, long-term mean annual unit discharge (MAUD) estimates were provided for seven project hydrometric sites, as presented in Table 2. The long-term estimates for each station were based on the average values for the 2007 to 2008 and 2010 to 2011 streamflow datasets. The validity of using four-year average values as representative of long-term values was supported by comparing the MAD values of the concurrent regional WSC data with the MAD values from the corresponding long-term WSC data. The results of the 2012 analysis are summarized in Table 2.

Table 2 Summary of Estimated Long-Term Mean Annual Discharge (KP, 2012)

Station	Drainage Area (km²)	Mean Measured Unit Runoff (l/s/km²)							
		Jan - May	Jun	Jul	Aug	Sept	Oct	Nov - Dec	MAUD
H1	250	0	36	30	16	7.5	0.4	0	7.5
H2	210	0	43	44	17	7.8	0.0	0	9.4
H3	30.5	0	54	57	17	8.9	0.0	0	11.5
H4	8.3	0	55	30	16	7.2	0.0	0	9.0
H5	5.3	0	46	26	20	8.5	0.0	0	8.5
H6	240	0	46	55	21	11	0.2	0	11.1
H7	14.7	0	48	50	12	6.3	0.0	0	9.7

The stations with the lowest and highest long-term MAUD from the previous analysis were H01 (7.5 L/s/km²) and H03 (11.5 L/s/km²), respectively. Accordingly, it was determined that the flow estimates for these stations should be updated with the additional 2012-2016 data, and that the updated values be used to represent the water crossing mean annual unit discharge (MAUD). However, because 2012-2016 data are not available for station H03, the mean monthly and annual unit runoff estimates were instead updated for H05.

The selected hydrometric stations used in this analysis (H01, H05, and H06) are seasonal hydrometric monitoring stations that are installed after the onset of freshet in May to June and removed prior to full freeze-up of the streams in September to October. The seasonal streamflow records at these stations were compared with regional WSC data to assess if sufficient data were available in each year to create annual hydrographs. Data in 2012, 2013, and 2015 are believed to be sufficiently complete to support such an exercise, but in 2014 the stations were installed too late into the freshet period for the collected data to be considered representative of the annual hydrograph. Furthermore, WSC data for 2016 are not available at this time, so the 2016 seasonal data were not used in the analysis.

The three additional years of data were then used to update the long-term average runoff values for the selected three regional stations. The resulting MAUD values, which are presented in Table 3, are based on the 2007, 2008, 2010 to 2013, and 2015 datasets. The estimates have dropped by approximately 5% compared to those from the previous analysis.

Table 3 Updated Hydrology Analysis Long-Term MAUD Estimates

Station	MAUD (L/s/km²)
H01	7.3
H05	7.9
H06	10.6

2.1 HYDROLOGIC MODEL

The northern railway water crossing catchment areas vary from approximately 0.001 km² to 540 km² and extend from the Mine Site north to the Milne Inlet Port. The MAUD for the crossing catchments are expected to vary with physiographic factors including size, aspect, latitude, and lake content. Accordingly, a review of the hydrology data was conducted to assess if any trends were evident for these catchment attributes; however, no discernable trends were found based on the available data. Given the limited hydrology, climate and physiography datasets available for the catchments upstream of the railway crossings, it was considered prudent to assess a range of possible MAUD for each catchment.

The following range of MAUD values was applied to the northern railway alignment water crossing catchments:

- Minimum – 7.3 L/s/km² based on the updated H01 value, and
- Maximum – 11.0 L/s/km² based on the updated H06 value of 10.6 L/s/km², with a slight increase to account for the fact that H03 had slightly higher values than H06 in the previous 2011 analysis.

These MAUD values were applied to the catchment area upstream of each crossing to determine an estimated range of mean annual discharge for each crossing.

2.2 UPDATED CATCHMENT AREAS

By utilizing the railway alignment, stream crossing locations and water diversion information provided by Hatch Ltd. (2017), catchment areas for the culvert locations were delineated manually using ArcGIS from the detailed 2.5 m contours and water features provided by Eagle Mapping (2005). If any topography was required outside of the detailed mapping extents, Natural Resources Canada (NRCan) topography (1:250,000 scale) was used to fill in the missing information.

In some instances, crossing locations were modified to align with the Eagle Mapping stream lines. Additionally, it was assumed that catchments would not cross the proposed rail alignment, as ditching and embankments would be installed to direct runoff to a crossing location. The latest catchment areas, as determined from the mapping, are presented in Appendix A.

The catchment area for each crossing was then determined with the ‘calculate geometry’ function in ArcGIS and provided for use in determining the mean annual discharge at each crossing.

3 – CULVERT DEPTH AND VELOCITIES

The water depth and velocity at each crossing was determined using Manning’s equation for open channel flow. A Microsoft Excel model was developed, which uses the Goal Seek tool within a VBA Macro to determine the resulting depth and velocity in all the culverts from given flows, pipe diameters and pipe slopes. The goal seek tool is an iterative function that determines the culvert water that would occur during the given flow. The VBA Macro runs the goal seek function at each of the 462 crossings. Flow at each crossing was determined using the MAUD estimates and the updated catchment areas. The model determines cross section average velocity and maximum depth at each crossing.

These hydraulic calculations were performed for four scenarios with different combinations of high or low flow and shallow and steep pipe slope. The minimum slope was assumed to be 1% (Hatch, 2017) while a maximum of 4% was assumed, based on the assumption that fish bearing streams likely aren’t steeper than approximately 4%. The range of flows were taken from the range of estimated MAUD values discussed in Section 2.1. The results of these four cases were used to determine a range of possible depths and flow velocities in each respective fish bearing crossing. This approach (sensitivity analysis) was used since the exact slope of each crossing is not known and the MAUD is presented as a range to represent the uncertainty associated with hydrologic variability along the route.

Key assumptions in this hydraulics analysis include:

- A Manning's n of 0.025
- The culverts are circular corrugated steel pipe. They have not been assessed as open bottom culverts
- Depths and velocities are associated with the hydraulic normal depth (i.e. there is no backwatering from downstream)
- Where there are multiple culverts, the total flow is uniformly distributed amongst the culverts, and
- Where the channel is split into multiple channels (e.g. at fans), flow is assumed to be uniformly distributed amongst the channels.

The results of this analysis are presented in Appendix B. The highest flow velocity comes from the steep slope and high flow combination, while the lowest flow velocity comes from the shallow slope and low flow combination. The shallowest water depth comes from the steep slope and low flow combination, and the deepest depth comes from the shallow slope and high flow combination.

4 – PHYSICAL EFFECTS OF FLOW DIVERSION

In areas where the rail alignment is cut into the terrain, it is not feasible to pass streams across the rail alignment. In these locations, the watercourse will be diverted along the rail alignment to an adjacent watercourse. Clearly, diversion will cause streamflow to be reduced downstream of the diversion and increased in the receiving watercourse. The diversions are shown in Appendix C and the length of impacted channel and the magnitude of flow changes are shown in Table 4. Mean annual discharge and the 2-year peak flow (Q_2) are presented. Mean annual discharge was estimated from a mean annual unit discharge of 9.2 l/s/km^2 and Q_2 was determined from the drainage area based scaling equation presented in KP (2016).

4.1 POTENTIAL GEOMORPHIC RESPONSE TO FLOW CHANGES

The North Railway alignment passes through terrain dominated by its glacial history; including till, moraines, glaciofluvial and glaciolacustrine deposits. Bedrock outcrops ranging from granitic gneiss to sedimentary rocks are present (Hatch, 2016). For the most part, the rail route follows glacial valleys that have been infilled with granular material that varies in texture from silty sand to sandy gravel with cobbles and some boulders. The lacustrine sediments are finer grained silt and fine sand prevalent. The rail route travels through a region of continuous permafrost, where ice and frozen soil are significant in formation of post-glacial landforms and terrain stability. The active permafrost layer is expected to be thin in the lake sediments (less than 0.5 m) whereas the higher, well-drained terraces probably support an active layer of 1.5 m or more (Tetratech EBA Inc., 2015).

This assessment focuses on the effect of increased flow in the receiving stream, with potential effects including:

- *Exceedance of channel capacity and flooding.* If flow increases are modest, flooding may be infrequent. Where flow increases are larger, the channel banks may be overtopped each year during freshet (nival runoff) or during rainfall driven runoff events. Given the lack of vegetation and shallow frozen soils, rainfall runoff is rapid, causing sudden pronounced and relatively large increases in flow. If the channel is within a well defined valley, the flooded extent may be modest, but in flat terrain flooding may be extensive or follow low terrain (e.g. ice wedges) into other drainages.
- *Changes in permafrost and frozen soil*. Flooding and higher water levels may affect permafrost and frozen soil conditions proximal to the channel, causing subsidence or slope instability.
- *Fluvial geomorphic change*. Increased flows may cause channel bed scour or bank erosion. Additionally, overbank flows may erode surficial soils. These eroded materials would be deposited downstream where the watercourse meets the diverted channel, larger river or lake.

In order to realize these potential effects, the magnitude of flow change must be sufficient and the channel morphology sensitive to flow changes. The likelihood of these potential effects occurring is discussed in the following section.

4.1.1 Effects Screening

Each of the 27 diversion locations were assessed, based on available desktop information, and were screened with consideration of the following:

- *Change in flow.* If the predicted increase in flow in the receiving stream is less 10% (i.e. less than 10% change in contributing catchment area), it is unlikely that measurable changes in channel morphology or flood conditions would be detected. These diversions were rated as low risk.
- *Channel morphology.* For catchments less than 0.5 km^2, mean annual discharge and 2-year peak flow were estimated to be less than 5 l/s and 0.4 m^3/s respectively. In these locations, the channels are small and channel morphology is dominated by ice, frozen soil and non-fluvial processes. If the combined catchment area (baseline plus diverted catchments) is less than 0.5 km^2, it is unlikely that measurable changes in channel morphology or flood conditions would be detected. These diversions were rated as low risk.

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, it is considered that there is potential to cause the effects discussed in Section 4.1, namely, more frequent overbank flooding, and potential changes in permafrost, frozen soil conditions and fluvial morphology.

Catchment area, mean annual discharge (MAD) and 2-year peak flow (Q2) and length of stream channel with affected flows were estimated for each diverted and receiving stream, as shown in Appendix D. Of the 27 diversions, 23 are considered low risk. The remaining four diversions are considered medium or high risk and are summarized in Table 4.

Table 4 Summary of Diversions with Medium/High Risk to Geomorphic Change

Diverted Stream	Receiving Stream	% flow increase from Baseline	Fish Bearing at crossing?
CV-8-0			No
CV-8-1			No
	CV-8-2	194%	No
CV-12-4b			No
CV-12-5			No
	CV-13-1	1,648%	No
CV-35-5			No
	CV-35-4	7,332%	No
CV-59-4b			No
CV-59-4a			No
	CV-59-4	44%	Probable

Site specific assessments should be undertaken at these diversions during detailed engineering design of the railway. The assesments should consider fish use and length of impacted channel, and potential mitigation options can be identified and incorporated into the final design.

4.1.2 Mitigation

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 having any unexpected effects as described in Section 4.1. Adaptive management can be used to address any 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. Options for mitigation may include:

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

Monitoring and adaptive management will also be conducted.

5 – CLOSURE

Please do not hesitate to contact the undersigned with any questions.

Yours truly,
Knight Piésold Ltd.

PROFESSIONAL PROVINCE OF T. J. PERKINS # 32079 BRITISH COLUMBIA ENGINEER 1 Sept 2017

Prepared:	Michael Barrett, EIT Junior Engineer	Reviewed:	Toby Perkins, M.A.Sc., P.Eng. Senior Engineer

Approval that this document adheres to Knight Piésold Quality Systems:

Attachments:

Figure 1 Rev 0	Streamflow Gauging Station - Mary River Project Site and Surrounding Area (Progress Print)
Figure 2 Rev 0	Streamflow Gauging Stations and Catchment Boundaries - Mine Site Area (Progress Print)
Appendix A	Northern Transportation Corridor Delineated Catchments
Appendix B	Culvert Depths and Velocities
Appendix C	Stream Diversion Figures
Appendix D	Hydrologic Impacts of Flow Diversions

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Baffinland, 2012. *Mary River Project - Final Environmental Impact Statement*. Baffinland: Toronto, Ontario.

Hatch, 2016. Preliminary Geotechnical Data. H352034-1000-220-230-0001.

Hatch Ltd., 2017. *Mary River Expansion Stage 3 Railway Design Criteria and Design Rational*. Ref. No. H353004-39000-224-210-0001, Rev. 0. Hatch: Oakville, Ontario.

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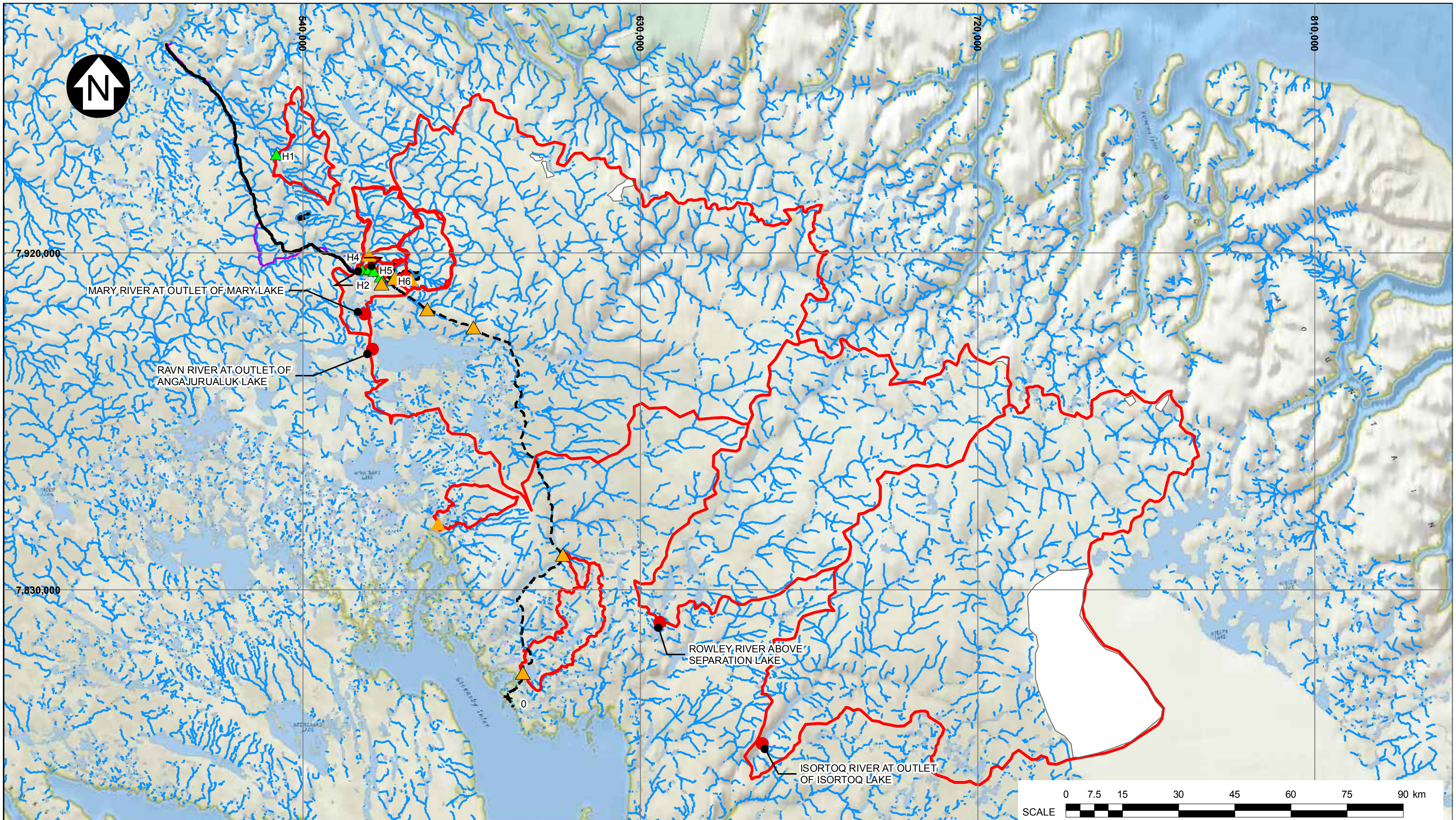
Tetratech EBA Inc., (2015). Inspection of the Milne Inlet Tote Road and Associated Borrow Sources (E14103210-01). Edmonton, AB.

Copy To: Megan Cooley, North/South Consultants Inc.



LEGEND:

- INACTIVE WSC STATION
- ACTIVE STREAMFLOW GAUGING STATION
- INACTIVE STREAMFLOW GAUGING STATION
- RIVER/STREAM/DRAINAGE
- MILNE INLET TOTE ROAD
- PROPOSED NORTHERN RAIL ALIGNMENT
- PROPOSED SOUTHERN RAIL ALIGNMENT
- CATCHMENT BOUNDARY
- WATER
- RAVN RIVER CATCHMENT
- GLACIER

NOTES:

1. COORDINATE GRID IS IN METRES.
   COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
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BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

STREAMFLOW GAUGING STATIONS MARY RIVER PROJECT AREA

Knight Piésold CONSULTING

P/A NO. NB102-181/39

REF NO. VA17-01009

FIGURE 1

REV 0

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
0	01SEP'17	ISSUED WITH LETTER	TJP	RF	TJP

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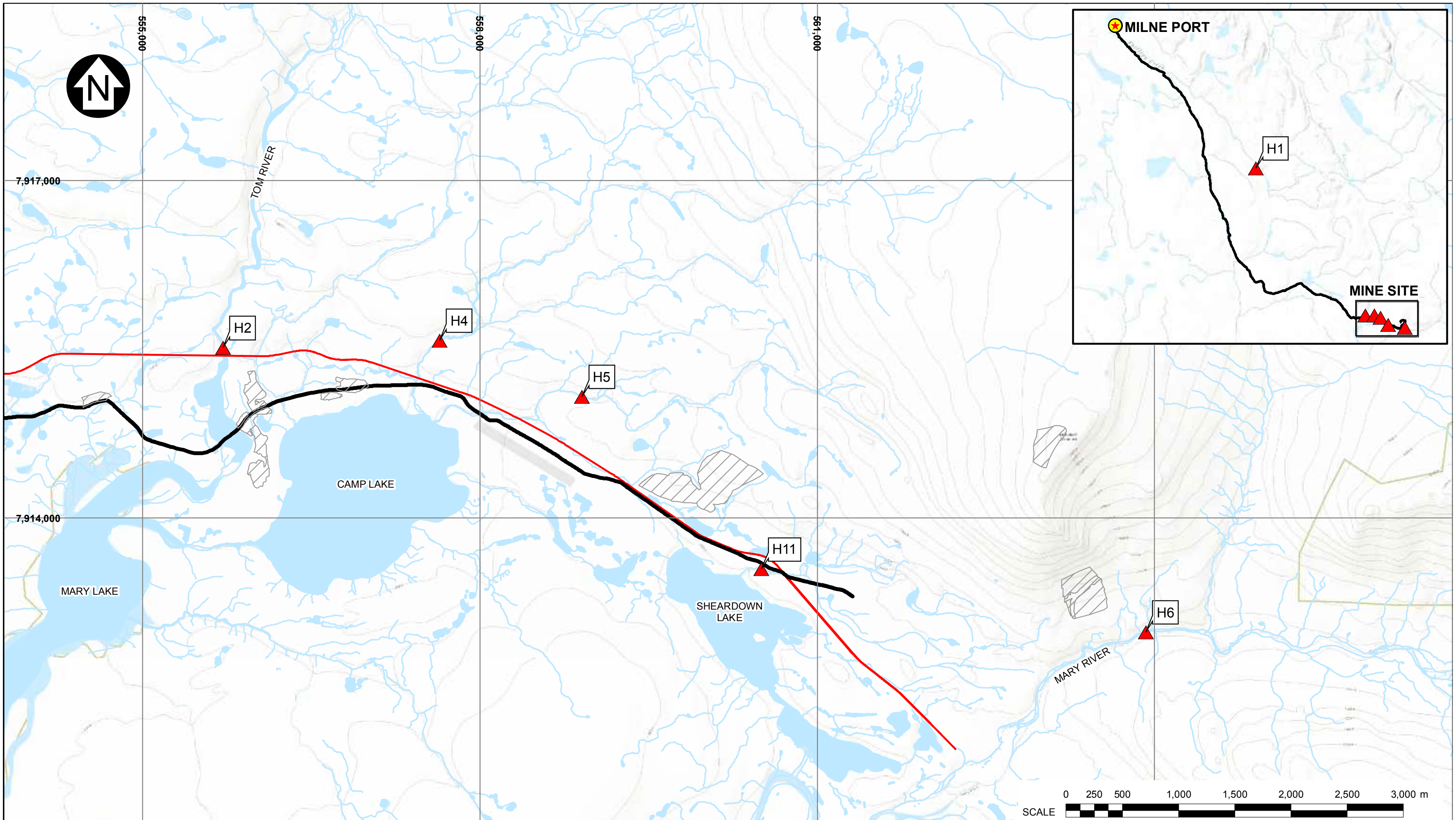

LEGEND:

- ACTIVE HYDROMETRIC STATION
- MILNE INLET TOTE ROAD
- EXISTING INFRASTRUCTURE
- RIVER/STREAM/DRAINAGE
- WATER

NOTES:

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2. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
3. INFRASTRUCTURE PROVIDED BY HATCH JANUARY 25, 2017.

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
0	01SEP'17	ISSUED WITH LETTER	MJB	AS	TJP

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

ACTIVE HYDROMETRIC STATIONS

Knight Piésold CONSULTING

P/A NO. NB102-181/39 | REF NO. VA17-01009

FIGURE 2 REV 0

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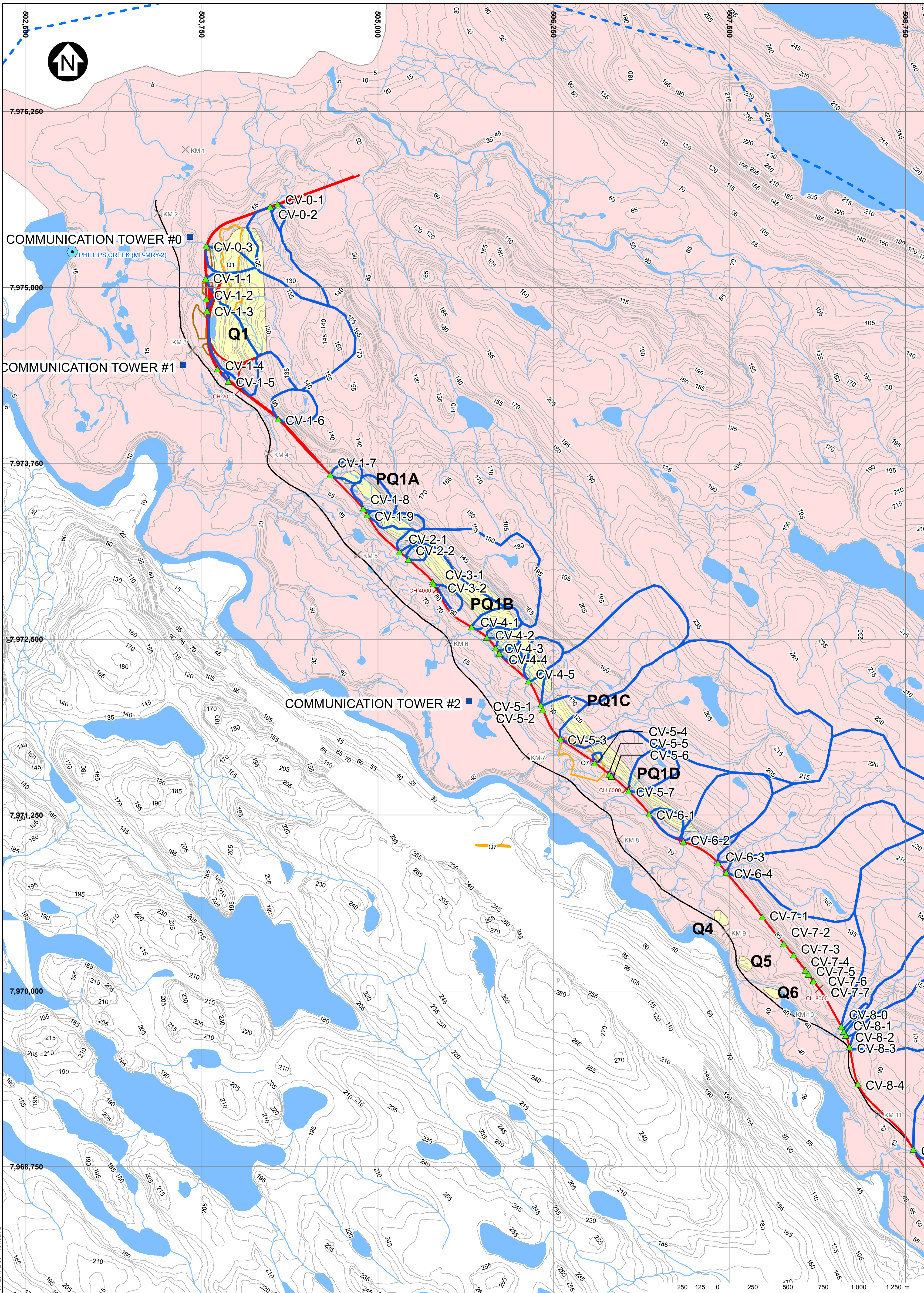
APPENDIX A

NORTHERN TRANSPORTATION CORRIDOR DELINEATED CATCHMENTS

(Figures A1 to A14)



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LEGEND

- APPROVED WATER SOURCE
- PROPOSED CONSTRUCTION WATER SOURCE
- STREAMS AFFECTED BY LARGE CUTS
- BRIDGE LOCATION
- EXISTING COMMUNICATION TOWER
- TOTE ROAD KILOMETRE POST
- RAILWAY CHAINAGE (m)
- POTENTIAL DEVELOPMENT AREA
- WATER
- IOL SURFACE AND SUBSURFACE INCLUDING MINERALS
- IOL SURFACE ONLY EXCLUDING MINERALS
- NORTHERN TRANSPORTATION CORRIDOR
- CATCHMENT AREA
- EXISTING BORROW PIT
- EXISTING QUARRY
- PROPOSED LAYDOWN AREA
- PROPOSED QUARRY LOCATION

RAIL CROSSING FISH HABITAT ASSESSMENT

- CUT OFF DRAIN
- NO
- POTENTIAL
- UNLIKLEY
- YES, PROBABLE
- MILNE INLET TOTE ROAD
- PROPOSED NORTH RAILWAY
- FLOW DIRECTION

NOTES:

1. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
2. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA DEPARTMENT OF NATURAL RESOURCES (2009). ALL RIGHTS RESERVED.
3, DETAILED WATER BASED ON EAGLE MAPPING (2005).
4. CONTOUR INTERVAL IS 2.5 METRES.

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
0	01SEP'17	ISSUED WITH LETTER	MJB	AS	TJP

BAFFINLAND IRON MINES CORPORATION

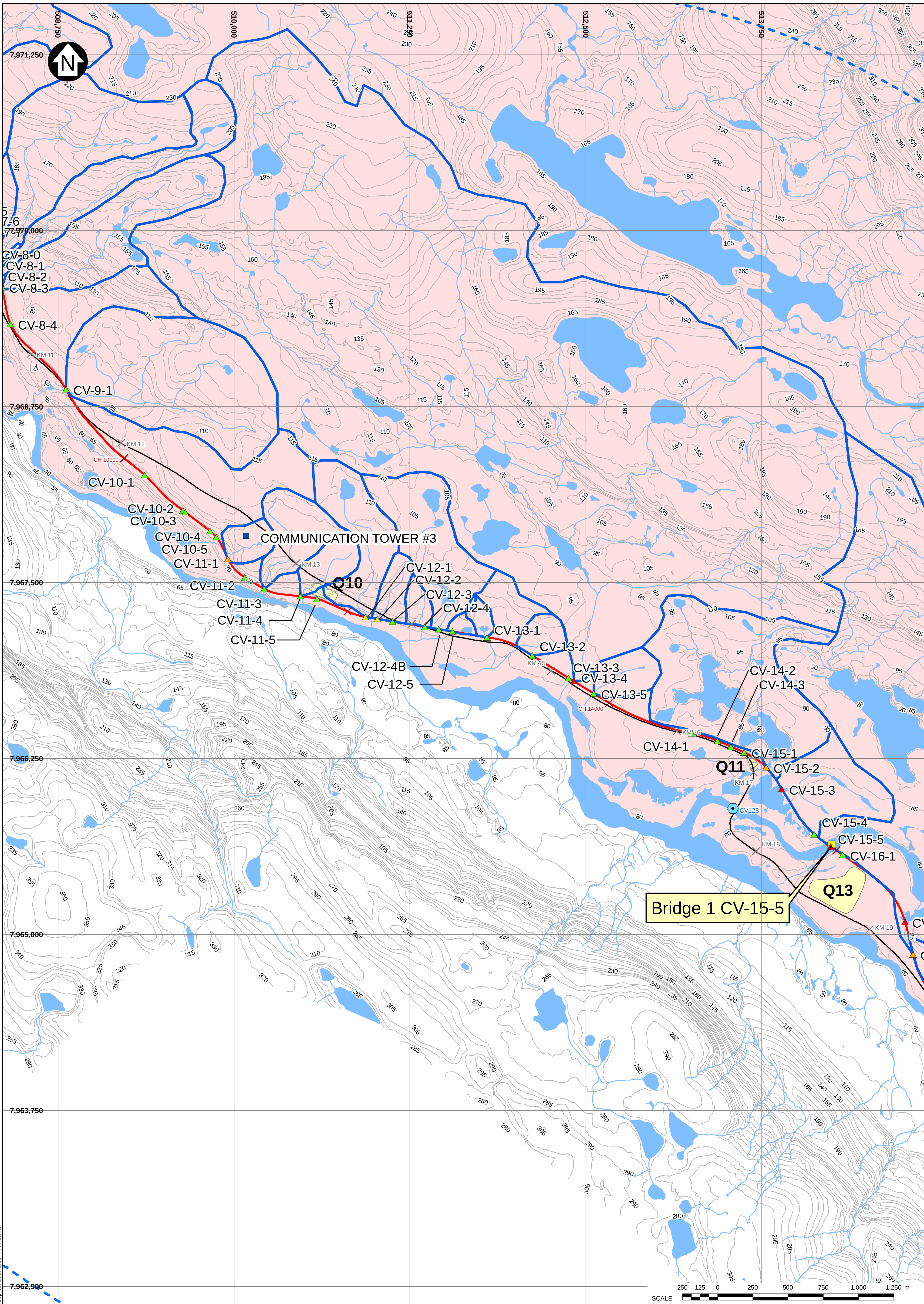
MARY RIVER PROJECT

NORTHERN TRANSPORTATION CORRIDOR STREAM CROSSING CATCHMENTS (SHEET 1 OF 14)

Baffinland

P/A NO.	REF NO.
NB102-181/39	VA17-01009

FIGURE A1 REV 0



LEGEND

- APPROVED WATER SOURCE
- PROPOSED CONSTRUCTION WATER SOURCE
- STREAMS AFFECTED BY LARGE CUTS
- BRIDGE LOCATION
- EXISTING COMMUNICATION TOWER
- TOTE ROAD KILOMETRE POST
- RAILWAY CHAINAGE (m)
- POTENTIAL DEVELOPMENT AREA
- WATER
- IOL SURFACE AND SUBSURFACE INCLUDING MINERALS
- IOL SURFACE ONLY EXCLUDING MINERALS
- NORTHERN TRANSPORTATION CORRIDOR
- CATCHMENT AREA
- EXISTING BORROW PIT
- EXISTING QUARRY
- PROPOSED LAYDOWN AREA
- PROPOSED QUARRY LOCATION

RAIL CROSSING FISH HABITAT ASSESSMENT

- CUT OFF DRAIN
- NO
- POTENTIAL
- UNLIKLEY
- YES, PROBABLE
- MILNE INLET TOTE ROAD
- PROPOSED NORTH RAILWAY
- FLOW DIRECTION

NOTES:

1. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
2. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA DEPARTMENT OF NATURAL RESOURCES (2009). ALL RIGHTS RESERVED.
3. DETAILED WATER BASED ON EAGLE MAPPING (2005).
4. CONTOUR INTERVAL IS 2.5 METRES.

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
0	01SEP'17	ISSUED WITH LETTER	MJB	AS	TJP

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BAFFINLAND IRON MINES CORPORATION

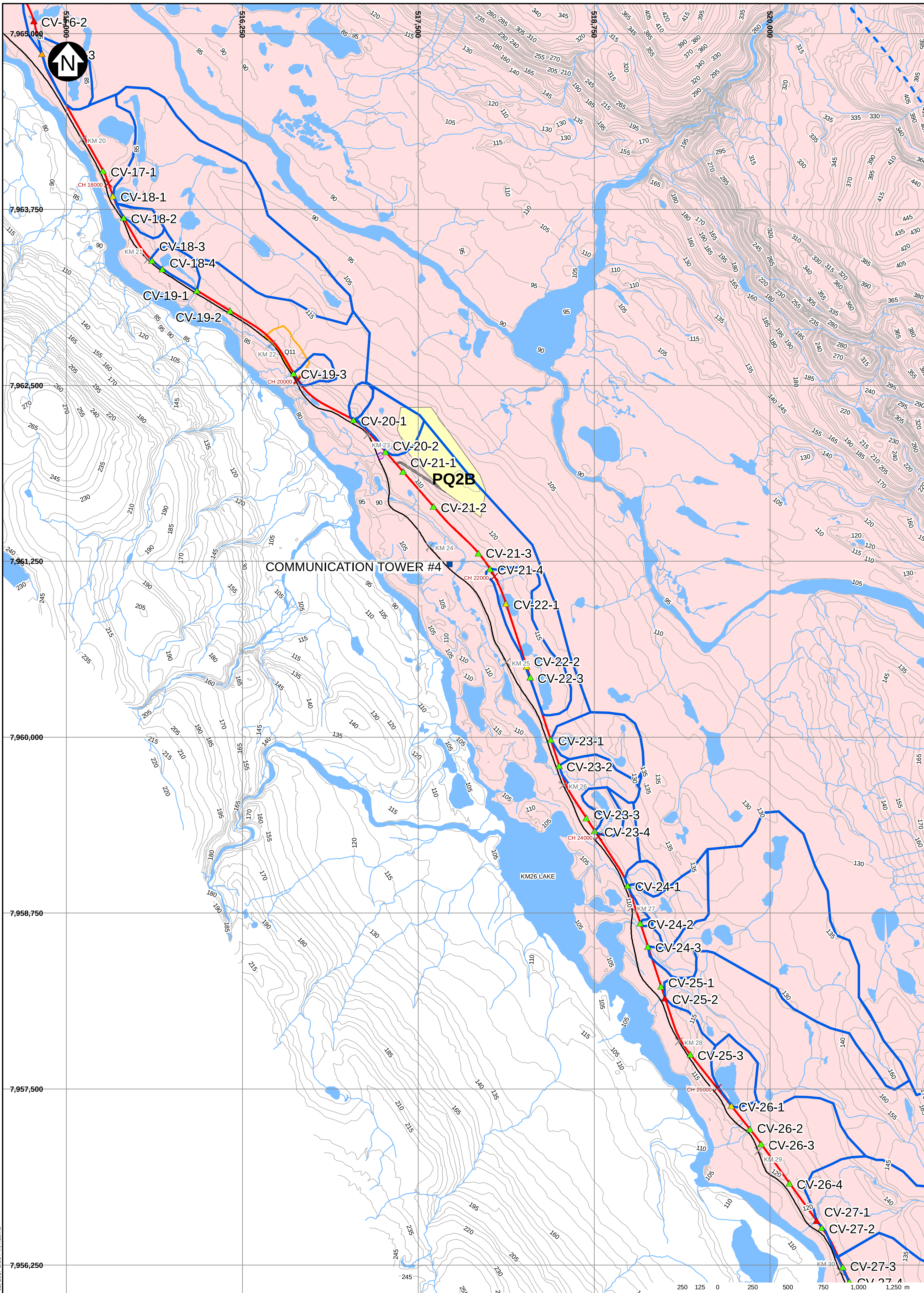
MARY RIVER PROJECT

NORTHERN TRANSPORTATION CORRIDOR STREAM CROSSING CATCHMENTS (SHEET 2 OF 14)

Baffinland

P/A NO.	REF NO.
NB102-181/39	VA17-01009

FIGURE A2 REV 0



LEGEND

- APPROVED WATER SOURCE
- PROPOSED CONSTRUCTION WATER SOURCE
- STREAMS AFFECTED BY LARGE CUTS
- BRIDGE LOCATION
- EXISTING COMMUNICATION TOWER
- TOTE ROAD KILOMETRE POST
- RAILWAY CHAINAGE (m)
- POTENTIAL DEVELOPMENT AREA
- WATER
- IOL SURFACE AND SUBSURFACE INCLUDING MINERALS
- IOL SURFACE ONLY EXCLUDING MINERALS
- NORTHERN TRANSPORTATION CORRIDOR
- CATCHMENT AREA
- EXISTING BORROW PIT
- EXISTING QUARRY
- PROPOSED LAYDOWN AREA
- PROPOSED QUARRY LOCATION

RAIL CROSSING FISH HABITAT ASSESSMENT

- CUT OFF DRAIN
- NO
- POTENTIAL
- UNLIKLEY
- YES, PROBABLE
- MILNE INLET TOTE ROAD
- PROPOSED NORTH RAILWAY
- FLOW DIRECTION

NOTES:

1. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
2. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA DEPARTMENT OF NATURAL RESOURCES (2009). ALL RIGHTS RESERVED.
3, DETAILED WATER BASED ON EAGLE MAPPING (2005).
4. CONTOUR INTERVAL IS 2.5 METRES.

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
0	01SEP'17	ISSUED WITH LETTER	MJB	AS	TJP

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

NORTHERN TRANSPORTATION CORRIDOR STREAM CROSSING CATCHMENTS (SHEET 3 OF 14)

P/A NO.	REF NO.
NB102-181/39	VA17-01009

FIGURE A3 REV 0

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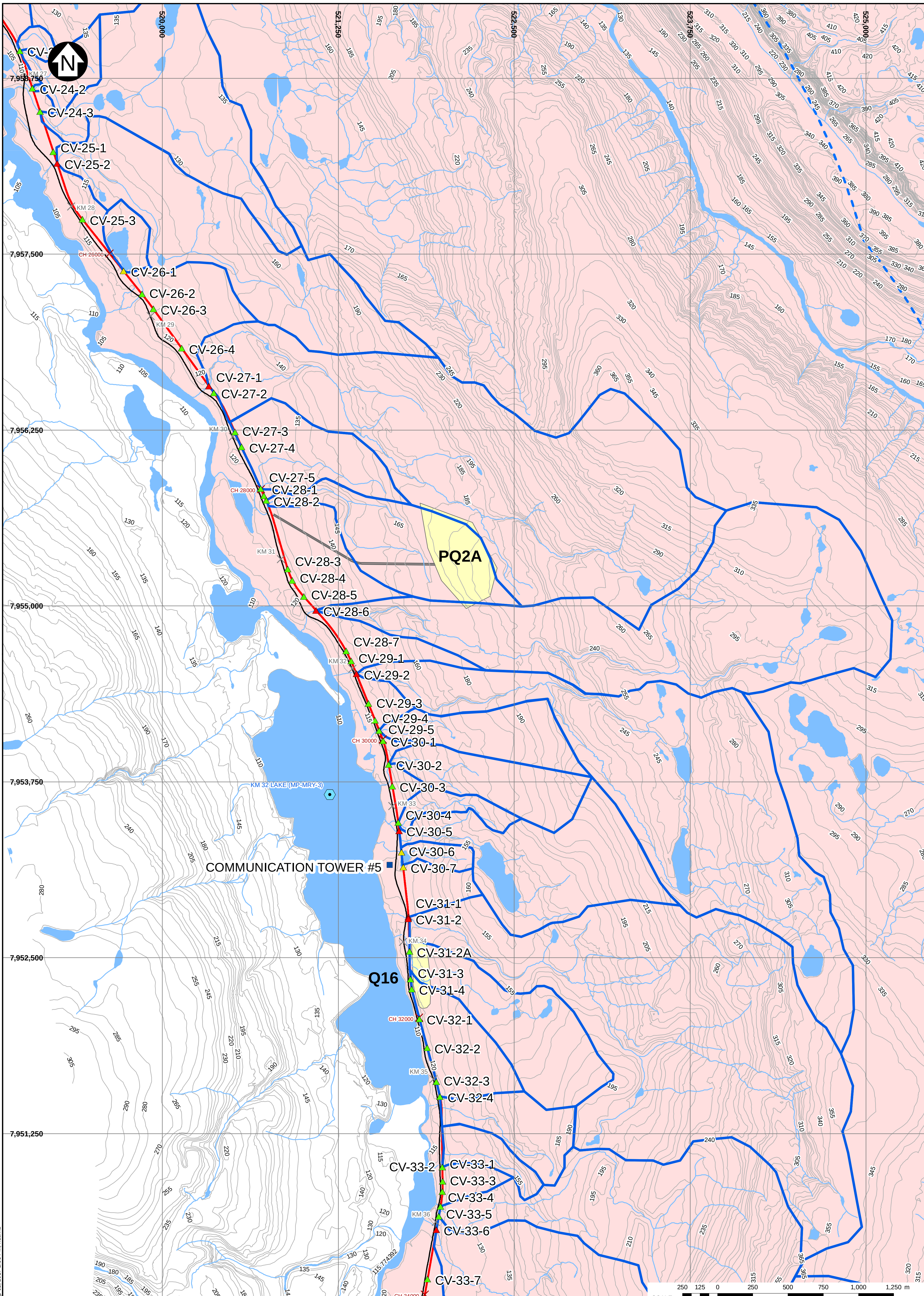

LEGEND

- APPROVED WATER SOURCE
- PROPOSED CONSTRUCTION WATER SOURCE
- STREAMS AFFECTED BY LARGE CUTS
- BRIDGE LOCATION
- EXISTING COMMUNICATION TOWER
- TOTE ROAD KILOMETRE POST
- RAILWAY CHAINAGE (m)
- POTENTIAL DEVELOPMENT AREA
- WATER
- IOL SURFACE AND SUBSURFACE INCLUDING MINERALS
- IOL SURFACE ONLY EXCLUDING MINERALS
- NORTHERN TRANSPORTATION CORRIDOR
- CATCHMENT AREA
- EXISTING BORROW PIT
- EXISTING QUARRY
- PROPOSED LAYDOWN AREA
- PROPOSED QUARRY LOCATION

RAIL CROSSING FISH HABITAT ASSESSMENT

- CUT OFF DRAIN
- NO
- POTENTIAL
- UNLIKLEY
- YES, PROBABLE
- MILNE INLET TOTE ROAD
- PROPOSED NORTH RAILWAY
- FLOW DIRECTION

NOTES:

1. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
2. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA DEPARTMENT OF NATURAL RESOURCES (2009). ALL RIGHTS RESERVED.
3, DETAILED WATER BASED ON EAGLE MAPPING (2005).
4. CONTOUR INTERVAL IS 2.5 METRES.

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
0	01SEP'17	ISSUED WITH LETTER	MJB	AS	TJP

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

NORTHERN TRANSPORTATION CORRIDOR STREAM CROSSING CATCHMENTS (SHEET 4 OF 14)

P/A NO. NB102-181/39 | REF NO. VA17-01009

FIGURE A4 REV 0

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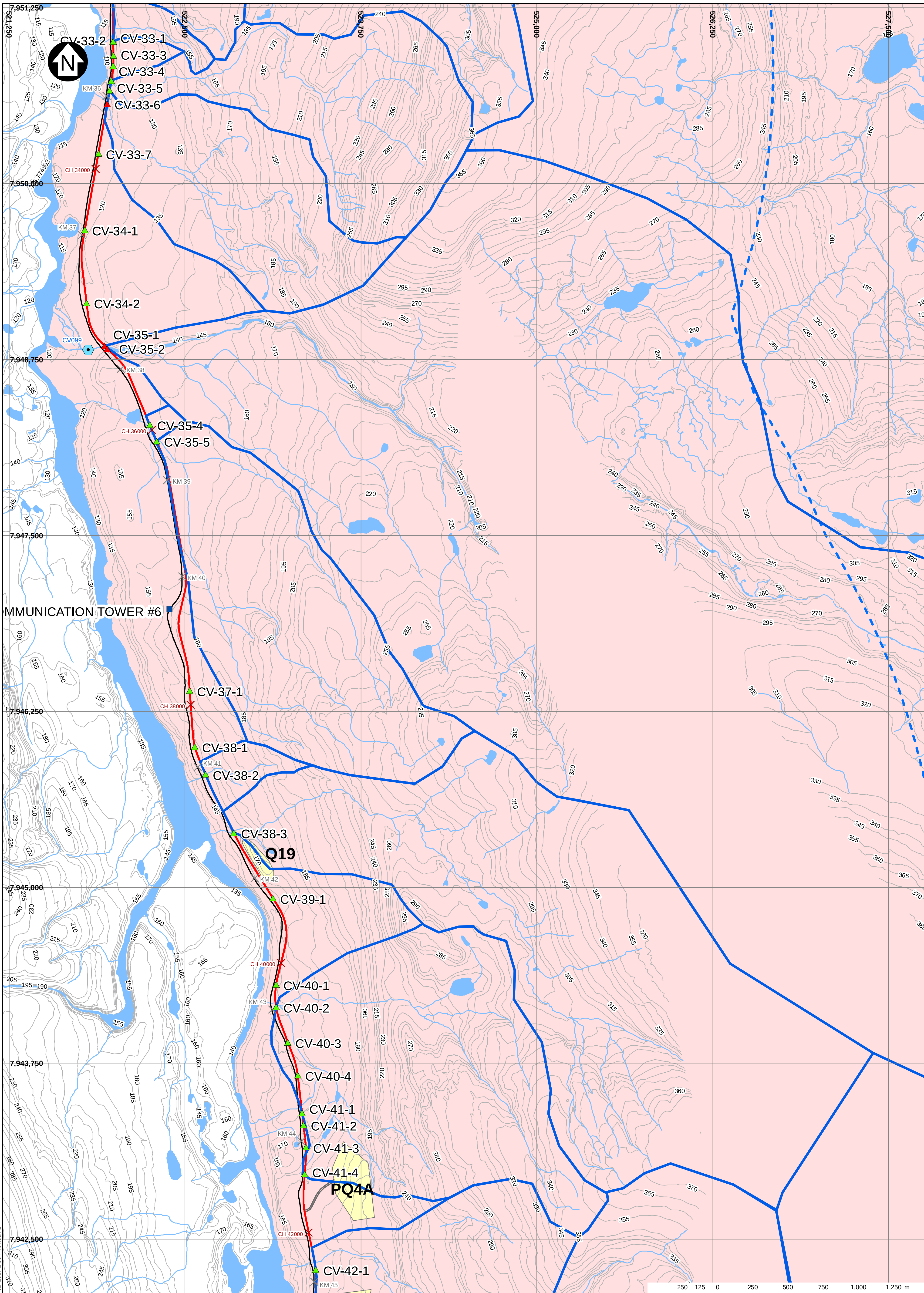

LEGEND

- APPROVED WATER SOURCE
- PROPOSED CONSTRUCTION WATER SOURCE
- STREAMS AFFECTED BY LARGE CUTS
- BRIDGE LOCATION
- EXISTING COMMUNICATION TOWER
- TOTE ROAD KILOMETRE POST
- RAILWAY CHAINAGE (m)
- POTENTIAL DEVELOPMENT AREA
- WATER
- IOL SURFACE AND SUBSURFACE INCLUDING MINERALS
- IOL SURFACE ONLY EXCLUDING MINERALS
- NORTHERN TRANSPORTATION CORRIDOR
- CATCHMENT AREA
- EXISTING BORROW PIT
- EXISTING QUARRY
- PROPOSED LAYDOWN AREA
- PROPOSED QUARRY LOCATION

RAIL CROSSING FISH HABITAT ASSESSMENT

- CUT OFF DRAIN
- NO
- POTENTIAL
- UNLIKLEY
- YES, PROBABLE
- MILNE INLET TOTE ROAD
- PROPOSED NORTH RAILWAY
- FLOW DIRECTION

NOTES:

1. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
2. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA DEPARTMENT OF NATURAL RESOURCES (2009). ALL RIGHTS RESERVED.
3. DETAILED WATER BASED ON EAGLE MAPPING (2005).
4. CONTOUR INTERVAL IS 2.5 METRES.

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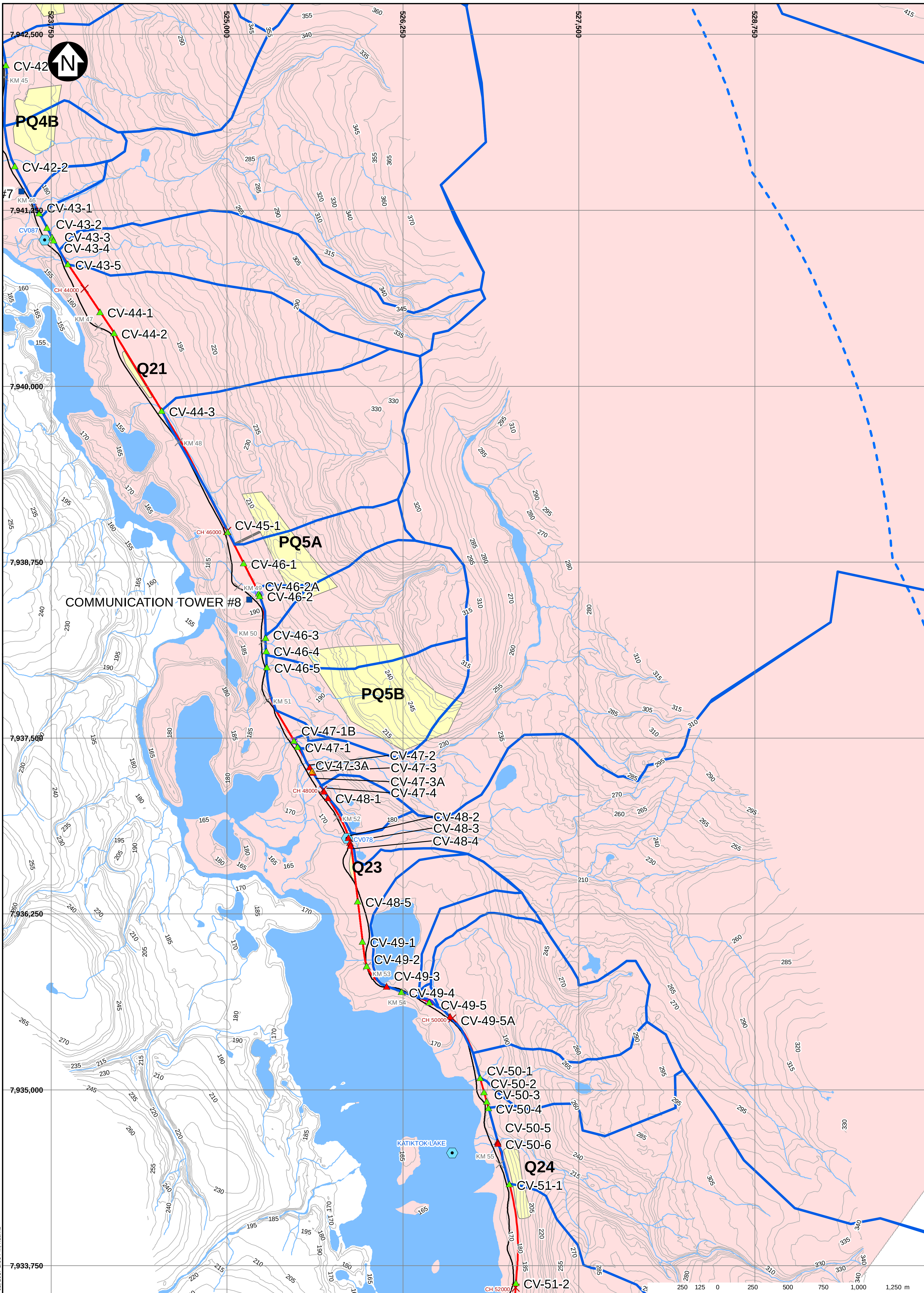
NORTHERN TRANSPORTATION CORRIDOR STREAM CROSSING CATCHMENTS (SHEET 5 OF 14)

Baffinland

P/A NO.	REF NO.
NB102-181/39	VA17-01009

FIGURE A5 REV 0



LEGEND

- APPROVED WATER SOURCE
- PROPOSED CONSTRUCTION WATER SOURCE
- STREAMS AFFECTED BY LARGE CUTS
- BRIDGE LOCATION
- EXISTING COMMUNICATION TOWER
- TOTE ROAD KILOMETRE POST
- RAILWAY CHAINAGE (m)
- POTENTIAL DEVELOPMENT AREA
- WATER
- IOL SURFACE AND SUBSURFACE INCLUDING MINERALS
- IOL SURFACE ONLY EXCLUDING MINERALS
- NORTHERN TRANSPORTATION CORRIDOR
- CATCHMENT AREA
- EXISTING BORROW PIT
- EXISTING QUARRY
- PROPOSED LAYDOWN AREA
- PROPOSED QUARRY LOCATION

RAIL CROSSING FISH HABITAT ASSESSMENT

- CUT OFF DRAIN
- NO
- POTENTIAL
- UNLIKLEY
- YES, PROBABLE
- MILNE INLET TOTE ROAD
- PROPOSED NORTH RAILWAY
- FLOW DIRECTION

NOTES:

1. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
2. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA DEPARTMENT OF NATURAL RESOURCES (2009). ALL RIGHTS RESERVED.
3. DETAILED WATER BASED ON EAGLE MAPPING (2005).
4. CONTOUR INTERVAL IS 2.5 METRES.

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
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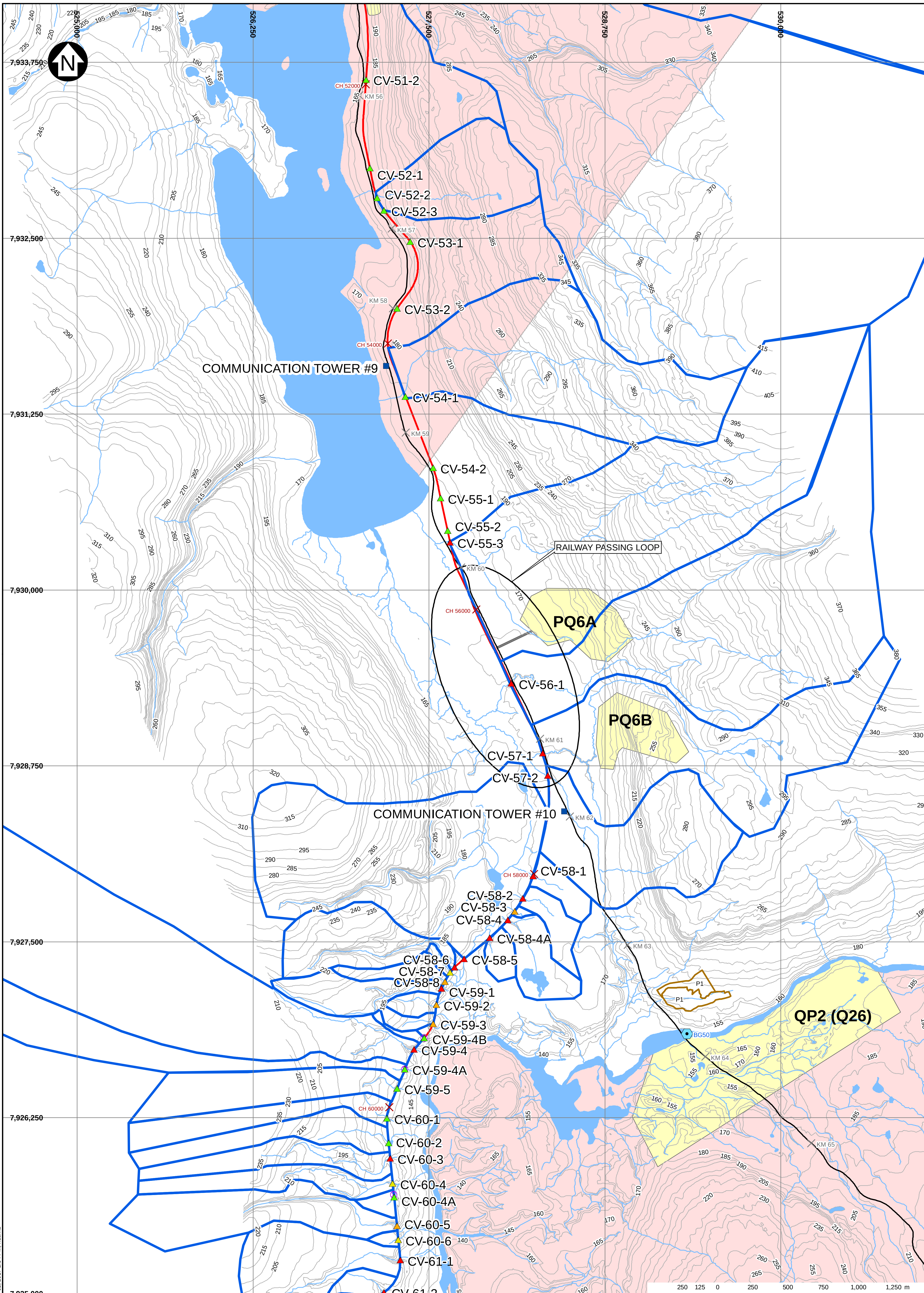
NORTHERN TRANSPORTATION CORRIDOR STREAM CROSSING CATCHMENTS (SHEET 6 OF 14)

Baffinland

P/A NO.	REF NO.
NB102-181/39	VA17-01009

FIGURE A6 REV 0



LEGEND

- APPROVED WATER SOURCE
- PROPOSED CONSTRUCTION WATER SOURCE
- STREAMS AFFECTED BY LARGE CUTS
- BRIDGE LOCATION
- EXISTING COMMUNICATION TOWER
- TOTE ROAD KILOMETRE POST
- RAILWAY CHAINAGE (m)
- POTENTIAL DEVELOPMENT AREA
- WATER
- IOL SURFACE AND SUBSURFACE INCLUDING MINERALS
- IOL SURFACE ONLY EXCLUDING MINERALS
- NORTHERN TRANSPORTATION CORRIDOR
- CATCHMENT AREA
- EXISTING BORROW PIT
- EXISTING QUARRY
- PROPOSED LAYDOWN AREA
- PROPOSED QUARRY LOCATION

RAIL CROSSING FISH HABITAT ASSESSMENT

- CUT OFF DRAIN
- NO
- POTENTIAL
- UNLIKLEY
- YES, PROBABLE
- MILNE INLET TOTE ROAD
- PROPOSED NORTH RAILWAY
- FLOW DIRECTION

NOTES:

1. COORDINATE GRID IS IN METRES.
   COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
2. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA DEPARTMENT OF NATURAL RESOURCES (2009). ALL RIGHTS RESERVED.
3. DETAILED WATER BASED ON EAGLE MAPPING (2005).
4. CONTOUR INTERVAL IS 2.5 METRES.

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
0	01SEP'17	ISSUED WITH LETTER	MJB	AS	TJP

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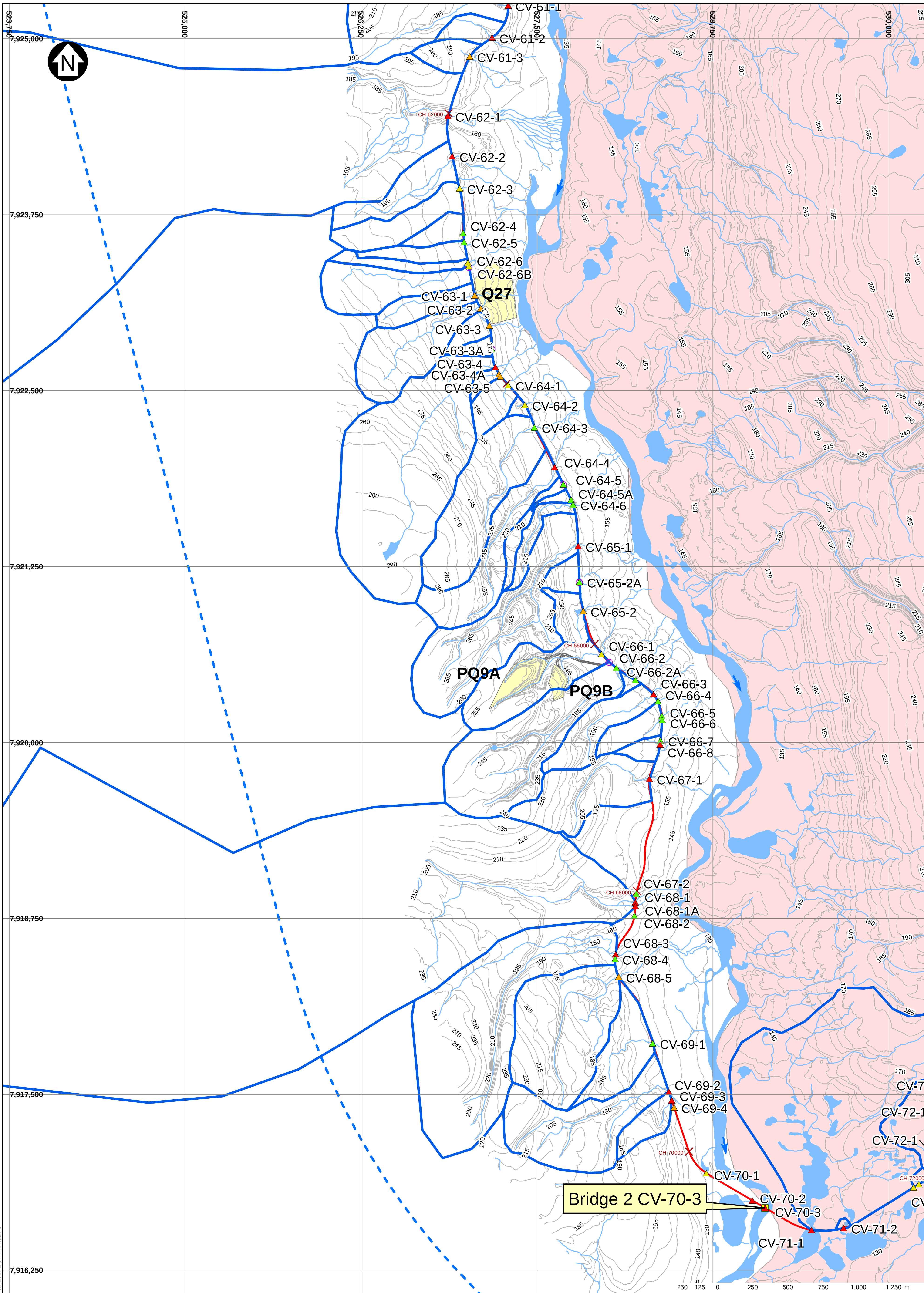
NORTHERN TRANSPORTATION CORRIDOR STREAM CROSSING CATCHMENTS (SHEET 7 OF 14)

Baffinland

P/A NO.	REF NO.	
NB102-181/39	VA17-01009	
FIGURE A7		REV 0



LEGEND

- APPROVED WATER SOURCE
- PROPOSED CONSTRUCTION WATER SOURCE
- STREAMS AFFECTED BY LARGE CUTS
- BRIDGE LOCATION
- EXISTING COMMUNICATION TOWER
- TOTE ROAD KILOMETRE POST
- RAILWAY CHAINAGE (m)
- POTENTIAL DEVELOPMENT AREA
- WATER
- IOL SURFACE AND SUBSURFACE INCLUDING MINERALS
- IOL SURFACE ONLY EXCLUDING MINERALS
- NORTHERN TRANSPORTATION CORRIDOR
- CATCHMENT AREA
- EXISTING BORROW PIT
- EXISTING QUARRY
- PROPOSED LAYDOWN AREA
- PROPOSED QUARRY LOCATION

RAIL CROSSING FISH HABITAT ASSESSMENT

- CUT OFF DRAIN
- NO
- POTENTIAL
- UNLIKLEY
- YES, PROBABLE
- MILNE INLET TOTE ROAD
- PROPOSED NORTH RAILWAY
- FLOW DIRECTION

NOTES:

1. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
2. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA DEPARTMENT OF NATURAL RESOURCES (2009). ALL RIGHTS RESERVED.
3. DETAILED WATER BASED ON EAGLE MAPPING (2005).
4. CONTOUR INTERVAL IS 2.5 METRES.

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
0	01SEP'17	ISSUED WITH LETTER	MJB	AS	TJP

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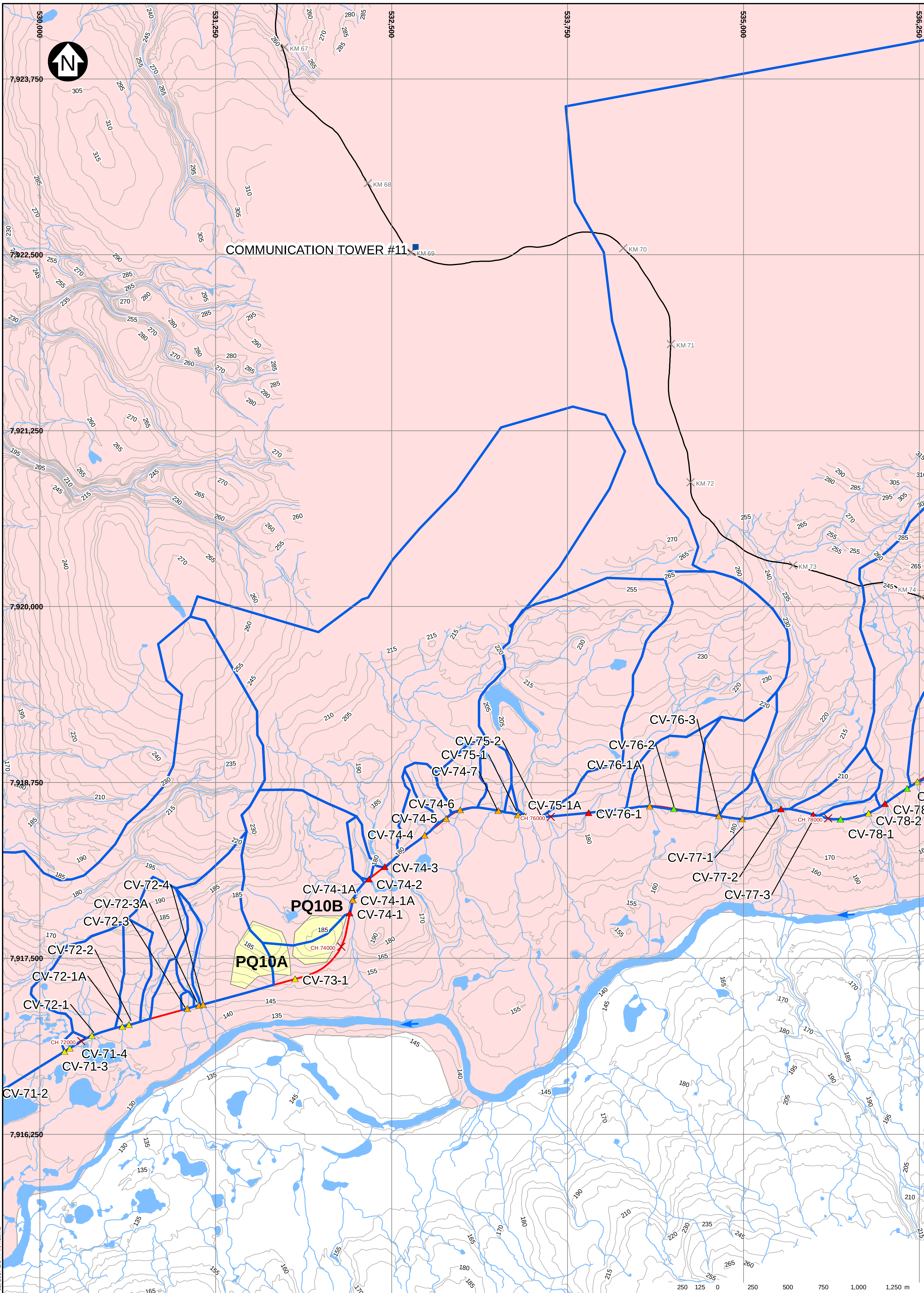
NORTHERN TRANSPORTATION CORRIDOR STREAM CROSSING CATCHMENTS (SHEET 8 OF 14)

Baffinland

P/A NO.	REF NO.
NB102-181/39	VA17-01009

FIGURE A8	REV 0



LEGEND

- APPROVED WATER SOURCE
- PROPOSED CONSTRUCTION WATER SOURCE
- STREAMS AFFECTED BY LARGE CUTS
- BRIDGE LOCATION
- EXISTING COMMUNICATION TOWER
- TOTE ROAD KILOMETRE POST
- RAILWAY CHAINAGE (m)
- POTENTIAL DEVELOPMENT AREA
- WATER
- IOL SURFACE AND SUBSURFACE INCLUDING MINERALS
- IOL SURFACE ONLY EXCLUDING MINERALS
- NORTHERN TRANSPORTATION CORRIDOR
- CATCHMENT AREA
- EXISTING BORROW PIT
- EXISTING QUARRY
- PROPOSED LAYDOWN AREA
- PROPOSED QUARRY LOCATION

RAIL CROSSING FISH HABITAT ASSESSMENT

- CUT OFF DRAIN
- NO
- POTENTIAL
- UNLIKELY
- YES, PROBABLE
- MILNE INLET TOTE ROAD
- PROPOSED NORTH RAILWAY
- FLOW DIRECTION

NOTES:

1. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
2. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA DEPARTMENT OF NATURAL RESOURCES (2009). ALL RIGHTS RESERVED.
3. DETAILED WATER BASED ON EAGLE MAPPING (2005).
4. CONTOUR INTERVAL IS 2.5 METRES.

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
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NORTHERN TRANSPORTATION CORRIDOR STREAM CROSSING CATCHMENTS (SHEET 9 OF 14)

Baffinland

P/A NO.	REF NO.
NB102-181/39	VA17-01009

FIGURE A9 REV 0

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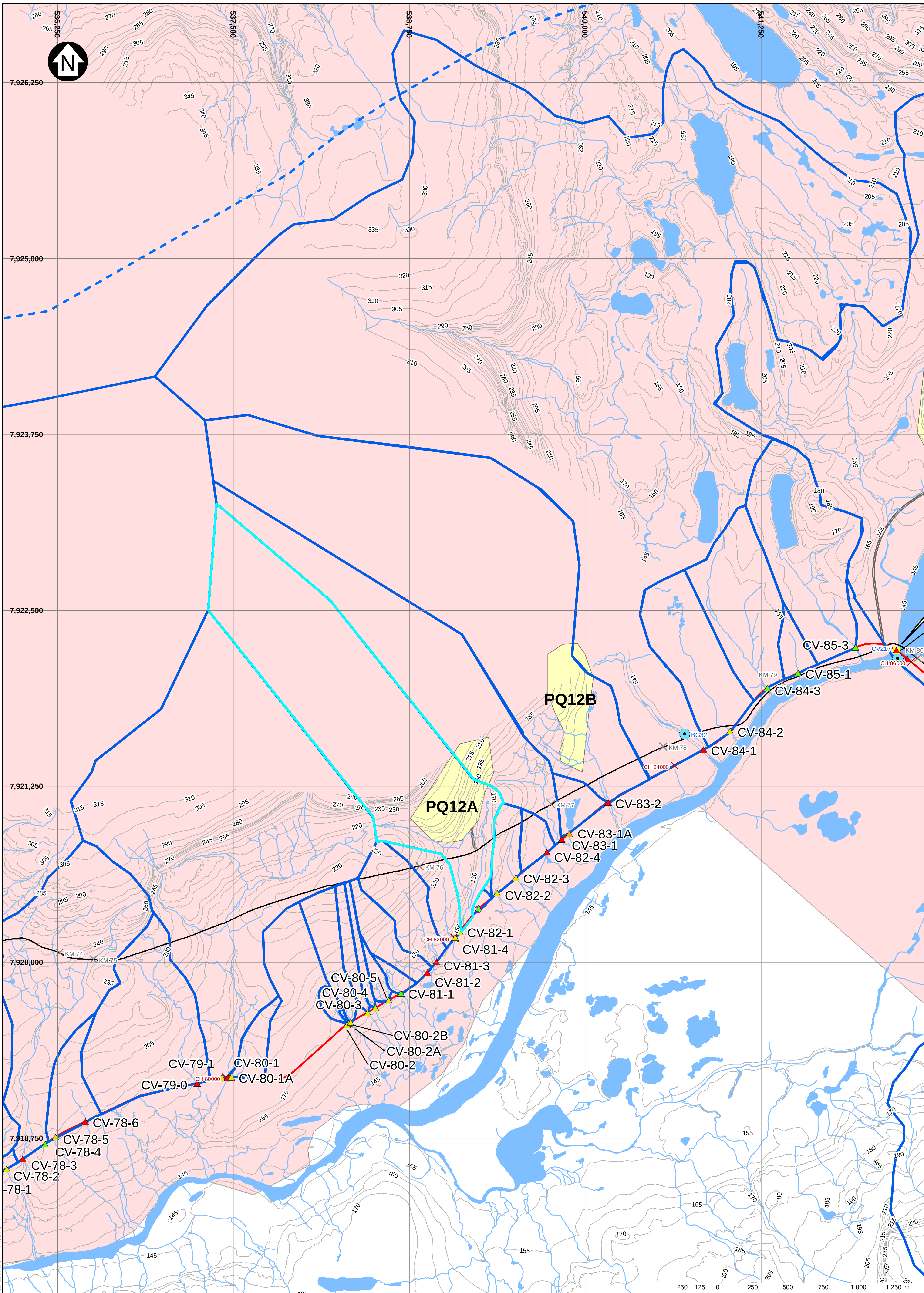

LEGEND

- APPROVED WATER SOURCE
- PROPOSED CONSTRUCTION WATER SOURCE
- STREAMS AFFECTED BY LARGE CUTS
- BRIDGE LOCATION
- EXISTING COMMUNICATION TOWER
- TOTE ROAD KILOMETRE POST
- RAILWAY CHAINAGE (m)
- POTENTIAL DEVELOPMENT AREA
- WATER
- IOL SURFACE AND SUBSURFACE INCLUDING MINERALS
- IOL SURFACE ONLY EXCLUDING MINERALS
- NORTHERN TRANSPORTATION CORRIDOR
- CATCHMENT AREA
- EXISTING BORROW PIT
- EXISTING QUARRY
- PROPOSED LAYDOWN AREA
- PROPOSED QUARRY LOCATION

RAIL CROSSING
FISH HABITAT ASSESSMENT

- CUT OFF DRAIN
- NO
- POTENTIAL
- UNLIKLEY
- YES, PROBABLE
- MILNE INLET TOTE ROAD
- PROPOSED NORTH RAILWAY
- FLOW DIRECTION

NOTES:

1. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
2. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA DEPARTMENT OF NATURAL RESOURCES (2009). ALL RIGHTS RESERVED.
3. DETAILED WATER BASED ON EAGLE MAPPING (2005).
4. CONTOUR INTERVAL IS 2.5 METRES.

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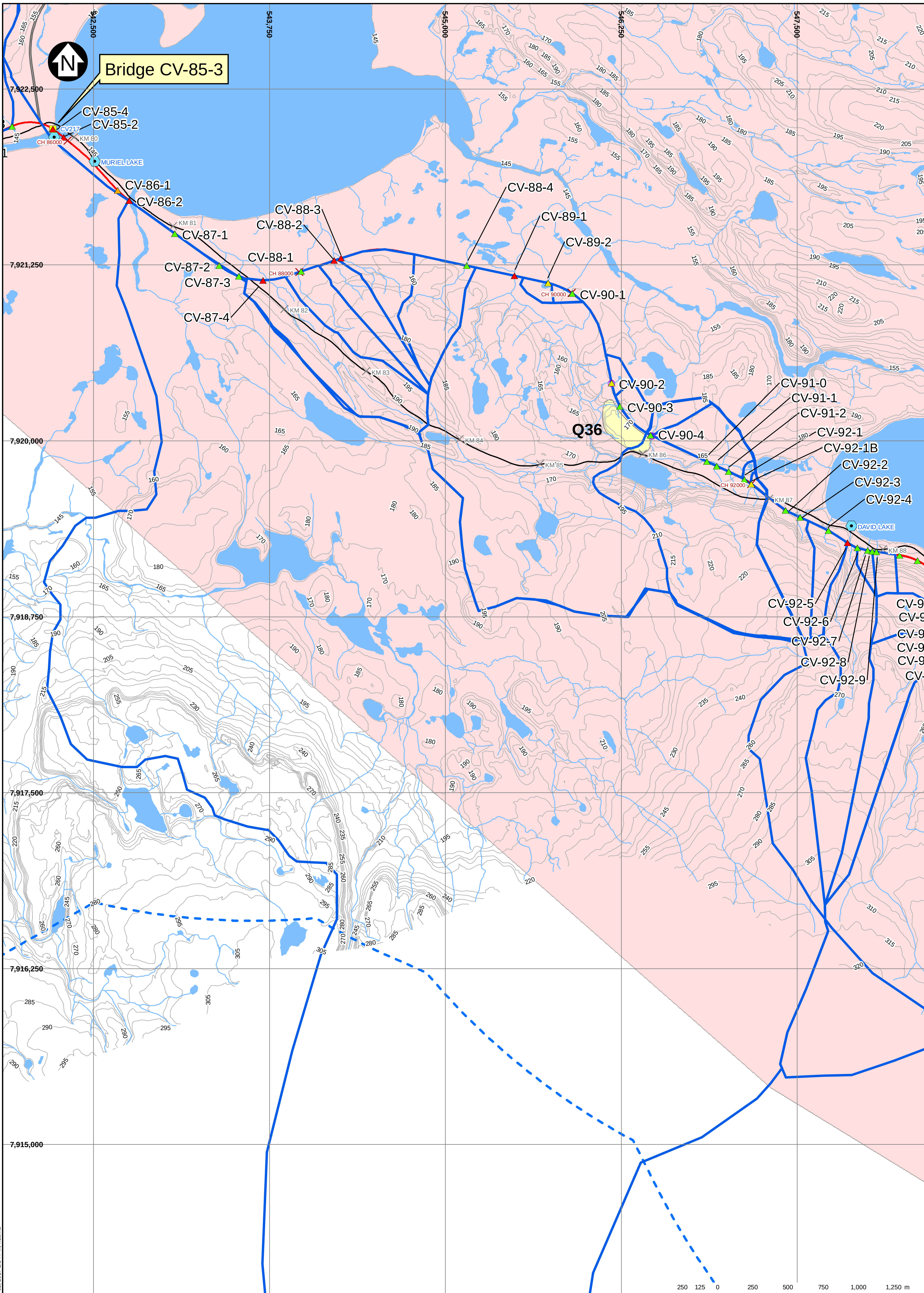
NORTHERN TRANSPORTATION CORRIDOR STREAM CROSSING CATCHMENTS (SHEET 10 OF 14)

Baffinland

P/A NO.	REF NO.
NB102-181/39	VA17-01009

FIGURE A10 REV 0



LEGEND

- APPROVED WATER SOURCE
- PROPOSED CONSTRUCTION WATER SOURCE
- STREAMS AFFECTED BY LARGE CUTS
- BRIDGE LOCATION
- EXISTING COMMUNICATION TOWER
- TOTE ROAD KILOMETRE POST
- RAILWAY CHAINAGE (m)
- POTENTIAL DEVELOPMENT AREA
- WATER
- IOL SURFACE AND SUBSURFACE INCLUDING MINERALS
- IOL SURFACE ONLY EXCLUDING MINERALS
- NORTHERN TRANSPORTATION CORRIDOR
- CATCHMENT AREA
- EXISTING BORROW PIT
- EXISTING QUARRY
- PROPOSED LAYDOWN AREA
- PROPOSED QUARRY LOCATION

RAIL CROSSING FISH HABITAT ASSESSMENT

- CUT OFF DRAIN
- NO
- POTENTIAL
- UNLIKLEY
- YES, PROBABLE
- MILNE INLET TOTE ROAD
- PROPOSED NORTH RAILWAY
- FLOW DIRECTION

NOTES:

1. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
2. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA DEPARTMENT OF NATURAL RESOURCES (2009). ALL RIGHTS RESERVED.
3. DETAILED WATER BASED ON EAGLE MAPPING (2005).
4. CONTOUR INTERVAL IS 2.5 METRES.

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
0	01SEP'17	ISSUED WITH LETTER	MJB	AS	TJP

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

NORTHERN TRANSPORTATION CORRIDOR STREAM CROSSING CATCHMENTS (SHEET 11 OF 14)

Baffinland

P/A NO.	REF NO.
NB102-181/39	VA17-01009

FIGURE A11 REV 0

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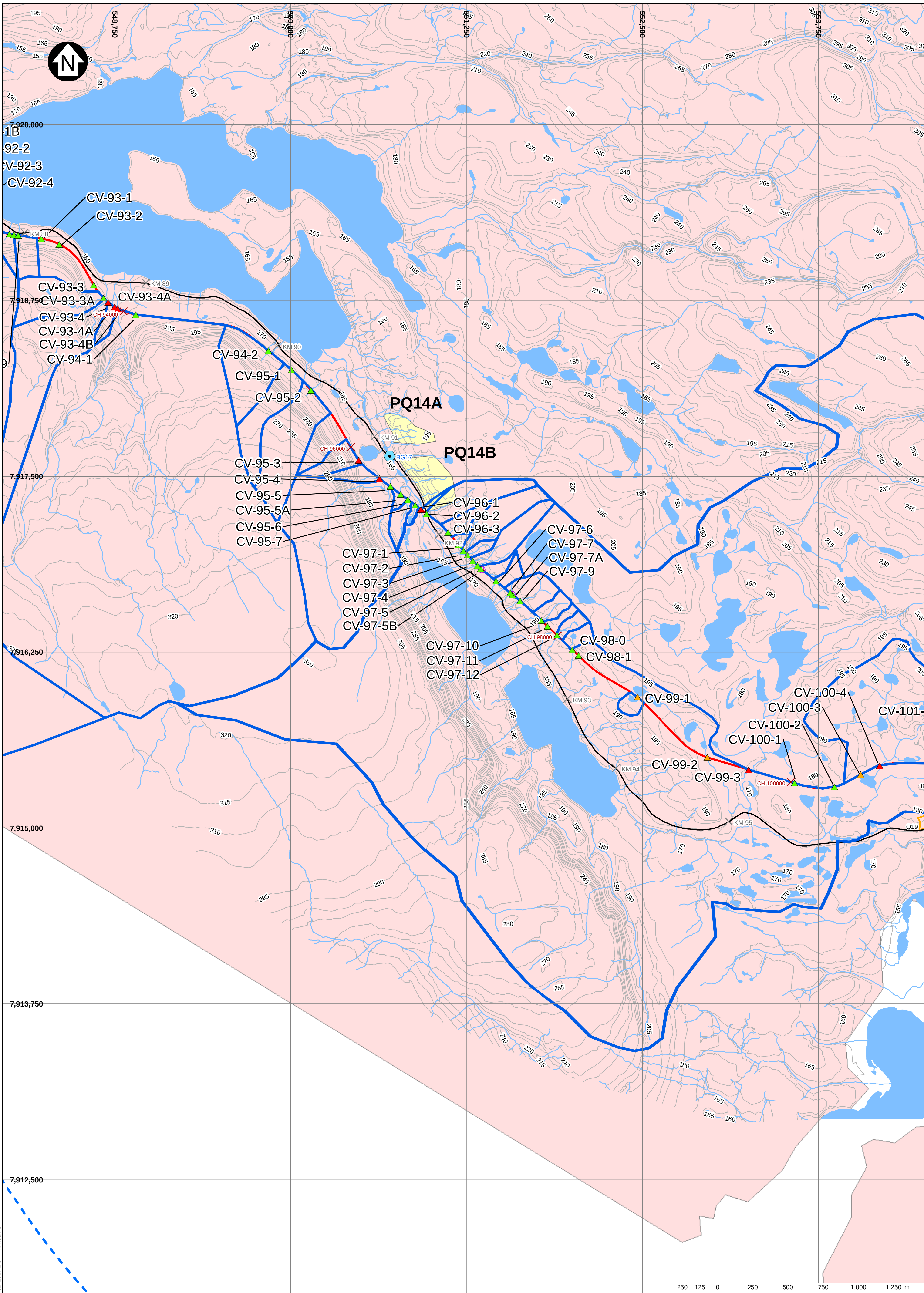

LEGEND

- APPROVED WATER SOURCE
- PROPOSED CONSTRUCTION WATER SOURCE
- STREAMS AFFECTED BY LARGE CUTS
- BRIDGE LOCATION
- EXISTING COMMUNICATION TOWER
- TOTE ROAD KILOMETRE POST
- RAILWAY CHAINAGE (m)
- POTENTIAL DEVELOPMENT AREA
- WATER
- IOL SURFACE AND SUBSURFACE INCLUDING MINERALS
- IOL SURFACE ONLY EXCLUDING MINERALS
- NORTHERN TRANSPORTATION CORRIDOR
- CATCHMENT AREA
- EXISTING BORROW PIT
- EXISTING QUARRY
- PROPOSED LAYDOWN AREA
- PROPOSED QUARRY LOCATION

RAIL CROSSING FISH HABITAT ASSESSMENT

- CUT OFF DRAIN
- NO
- POTENTIAL
- UNLIKLEY
- YES, PROBABLE
- MILNE INLET TOTE ROAD
- PROPOSED NORTH RAILWAY
- FLOW DIRECTION

NOTES:

1. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
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3. DETAILED WATER BASED ON EAGLE MAPPING (2005).
4. CONTOUR INTERVAL IS 2.5 METRES.

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
0	01SEP'17	ISSUED WITH LETTER	MJB	AS	TJP

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NORTHERN TRANSPORTATION CORRIDOR STREAM CROSSING CATCHMENTS (SHEET 12 OF 14)

Baffinland

P/A NO.	REF NO.
NB102-181/39	VA17-01009

FIGURE A12 REV 0

LEGEND

- APPROVED WATER SOURCE
- PROPOSED CONSTRUCTION WATER SOURCE
- STREAMS AFFECTED BY LARGE CUTS
- BRIDGE LOCATION
- EXISTING COMMUNICATION TOWER
- TOTE ROAD KILOMETRE POST
- RAILWAY CHAINAGE (m)
- POTENTIAL DEVELOPMENT AREA
- WATER
- IOL SURFACE AND SUBSURFACE INCLUDING MINERALS
- IOL SURFACE ONLY EXCLUDING MINERALS
- NORTHERN TRANSPORTATION CORRIDOR
- CATCHMENT AREA
- EXISTING BORROW PIT
- EXISTING QUARRY
- PROPOSED LAYDOWN AREA
- PROPOSED QUARRY LOCATION

RAIL CROSSING FISH HABITAT ASSESSMENT

- CUT OFF DRAIN
- NO
- POTENTIAL
- UNLIKLEY
- YES, PROBABLE
- MILNE INLET TOTE ROAD
- PROPOSED NORTH RAILWAY
- FLOW DIRECTION

NOTES:

1. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
2. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA DEPARTMENT OF NATURAL RESOURCES (2009). ALL RIGHTS RESERVED.
3. DETAILED WATER BASED ON EAGLE MAPPING (2005).
4. CONTOUR INTERVAL IS 2.5 METRES.

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
0	01SEP'17	ISSUED WITH LETTER	MJB	AS	TJP

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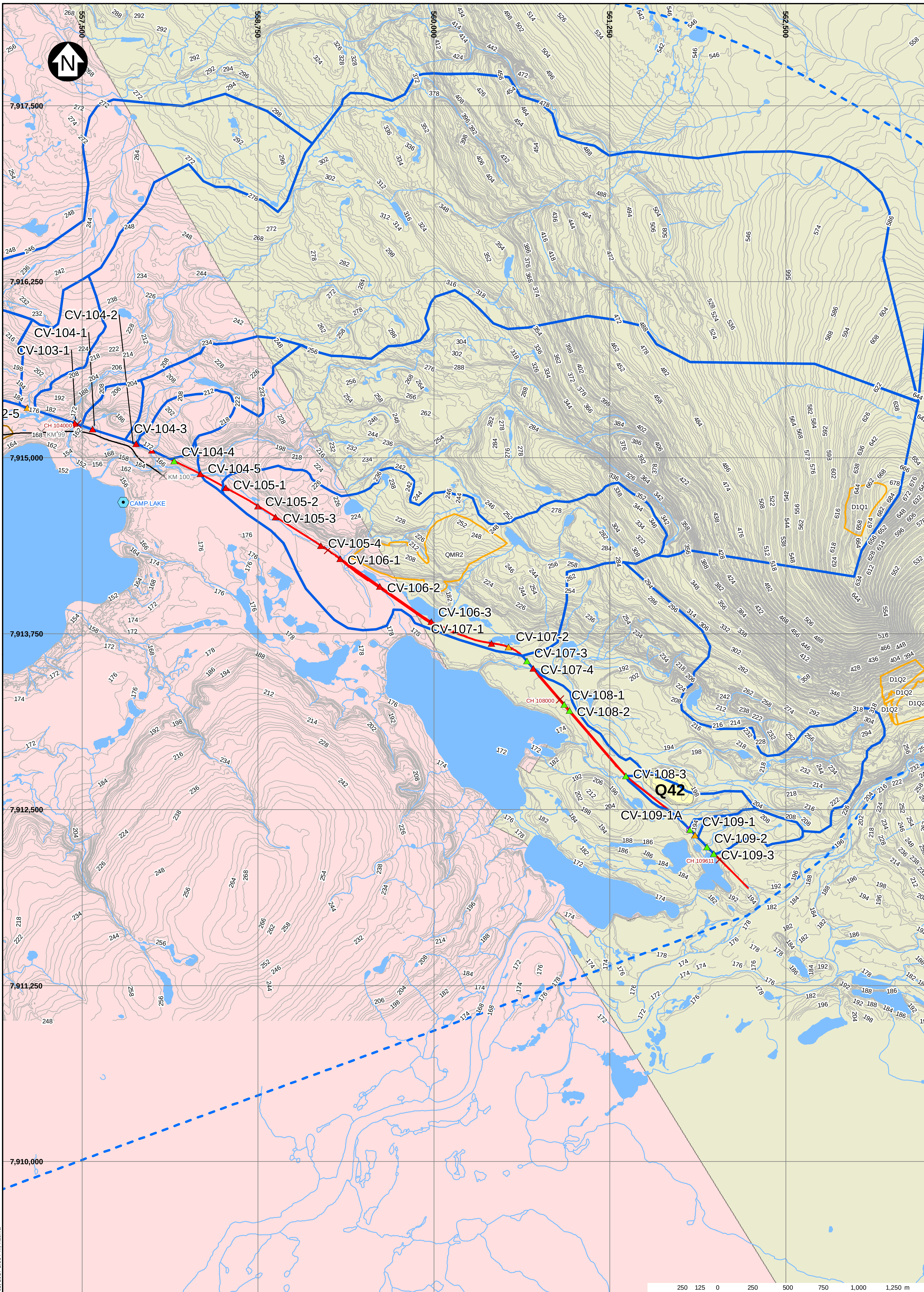
NORTHERN TRANSPORTATION CORRIDOR STREAM CROSSING CATCHMENTS (SHEET 13 OF 14)

Baffinland

P/A NO.	REF NO.
NB102-181/39	VA17-01009

FIGURE A13 REV 0



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LEGEND

- APPROVED WATER SOURCE
- PROPOSED CONSTRUCTION WATER SOURCE
- STREAMS AFFECTED BY LARGE CUTS
- BRIDGE LOCATION
- EXISTING COMMUNICATION TOWER
- TOTE ROAD KILOMETRE POST
- RAILWAY CHAINAGE (m)
- POTENTIAL DEVELOPMENT AREA
- WATER
- IOL SURFACE AND SUBSURFACE INCLUDING MINERALS
- IOL SURFACE ONLY EXCLUDING MINERALS
- NORTHERN TRANSPORTATION CORRIDOR
- CATCHMENT AREA
- EXISTING BORROW PIT
- EXISTING QUARRY
- PROPOSED LAYDOWN AREA
- PROPOSED QUARRY LOCATION

RAIL CROSSING FISH HABITAT ASSESSMENT

- CUT OFF DRAIN
- NO
- POTENTIAL
- UNLIKLEY
- YES, PROBABLE
- MILNE INLET TOTE ROAD
- PROPOSED NORTH RAILWAY
- FLOW DIRECTION

NOTES:

1. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
2. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA DEPARTMENT OF NATURAL RESOURCES (2009). ALL RIGHTS RESERVED.
3. DETAILED WATER BASED ON EAGLE MAPPING (2005).
4. CONTOUR INTERVAL IS 2.5 METRES.

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
0	01SEP'17	ISSUED WITH LETTER	MJB	AS	TJP

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

NORTHERN TRANSPORTATION CORRIDOR STREAM CROSSING CATCHMENTS (SHEET 14 OF 14)

Baffinland

P/A NO.	REF NO.
NB102-181/39	VA17-01009

FIGURE A14 REV 0

APPENDIX B

CULVERT DEPTHS AND VELOCITIES

(Pages B-1 to B-2)

Knight Piésold
CONSULTING

APPENDIX B

BAFFINLAND IRON MINES CORPORATION
MARY RIVER

PROPOSED NORTHERN RAIL ALIGNMENT - FISH BEARING STREAM CROSSINGS
ESTIMATED DEPTHS AND VELOCITIES

Print Jul/18/17 14:10:36

Culvert Name	KP Catchment Areas	No. Barrels	Culvert Diameter (mm)	Mean Annual Flow		Fish Bearing?	Ranges of results				Notes
	(m^2)			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	88631	1	900	0.6	1.0	Potential	0.21	0.38	0.01	0.02	
CV-12-1	348946	1	900	2.5	3.8	Unlikely	0.32	0.59	0.02	0.04	
CV-12-2	91287	1	900	0.7	1.0	Unlikely	0.21	0.39	0.01	0.02	
CV-13-4	10849900	2	1400	79.2	119.3	Fish Bearing	0.69	1.27	0.08	0.14	
CV-15-2	1038020	1	1400	7.6	11.4	Potential	0.42	0.76	0.04	0.06	
CV-15-3	331285	2	900	2.4	3.6	Fish Bearing	0.25	0.47	0.02	0.03	
Bridge CV-15-5	538280000	0	0	3929.4	5921.1	Fish Bearing	0.00	0.00	0.00	0.00	Bridge - depth and velocity not assessed
CV-16-2	117686	4	1200	0.9	1.3	Probable	0.14	0.26	0.01	0.01	
CV-16-3	117686	1	900	0.9	1.3	Potential	0.23	0.42	0.02	0.03	
CV-18-1	1094950	1	900	8.0	12.0	Unlikely	0.45	0.83	0.04	0.07	
CV-25-2	1392440	2	900	10.2	15.3	Fish Bearing	0.39	0.72	0.03	0.06	
CV-26-1	120830	1	900	0.9	1.3	Unlikely	0.23	0.42	0.02	0.03	
CV-27-1	3428310	2	1200	25.0	37.7	Fish Bearing	0.50	0.91	0.05	0.08	
CV-28-6	2677000	1	1400	19.5	29.4	Fish Bearing	0.56	1.02	0.06	0.10	
CV-29-2	2696280	1	1400	19.7	29.7	Fish Bearing	0.56	1.02	0.06	0.10	
CV-30-5	976854	1	900	7.1	10.7	Fish Bearing	0.44	0.80	0.04	0.07	
CV-30-6	78862	1	900	0.6	0.9	Unlikely	0.20	0.37	0.01	0.02	
CV-31-1	4378030	1	1200	32.0	48.2	Fish Bearing	0.66	1.21	0.08	0.13	
CV-31-2	4378030	1	1200	32.0	48.2	Fish Bearing	0.66	1.21	0.08	0.13	
CV-33-6	1772810	4	1200	12.9	19.5	Fish Bearing	0.33	0.60	0.03	0.04	
CV-35-2	34732700	5	1400	253.5	382.1	Fish Bearing	0.74	1.36	0.09	0.15	
CV-47-2	7445800	4	1400	54.4	81.9	Fish Bearing	0.50	0.91	0.05	0.08	Depth and velocity assume flow split evenly between the three branches.
CV-47-3	7445800	2	1400	54.4	81.9	Fish Bearing	0.62	1.13	0.07	0.11	Depth and velocity assume flow split evenly between the three branches.
CV-47-3a	7445800	1	900	54.4	81.9	Potential	0.80	1.48	0.11	0.18	Depth and velocity assume flow split evenly between the three branches.
CV-47-4	78912	1	900	0.6	0.9	Fish Bearing	0.20	0.37	0.01	0.02	
CV-48-1	78912	1	1400	0.6	0.9	Fish Bearing	0.19	0.35	0.01	0.02	
CV-48-2	21667300	5	1400	158.2	238.3	Fish Bearing	0.64	1.18	0.07	0.12	
CV-48-3	-	2	1200	-	-	Fish Bearing	0.02	0.04	0.00	0.00	Minor/secondary crossing, negligable drainage area
CV-48-4	-	2	1200	-	-	Fish Bearing	0.02	0.04	0.00	0.00	Minor/secondary crossing, negligable drainage area
CV-49-5	1263730	1	1200	9.2	13.9	Fish Bearing	0.45	0.83	0.04	0.07	
CV-50-5	7949400	2	1200	58.0	87.4	Fish Bearing	0.64	1.18	0.07	0.12	Depth and velocity assume all flow through each branch, so may overestimate.
CV-50-6	7949400	2	1200	58.0	87.4	Fish Bearing	0.64	1.18	0.07	0.12	Depth and velocity assume all flow through each branch, so may overestimate.
CV-55-3	2783990	5	900	20.3	30.6	Fish Bearing	0.37	0.68	0.03	0.05	
CV-56-1	2731000	2	1200	19.9	30.0	Fish Bearing	0.46	0.85	0.04	0.07	
CV-57-1	1613800	1	900	11.8	17.8	Fish Bearing	0.51	0.93	0.05	0.09	
CV-57-2	886436	1	900	6.5	9.8	Fish Bearing	0.42	0.78	0.04	0.06	
CV-58-1	94000	2	900	0.7	1.0	Probable	0.17	0.32	0.01	0.02	
CV-58-2	115501	1	900	0.8	1.3	Fish Bearing	0.23	0.42	0.01	0.02	
CV-58-3	7281	1	900	0.1	0.1	Potential	0.10	0.18	0.00	0.01	
CV-58-4	192771	1	900	1.4	2.1	Fish Bearing	0.27	0.49	0.02	0.03	
CV-58-4a	64172	1	900	0.5	0.7	Fish Bearing	0.19	0.35	0.01	0.02	
CV-58-5	18710	1	900	0.1	0.2	Probable	0.13	0.24	0.01	0.01	
CV-58-6	417954	1	900	3.1	4.6	Probable	0.34	0.62	0.03	0.05	
CV-58-7	417954	0	0	3.1	4.6	Unlikely	0.00	0.00	0.00	0.00	Diverted to 59-1
CV-58-8	304042	0	0	2.2	3.3	Potential	0.00	0.00	0.00	0.00	Diverted to 59-1
CV-59-1	93947	1	900	0.7	1.0	Probable	0.21	0.39	0.01	0.02	
CV-59-2	49972	1	900	0.4	0.5	Potential	0.18	0.32	0.01	0.02	
CV-59-3	38859	1	900	0.3	0.4	Potential	0.16	0.30	0.01	0.02	
CV-59-4	4768110	3	1200	34.8	52.4	Fish Bearing	0.49	0.89	0.05	0.08	
CV-60-3	278620	1	900	2.0	3.1	Probable	0.30	0.55	0.02	0.04	
CV-60-4	247545	1	900	1.8	2.7	Unlikely	0.29	0.53	0.02	0.04	
CV-60-5	601714	1	1200	4.4	6.6	Potential	0.36	0.66	0.03	0.05	
CV-60-6	16958	1	900	0.1	0.2	Unlikely	0.13	0.23	0.01	0.01	
CV-61-1	488972	1	900	3.6	5.4	Probable	0.35	0.65	0.03	0.05	
CV-61-2	135669	1	900	1.0	1.5	Probable	0.24	0.44	0.02	0.03	
CV-61-3	135669	0	0	1.0	1.5	Potential	0.00	0.00	0.00	0.00	Diverted to 61-2
CV-62-1	117005000	7	1800	854.1	1287.1	Fish Bearing	0.94	1.72	0.13	0.22	
CV-62-2	375979	1	900	2.7	4.1	Probable	0.33	0.60	0.03	0.04	
CV-63-1	111322	1	900	0.8	1.2	Potential	0.22	0.41	0.01	0.02	
CV-63-2	304270	1	900	2.2	3.3	Potential	0.31	0.56	0.02	0.04	
CV-63-3	74396	1	900	0.5	0.8	Potential	0.20	0.36	0.01	0.02	
CV-63-4	1164850	1	900	8.5	12.8	Probable	0.46	0.85	0.04	0.07	
CV-63-4a	23078	1	900	0.2	0.3	Potential	0.14	0.25	0.01	0.01	
CV-63-5	-	1	900	-	-	Potential	0.03	0.04	0.00	0.00	Minor/secondary crossing, negligable drainage area
CV-64-1	82363	1	900	0.6	0.9	Unlikely	0.21	0.38	0.01	0.02	
CV-64-2	13643	1	900	0.1	0.2	Unlikely	0.12	0.22	0.01	0.01	
CV-64-4	313201	1	900	2.3	3.4	Fish Bearing	0.31	0.57	0.02	0.04	
CV-65-1	612555	1	900	4.5	6.7	Probable	0.38	0.70	0.03	0.05	
CV-65-2	129361	1	900	0.9	1.4	Potential	0.24	0.43	0.02	0.03	
CV-66-1	329312	1	900	2.4	3.6	Unlikely	0.31	0.58	0.02	0.04	
CV-66-3	182193	1	900	1.3	2.0	Probable	0.26	0.48	0.02	0.03	
CV-66-8	36437	1	900	0.3	0.4	Probable	0.16	0.29	0.01	0.01	
CV-67-1	331786	1	900	2.4	3.6	Probable	0.31	0.58	0.02	0.04	
CV-68-1a	3551025	1	900	25.9	39.1	Fish Bearing	0.65	1.18	0.07	0.13	Depth and velocity assume flow split evenly between the two branches.
CV-68-1	3551025	3	1400	25.9	39.1	Fish Bearing	0.43	0.80	0.04	0.07	Depth and velocity assume flow split evenly between the two branches.
CV-68-3	1076140	1	1200	7.9	11.8	Probable	0.43	0.79	0.04	0.07	
CV-68-5	587722	1	900	4.3	6.5	Potential	0.37	0.69	0.03	0.05	
CV-69-2	469963	1	900	3.4	5.2	Fish Bearing	0.35	0.64	0.03	0.05	
CV-69-3	83120	1	900	0.6	0.9	Fish Bearing	0.21	0.38	0.01	0.02	
CV-69-4	-	1	900	-	-	Potential	0.03	0.04	0.00	0.00	Minor/secondary crossing, negligable drainage area
CV-70-2	-	1	900	-	-	Fish Bearing	0.03	0.04	0.00	0.00	In bridge approach
Bridge 2 CV-70-3	-	0	0	-	-	Fish Bearing	0.00	0.00	0.00	0.00	Bridge - depth and velocity not assessed
CV-71-1	2962380	4	1800	21.6	32.6	Fish Bearing	0.36	0.66	0.03	0.05	
CV-71-2	5376	1	900	0.0	0.1	Fish Bearing	0.09	0.16	0.00	0.01	
CV-71-4	11370	1	900	0.1	0.1	Unlikely	0.11	0.21	0.01	0.01	
CV-72-1	332965	1	1200	2.4	3.7	Unlikely	0.30	0.55	0.02	0.04	
CV-72-1a	128088	1	1200	0.9	1.4	Unlikely	0.22	0.41	0.01	0.02	
CV-72-2	189785	1	900	1.4	2.1	Unlikely	0.26	0.49	0.02	0.03	
CV-72-3	9437	1	900	0.1	0.1	Potential	0.11	0.19	0.00	0.01	
CV-72-3a	68079	1	900	0.5	0.7	Potential	0.19	0.35	0.01	0.02	
CV-72-4	416570	2	900	3.0	4.6	Potential	0.27	0.50	0.02	0.03	
CV-73-1	-	1	900	-	-	Unlikely	0.03	0.04	0.00	0.00	Minor/secondary crossing, negligable drainage area
CV-74-1	765313	1	1200	5.6	8.4	Probable	0.39	0.71	0.03	0.06	
CV-74-1a	765313	1	1200	5.6	8.4	Potential	0.39	0.71	0.03	0.06	
CV-74-2	47955	1	1400	0.4	0.5	Fish Bearing	0.16	0.30	0.01	0.01	
CV-74-3	3802880	1	1800	27.8	41.8	Fish Bearing	0.60	1.10	0.06	0.11	
CV-74-4	73490	1	1800	0.5	0.8	Potential	0.18	0.33	0.01	0.02	
CV-74-5	69500	1	1800	0.5	0.8	Potential	0.18	0.32	0.01	0.02	
CV-74-6	207620	1	900	1.5	2.3	Potential	0.27	0.50	0.02	0.03	
CV-74-7	-	0	0	-	-	Potential	0.00	0.00	0.00	0.00	Diverted to 74-6
CV-75-1	11949	1	1200	0.1	0.1	Potential	0.11	0.20	0.00	0.01	

Culvert Name	KP Catchment Areas (m²)	No. Barrels	Culvert Diameter (mm)	Mean Annual Flow		Fish Bearing?	Ranges of results				Notes
				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-75-2	1402300	1	900	10.2	15.4	Potential	0.49	0.89	0.05	0.08	
CV-76-1	1164060	1	1200	8.5	12.8	Probable	0.44	0.81	0.04	0.07	
CV-76-1a	237009	1	1200	1.7	2.6	Potential	0.27	0.50	0.02	0.03	
CV-76-3	260046	1	900	1.9	2.9	Potential	0.29	0.53	0.02	0.04	
CV-77-1	57775	1	900	0.4	0.6	Potential	0.18	0.34	0.01	0.02	
CV-77-2	11197600	3	1400	81.7	123.2	Fish Bearing	0.62	1.13	0.07	0.11	
CV-77-3	122463	1	900	0.9	1.3	Probable	0.23	0.42	0.02	0.03	
CV-78-2	36136	1	900	0.3	0.4	Unlikely	0.16	0.29	0.01	0.01	
CV-78-3	1212000	1	900	8.8	13.3	Fish Bearing	0.47	0.86	0.04	0.07	
CV-78-5	-	1	900	-	-	Unlikely	0.03	0.04	0.00	0.00	Minor/secondary crossing, negligable drainage area
CV-78-6	70000	1	900	0.5	0.8	Probable	0.20	0.36	0.01	0.02	
CV-79-0	775494	1	900	5.7	8.5	Probable	0.41	0.75	0.04	0.06	
CV-79-1	-	1	900	-	-	Unlikely	0.03	0.04	0.00	0.00	Minor/secondary crossing, negligable drainage area
CV-80-1	3261440	2	1200	23.8	35.9	Fish Bearing	0.49	0.90	0.05	0.08	
CV-80-1a	94000	1	1200	0.7	1.0	Unlikely	0.20	0.37	0.01	0.02	
CV-80-2	2415	1	900	0.0	0.0	Unlikely	0.07	0.13	0.00	0.00	
CV-80-2a	26262	1	900	0.2	0.3	Unlikely	0.14	0.26	0.01	0.01	
CV-80-2b	161892	1	900	1.2	1.8	Unlikely	0.25	0.46	0.02	0.03	
CV-80-3	74433	1	900	0.5	0.8	Unlikely	0.20	0.36	0.01	0.02	
CV-80-4	47083	1	900	0.3	0.5	Unlikely	0.17	0.32	0.01	0.02	
CV-80-5	38715	1	900	0.3	0.4	Unlikely	0.16	0.30	0.01	0.01	
CV-81-2	145625	1	900	1.1	1.6	Probable	0.24	0.45	0.02	0.03	
CV-81-3	263562	1	900	1.9	2.9	Probable	0.29	0.54	0.02	0.04	
CV-81-4	149049	1	900	1.1	1.6	Unlikely	0.25	0.45	0.02	0.03	
CV-82-1	2043550	2	900	14.9	22.5	Unlikely	0.44	0.81	0.04	0.07	
CV-82-2	-	1	900	-	-	Unlikely	0.03	0.04	0.00	0.00	Minor/secondary crossing, negligable drainage area
CV-82-3	110862	1	900	0.8	1.2	Unlikely	0.22	0.41	0.01	0.02	
CV-82-4	69358	1	1200	0.5	0.8	Probable	0.19	0.34	0.01	0.02	
CV-83-1	1235590	1	1200	9.0	13.6	Probable	0.45	0.83	0.04	0.07	
CV-83-2	3235620	4	1800	23.6	35.6	Fish Bearing	0.37	0.68	0.03	0.05	
CV-84-1	11469400	1	1200	83.7	126.2	Fish Bearing	0.88	1.62	0.12	0.20	
CV-84-2	473522	1	900	3.5	5.2	Unlikely	0.35	0.64	0.03	0.05	
Bridge CV-85-3	-	0	0	-	-	Fish Bearing	0.00	0.00	0.00	0.00	Bridge - depth and velocity not assessed
CV-85-4	-	1	1800	-	-	Fish Bearing	0.02	0.03	0.00	0.00	In bridge approach
CV-86-1	-	6	900	-	-	Potential	0.03	0.04	0.00	0.00	Minor/secondary crossing, negligable drainage area
CV-86-2	24812000	2	1800	181.1	272.9	Fish Bearing	0.86	1.57	0.11	0.19	
CV-87-4	481790	1	900	3.5	5.3	Fish Bearing	0.35	0.65	0.03	0.05	
CV-88-2	154608	1	900	1.1	1.7	Fish Bearing	0.25	0.46	0.02	0.03	
CV-88-3	162324	1	900	1.2	1.8	Fish Bearing	0.25	0.46	0.02	0.03	
CV-89-1	3859280	1	900	28.2	42.5	Fish Bearing	0.66	1.22	0.08	0.13	
CV-89-2	26727	1	1400	0.2	0.3	Unlikely	0.14	0.25	0.01	0.01	
CV-90-2	29653	0	0	0.2	0.3	Unlikely	0.00	0.00	0.00	0.00	
CV-92-1	-	1	1200	-	-	Unlikely	0.02	0.04	0.00	0.00	
CV-92-5	647107	1	900	4.7	7.1	Fish Bearing	0.39	0.71	0.03	0.06	
CV-93-4a	21011	1	900	0.2	0.2	Probable	0.14	0.25	0.01	0.01	
CV-93-4b	450089	1	1200	3.3	5.0	Probable	0.33	0.61	0.03	0.04	
CV-93-4	5385000	3	1400	39.3	59.2	Fish Bearing	0.49	0.90	0.05	0.08	
CV-95-3	49194	1	900	0.4	0.5	Probable	0.18	0.32	0.01	0.02	
CV-95-4	30074	1	900	0.2	0.3	Probable	0.15	0.28	0.01	0.01	
CV-96-1	16427000	1	900	119.9	180.7	Fish Bearing	1.02	1.87	0.15	0.27	
CV-99-1	20380	1	900	0.1	0.2	Potential	0.13	0.25	0.01	0.01	
CV-99-3	6936290	5	900	50.6	76.3	Fish Bearing	0.49	0.89	0.05	0.08	
CV-100-3	783746	1	900	-	-	Potential	0.03	0.04	0.00	0.00	Pond
CV-100-4	783746	2	1200	5.7	8.6	Probable	0.32	0.58	0.02	0.04	
CV-101-1	783746	1	900	5.7	8.6	Probable	0.41	0.75	0.04	0.06	Diversion from 101-1a and 101-1b
CV-101-1a	783746	0	0	5.7	8.6	Probable	0.00	0.00	0.00	0.00	
CV-101-1b	783746	0	0	5.7	8.6	Probable	0.00	0.00	0.00	0.00	
CV-101-2	123606	5	1400	0.9	1.4	Unlikely	0.13	0.24	0.01	0.01	
Bridge CV-102-1	-	0	0	-	-	Fish Bearing	0.00	0.00	0.00	0.00	Bridge - depth and velocity not assessed
CV-102-2	1674540	1	1200	12.2	18.4	Fish Bearing	0.49	0.91	0.05	0.08	
CV-102-3	78218	1	900	0.6	0.9	Probable	0.20	0.37	0.01	0.02	
CV-102-4	307965	3	900	2.2	3.4	Fish Bearing	0.22	0.40	0.01	0.02	
CV-102-5	8505630	0	0	62.1	93.6	Potential	0.00	0.00	0.00	0.00	
CV-103-1	8505630	1	1800	62.1	93.6	Fish Bearing	0.76	1.40	0.09	0.16	Diversion from 102-5
CV-104-1	117626	1	900	0.9	1.3	Probable	0.23	0.42	0.02	0.03	
CV-104-2	355737	1	1200	2.6	3.9	Fish Bearing	0.31	0.56	0.02	0.04	
CV-104-3	196000	3	1400	1.4	2.2	Fish Bearing	0.18	0.33	0.01	0.02	
CV-104-5	8097550	1	1800	59.1	89.1	Fish Bearing	0.75	1.38	0.09	0.15	
CV-105-1	-	1	900	-	-	Probable	0.03	0.04	0.00	0.00	Minor/secondary crossing, negligable drainage area
CV-105-2	2357990	1	900	17.2	25.9	Fish Bearing	0.57	1.05	0.06	0.10	Confirm geometry
CV-105-3	-	1	900	-	-	Fish Bearing	0.03	0.04	0.00	0.00	Pond
CV-105-4	2357990	1	900	17.2	25.9	Fish Bearing	0.57	1.05	0.06	0.10	Confirm geometry
CV-106-1	-	1	900	-	-	Fish Bearing	0.03	0.04	0.00	0.00	Pond
CV-106-2	-	1	900	-	-	Fish Bearing	0.03	0.04	0.00	0.00	Pond
CV-106-3	-	1	900	-	-	Fish Bearing	0.03	0.04	0.00	0.00	Pond
CV-107-1	-	1	900	-	-	Probable	0.03	0.04	0.00	0.00	Pond
CV-107-2	-	1	900	-	-	Potential	0.03	0.04	0.00	0.00	Pond
CV-107-4	1879500	1	1400	13.7	20.7	Fish Bearing	0.50	0.92	0.05	0.08	
CV-109-1	8459	1	900	0.1	0.1	Potential	0.10	0.19	0.00	0.01	

M:\1\02\00181\39\A\Data\Culvert Crossing Spreadsheet\[Culvert Crossings Annual Flow_20170714.xlsm]Results Table

NOTES:

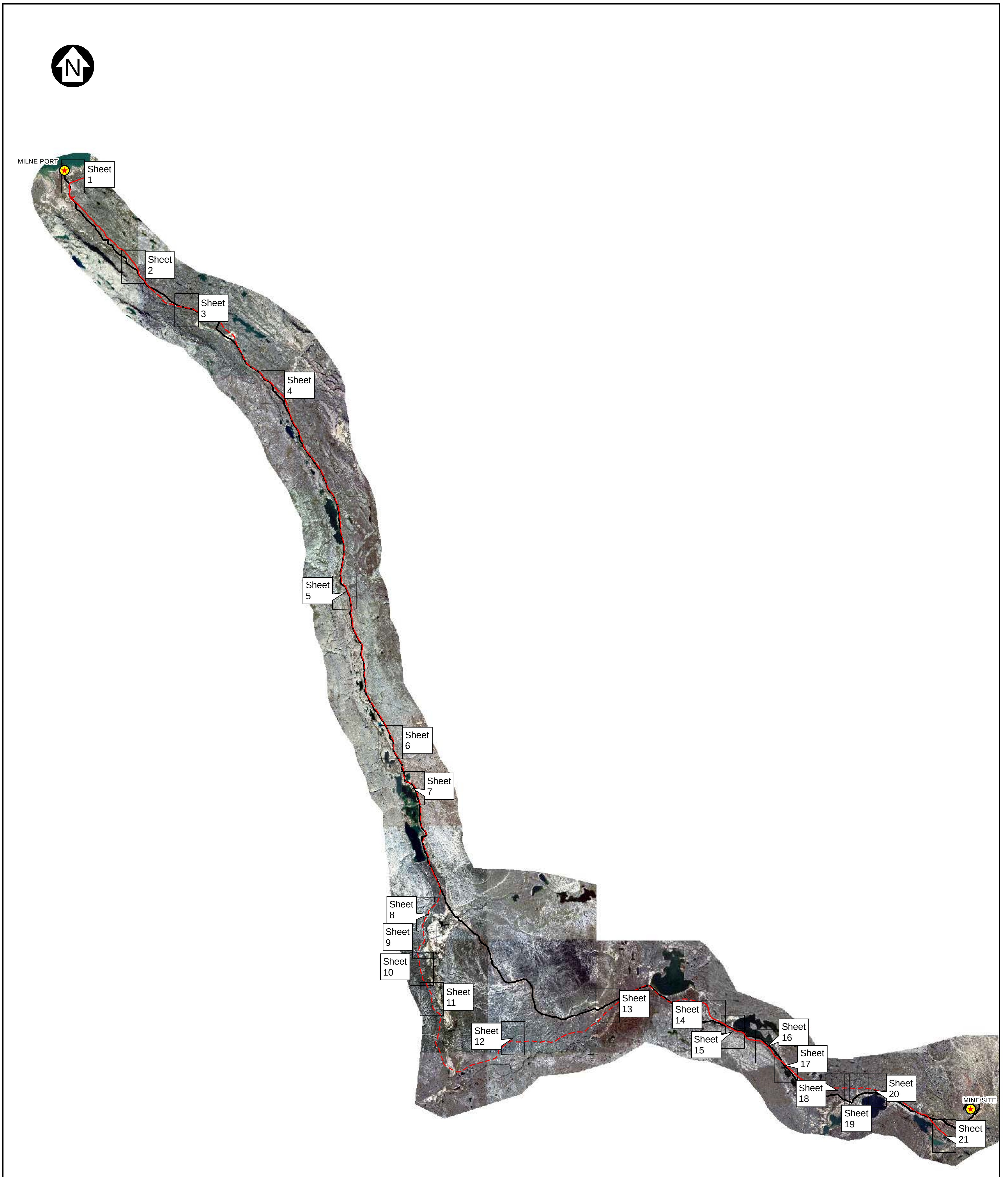
1. MIN AND MAX VELOCITY RESULTS REPRESENT THE RANGE OF RESULTS FROM THE DIFFERENT FLOWS AND CULVERT SLOPE SCENARIOS. ALL VELOCITIES ARE CROSS SECTION AVERAGE VALUES.
2. MIN AND MAX DEPTH RESULTS REPRESENT THE RANGE OF RESULTS FROM THE DIFFERENT FLOWS AND CULVERT SLOPE SCENARIOS. ALL DEPTHS ARE CROSS SECTION MAXIMUM VALUES.
3. WATER DEPTHS AND VELOCITIES ARE NOT CLACULATED FOR NON-FISHBEARING CROSSINGS

A	18JUL'17	ISSUED WITH LETTER VA17-01009	MJB	TJP
REV	DATE	DESCRIPTION	PREP'D	RVW'D

APPENDIX C

STREAM DIVERSION FIGURES

(Pages C-1 to C-22)



LEGEND

- PROJECT FACILITY LOCATION
- PROPOSED NORTH RAILWAY
- MILNE INLET TOTE ROAD

NOTES:

1. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
2. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA DEPARTMENT OF NATURAL RESOURCES (2009). ALL RIGHTS RESERVED.
3. DETAILED WATER AND ORTH IMAGERY FROM EAGLE MAPPING (2005).
4. CONTOUR INTERVAL IS 2.5 METRES.

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BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

STREAM DIVERSIONS (INDEX MAP)

Knight Piésold CONSULTING

P/A NO.	REF NO.
NB102-181/39	VA17-01009

FIGURE C.0 REV 0

LEGEND

- PROJECT FACILITY LOCATION

DIVERTED STREAMS

FISH HABITAT ASSESSMENT - ARCTIC CHAR, NINESPINE STICKLEBACK

- NO, NO
- NO, UNLIKELY
- POTENTIAL, POTENTIAL
- PROBABLE, PROBABLE
- UNLIKELY, UNLIKELY
- YES, YES

RECEIVING STREAMS

FISH HABITAT ASSESSMENT - ARCTIC CHAR, NINESPINE STICKLEBACK

- NO, NO
- NO, UNLIKELY
- POTENTIAL, POTENTIAL
- PROBABLE, PROBABLE
- UNLIKELY, UNLIKELY
- YES, YES

- STREAM DIVERSION
- DECREASE IN FLOW
- INCREASE IN FLOW
- PROPOSED NORTH RAILWAY
- MILNE INLET TOTE ROAD
- CATCHMENT AREA

NOTES:

1. COORDINATE GRID IS IN METRES.
   COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
2. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA DEPARTMENT OF NATURAL RESOURCES (2009). ALL RIGHTS RESERVED.
3. DETAILED WATER AND ORTH IMAGERY FROM EAGLE MAPPING (2005).
4. CONTOUR INTERVAL IS 2.5 METRES.

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
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BAFFINLAND IRON MINES CORPORATION

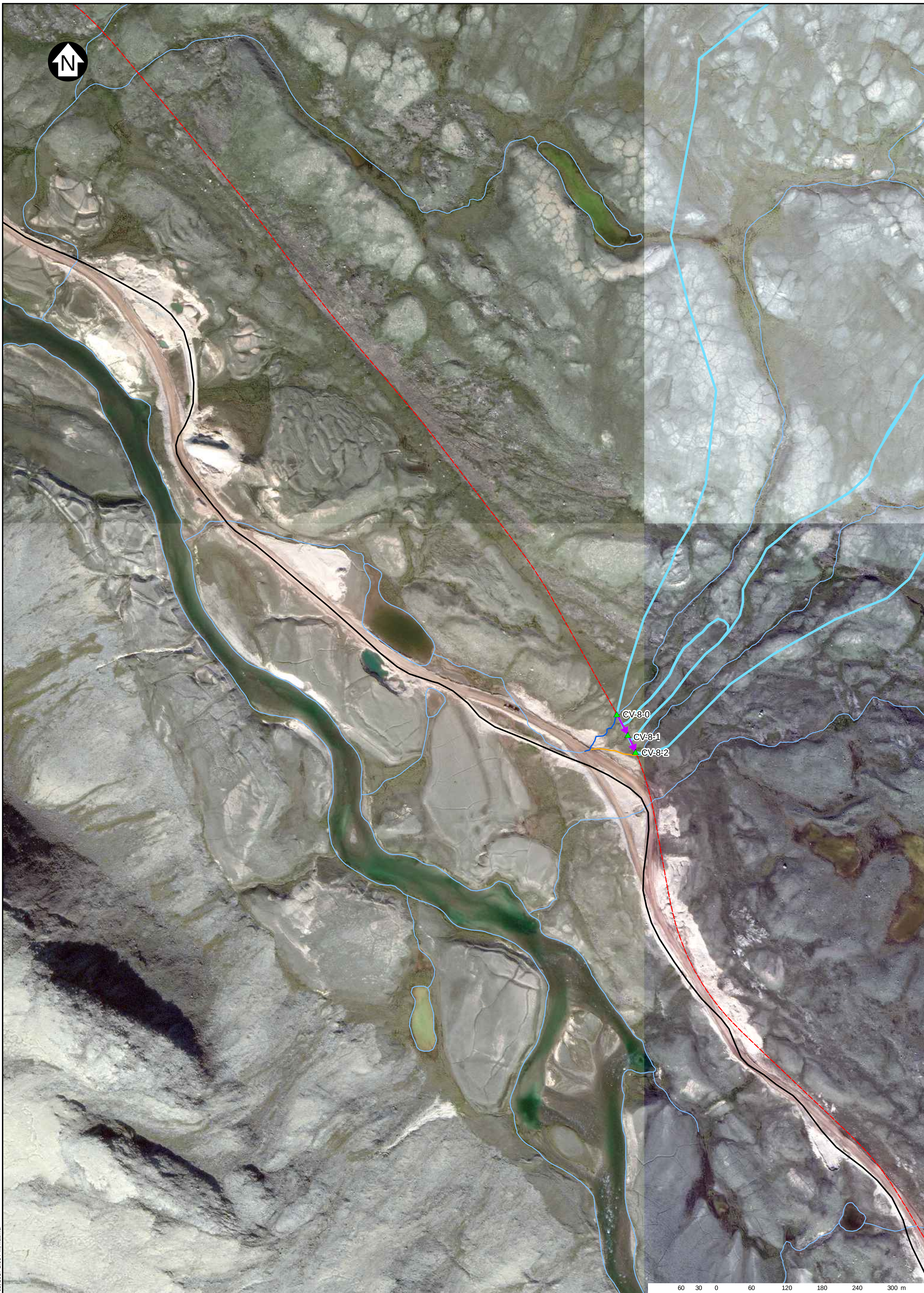
MARY RIVER PROJECT

STREAM DIVERSIONS
(SHEET 1 OF 21)

Knight Piésold CONSULTING

P/A NO.	REF NO.
NB102-181/39	VA17-01009

FIGURE C.1 REV 0



LEGEND

PROJECT FACILITY LOCATION

DIVERTED STREAMS FISH HABITAT ASSESSMENT - ARCTIC CHAR, NINESPINE STICKLEBACK	RECEIVING STREAMS FISH HABITAT ASSESSMENT - ARCTIC CHAR, NINESPINE STICKLEBACK
NO, NO	NO, NO
NO, UNLIKELY	NO, UNLIKELY
POTENTIAL, POTENTIAL	POTENTIAL, POTENTIAL
PROBABLE, PROBABLE	PROBABLE, PROBABLE
UNLIKELY, UNLIKELY	UNLIKELY, UNLIKELY
YES, YES	YES, YES

STREAM DIVERSION
DECREASE IN FLOW
INCREASE IN FLOW
PROPOSED NORTH RAILWAY
MILNE INLET TOTE ROAD
CATCHMENT AREA

NOTES:
1. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
2. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA DEPARTMENT OF NATURAL RESOURCES (2009). ALL RIGHTS RESERVED.
3. DETAILED WATER AND ORTH IMAGERY FROM EAGLE MAPPING (2005).
4. CONTOUR INTERVAL IS 2.5 METRES.

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
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BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

STREAM DIVERSIONS (SHEET 2 OF 21)

Knight Piésold CONSULTING

P/A NO. NB102-181/39 | REF NO. VA17-01009

FIGURE C.2 REV 0

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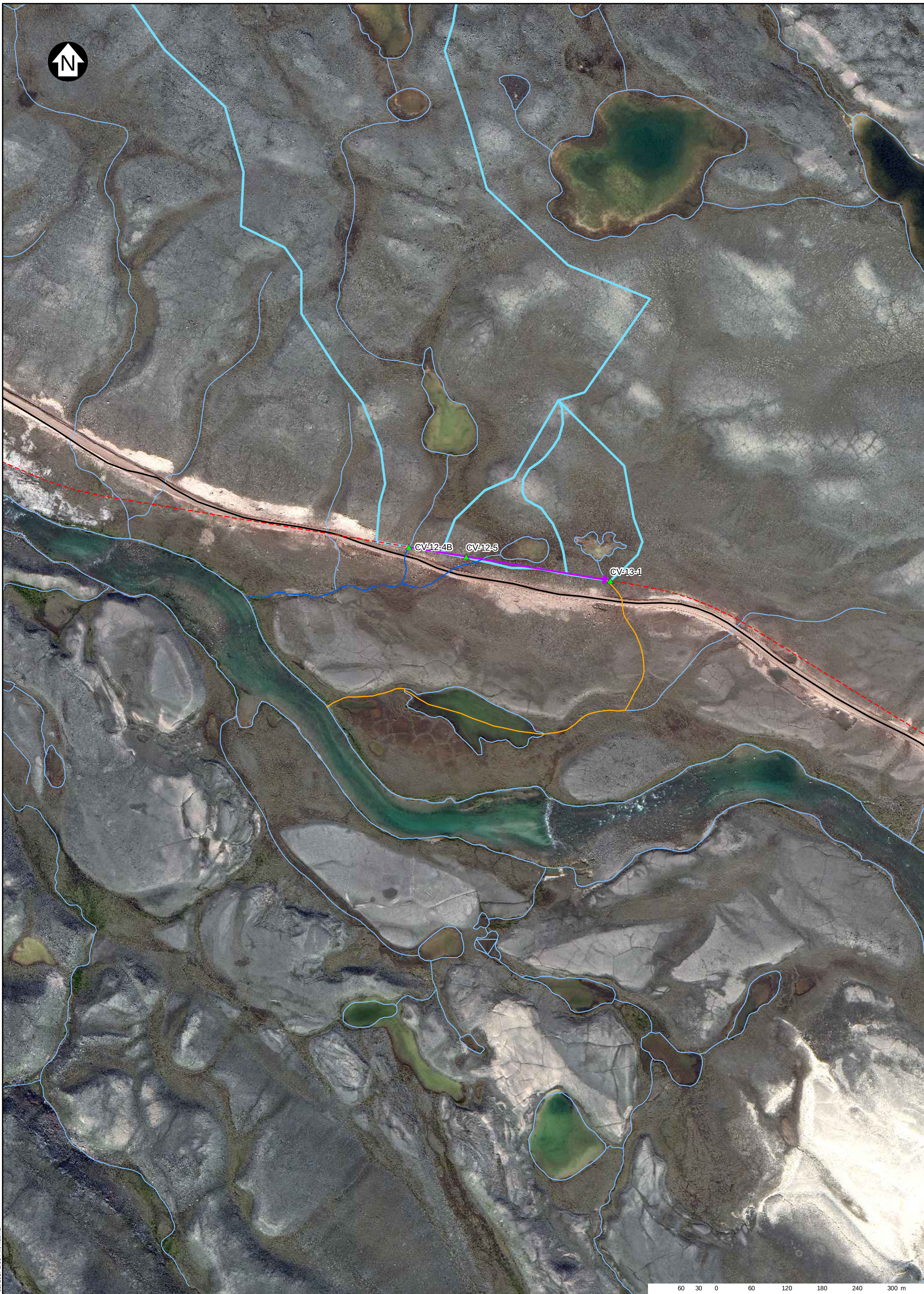

LEGEND

PROJECT FACILITY LOCATION

DIVERTED STREAMS

FISH HABITAT ASSESSMENT - ARCTIC CHAR, NINESPINE STICKLEBACK

- NO, NO
- NO, UNLIKELY
- POTENTIAL, POTENTIAL
- PROBABLE, PROBABLE
- UNLIKELY, UNLIKELY
- YES, YES

RECEIVING STREAMS

FISH HABITAT ASSESSMENT - ARCTIC CHAR, NINESPINE STICKLEBACK

- NO, NO
- NO, UNLIKELY
- POTENTIAL, POTENTIAL
- PROBABLE, PROBABLE
- UNLIKELY, UNLIKELY
- YES, YES

- STREAM DIVERSION
- DECREASE IN FLOW
- INCREASE IN FLOW
- PROPOSED NORTH RAILWAY
- MILNE INLET TOTE ROAD
- CATCHMENT AREA

NOTES:

1. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
2. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA DEPARTMENT OF NATURAL RESOURCES (2009). ALL RIGHTS RESERVED.
3. DETAILED WATER AND ORTH IMAGERY FROM EAGLE MAPPING (2005).
4. CONTOUR INTERVAL IS 2.5 METRES.

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
0	30AUG'17	ISSUED WITH LETTER	TJP	RF	TJP

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

STREAM DIVERSIONS (SHEET 3 OF 21)

Knight Piésold CONSULTING

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FIGURE C.3 REV 0

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LEGEND

PROJECT FACILITY LOCATION

DIVERTED STREAMS

FISH HABITAT ASSESSMENT - ARCTIC CHAR, NINESPINE STICKLEBACK

- NO, NO
- NO, UNLIKELY
- POTENTIAL, POTENTIAL
- PROBABLE, PROBABLE
- UNLIKELY, UNLIKELY
- YES, YES

RECEIVING STREAMS

FISH HABITAT ASSESSMENT - ARCTIC CHAR, NINESPINE STICKLEBACK

- NO, NO
- NO, UNLIKELY
- POTENTIAL, POTENTIAL
- PROBABLE, PROBABLE
- UNLIKELY, UNLIKELY
- YES, YES

- STREAM DIVERSION
- DECREASE IN FLOW
- INCREASE IN FLOW
- PROPOSED NORTH RAILWAY
- MILNE INLET TOTE ROAD
- CATCHMENT AREA

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
0	30AUG'17	ISSUED WITH LETTER	TJP	RF	TJP

NOTES:

1. COORDINATE GRID IS IN METRES.
   COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
2. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA DEPARTMENT OF NATURAL RESOURCES (2009). ALL RIGHTS RESERVED.
3. DETAILED WATER AND ORTH IMAGERY FROM EAGLE MAPPING (2005).
4. CONTOUR INTERVAL IS 2.5 METRES.

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

STREAM DIVERSIONS
(SHEET 4 OF 21)

Knight Piésold CONSULTING

P/A NO.	REF NO.
NB102-181/39	VA17-01009

FIGURE C.4 REV 0

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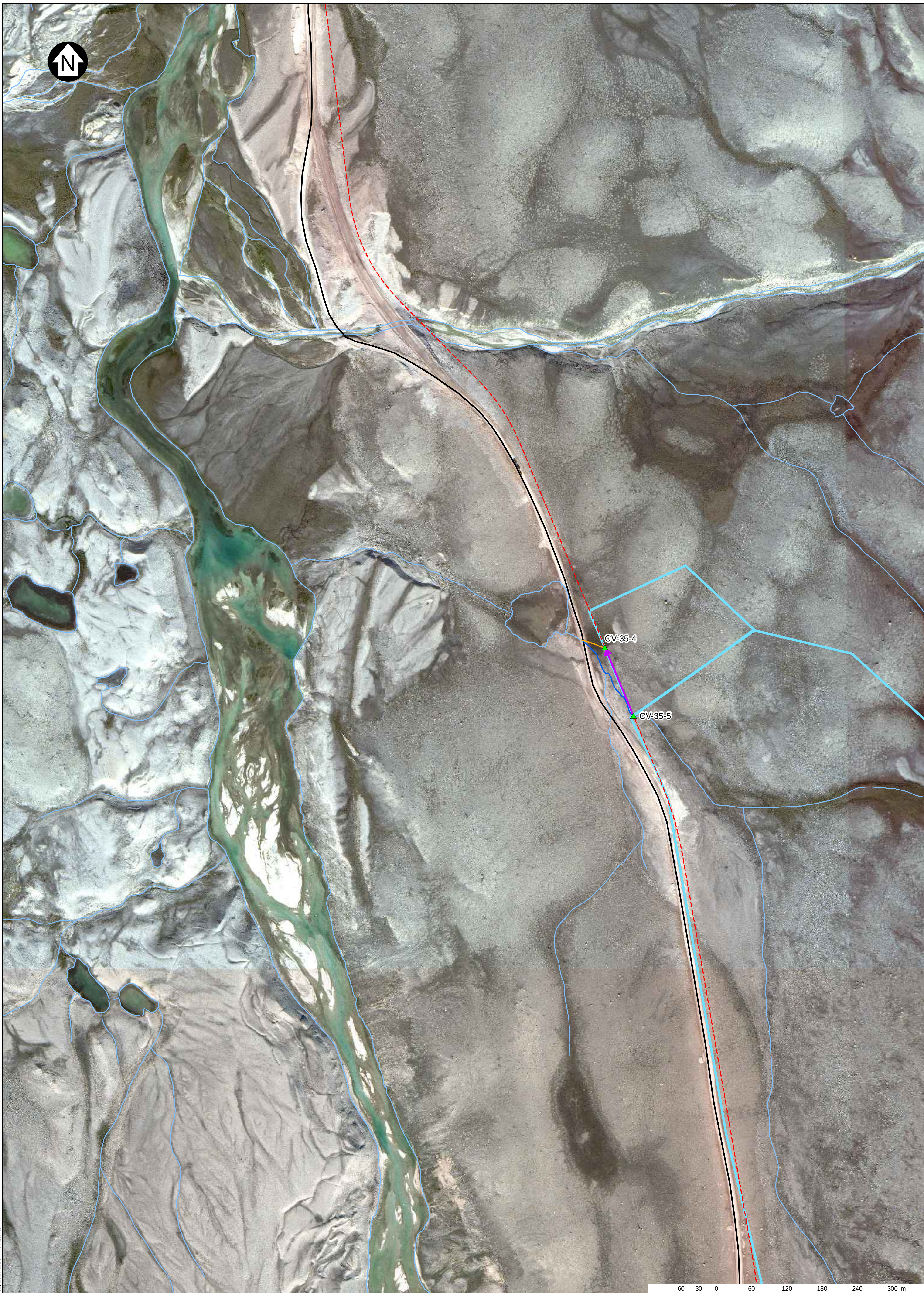

LEGEND

PROJECT FACILITY LOCATION

DIVERTED STREAMS

FISH HABITAT ASSESSMENT - ARCTIC CHAR, NINESPINE STICKLEBACK

- NO, NO
- NO, UNLIKELY
- POTENTIAL, POTENTIAL
- PROBABLE, PROBABLE
- UNLIKELY, UNLIKELY
- YES, YES

RECEIVING STREAMS

FISH HABITAT ASSESSMENT - ARCTIC CHAR, NINESPINE STICKLEBACK

- NO, NO
- NO, UNLIKELY
- POTENTIAL, POTENTIAL
- PROBABLE, PROBABLE
- UNLIKELY, UNLIKELY
- YES, YES

- STREAM DIVERSION
- DECREASE IN FLOW
- INCREASE IN FLOW
- PROPOSED NORTH RAILWAY
- MILNE INLET TOTE ROAD
- CATCHMENT AREA

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
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NOTES:

1. COORDINATE GRID IS IN METRES.
   COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
2. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA DEPARTMENT OF NATURAL RESOURCES (2009). ALL RIGHTS RESERVED.
3. DETAILED WATER AND ORTH IMAGERY FROM EAGLE MAPPING (2005).
4. CONTOUR INTERVAL IS 2.5 METRES.

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

STREAM DIVERSIONS (SHEET 5 OF 21)

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FIGURE C.5 REV 0

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LEGEND

PROJECT FACILITY LOCATION

DIVERTED STREAMS

FISH HABITAT ASSESSMENT - ARCTIC CHAR, NINESPINE STICKLEBACK

- NO, NO
- NO, UNLIKELY
- POTENTIAL, POTENTIAL
- PROBABLE, PROBABLE
- UNLIKELY, UNLIKELY
- YES, YES

RECEIVING STREAMS

FISH HABITAT ASSESSMENT - ARCTIC CHAR, NINESPINE STICKLEBACK

- NO, NO
- NO, UNLIKELY
- POTENTIAL, POTENTIAL
- PROBABLE, PROBABLE
- UNLIKELY, UNLIKELY
- YES, YES

- STREAM DIVERSION
- DECREASE IN FLOW
- INCREASE IN FLOW
- PROPOSED NORTH RAILWAY
- MILNE INLET TOTE ROAD
- CATCHMENT AREA

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
0	30AUG'17	ISSUED WITH LETTER	TJP	RF	TJP

NOTES:

1. COORDINATE GRID IS IN METRES.
   COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
2. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA DEPARTMENT OF NATURAL RESOURCES (2009). ALL RIGHTS RESERVED.
3. DETAILED WATER AND ORTH IMAGERY FROM EAGLE MAPPING (2005).
4. CONTOUR INTERVAL IS 2.5 METRES.

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

STREAM DIVERSIONS
(SHEET 6 OF 21)

Knight Piésold CONSULTING

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FIGURE C.6 REV 0

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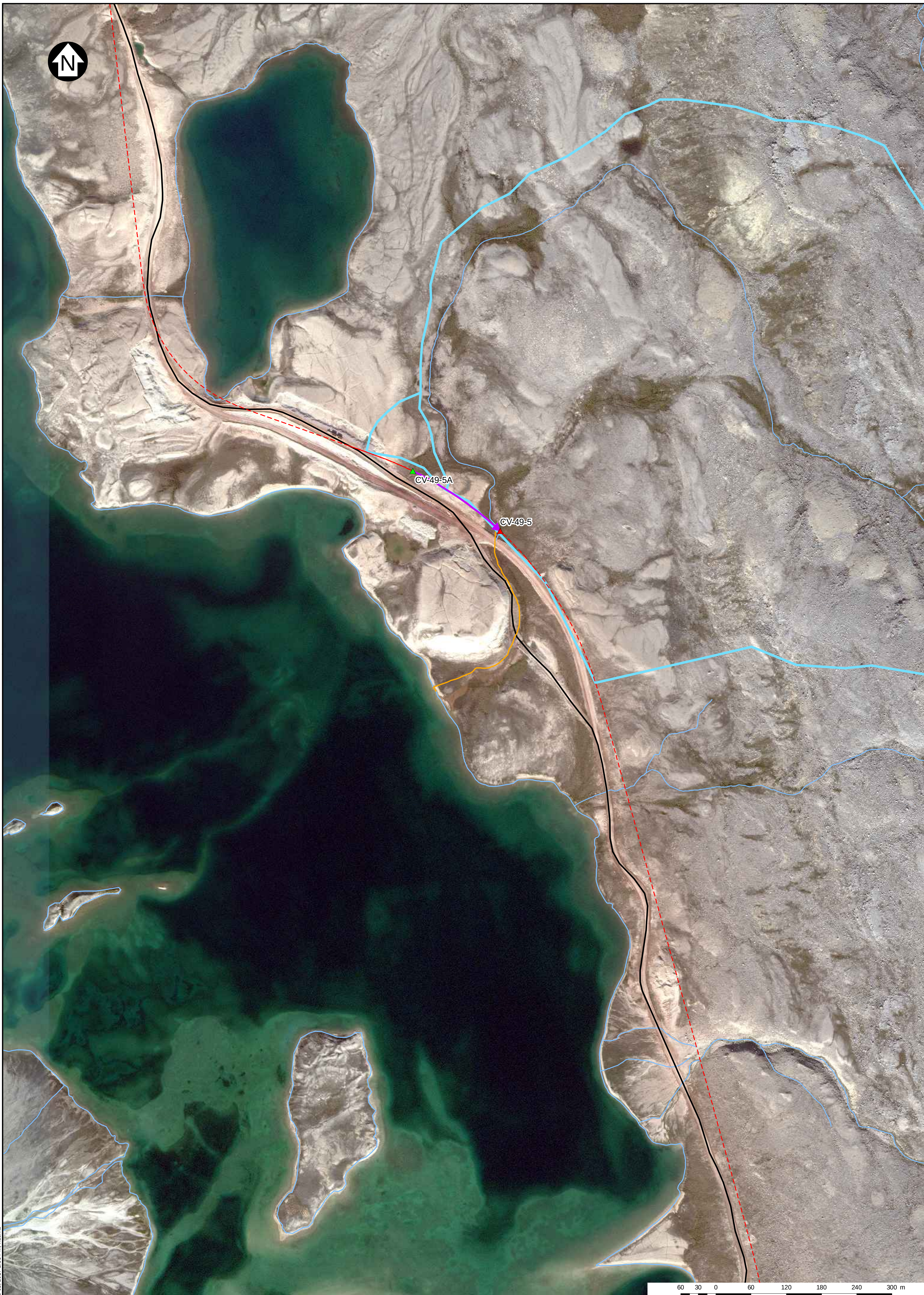

LEGEND

PROJECT FACILITY LOCATION

DIVERTED STREAMS

FISH HABITAT ASSESSMENT - ARCTIC CHAR, NINESPINE STICKLEBACK

- NO, NO
- NO, UNLIKELY
- POTENTIAL, POTENTIAL
- PROBABLE, PROBABLE
- UNLIKELY, UNLIKELY
- YES, YES

RECEIVING STREAMS

FISH HABITAT ASSESSMENT - ARCTIC CHAR, NINESPINE STICKLEBACK

- NO, NO
- NO, UNLIKELY
- POTENTIAL, POTENTIAL
- PROBABLE, PROBABLE
- UNLIKELY, UNLIKELY
- YES, YES

STREAM DIVERSION
DECREASE IN FLOW
INCREASE IN FLOW
PROPOSED NORTH RAILWAY
MILNE INLET TOTE ROAD
CATCHMENT AREA

NOTES:

1. COORDINATE GRID IS IN METRES.
   COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
2. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA DEPARTMENT OF NATURAL RESOURCES (2009). ALL RIGHTS RESERVED.
3. DETAILED WATER AND ORTH IMAGERY FROM EAGLE MAPPING (2005).
4. CONTOUR INTERVAL IS 2.5 METRES.

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BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

STREAM DIVERSIONS (SHEET 7 OF 21)

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FIGURE C.7 REV 0

LEGEND

PROJECT FACILITY LOCATION

DIVERTED STREAMS

FISH HABITAT ASSESSMENT - ARCTIC CHAR, NINESPINE STICKLEBACK

- NO, NO
- NO, UNLIKELY
- POTENTIAL, POTENTIAL
- PROBABLE, PROBABLE
- UNLIKELY, UNLIKELY
- YES, YES

RECEIVING STREAMS

FISH HABITAT ASSESSMENT - ARCTIC CHAR, NINESPINE STICKLEBACK

- NO, NO
- NO, UNLIKELY
- POTENTIAL, POTENTIAL
- PROBABLE, PROBABLE
- UNLIKELY, UNLIKELY
- YES, YES

- STREAM DIVERSION
- DECREASE IN FLOW
- INCREASE IN FLOW
- PROPOSED NORTH RAILWAY
- MILNE INLET TOTE ROAD
- CATCHMENT AREA

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
0	30AUG'17	ISSUED WITH LETTER	TJP	RF	TJP

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NOTES:

1. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
2. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA DEPARTMENT OF NATURAL RESOURCES (2009). ALL RIGHTS RESERVED.
3. DETAILED WATER AND ORTH IMAGERY FROM EAGLE MAPPING (2005).
4. CONTOUR INTERVAL IS 2.5 METRES.

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

STREAM DIVERSIONS (SHEET 8 OF 21)

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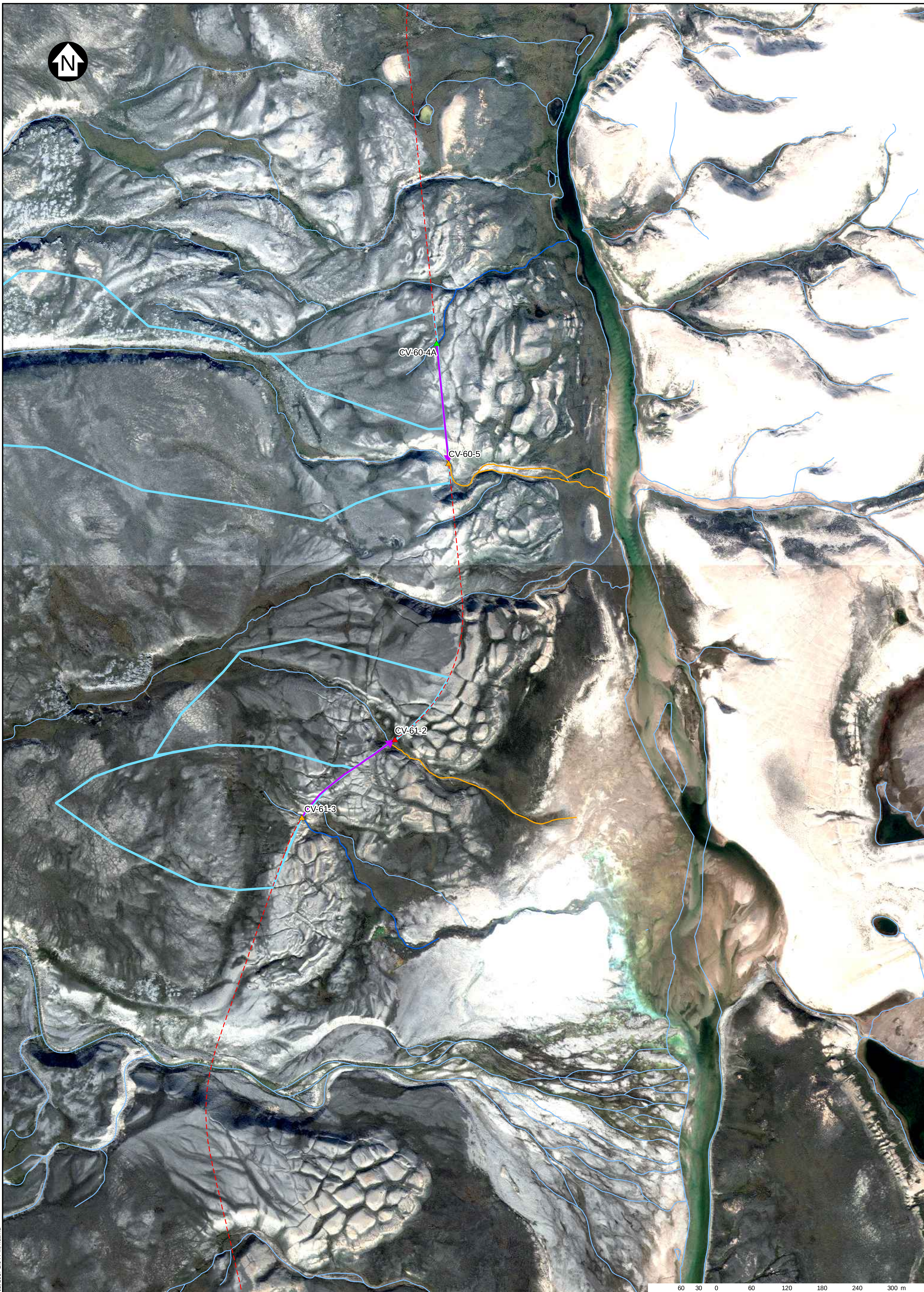
REF NO. VA17-01009

FIGURE C.8

REV 0



LEGEND

PROJECT FACILITY LOCATION

DIVERTED STREAMS

FISH HABITAT ASSESSMENT - ARCTIC CHAR, NINESPINE STICKLEBACK

- NO, NO
- NO, UNLIKELY
- POTENTIAL, POTENTIAL
- PROBABLE, PROBABLE
- UNLIKELY, UNLIKELY
- YES, YES

RECEIVING STREAMS

FISH HABITAT ASSESSMENT - ARCTIC CHAR, NINESPINE STICKLEBACK

- NO, NO
- NO, UNLIKELY
- POTENTIAL, POTENTIAL
- PROBABLE, PROBABLE
- UNLIKELY, UNLIKELY
- YES, YES

- STREAM DIVERSION
- DECREASE IN FLOW
- INCREASE IN FLOW
- PROPOSED NORTH RAILWAY
- MILNE INLET TOTE ROAD
- CATCHMENT AREA

NOTES:

1. COORDINATE GRID IS IN METRES.
   COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
2. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA DEPARTMENT OF NATURAL RESOURCES (2009). ALL RIGHTS RESERVED.
3. DETAILED WATER AND ORTH IMAGERY FROM EAGLE MAPPING (2005).
4. CONTOUR INTERVAL IS 2.5 METRES.

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BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

STREAM DIVERSIONS (SHEET 9 OF 21)

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REF NO. VA17-01009

FIGURE C.9

REV 0

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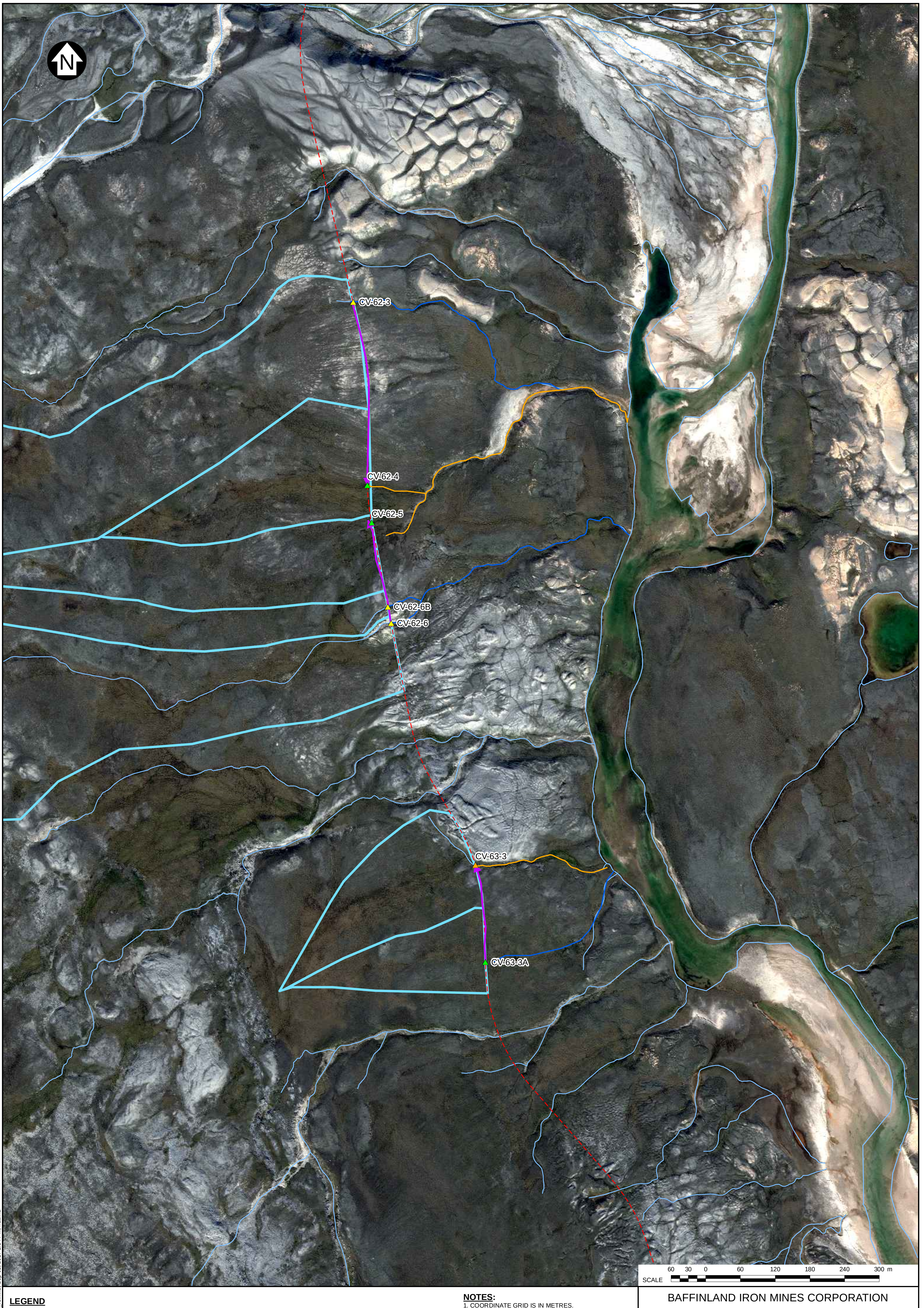

LEGEND

PROJECT FACILITY LOCATION

DIVERTED STREAMS

FISH HABITAT ASSESSMENT - ARCTIC CHAR, NINESPINE STICKLEBACK

- NO, NO
- NO, UNLIKELY
- POTENTIAL, POTENTIAL
- PROBABLE, PROBABLE
- UNLIKELY, UNLIKELY
- YES, YES

RECEIVING STREAMS

FISH HABITAT ASSESSMENT - ARCTIC CHAR, NINESPINE STICKLEBACK

- NO, NO
- NO, UNLIKELY
- POTENTIAL, POTENTIAL
- PROBABLE, PROBABLE
- UNLIKELY, UNLIKELY
- YES, YES

- STREAM DIVERSION
- DECREASE IN FLOW
- INCREASE IN FLOW
- PROPOSED NORTH RAILWAY
- MILNE INLET TOTE ROAD
- CATCHMENT AREA

NOTES:

1. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
2. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA DEPARTMENT OF NATURAL RESOURCES (2009). ALL RIGHTS RESERVED.
3. DETAILED WATER AND ORTH IMAGERY FROM EAGLE MAPPING (2005).
4. CONTOUR INTERVAL IS 2.5 METRES.

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BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

STREAM DIVERSIONS (SHEET 10 OF 21)

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FIGURE C.10 | REV 0

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LEGEND

PROJECT FACILITY LOCATION

DIVERTED STREAMS

FISH HABITAT ASSESSMENT - ARCTIC CHAR, NINESPINE STICKLEBACK

- NO, NO
- NO, UNLIKELY
- POTENTIAL, POTENTIAL
- PROBABLE, PROBABLE
- UNLIKELY, UNLIKELY
- YES, YES

RECEIVING STREAMS

FISH HABITAT ASSESSMENT - ARCTIC CHAR, NINESPINE STICKLEBACK

- NO, NO
- NO, UNLIKELY
- POTENTIAL, POTENTIAL
- PROBABLE, PROBABLE
- UNLIKELY, UNLIKELY
- YES, YES

- STREAM DIVERSION
- DECREASE IN FLOW
- INCREASE IN FLOW
- PROPOSED NORTH RAILWAY
- MILNE INLET TOTE ROAD
- CATCHMENT AREA

NOTES:

1. COORDINATE GRID IS IN METRES.
   COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
2. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA DEPARTMENT OF NATURAL RESOURCES (2009). ALL RIGHTS RESERVED.
3. DETAILED WATER AND ORTH IMAGERY FROM EAGLE MAPPING (2005).
4. CONTOUR INTERVAL IS 2.5 METRES.

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
0	30AUG'17	ISSUED WITH LETTER	TJP	RF	TJP

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

STREAM DIVERSIONS (SHEET 11 OF 21)

Knight Piésold CONSULTING

P/A NO. NB102-181/39

REF NO. VA17-01009

FIGURE C.11

REV 0

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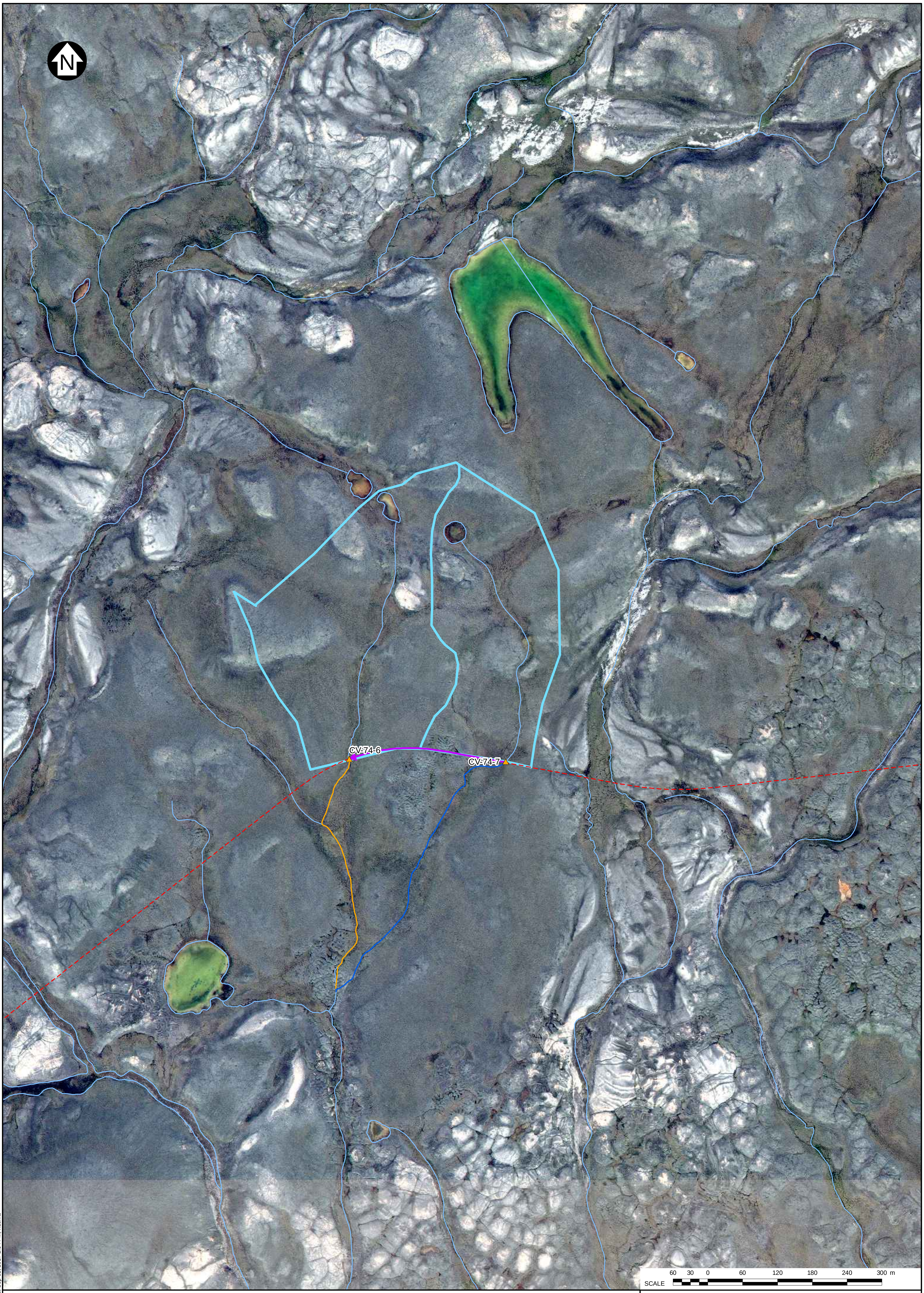

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LEGEND

PROJECT FACILITY LOCATION

DIVERTED STREAMS

FISH HABITAT ASSESSMENT - ARCTIC CHAR, NINESPINE STICKLEBACK

- NO, NO
- NO, UNLIKELY
- POTENTIAL, POTENTIAL
- PROBABLE, PROBABLE
- UNLIKELY, UNLIKELY
- YES, YES

RECEIVING STREAMS

FISH HABITAT ASSESSMENT - ARCTIC CHAR, NINESPINE STICKLEBACK

- NO, NO
- NO, UNLIKELY
- POTENTIAL, POTENTIAL
- PROBABLE, PROBABLE
- UNLIKELY, UNLIKELY
- YES, YES

- STREAM DIVERSION
- DECREASE IN FLOW
- INCREASE IN FLOW
- PROPOSED NORTH RAILWAY
- MILNE INLET TOTE ROAD
- CATCHMENT AREA

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
0	30AUG'17	ISSUED WITH LETTER	TJP	RF	TJP

NOTES:

1. COORDINATE GRID IS IN METRES.
   COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
2. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA DEPARTMENT OF NATURAL RESOURCES (2009). ALL RIGHTS RESERVED.
3. DETAILED WATER AND ORTH IMAGERY FROM EAGLE MAPPING (2005).
4. CONTOUR INTERVAL IS 2.5 METRES.

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

STREAM DIVERSIONS
(SHEET 12 OF 21)

Knight Piésold CONSULTING

P/A NO.	REF NO.
NB102-181/39	VA17-01009

FIGURE C.12 REV 0

LEGEND

PROJECT FACILITY LOCATION

DIVERTED STREAMS

FISH HABITAT ASSESSMENT - ARCTIC CHAR, NINESPINE STICKLEBACK

- NO, NO
- NO, UNLIKELY
- POTENTIAL, POTENTIAL
- PROBABLE, PROBABLE
- UNLIKELY, UNLIKELY
- YES, YES

RECEIVING STREAMS

FISH HABITAT ASSESSMENT - ARCTIC CHAR, NINESPINE STICKLEBACK

- NO, NO
- NO, UNLIKELY
- POTENTIAL, POTENTIAL
- PROBABLE, PROBABLE
- UNLIKELY, UNLIKELY
- YES, YES

- STREAM DIVERSION
- DECREASE IN FLOW
- INCREASE IN FLOW
- PROPOSED NORTH RAILWAY
- MILNE INLET TOTE ROAD
- CATCHMENT AREA

NOTES:

1. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
2. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA DEPARTMENT OF NATURAL RESOURCES (2009). ALL RIGHTS RESERVED.
3. DETAILED WATER AND ORTH IMAGERY FROM EAGLE MAPPING (2005).
4. CONTOUR INTERVAL IS 2.5 METRES.

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BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

STREAM DIVERSIONS (SHEET 13 OF 21)

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FIGURE C.13 REV 0

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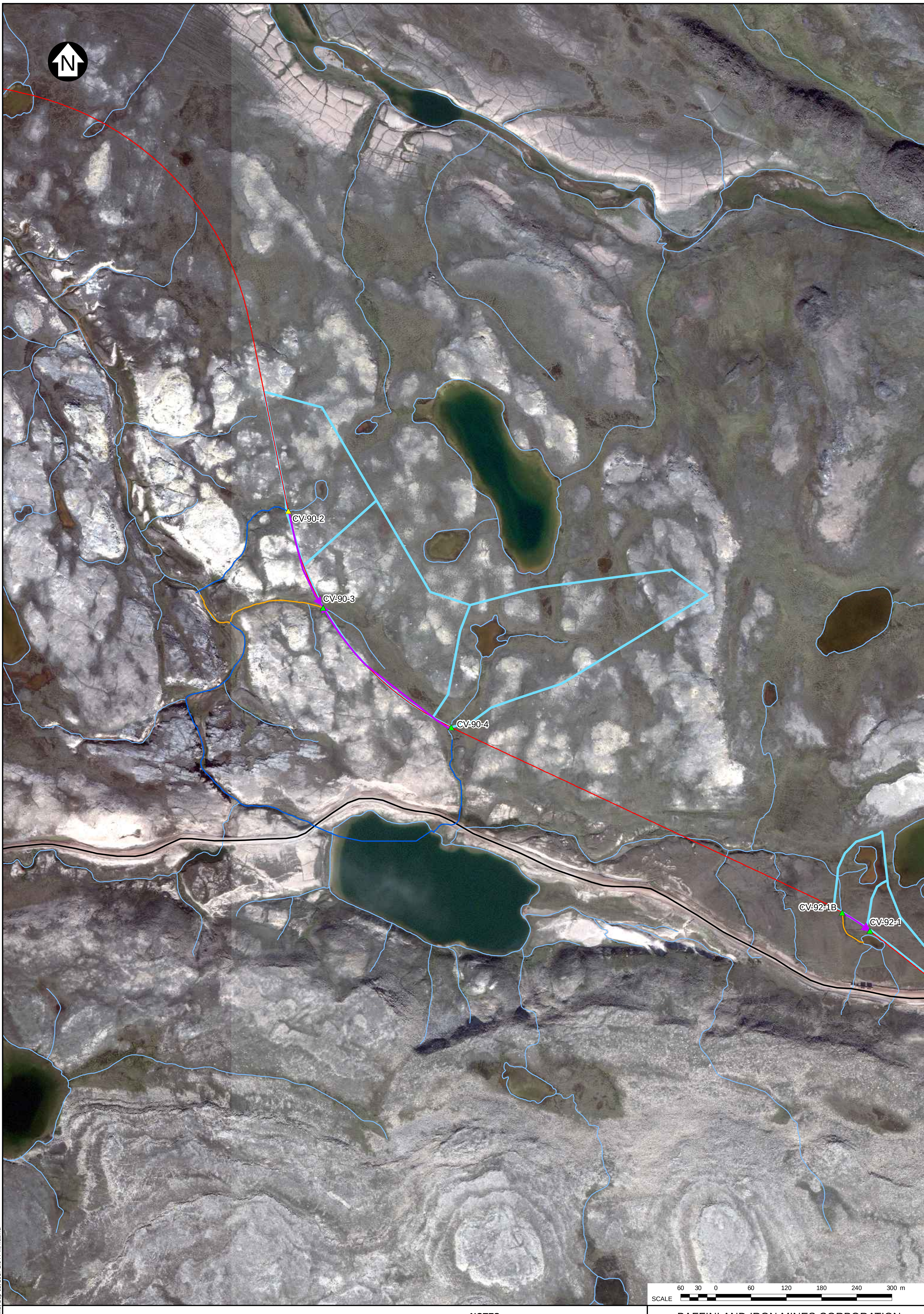

LEGEND

PROJECT FACILITY LOCATION

DIVERTED STREAMS

FISH HABITAT ASSESSMENT - ARCTIC CHAR, NINESPINE STICKLEBACK

- NO, NO
- NO, UNLIKELY
- POTENTIAL, POTENTIAL
- PROBABLE, PROBABLE
- UNLIKELY, UNLIKELY
- YES, YES

RECEIVING STREAMS

FISH HABITAT ASSESSMENT - ARCTIC CHAR, NINESPINE STICKLEBACK

- NO, NO
- NO, UNLIKELY
- POTENTIAL, POTENTIAL
- PROBABLE, PROBABLE
- UNLIKELY, UNLIKELY
- YES, YES

STREAM DIVERSION
DECREASE IN FLOW
INCREASE IN FLOW
PROPOSED NORTH RAILWAY
MILNE INLET TOTE ROAD
CATCHMENT AREA

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NOTES:

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3. DETAILED WATER AND ORTH IMAGERY FROM EAGLE MAPPING (2005).
4. CONTOUR INTERVAL IS 2.5 METRES.

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MARY RIVER PROJECT

STREAM DIVERSIONS (SHEET 14 OF 21)

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FIGURE C.14 REV 0

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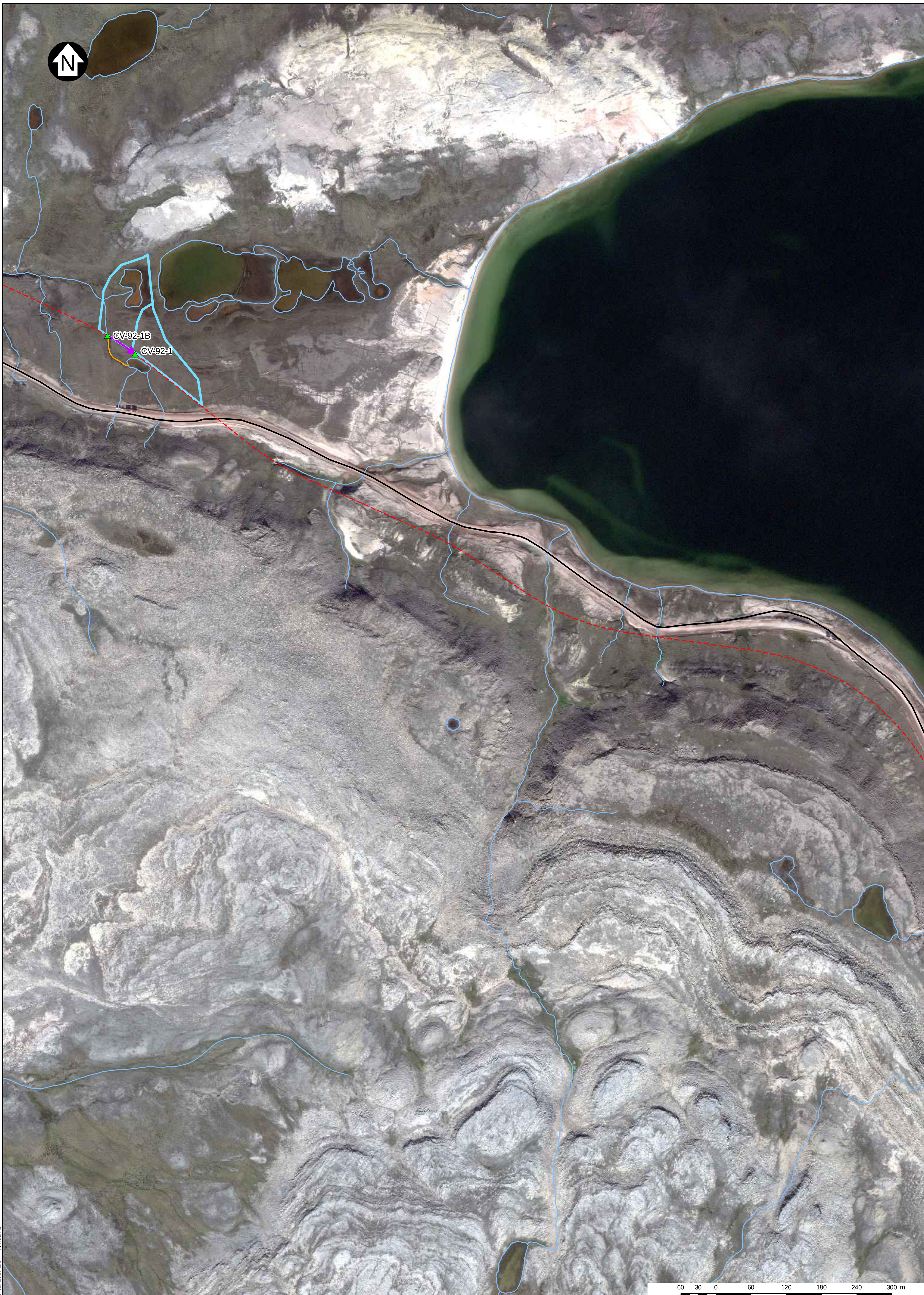

LEGEND

PROJECT FACILITY LOCATION

DIVERTED STREAMS

FISH HABITAT ASSESSMENT - ARCTIC CHAR, NINESPINE STICKLEBACK

- NO, NO
- NO, UNLIKELY
- POTENTIAL, POTENTIAL
- PROBABLE, PROBABLE
- UNLIKELY, UNLIKELY
- YES, YES

RECEIVING STREAMS

FISH HABITAT ASSESSMENT - ARCTIC CHAR, NINESPINE STICKLEBACK

- NO, NO
- NO, UNLIKELY
- POTENTIAL, POTENTIAL
- PROBABLE, PROBABLE
- UNLIKELY, UNLIKELY
- YES, YES

- STREAM DIVERSION
- DECREASE IN FLOW
- INCREASE IN FLOW
- PROPOSED NORTH RAILWAY
- MILNE INLET TOTE ROAD
- CATCHMENT AREA

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
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NOTES:

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3. DETAILED WATER AND ORTH IMAGERY FROM EAGLE MAPPING (2005).
4. CONTOUR INTERVAL IS 2.5 METRES.

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MARY RIVER PROJECT

STREAM DIVERSIONS (SHEET 15 OF 21)

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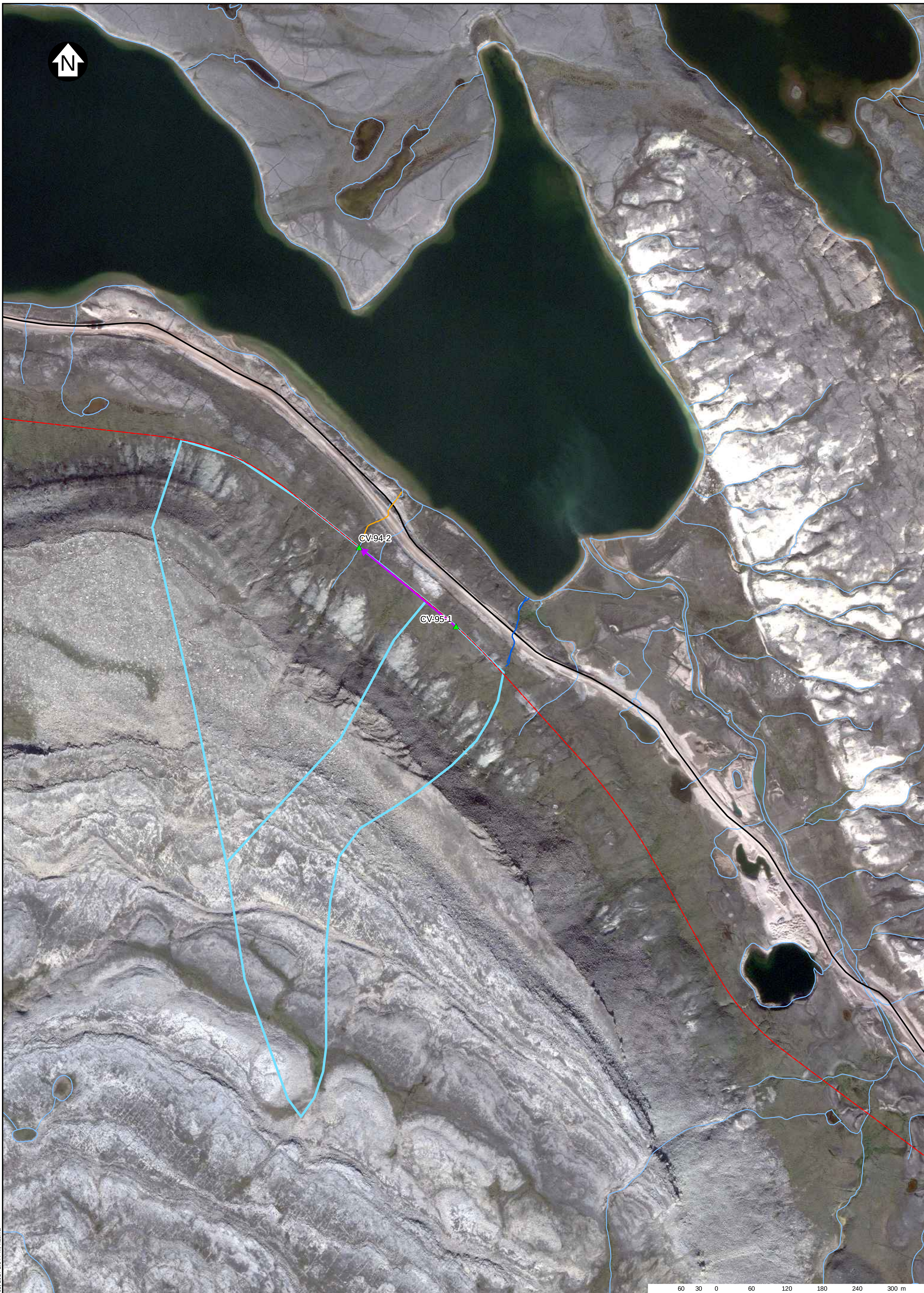
FIGURE C.15 REV 0



LEGEND

PROJECT FACILITY LOCATION

DIVERTED STREAMS

FISH HABITAT ASSESSMENT - ARCTIC CHAR, NINESPINE STICKLEBACK

- NO, NO
- NO, UNLIKELY
- POTENTIAL, POTENTIAL
- PROBABLE, PROBABLE
- UNLIKELY, UNLIKELY
- YES, YES

RECEIVING STREAMS

FISH HABITAT ASSESSMENT - ARCTIC CHAR, NINESPINE STICKLEBACK

- NO, NO
- NO, UNLIKELY
- POTENTIAL, POTENTIAL
- PROBABLE, PROBABLE
- UNLIKELY, UNLIKELY
- YES, YES

STREAM DIVERSION
DECREASE IN FLOW
INCREASE IN FLOW
PROPOSED NORTH RAILWAY
MILNE INLET TOTE ROAD
CATCHMENT AREA

NOTES:

1. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
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3. DETAILED WATER AND ORTH IMAGERY FROM EAGLE MAPPING (2005).
4. CONTOUR INTERVAL IS 2.5 METRES.

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MARY RIVER PROJECT

STREAM DIVERSIONS (SHEET 16 OF 21)

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FIGURE C.16 REV 0

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LEGEND

PROJECT FACILITY LOCATION

DIVERTED STREAMS

FISH HABITAT ASSESSMENT - ARCTIC CHAR, NINESPINE STICKLEBACK

- NO, NO
- NO, UNLIKELY
- POTENTIAL, POTENTIAL
- PROBABLE, PROBABLE
- UNLIKELY, UNLIKELY
- YES, YES

RECEIVING STREAMS

FISH HABITAT ASSESSMENT - ARCTIC CHAR, NINESPINE STICKLEBACK

- NO, NO
- NO, UNLIKELY
- POTENTIAL, POTENTIAL
- PROBABLE, PROBABLE
- UNLIKELY, UNLIKELY
- YES, YES

- STREAM DIVERSION
- DECREASE IN FLOW
- INCREASE IN FLOW
- PROPOSED NORTH RAILWAY
- MILNE INLET TOTE ROAD
- CATCHMENT AREA

NOTES:

1. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
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3. DETAILED WATER AND ORTH IMAGERY FROM EAGLE MAPPING (2005).
4. CONTOUR INTERVAL IS 2.5 METRES.

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BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

STREAM DIVERSIONS (SHEET 17 OF 21)

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FIGURE C.17

REV 0

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LEGEND

PROJECT FACILITY LOCATION

DIVERTED STREAMS

FISH HABITAT ASSESSMENT - ARCTIC CHAR, NINESPINE STICKLEBACK

- NO, NO
- NO, UNLIKELY
- POTENTIAL, POTENTIAL
- PROBABLE, PROBABLE
- UNLIKELY, UNLIKELY
- YES, YES

RECEIVING STREAMS

FISH HABITAT ASSESSMENT - ARCTIC CHAR, NINESPINE STICKLEBACK

- NO, NO
- NO, UNLIKELY
- POTENTIAL, POTENTIAL
- PROBABLE, PROBABLE
- UNLIKELY, UNLIKELY
- YES, YES

- STREAM DIVERSION
- DECREASE IN FLOW
- INCREASE IN FLOW
- PROPOSED NORTH RAILWAY
- MILNE INLET TOTE ROAD
- CATCHMENT AREA

NOTES:

1. COORDINATE GRID IS IN METRES.
   COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
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3. DETAILED WATER AND ORTH IMAGERY FROM EAGLE MAPPING (2005).
4. CONTOUR INTERVAL IS 2.5 METRES.

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BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

STREAM DIVERSIONS (SHEET 18 OF 21)

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FIGURE C.18 REV 0

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LEGEND

PROJECT FACILITY LOCATION

DIVERTED STREAMS

FISH HABITAT ASSESSMENT - ARCTIC CHAR, NINESPINE STICKLEBACK

- NO, NO
- NO, UNLIKELY
- POTENTIAL, POTENTIAL
- PROBABLE, PROBABLE
- UNLIKELY, UNLIKELY
- YES, YES

RECEIVING STREAMS

FISH HABITAT ASSESSMENT - ARCTIC CHAR, NINESPINE STICKLEBACK

- NO, NO
- NO, UNLIKELY
- POTENTIAL, POTENTIAL
- PROBABLE, PROBABLE
- UNLIKELY, UNLIKELY
- YES, YES

- STREAM DIVERSION
- DECREASE IN FLOW
- INCREASE IN FLOW
- PROPOSED NORTH RAILWAY
- MILNE INLET TOTE ROAD
- CATCHMENT AREA

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
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NOTES:

1. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
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3. DETAILED WATER AND ORTH IMAGERY FROM EAGLE MAPPING (2005).
4. CONTOUR INTERVAL IS 2.5 METRES.

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

STREAM DIVERSIONS (SHEET 19 OF 21)

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FIGURE C.19 REV 0

LEGEND

PROJECT FACILITY LOCATION

DIVERTED STREAMS

FISH HABITAT ASSESSMENT - ARCTIC CHAR, NINESPINE STICKLEBACK

- NO, NO
- NO, UNLIKELY
- POTENTIAL, POTENTIAL
- PROBABLE, PROBABLE
- UNLIKELY, UNLIKELY
- YES, YES

RECEIVING STREAMS

FISH HABITAT ASSESSMENT - ARCTIC CHAR, NINESPINE STICKLEBACK

- NO, NO
- NO, UNLIKELY
- POTENTIAL, POTENTIAL
- PROBABLE, PROBABLE
- UNLIKELY, UNLIKELY
- YES, YES

- STREAM DIVERSION
- DECREASE IN FLOW
- INCREASE IN FLOW
- PROPOSED NORTH RAILWAY
- MILNE INLET TOTE ROAD
- CATCHMENT AREA

NOTES:

1. COORDINATE GRID IS IN METRES.
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3. DETAILED WATER AND ORTH IMAGERY FROM EAGLE MAPPING (2005).
4. CONTOUR INTERVAL IS 2.5 METRES.

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BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

STREAM DIVERSIONS (SHEET 20 OF 21)

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REF NO. VA17-01009

FIGURE C.20

REV 0

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LEGEND

PROJECT FACILITY LOCATION

DIVERTED STREAMS

FISH HABITAT ASSESSMENT - ARCTIC CHAR, NINESPINE STICKLEBACK

- NO, NO
- NO, UNLIKELY
- POTENTIAL, POTENTIAL
- PROBABLE, PROBABLE
- UNLIKELY, UNLIKELY
- YES, YES

RECEIVING STREAMS

FISH HABITAT ASSESSMENT - ARCTIC CHAR, NINESPINE STICKLEBACK

- NO, NO
- NO, UNLIKELY
- POTENTIAL, POTENTIAL
- PROBABLE, PROBABLE
- UNLIKELY, UNLIKELY
- YES, YES

STREAM DIVERSION
DECREASE IN FLOW
INCREASE IN FLOW
PROPOSED NORTH RAILWAY
MILNE INLET TOTE ROAD
CATCHMENT AREA

NOTES:

1. COORDINATE GRID IS IN METRES.
   COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
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3. DETAILED WATER AND ORTH IMAGERY FROM EAGLE MAPPING (2005).
4. CONTOUR INTERVAL IS 2.5 METRES.

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

STREAM DIVERSIONS
(SHEET 21 OF 21)

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FIGURE C.21 REV 0

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APPENDIX D

HYDROLOGIC IMPACTS OF FLOW DIVERSIONS

(Pages D-1 to D-2)

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APPENDIX D

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

PROPOSED NORTHERN RAIL ALIGNMENT
HYDROLOGIC IMPACTS OF FLOW DIVERSIONS

Diversion Reference	Diverted Stream ID	Receiving Stream ID	Diverted Stream				Receiving Stream					Risk
			Catchment Area (km^2)	MAD (l/s)	Q2 (m^3/s)	Lenth of stream with flow reduction (km)	Catchment Area (km^2)	MAD (l/s)	Q2 (m^3/s)	Lenth of stream with flow increase (km)	% flow increase from Baseline	
1	CV-0-2		0.14	1.3	0.14	0.10						Low (catchment area less than 0.5 km^2)
		CV-0-1					0.01	0.1	0.02	0.05	**1227%**	
2	CV-8-0		0.79	7.2	0.59	0.09						Medium/High
	CV-8-1		0.01	0.1	0.01							
		CV-8-2					0.41	3.8	0.33	0.09	**194%**	
3	CV-12-4b		0.47	4.3	0.38	0.49						Medium/High
	CV-12-5		0.02	0.2	0.03							
		CV-13-1					0.03	0.3	0.04	0.79	**1648%**	
4	CV-20-2		0.13	1.2	0.12	0.29						Low (catchment area less than 0.5 km^2)
		CV-20-1					0.03	0.3	0.04	0.23	**433%**	
5	CV-35-5		2.76	25.2	1.72	0.16						Medium/High
		CV-35-4					0.04	0.3	0.04	0.04	**7332%**	
6	CV-46-1a		0.06	0.5	0.06	0.61						Low (less than 10% change in catchment area)
		CV-46-3					0.92	8.4	0.67	0.81	**7%**	
7	CV-49-5a		0.01	0.1	0.01	-						Low (less than 10% change in catchment area)
		CV-49-5					1.10	10.1	0.78	0.37	**1%**	
8	CV-58-7		0.02	0.2	0.02	0.10						Low (catchment area less than 0.5 km^2)
	CV-58-8		0.09	0.8	0.09	0.11						
		CV-59-1					0.22	2.0	0.20	0.11	**50%**	
9	CV-59-4b		0.02	0.2	0.02	0.25						Medium/High
	CV-59-4a		1.43	13.1	0.98							
		CV-59-4					3.32	30.4	2.02	0.18	**44%**	
10	CV-60-4a		0.03	0.3	0.04	0.33						Low (less than 10% change in catchment area)
		CV-60-5					0.57	5.2	0.44	0.58	**6%**	
11	CV-61-3		0.08	0.7	0.08	0.36						Low (catchment area less than 0.5 km^2)
		CV-61-2					0.07	0.6	0.07	0.36	**114%**	
12	CV-62-3		0.18	1.6	0.16	0.47						Low (catchment area less than 0.5 km^2)
		CV-62-4					0.06	0.5	0.06	0.57	**300%**	
13	CV-62-6		0.25	2.3	0.22	0.58						Low (catchment area less than 0.5 km^2)
	CV-62-6b		0.06	0.5	0.06							
		CV-62-5					0.08	0.7	0.08	0.60	**388%**	
14	CV-63-3a		0.07	0.7	0.08	0.29						Low (catchment area less than 0.5 km^2)
		CV-63-3					0.05	0.5	0.05	0.24	**149%**	
15	CV-64-5a		0.01	0.1	0.01	0.95						Low (catchment area less than 0.5 km^2)
		CV-64-5					0.01	0.1	0.01	0.33	**100%**	

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Diversion Reference	Diverted Stream ID	Receiving Stream ID	Diverted Stream				Receiving Stream					Risk
			Catchment Area (km^2)	MAD (l/s)	Q2 (m^3/s)	Lenth of stream with flow reduction (km)	Catchment Area (km^2)	MAD (l/s)	Q2 (m^3/s)	Lenth of stream with flow increase (km)	% flow increase from Baseline	
16	CV-65-2a		0.05	0.5	0.05	0.47						Low (catchment area less than 0.5 km^2)
		CV-65-2					0.08	0.7	0.08	0.47	**63%**	
17	CV-66-2a		0.01	0.1	0.01	0.48						Low (less than 10% change in catchment area)
		CV-66-2					0.60	5.5	0.47	0.82	**2%**	
18	CV-74-7		0.09	0.8	0.09	0.53						Low (catchment area less than 0.5 km^2)
		CV-74-6					0.12	1.1	0.12	0.44	**75%**	
19	CV-82-1a		0.01	0.1	0.01	0.54						Low (less than 10% change in catchment area)
		CV-82-1					2.03	18.6	1.32	0.33	**0%**	
20	CV-90-2		0.03	0.3	0.03	0.24						Low (catchment area less than 0.5 km^2)
	CV-90-4		0.06	0.5	0.06	0.96						
		CV-90-3					0.05	0.5	0.06	0.25	**171%**	
21	CV-92-1b		0.01	0.1	0.01	-						Low (catchment area less than 0.5 km^2)
		CV-92-1					0.01	0.1	0.01	0.07	**100%**	
22	CV-95-1		0.14	1.3	0.13	0.13						Low (catchment area less than 0.5 km^2)
		CV-94-2					0.18	1.6	0.16	0.12	**78%**	
23	CV-97-6		0.02	0.2	0.03	0.13						Low (catchment area less than 0.5 km^2)
		CV-97-5					0.02	0.2	0.02	0.23	**112%**	
24	CV-101-1a		0.09	0.8	0.09	0.12						Low (channel realignment)
	CV-101-1b											
		CV-101-1					0.52	4.8	-	0.32	-	
25	CV-102-1a		0.03	0.3	0.04	0.13						Low (less than 10% change in catchment area)
		CV-102-2					1.68	15.4	1.12	0.05	**2%**	
26	CV-102-5		0.30	2.7	0.26	0.45						Low (less than 10% change in catchment area)
		CV-103-1					8.20	75.0	4.40	0.03	**4%**	
27	CV-109-1		0.01	0.1	0.01	0.21						Low (less than 10% change in catchment area)
		CV-109-2					0.14	1.3	0.14	0.06	**6%**	

M:\1\02\00181\39\A\Data\Diversion Morphology Effects\[North_Rail_Catchments_cuts- 08-31-2017.xlsx]Table 4

NOTES:

1. MAD = MEAN ANNUAL DISCHARGE. MAD DETERMINED FROM A MEAN ANNUAL UNIT DISCHARGE OF 9.2 $l/s/km^2$
2. Q2 = PEAK INSTANTANEOUS DISCHARGE WITH A RETURN PERIOD OF 2 YEARS. Q2 IS DETERMINED FROM THE METHODOLOGY PRESENTED IN KP (2016)

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