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Final Environmental Impact Statement (FEIS) – Meliadine Gold Project, Nunavut

REPORT

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Golder Associates

ᐅᓂᒃᑲᓕᒋᐊᑦ ᓇᐃᔪᖅᑭᒧᒪᔪᖅ

ᐱᔪᓐᓇᕐᓂᐅᔪᖅ

6-ᑎᓴᖓᑦ ᑭᖓᔪᓕᖅᑐᓕᐹᑦ ᓄᓇᑦ ᐊᒪᓗ ᐊᒃᑐᖅᓯᓂᖅᓗᑦ ᐅᖅᑲᐅᓯᐅᔪᖅ (FEIS) ᑕᓯᔪᐊᖅ ᔫᓗᓗᑦ ᐅᓴᖅᑕᕆᐊᒪᑦ ᐱᓕᕆᐊᒪᑦ (ᐱᓕᕆᐊᖅ) ᐃᓱᒪᒃᑯᓯᐅᑕᕐᓂᖅᑐᑐᖅ ᓄᓇᐅᔪᐹᑦ. ᐱᔪᓐᓇᕐᓂᐅᔪᖅ 6-ᑎᓴᖓᑦ ᐱᓕᕆᐊᕆᔪᒪᓕᒃᑐᑦ ᒪᓕᖅᑕᐅᔪᒃᓴᐃᑦ ᓴᖅᑭᑕᐅᔪᑦ ᓄᓇᕗᓂᑦ ᐊᔭᑕᓕᕆᓚᖅᑯᑦ ᑲᑎᒪᔨᖓᒥᓄᑦ ᐱᔪᓐᓇᖅᑐᓗᐊᖅᑐᒥ ᖃᐅᔨᓴᓯᒪᔭᖓᔾᔪᑎᒃᓴᖅᑐᒃ ᐊᒪᓗ ᖃᐅᔨᓴᓯᒪᔭᖓᔾᔪᑎᒃᓴᖅᑐᒃ ᓄᓇᓕᒃ, ᓄᓇᓕᒃ ᐃᓱᒪᓂᓗ, ᐱᕈᖅᑐᓂᒃ, ᓄᓇᓕᐅᑕᐃᑦ ᓂᓯᔨᑎᑦ ᐊᒪᓗ ᓂᓯᕐᑎᓄᑦ ᓄᓇᕐᓂᐅᔪᑦ, ᐊᒪᓗ ᑎᒥᕆᐊᓂᖅᑐᓗ ᓄᓇᕐᓂᓕᕆᓗ.

ᖃᐅᔨᓴᐃᓂᖅᓯᒪᑦ ᐃᓕᓐᓂᑦ ᐊᓯᐊᖏᕈᑎᐅᔪᖅᓇᖅᑐᑦ ᐱᓕᕆᐊᖅ ᐱᔪᓐᓇᕐᓂᓗᐊ ᐊᓯᐊᔪᓪᓚᑐᑦ ᐊᒪᓗ ᖃᐅᓄᐃᓕᐅᑎᓂᖅᓯᐅᑦᓄᑦ, ᐊᒪᓗ ᐅᑎᖅᑕᕐᓂᖅᑐᑐᖅ ᐱᓕᕆᐊᑦ ᐊᐅᓪᓚᕆᐊᖃᖅᑐᒥᓂᕐᓂᑦ, ᐃᓕᓐᓂᑦ ᐊᓯᐊᔪᓪᓚᑐᑦ, ᐊᒪᓗ ᑎᓐᓯᐊᓂᖅ; ᐊᐅᓪᓚᖅᑐᓂᖅ; ᐊᐳᑭᐅᒪᑎᑎᓂᖅ; ᐊᒪᓗ ᐅᖃᐊᓕᐅᐱᓪᓕᖅᑐᖅ, ᑭᖑᓪᓕᖅᑐᖃᓕᖅ, ᐊᒪᓗ ᐅᖃᐊᖅᑕᐅᓂᐊᓴᖅᑎᑎᓂᓗᐊ ᖃᐅᔨᓴᐃᓂᖅᓯᒪᓂᖅ. ᐊᓐᓱᑎᓪᓕᓐᓂᐊᓴᐅᑎᓗᐊ ᐊᒃᑐᔪᑕᐅᔪᓐᓇᖅᑐᑦ ᐱᓕᕆᐊᖅ ᐱᔪᓐᓇᕐᓂᖏᓐᓇᓂᐊᓗ ᐊᒪᓗ ᐱᓕᕆᐊᖅᑐᓂᖏᓐᓇᖅᑐᑦ ᐃᓄᐃᑦᑐᑎᒃᓴᖅᑐᑦ, ᐱᓴᕆᐊᖅᑎᖓᓕᒃ.

ᖃᐅᔨᓴᐃᓂᖅᓯᒪᑦ

- ᐱᓕᕆᐊᕆᓂᐊᖅᓯᓗᒍ ᖃᐅᔨᓴᐃᓂᖅᓯᒪᓂᖅ ᐊᒪᓗ ᑐᑭᓯᐅᕆᓂᖅᓯᒪᓂᖅ ᐊᒃᑐᖅᓯᓂᐅᔪᓐᓇᖅᑐᑐᒃᓯ ᐱᔪᓐᓇᓐᓄᑦ ᐱᓕᕆᐊᒧᑦ, ᓇᓗᓇᐃᖅᓯᓯᑎᐊᖅᓂᖅᖃᕆᐊᖃᖅᑐᑦᓴᖅᑐᑦ ᐃᓱᒪᒋᑐᓂᖅ ᖃᐅᔨᓂᖅ ᐊᖏᑎᑎᓯᓂᖅ ᑭᓯᓚᐅᑎᓂᖅ. ᓄᓇᒧᑦ ᖃᐅᔨᓂᖅ ᐊᖏᑎᑎᓯᓂᖅ ᑭᓯᐅᑎᑎᓯᓂᖅ ᐊᐅᓚᑦᓯᐊᓂᖅ ᐊᒃᑐᖅᓯᓂᐅᔪᓐᓇᖅᑐᑐᒃᓯ ᐱᓕᕆᐊᒧᑦ ᐊᒃᑐᖅᓯᓂᖅ ᐊᐳᑭᐅᒪᑎᑎᓂᖅ ᐊᒃᑐᖅᓯᓂᖅ ᐊᒪᓗ ᐱᓕᕆᐊᖅᑐᓂᖅ ᐊᒃᑐᖅᓯᓂᖅ ᐊᒪᓗ ᖃᐅᔨᓴᐃᓂᖅᓯᒪᓂᖅ ᐊᒃᑐᖅᓯᓂᖅ ᐊᒪᓗ ᐱᓕᕆᐊᖅᑐᓂᖅ ᐊᒃᑐᖅᓯᓂᖅ ᐊᒪᓗ ᐃᓱᒪᒋᑐ

ᐊᒃᑐᖅᓯᓂ ᑐᒃᑐᓄ ᖃᐅᔨᓴᐃᓂᖅ ᐊᑐᖅᑕᐅᓪᓕᐊᔪᖅ ᓂᕆᐊᑎᓂ ᐊᒪᓗ ᓂᕆᐊᑏᑦ ᐃᓂᑎᖏᓐᓄᓄ ᓄᐅᔨᓴᐃᓂᖏᑦ ᖃᐅᔨᓴᐅᒪᔪᓗᒍ ᐊᖏᑎᓪᓗᓂᒋᐊᓂᓄ ᐊᒃᑐᖅᓯᓂ.

ᐊᒃᑐᖅᓯᐊᑎᓄᑦ ᖃᐅᔨᓴᐅᑎ

ᐊᒃᑐᖅᓯᐊᑎᓄᑦ ᖃᐅᔨᓴᐅᑎ ᖃᐅᔨᓴᐃᓂᖅᑕᖃᖅᑎᑎᖃᑎᒋᑕᖅᑐᖅ ᐱᓕᕆᐊᒧᑦ ᐊᒪᓗ ᐊᖏᑎᓪᓗᓂᒋᐊᓂᓄ (ᐊᑐᕆᐊᖃᖅᐸᑦ) ᐊᒃᑐᖅᓯᐊᑎᐅᑐᐃᓇᕆᐊᖃᖅᑐᓂᒃ ᓄᓇᒥᑦ. ᐊᒃᑐᖅᓯᐊᑎᓄᑦ ᖃᐅᔨᓴᐅᑎ ᖃᐅᔪᖅᓯᒪᓂᖅᓴᐅᔪᖅᑐᒥᒃ ᐊᒪᓗ ᖃᐅᔪᖅᓯᒪᓂᖅᓴᐅᔪᖅᑐᒥᒃ ᓄᓇᒥᒃ, ᓄᓇᒥᒃ ᐃᐸᔪᓂᓗ, ᐱᑭᖅᑐᐃᓐᓂ, ᓄᓇᒥᑦ ᓂᕆᔨᑎᑦ ᐊᒪᓗ ᓂᕆᔨᑎᑦ ᓄᓇᑎᖕᖓᑦ, ᐊᒪᓗ ᑎᖏᒥᑦ ᓄᓇᑎᖕᖓᑦᓗ ᐊᑐᖅᓯᐊᑦ ᓄᓇᒪᑦ VECs ᖃᐅᔨᓴᐃᓂᐅᔪᑦ ᐊᑐᖅᑕᐅᓪᓗᖅᑐᑦ ᐅᖃᐅᔨᐅᔪᑦ 4-ᑎᖕᖓᓐᓂᑦ ᑭᖓᓪᓕᖅᑐᓪᓗᒥᑦ ᓄᓇᒥᑦ ᐊᒪᓗ ᐊᑐᖅᓯᓂᖅᓗᑦ ᐅᖃᐅᔨᐅᔪᒥᑦ (FEIS).

ᐊᑐᖅᓯᓂᖓᑦ ᐱᓕᕆᐊᑦ ᓄᓇᒥᑦ

ᖃᐅᔨᓴᐅᑎᓪᓗᖅᑐᖅ ᐊᒪᓗ ᖃᐅᔨᓴᐅᑎᓪᓗᖅᑐᖅ ᓄᓇᓕ

ᓄᓇᒥᑦ ᐊᑐᖅᓯᓂᖅ, ᐃᓕᐅᑦᓗᑎᒃ ᐅᓴᖅᑲᐃᑦ, ᐃᑦᔪᐃᑦ, ᐊᒪᓗ ᖃᐅᔨᓴᐅᑎᓪᓗᖅᑐᖅ, ᓂᕆᐅᑎᓴᐅᔪᖅ ᑕᖅᖢᓂ ᐱᓕᕆᐊᑦ ᐃᓗᐊᓂᓐᓂᐊᖅᓂᓕᓂᒃ. ᐊᑦᖁᓂᖓᖓᑲᑎᑕᖅᑐᑦ ᖃᐅᔨᓴᐅᑎᓪᓗᖅᑐᖅ ᐊᒪᓗ ᐊᐅᒪᓂᐅᔪᖅᑐᒥᒃ (ᐊᐅᒪᒪᖅ ᓄᓇ ᐊᑐᖅᓯᖃᑕᑕᖅᑐᖅ ᖃᐅᔨᓴᐅᑎᓪᓗᖅᑐᖅᑐᒍᑦ) ᐃᓕᖏᓐᓂᒃ ᑕᓯᖏᓐᓂᑦ ᐊᖏᓂᖏᓐᓂ ᓱᓪᒪᒃᖢᖓᑕ ᐊᐅᒪᓂᓕᐅᖅᓂᖅᓗᒍ, ᐊᒪᓗ ᓄᓇᐅᑦ ᐊᑕᓂᑦ ᐱᓕᕆᐊᖓᔪᖅ ᖃᐅᔨᓴᐅᑎᓪᓗᖅᑐᖅᑐᑦ ᐊᑐᖅᑕᐅᓪᓗᒥᑦ ᐊᐅᒪᓂᐅᔪᖅᑐᒥᒃ ᐊᑐᖅᑕᐅᓪᓗᖅᑐᖅᑐᒥᒃ ᓄᓇᒥᒃ. ᐊᓪᓚᕆᖏᓐᓂᐅᔪᑦ ᖃᓄᐃᓕᖅᑐᓂᒃ, ᐊᑦᔪᖓᖅᓂᒃ ᐱᓕᕆᐊᒥᖅᑎᒍᑐᒃ ᖃᐅᔨᓴᓕᓐᓄᖅᑐᓂᒃ ᐊᑦᔪᖓᓂᖅᓴᐃᓚᖅᑐᑦᑎᓪᓗᒥᑦ ᐊᒪᓗ ᖃᐅᔨᓴᐃᓐᓇᖅᑐᓂᒃ ᐊᑦᔪᖓᓂᖅᓴᐃᓚᖅᑐᑦᑎᓪᓗᒥᑦ ᓄᓇᒥᒃ. ᐊᓪᓚᕆᖏᓐᓂᐅᔪᑦ ᖃᓄᐃᓕᖅᑐᓂᒃ ᐊᑦᔪᖓᓂᖅᓴᐃᓚᖅᑐᑦᑎᓪᓗᒥᑦ ᐊᒪᓗ ᐃᓗᐊᓂᓐᓂᐊᖅᓂᓕᓂᒃ ᐊᑦᔪᖓᓂᖅᓴᐃᓚᖅᑐᑦᑎᓪᓗᒥᑦ ᐊᑐᖅᑕᐅᓪᓗᖅᑐᖅᑐᑦ ᐊᒪᓗ ᐃᓗᐊᓂᓐᓂᐊᖅᓂᓕᓂᒃ ᐊᑦᔪᖓᓂᖅᓴᐃᓚᖅᑐᑦᑎᓪᓗᒥᑦ ᓄᓇᒥᒃ. ᐊᓪᓚᕆᖏᓐᓂᐅᔪᑦ ᖃᓄᐃᓕᖅᑐᓂᒃ, ᐊᑦᔪᖓᓂᖅᓴᐃᓐᓇᖅᑐᓂᒃ ᐱᓕᕆᐊᒥᖅᑎᒍᑐᒃ ᖃᐅᔨᓴᓕᓐᓄ

ᐊᒃᑐᖅᓯᓂᐅᕐᓂ ᐊᖏᑎᓪᓗᓕᓪᓕᐊᓂᖏᓐᓄ ᓄᓇᒋᔭᐅᔪᒥᒃ ᐊᓯᐅᔨᓂᖅᓗᑦ ᐊᒪᓗ ᓯᕆᔨᕿᑎᓴᓂᖅ ᐃᖅᑭᕋᒋᓴᓯᒋᔭᐅᔪᓂ ᓯᓚᓂᕐᑎᓂᑦ ᐊᑯᓂᐅᔪᒥᑦ.

ᐊᓯᐊᖓᖅᓯᒪᓕᕆᓇᖅᓂᐅᔪᓂ ᓂᕐᔾᑎᓄᑦ ᓄᓇᒋᔭᐅᔪᓂᒃ ᐅᒃᑯᐃᖏᓚᔪᓂ ᒪᓂᕋᒥᑦ, ᐊᒪᓗ ᖃᐅᓕᖏᐊᐅᓚᖅᓄᑦ ᐃᓕᑦᑕᐅᔪᓂᑦ ᑐᖅᑯᓂᖅᓴᓂᖅ ᑐᓴᕐᓂᖅᓴᓂᖅ (RSA)ᒥᑦ ᐊᒪᓗ ᑐᒃᑐᐃᑦ ᐊᒃᑐᖅᑕᐅᓂᖏᓐᓄᓄᑦ ᖃᐅᔨᓴᓂᖅᓴᓂᖅᒥᑦ. ᐊᓯᐊᖓᖅᓯᒪᓕᕆᓇᖅᓂᐅᕐᓂᖅᑐᑦ ᐅᖃᖅᑎᒋᔭᐅᓂᖅᓴᓂᖅᓴᓂᒃ ᐊᑐᖅᓯᓄᑦᓯᐅᑎᓪᓗᒍ ᓄᓇᒋᔭᐅᔪᓂᑦ ᐊᓯᐊᖓᖅᓯᒪᓕᕆᓇᖅᓂᐅᕐᓂᖅᑐᑦ ᐊᓯᐅᔨᓂᖅᑎᓇᖅᓂᐅᔪᓂᒃ ᓄᓇᒋᔭᐅᔪᓂᑦ ᐊᒪᓗ ᓯᓚᓂᕐᑎᓂᖅᓴᓂᖅᓴᓂᒃ ᓄᓇᒋᔭᐅᔪᓂᑦ ᐊᒪᓗ ᑐᒃᑐᐃᑦ ᐊᓯᐊᖓᖅᓴᓂᖅᓴᓂᒃ ᓄᓇᒋᔭᐅᔪᓂᑦ ᐅᓴᖅᑕᕆᓚᐊᖅᓴᓂᖅᓴᓂᒃ ᓄᓇᒋᔭᐅᔪᓂᑦ ᐅᓇᓱᐊᓂ ᐊᒃᑐᖅᑕᐅᓂᖏᓐᓄᓄᑦ ᓄᓇᒋᔭᐅᔪᓂᑦ ᐊᒪᓗ ᓯᓚᓂᕐᑎᓂ

ᑐᖁᓂᖅᑐᐃᓐᓇᑦ ᐊᑲᑐᓂᓯᒋᐊᖏᓂᖅᓄᓇᓕᕆᔨᐅᔪᑦ ᐅᓪᓗᖅᓄᖅᑕᓪᓚᑐᓂᓗ ᐊᑲᑐᓂᓯᓂᖅ ᑎᖅᑕᐊᓂᖅ ᓄᓇᕕᐅᑕᓂᖅ ᐃᒪᖅᕕᐅᑕᓂᓪᓗ, ᑎᖅᑕᐊᓄᑦᓗ ᓂᕆᔨᑎᓂᖅ ᓂᕆᓂᖅᑕᖅᑐᑐᓂᖅ ᓄᓇᕕᒃ ᖃᐅᔨᓴᐃᓂᖅ (RSA)ᑕᑦ.

ᐃᓕᐱᔪᓂᕆᓚᖏᖅᑎᑦ ᐸᓗᐃᖅᑲᐅᐅᓂᖅᑎᑦ ᐅᓪᓗᖅᓄᓇᓗᐊᖅᑎᑐᑐᑎᒃ ᐊᑲᑐᓂᓯᓂᖅᑐᐃᓐᓇᑦ ᓄᓇᕕᐅᑕᓂᖅ ᐃᒪᖅᕕᐅᑕᓂᓪᓗ ᑎᖅᑕᐊᓂᑦ ᓄᓇᕕᒃ ᖃᐅᔨᓴᐃᓂᖅ (RSA)ᑕᑦ, ᐊᒪᓗ ᐊᖏᑎᐸᒃ ᐊᑲᑐᓂᓯᓂᖅᑎᔪᓂᑦ ᑎᖅᑕᐊᓄᑦ ᓂᕆᓂᖅᑕᖅᑐᑐᓂᖅ ᖃᐅᔨᓴᐃᓂᖅ (LSA)ᑕᑦ. ᐊᑲᑐᓂᓯᓄᑦ ᐃᓕᐱᔪᓂᕆᓚᖏᖅᓄᓇᓂ ᐸᓗᐃᖅᑲᐅᐅᓂᖅᑎᑦ ᐊᑲᑐᓂᓯᓂᖅᑎᖅᓂᕆᓚᓂᕆᔨᐅᔪᓄᑦ ᑎᖅᑕᐊᓂᑦ ᓄᓇᕕᒃ ᐊᑲᑐᐊᔪᑦ ᐊᖏᖅᑲᐅᓂᖅᑎᖅᓂᕆᓚᓂᕆᔨᐅᔪᓄᑦ ᐅᑭᐅᑦ ᑕᓪᓕᒪᓂ ᐃᓗᐊᓂᑦ ᐅᑎᖅᓂᖅ (ᐊᒻᒪᓂᐅᔪᑦ).

ᐊᑲᑐᓂᓯᓐᓕᐊᓂᐅᔪᑦ ᓄᓇᓕᖅᑎᖏᐅᔪᓂᐅᓂᖅᑎᓂᕆᔨᐅᔪᓄᑦ. ᓄᓇᕆᔨᐅᔪᑦ ᐊᓯᐅᔭᐅᓕᓐᓂᐊᓂᖅ ᐊᒪᓗ ᓯᓂᔨᑎᓚᓂᖅ ᐊᓂᔪᖅᑐᓂᖅ, ᐃᓐᓇᐅᔪᓂᖅ, ᐊᒪᓗ ᓯᕐᓂᓂᖅᑎᑦ ᐱᐅᓐᓕᐊᔪᓂᖅ ᓄᓇᕕᒃ ᖃᐅᔨᓴᐃᓂᖅ (RSA)ᑕᑦ ᐊᑲᑐᓂᓯᓂᖅᑎᖅᓂᕆᓚᓂᕆᔨᐅᔪᓄᑦ ᑎᖅᑕᐊᓂᑦ ᐅᔪᓂᖅᓄᓇᓕᖅᑐᑐᓂᖅᑎᑦ ᐊᖏᓂᖅᑐᓂᓕᕆᓂᖅᑐᑦ. ᐊᑲᑐᓂᓯᓂᐅᐅᓐᓕᐊᔪᓂ ᐱᓕᓚᐊᑦᓷᐃᒪᓚᓇᖅᑎᓂᑎᑦ ᐊᓂᔪᖅᑐᓂᖅ, ᐃᓐᓇᐅᔪᓂᖅ, ᐊᒪᓗ ᓯᕐᓂᓂᖅᑎᑦ ᐱᐅᓐᓕᐊᔪᓂᖅ ᐊᑲᑐᓂᓯᓂᖅᑎᖅᑐᓂᕆᓚᓂᕆᔨᐅᔪᓄᑦ ᓄᓇᕕᐅᑕᓂᖅ ᐃᒪᖅᕕᐅᑕᓂᓪᓗ ᑎᖅᑕᐊᓂᑦ ᐊᑲᑐᓂᓯᓂᖅ ᐊᑐᓚᐊᑦᓷᐃᒪᓚᓇᖅᑎᓂᑎᑦ ᐊᓂᔪᖅᑐᓂᖅ, ᐃᓐᓇᐅᔪᓂᖅ, ᐊᒪᓗ ᓯᕐᓂᓂᖅᑎᑦ ᐱᐅᓐᓕᐊᔪᓂᖅ ᐊᑲᑐᓂᓯᓂᖅᑎᖅᑐᓂᕆᓚᓂᕆᔨᐅᔪᓄᑦ ᓄᓇᕕᐅᑕᓂᖅ ᐃᒪᖅᕕᐅᑕᓂᓪᓗ ᑎᖅᑕᐊᓂᑦ ᐊᑲᑐᓂᓯᓂᖅᑎᖅᓂᕆᓚᓂᕆᔨᐅᔪᓄᑦ

EXECUTIVE SUMMARY

Purpose

Volume 6 of the Final Environmental Impact Statement (FEIS) for the Meliadine Gold Project (Project) considers the terrestrial environment. The purpose of Volume 6 is to address the Guidelines issued by the Nunavut Impact Review Board for the Project, specifically relating to the impact of the Project on permafrost and permafrost terrain, terrain and soils, vegetation, terrestrial wildlife and wildlife habitat, and birds and bird habitat.

The assessment includes potential direct and indirect changes resulting from Project-related components and associated activities, and evaluates all Project phases, including construction; operation; maintenance; and temporary, final, and post-closure activities. Cumulative effects for existing and reasonably foreseeable projects in the Project area have been incorporated, where applicable.

Study Areas

To facilitate the assessment and interpretation of potential effects associated with the Project, it is necessary to define appropriate spatial boundaries. Terrestrial spatial boundaries were delineated based on the predicted spatial extent of the Project-related effects and the life history attributes of valued ecosystem components (VECs) potentially influenced by the Project. The following spatial boundaries were used for the terrestrial environment assessment:

- A local study area (LSA) consisting of the mine site, mine roads, Rankin Inlet infrastructure, and the All-weather access road (AWAR), was used to assess the combined local direct and indirect effects from the Project; and
- A regional study area (RSA) was used to assess the combined regional direct and indirect effects from the Project.

The total area of the LSA for the terrestrial environment is 10 598 hectares. The boundary for the LSA was defined based on the anticipated spatial extent of the immediate direct (e.g., Project footprint) and indirect (e.g., dust deposition) effects from the Project on the surrounding terrestrial environment, including soils, vegetation, and wildlife. The LSA consists of a 500 metre buffer surrounding the mine footprint, and 1000 metre surrounding the AWAR, the Discovery area road, and the Rankin Inlet bypass road. The larger buffer was adopted on either side of the planned road rights-of way to account for anticipated effects from the road (e.g., dust, increased access for recreation and hunting).

The RSA for the terrestrial environment was selected to measure the existing baseline conditions at a scale large enough to capture the maximum predicted spatial extent of the combined direct and indirect effects from the Project on soils, vegetation, and wildlife. This study area is intended to capture effects that extend beyond the immediate Project footprint, such as noise, air quality, and other factors that can indirectly affect the environment at a distance.

It was recognized that developments outside the RSA can impact wide ranging species, such as Barren-ground caribou (Qamanirjuaq and Lorillard herds), and act cumulatively with the Project impacts. As caribou have the potential to interact with the Project, a caribou effects study area was also used in the wildlife and wildlife habitat assessment to assess the incremental and cumulative effects from the Project and other existing and reasonably foreseeable developments, where applicable.

Effects Analysis

An effects analysis provides the general approach to analyzing potential Project-specific and cumulative (where applicable) effects on the terrestrial environment. The effects analysis for permafrost and permafrost terrain, terrain and soils, vegetation, terrestrial wildlife and wildlife habitat, and birds and bird habitat VECs followed the assessment methodology described in Volume 4 of the FEIS.

Effects from the Project on the Terrestrial Environment

Permafrost and Permafrost Terrain

Effects to the terrain, including rock, soil, and permafrost, are anticipated to be confined to the footprint area of the Project. The primary pathways develop as the result of permafrost retreat and the formation of open taliks (layer or body of unfrozen ground that penetrates completely the permafrost layer) beneath certain pit lakes large enough to develop such taliks, and underground workings that extend beneath the permafrost. However, the effects analysis indicates that the Project should not result in significant adverse impacts to permafrost and permafrost terrain. When compared to baseline conditions, changes from the Project are predicted to either have no detectable environmental change and no residual effects, or measureable but minor environmental change and negligible residual effects. No net cumulative effects are predicted.

Terrain and Soils

No impact predictions are made for terrain and soils as potential impacts to these components are captured in the other sections of the FEIS. For example, terrain and soils provide the basic form for the terrestrial environment such that vegetation can grow which in turns creates wildlife habitat. Changes in terrain or soils by itself can only be evaluated in context to how it changes the other components, such as vegetation and wildlife habitat. No net cumulative effects are predicted.

Vegetation

The effects analysis results on vegetation pathways indicate that the Project should not result in significant adverse impacts to the persistence of plant populations and communities, including listed plant species and the use of traditional plants. Changes from the Project are predicted to result in moderate, local-scale impacts to plant populations and communities, and should be reversible in the long-term (i.e., 50 to 75 years following closure) for those areas that will be reclaimed (i.e., scarified and left to naturally re-vegetate). As there is limited development in the RSA, the overall cumulative effects to vegetation, including effects to listed plant species and traditional use plant species, are predicted to be negligible to low.

Terrestrial Wildlife and Wildlife Habitat

Incremental loss and fragmentation of habitat from the Project are predicted to have negative and negligible to low magnitude effects on wildlife populations in the RSA and caribou effects study area. Habitat loss from the Project is expected to be a local scale effect but habitat fragmentation is a landscape-scale process and so is expected to have effects on wildlife populations at the regional scale. Incremental effects from habitat loss and fragmentation and expected to be reversible in the long-term.

Permanent changes to wildlife habitat from open pits, and the tailings and waste rock storage facilities are expected to have low magnitude effects on wildlife populations in the RSA and caribou effects study area. Permanent changes at the main mine site will result in long-term habitat loss and fragmentation but the effects to wildlife populations are reversible.

Sensory disturbance from the Project is predicted to have low to high magnitude effects on wildlife populations in the RSA and caribou effects study area. Indirect effects from the Project are expected to be regional in geographic extent given zones of influence for caribou. Sensory effects from the Project are predicted to be reversible within a few years following closure (long-term).

Incremental Project effects from changes in the migration patterns of caribou are expected to be negative but low in magnitude. The extent of the effect will be regional to beyond regional, occurring at the home range scale. Permanent changes at the main mine site will result in long-term disruption or alteration of migratory routes but the effect to wildlife populations is reversible.

Improved access for harvesting wildlife from the development of the Project is expected to have low to moderate negative effects on wolf and caribou populations. Incremental effects will be local in geographic extent and reversible at the end of active closure (medium-term).

Cumulative habitat loss and fragmentation from previous, existing, and future developments in the regional study area are expected to have negative effects that are low in magnitude. Individuals from the caribou population may interact with other developments and activities in the caribou effects study area. Therefore, the cumulative impacts from direct habitat loss and fragmentation from the Project and other developments on population size and distribution are expected to be beyond regional in geographic extent.

Cumulative direct effects from permanent habitat loss and fragmentation from previous, existing, and future developments are predicted to be low in magnitude and regional in geographic extent, while cumulative indirect effects are predicted to have high magnitude effects on wildlife populations, which are expected to be regional to beyond regional in geographic extent.

Cumulative effects from changes in the availability of wildlife for human use are predicted to be positive and low to moderate in magnitude and regional in geographic extent. The AWAR will be scarified during closure, so effects are expected to be medium-term and reversible. Effects are expected to occur periodically during traditional and non-traditional hunting seasons.

Birds and Bird Habitat

Incremental loss and fragmentation of habitat from the Project are predicted to have a negative and negligible to low magnitude effect on upland bird and waterbird populations in the RSA. However, incremental habitat loss from the Project footprint is expected to have a moderate magnitude effect on raptor populations. Habitat loss from the Project is expected to be a local scale effect but fragmentation is a landscape-scale process and so is expected to have effects on bird populations at the regional scale. Effects from Project areas are expected to be reversed within 5 years following closure (long-term). Permanent changes to bird habitat from open pits, and the tailings and waste rock storage facilities are expected to have negative and negligible magnitude effects on upland bird, waterbird, and raptor populations in the RSA.

Sensory disturbance from the Project is predicted to have negligible to low magnitude effects on upland bird and waterbird populations in the RSA, and a high magnitude effect on raptor populations in the LSA. Effects from sensory disturbance are expected to affect bird populations at the local scale and are predicted to be reversed within 5 years following closure (long-term).

Cumulative effects are expected to be regional in geographic extent. Cumulative habitat loss and fragmentation from previous, existing, and future developments in the RSA are expected to have negative effects on bird populations that are negligible to moderate in magnitude. Cumulative indirect effects from previous, existing, and future developments are predicted to have low to moderate magnitude effects on upland bird, waterbird, and raptor populations.

Monitoring and Follow-up

Monitoring programs implemented during the life of the Project may be a combination of environmental monitoring to track conditions and implement further mitigation as required (e.g., monitoring for soil erosion during construction), and follow-up monitoring to verify the accuracy of effect predictions and adaptively implement further mitigation as required.

Upon approval of the Project, a Terrestrial Environment Management and Monitoring Plan (TEMMP) will be implemented to limit effects to the terrestrial environment, determine the effectiveness of mitigation, and test impact predictions. The principal goal of the TEMMP is to provide information required to adaptively manage the Project to protect vegetation, terrestrial wildlife and wildlife habitat, and bird and bird habitat. In addition, the TEMMP is designed to provide a process for regulators, communities, and other people interested in the Project to participate in the development and review of vegetation and wildlife effects mitigation and monitoring.

The objectives, measurement endpoints, and methods of re-vegetation will need to be determined with input from regulators and communities. Analyzing and assessing the success of natural re-vegetation will be a component of the TEMMP, and will provide input into the Closure and Reclamation Plan. Environmental monitoring will also include protocols for monitoring non-native invasive plant species, which will follow Department of Environment guidelines for reporting on non-native invasive plant species.

Terrain stability and soil quantity and quality will be assessed and monitored during the construction and operations phases of the Project, and during closure and post-closure as part of reclamation. Soil conditions may be monitored to estimate reclamation success, and other soil quality issues such as erosion, mixing, and compaction will be visually assessed. Results from this program will be used to support adjustments to the Closure and Reclamation Plan and incorporated into the ongoing reclamation activities.

Abbreviation and Acronym List

AANDC	Aboriginal Affairs and Northern Development Canada
AEM	Agnico Eagle Mines Limited
ARD	Acid Rock Drainage
ATV	All-terrain Vehicle
AWAR	All-weather Access Road
CALM	Circumpolar Active Layer Monitoring
CCME	Canadian Council of Ministers of the Environment
CESA	Caribou Effects Study Area
COPC	Contaminants of Potential Concern

COSEWIC	Committee on the Status of Endangered Wildlife in Canada
DC	Disturbance Coefficients
DDEAR	Draft Detailed Environmental Assessment Report
DFO	Fisheries and Oceans Canada
DoE	Department of Environment
ELC	Ecological Landscape Classification
FEIS	Final Environmental Impact Statement
GIS	Geographical Information System
GN	Government of Nunavut
Golder	Golder Associates Ltd.
GPS	Global Positioning System
HTO	Hunters and Trappers Organizations
IQ	Inuit Qaujimajatuqangit (see note [1])
KIA	Kivalliq Inuit Association
LSA	Local Study Area
MEND	Mine Environment Neutral Drainage Program
MMER	Metal Mining Effluent Regulations
NIRB	Nunavut Impact Review Board
non-PAG	Non-Potentially Acid-Generating
NRC	Natural Resources Canada
NT	Northwest Territories
NU	Nunavut
PAG	Potentially Acid-Generating
PAI	Potential Acid Input
PM	Particulate Matter
PRISM	Program for Regional and International Shorebird Monitoring
Project	Meliadine Gold Project
RSA	Regional Study Area
SARA	*Species At Risk Act*
TEMMP	Terrestrial Environment Management and Monitoring Plan
TLU	Traditional Land Use
TSF	Tailings Storage Facility
TSP	Total Suspended Particulate
TSS	Total Suspended Solid
VEC	Valued Ecosystem Component
VSEC	Valued Socio-Economic Component
ZOI	Zone Of Influence

Note: [1] IQ symbol appearing in right hand margin denotes where IQ is referenced in the assessment.

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6.0 TERRESTRIAL ENVIRONMENT

For the purpose of the current Guidelines, terrestrial environment includes terrestrial ecology, landform and soils, permafrost, and ground stability.

6.1 Spatial and Temporal Boundaries

6.1.1 Spatial Boundaries

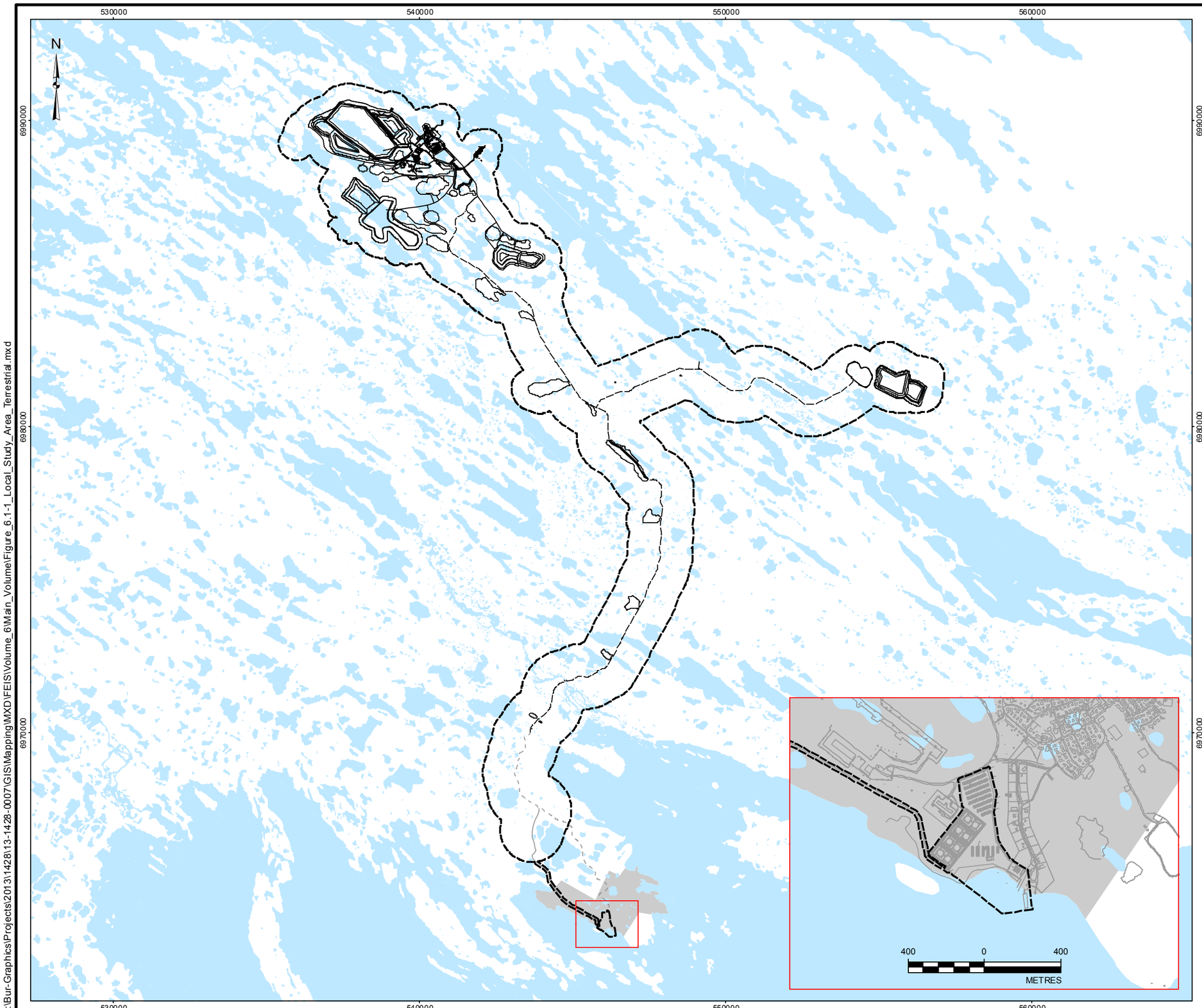
To facilitate the assessment and interpretation of potential effects associated with the Meliadine Gold Project (Project), it is necessary to define appropriate spatial boundaries. Terrestrial study area boundaries were delineated based on the predicted spatial extent of the Project-related effects and the life history attributes of wildlife valued ecosystem components (VECs) potentially influenced by the Project. The following 3 spatial boundaries were used to assess effects on the terrestrial environment:

- caribou effects study area (CESA) was used to assess the incremental and cumulative effects from the Project and other developments;
- regional study area (RSA) was used to assess the combined direct and indirect effects from the Project on permafrost, soils and terrain, plant and plant communities, and wildlife; and
- local study area (LSA) was used for small-scale direct and indirect effects from the Project, which consists of the mine site, mine roads, Rankin Inlet infrastructure, and the Project All-weather Access Road (AWAR).

6.1.1.1 Local Study Area

The proposed Project consists of 3 distinct Project components that cover 3 distinct geographical locations. The main component of the Project includes the mine site and associated infrastructure (e.g., tailings storage facility [TSF], open pits, waste rock storage facilities, and camp), which is roughly surrounded on 3 sides by Meliadine Lake. The second component of the Project includes the Phase 2 AWAR between the mine and Rankin Inlet. Finally, the third component of the Project includes the direct footprint of proposed infrastructure within the boundary of the Hamlet of Rankin Inlet including associated roads, floating dock, laydown yard and tank farm.

The LSA boundary was defined based on the anticipated spatial extent of the immediate direct (e.g., Project footprint) and indirect (e.g., dust deposition) effects from the Project on the surrounding terrestrial environment, including soils, vegetation, and wildlife (Figure 6.1-1). The LSA for the anticipated mine site was defined to encompass the expected spatial extent of potential changes in water quantity and air quality directly related to the Project. Consequently, a 500 metre (m) buffer was used to define the LSA surrounding the mine footprint; where potential changes were greater than 500 metres from the mine footprint, the LSA was expanded (Figure 6.1-1). The Phase 2 AWAR, the Discovery access road, and the Rankin Inlet bypass road were buffered by 1000 m on either side of the anticipated road rights-of-way to account for potential effects from the road (e.g., dust, increased access for recreation and hunting). The LSA for the Rankin Inlet footprint was limited to the Project footprint within the hamlet boundary (i.e., the outward limit of Rankin Inlet infrastructure) and did not include a buffer. A buffer was not included to assess the anticipated effects from the Project in isolation from effects due to Rankin Inlet. The total area of the LSA is 10 598 hectares (ha).



REFERENCE

Base data obtained from Agnico Eagle Mines Ltd (AEM).
Datum: NAD 83 Projection: UTM Zone 15

2500 0 2500
METRES

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

LOCAL STUDY AREA

Golder Associates

PROJECT NO. 10-1373-0076			FILE No.	
DESIGN	LY	09 Nov. 2012	SCALE AS SHOWN	REV. 0
GIS	CDB	09 Nov. 2012		
CHECK	DW	17 Jan. 2013		
REVIEW	DW	17 Jan. 2013		

FIGURE 6.1-1

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The LSA habitat is characteristic of regional habitat conditions and vegetation within the Maguse River Upland Ecoregion. However, the LSA is located in a large area of “ribbed (rogen) moraine” that is characterized by a radiating esker-outwash systems and linear drumlin fields (Aylsworth and Shilts 1989). As a result, the major landforms in the LSA are dominated by a large esker that runs northwest/southeast and numerous drumlins or drumlinoid ridges. Ridge complexes on drumlins and eskers are characterized by a range of plant communities and associations depending on substrate, orientation, and snow accumulation, but are typically dominated by heath tundra and lichen-heath communities. Low-lying areas between the drumlins and eskers are dominated by sedge wetlands, shallow ponds, and various shallow and deep water lakes.

The LSA for the Phase 2 AWAR road contains vegetation and landscape terrain features that are typical of the regional conditions. However, the road is located primarily on high ground and tends to follow the ridge lines of eskers and bedrock outcrops. As such, vegetation tends to be dominated by heath tundra and heath lichen communities.

The portion of the LSA within Rankin Inlet is also characteristic of the Maguse River Upland Ecoregion. However, because of the proximity of the Rankin Inlet Project footprint to the coast, the site is characterized by lichen rock and heath tundra communities.

6.1.1.2 Regional Study Area

The RSA was selected to measure the existing baseline conditions at a scale large enough to capture the maximum predicted spatial extent of the combined direct and indirect effects (i.e., zone of influence [ZOI]) from the Project on soils, vegetation, and wildlife) (Figure 6.1-2). This area is intended to capture effects that could extend beyond the immediate Project footprint, such as noise, lights, smells, and other factors that can indirectly affect the environment at a distance. Cumulative effects from the Project and other developments in the RSA (if present) can be assessed at this scale for VECs that exhibit little to no movement within RSA, such as geology, permafrost, terrain and soil, and plants and plant communities. They can also be assessed at this scale for VECs that have most of the population distributed within the RSA. For species that have small to moderate breeding home ranges (e.g., waterbirds, songbirds, and raptors), the population would be primarily affected by natural and human-related factors that change survival and reproduction of individuals within the RSA, and should be little influenced by emigration and immigration (Berryman 2002). Developments outside of the RSA should have no or little influence on these populations during the breeding season.

During baseline data collection activities between 1998 and 2011, the Project RSA was 520 000 ha in size to encompass the potential ZOI on caribou from mining activities as described by Johnson et al. 2005. In 2012, the RSA was reduced to 280 000 ha (i.e., radius of 28 kilometres [km] centered on the proposed mine site) because of increased knowledge about the effects from disturbance on barren-ground caribou (Boulanger et al 2009; Boulanger et al. 2012), and based on an estimated 14 km ZOI on caribou from the mine site. Recent analysis has suggested that caribou are 4 times more likely to occur in areas greater than 11 to 14 km from the Ekati-Diavik mine complex (Boulanger et al. 2009; Boulanger et al. 2012). For the smaller Snap Lake Mine, caribou tend to prefer areas greater than 6.5 km from the mine, although the measurable avoidance of the mine was weak (Boulanger et al. 2009; Boulanger et al. 2012). The RSA extends an additional 14 km beyond the ZOI so that effects from the mine can be assessed through wildlife monitoring. The RSA encompasses the entire Project footprint, including the AWAR and Rankin Inlet infrastructure.

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6980000
6960000
N

LEGEND

- Regional Study Area (RSA)
- Proposed Project Infrastructure
- All-weather Access Road (AWAR)
- Road - New
- Road - Existing
- Watercourse
- Waterbody

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).
Datum: NAD 83 Projection: UTM Zone 15

5000 0 5000
METRES

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

REGIONAL STUDY AREA

Golder Associates

PROJECT NO. 10-1373-0076			FILE No.	
DESIGN	LY	09 Nov. 2012	SCALE AS SHOWN	REV. 0
GIS	CDB	09 Nov. 2012		
CHECK	DW	17 Jan. 2013		
REVIEW	DW	17 Jan. 2013		

FIGURE 6.1-2

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The RSA is located within the Maguse River Upland Ecoregion portion of the Southern Arctic Ecozone. The landscape of the Maguse River Upland Ecoregion is dominated by broad, sloping uplands and lowlands of crystalline Archean origin, interspersed by hummocky bedrock outcrops that are covered with discontinuous acidic, sandy, granitic till and prominent fluvio-glacial ridges or eskers. Areas of continuous permafrost with medium ice content are quite common, and soils are typically composed of Turbic Cryosols, with Organic (Mesisol) and Regosolic soils occurring in areas without permafrost (Ecological Stratification Working Group 1995).

The regional landscape is dominated by an abundance of waterbodies that account for about 30% of the area. The waterbodies are surrounded by uplands with terrestrial vegetation. The most common terrestrial plant community in the RSA is heath tundra, which is dominated by low-growing heath shrubs, such as marsh Labrador tea (*Ledum palustre*), bearberry (*Arctostaphylos* sp.), and black crowberry (*Empetrum nigrum*).

There are no Migratory Bird Sanctuaries or Key Migratory Bird Sites in the RSA (Bird Studies Canada and Nature Canada 2012). There are 6 Important Bird Areas near the shipping route as shown on Map 1 in Volume 9, Appendix 9.3-C. These are:

- Digges Sound – important for thick-billed murres (*Uria lomvia*) and black guillemots (*Cepphus grylle*);
- Fraser Island – important for common eiders (*Somateria mollissima*);
- East Bay/Native Bay – important for common eiders and snow geese (*Chen caerulescens*);
- Coats Island/Cape Pembroke – important for thick-billed murres and black guillemots;
- Awrey Isalnd – important for common eiders; and
- Boas River and associated wetlands – important for snow geese.

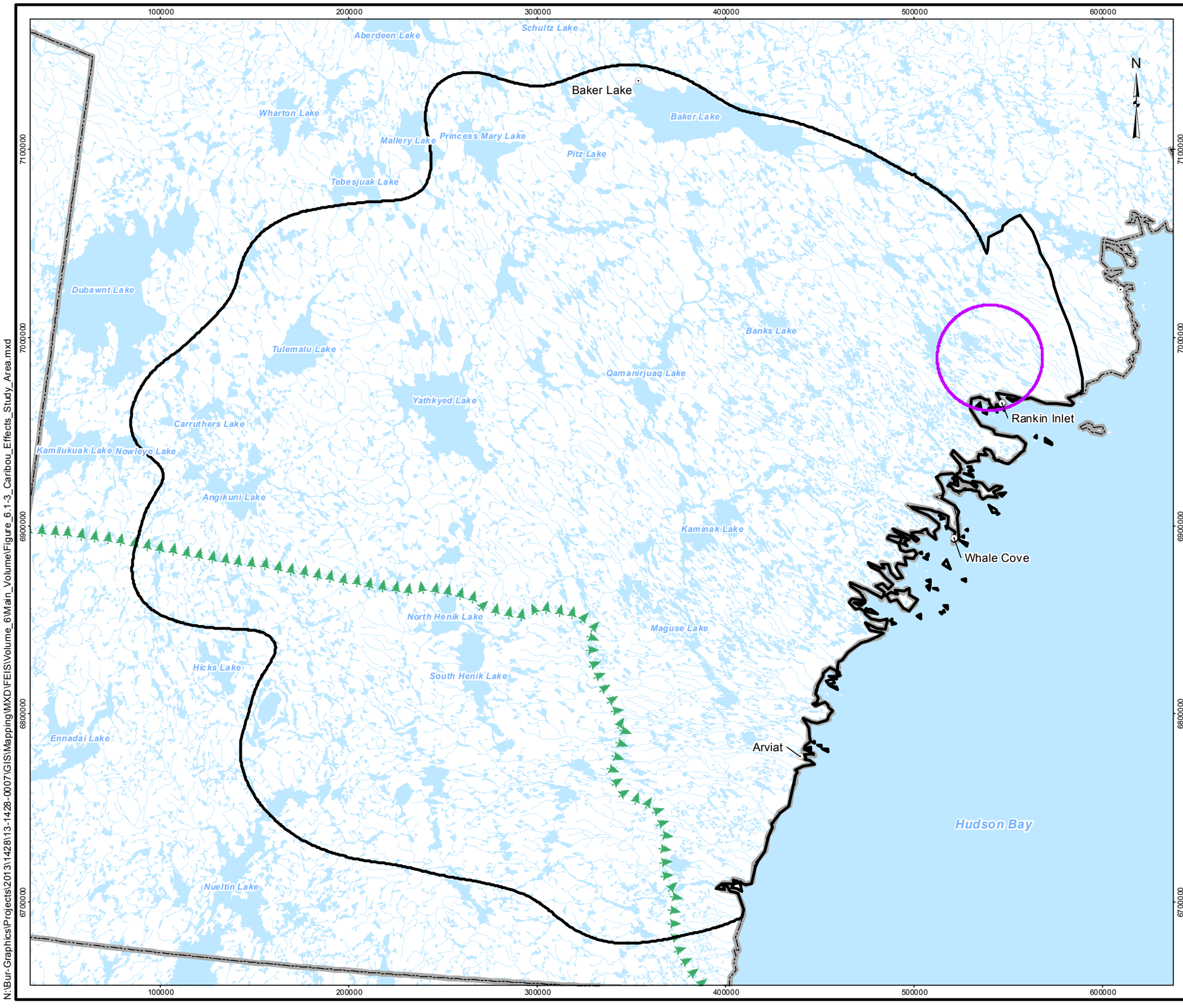
Most of the species that use these Important Bird Areas are marine species and are addressed in Volume 8 – Marine Environment.

6.1.1.3 Caribou Effects Study Area

Barren-ground caribou (Qamanirjuaq and Lorillard herds) and wolf have the potential to interact with the Project. Annual and seasonal ranges for Qamanirjuaq and Lorillard herds were calculated using satellite and global positioning system collar data for caribou (courtesy of Government of Nunavut [GN], Department of the Environment). Based on annual and seasonal range estimates, the Lorillard Caribou Herd should not be influenced by the Project in most years. The Lorillard Caribou Herd is a sedentary herd (non-migratory) and their traditional calving grounds are north of Chesterfield Inlet (Section 6.6.3). While the Project will not contribute to the cumulative disturbance footprint in most GN defined seasonal home ranges for the Qamanirjuaq herd, the post-calving range of the Qamanirjuaq Caribou Herd has the potential to overlap with the Project (Section 6.6.3).

The post-calving range of the Qamanirjuaq Caribou Herd was delineated using collar data from 1998 to July 2011 to produce a 95% kernel density estimate. This was modified using an 85% volume contour to create the CESA for caribou and wolf (Figure 6.1-3). A percent volume contour is typically used to delineate animal home ranges (Laver and Kelly 2008) and represents the boundary of the area that contains x% of the volume of a probability density distribution. The 85% volume contour would therefore contain 85% of caribou collar locations recorded during the post-calving season.

Seasonal home ranges give space use at an ecologically relevant scale, and summarizing density of development at the annual home range scale would dilute the disturbance density. The complete post-calving range was modified to delineate the CESA as a conservative method for including areas around satellite positions where there were likely non-collared caribou (and wolf). A larger CESA would have diluted the effect of the Project when effects are calculated as a percentage of the range area. The GN has modified their approach to delineating seasonal home ranges for caribou herds since the CESA was originally defined, and new data have been collected. The most recently defined core ranges are smaller than previously identified. As such, the CESA now encompasses the entire spring migration, calving, post-calving, and summer ranges, as well as part of the rut, fall migration, and winter ranges (M. Campbell, Government of Nunavut, 2014, pers. comm). In the Kivalliq region, wolves likely migrate with the caribou herds, as do the wolves of the central Northwest Territories (NT) (see Walton et al. 2001).



LEGEND

- Community
- Regional Study Area (RSA)
- Caribou Effects Study Area (CESA)
- Provincial/Territorial Boundary
- Treeline
- Watercourse
- Waterbody

REFERENCE

Caribou data obtained from the Department of Environment (Government of Nunavut) and Caslys Consulting Ltd. Base data obtained from ESRI and Natural Resources Canada.
Datum: NAD 83 Projection: UTM Zone 15

40 0 40
KILOMETRES

PROJECT
AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

REGIONAL STUDY AREA AND CARIBOU EFFECTS STUDY AREA

Golder Associates

PROJECT NO. 10-1373-0076			FILE No.		
DESIGN	LY	09 Nov. 2012	SCALE AS SHOWN	REV.	0
GIS	CDB	09 Nov. 2012			
CHECK	DW	17 Jan. 2013			
REVIEW	DW	17 Jan. 2013			

FIGURE 6.1-3

N:\Bur-Graphics\Projects\2013\1428\13-1428-0007\GIS\Mapping\MXD\EIS\Volume_6\Main_Volume\Figure_6.1-3_Caribou_Effects_Study_Area.mxd

6.1.2 Temporal Boundaries

The approach used to determine the temporal boundaries of effects from natural and human-related disturbances on VECs is similar to the approach used to define spatial boundaries. Temporal boundaries are linked to 2 concepts:

- the development phases of the Project (i.e., construction, operation, maintenance, temporary closure, closure [decommissioning and reclamation], and post-closure); and
- the predicted duration of effects from the Project on a VEC, which may extend beyond final closure (i.e., post-closure).

Thus, the temporal boundary for a VEC is defined as the amount of time between the start and end of a relevant Project activity or stressors (which are related to development phases), plus the duration required for the effect to be reversed. The temporal boundaries must be determined separately for construction, operation, maintenance, temporary closure, final closure, and post-closure periods (NIRB 2012). Traditional and contemporary (non-traditional) land uses are VSECs; therefore the duration of effects to these components is a factor in determining termporal boundaries. The acronym VSEC is used rather than traditional and non-traditional land use because all VSECs are considered in defining temporal boundaries.

6.2 Geology and Geochemistry

6.2.1 Introduction

The purpose of this section is to address the Guidelines issued by the Nunavut Impact Review Board (NIRB) for the Project (NIRB 2012) specifically relating to geology and geochemistry. Specific requirements set out in the Guidelines relating to the baseline and impact assessment for geology and geochemistry are presented in Volume 1, Appendix 1.0-A.

Pursuant to NIRB *Guide 7: Guide to the Preparation of Environmental Impact Statements* (NIRB 2006), "[a]n EIS is a documented evaluation of the project proposal, providing detailed information regarding the proposal's environmental and socio-economic impacts (NIRB 2012, p1). Therefore, an assessment of direct and indirect impacts from geology and geochemistry on the Project is outside the scope of an EIS. Furthermore, as the Project will not change the local or regional geology, nor the geochemical characteristics of these materials (i.e., no pathways), geology and geochemistry were not considered valued components, and were not subject to a formal effects assessment for the Project. However, it is recognized that geology and geochemistry are important considerations to how the Project is designed, constructed, operated, and closed. Geology and geochemistry influence potential Project impacts on VECs such as water quality, water quantity, and terrain and soil, and were considered in the effects assessment for other valued components, where applicable.

The following section provides a summary of the geology and geochemistry baseline environment in the Project area. A more detailed description of the geology can be found in Volume 2.0, Section 2.6.1.1. Additional information can be found elsewhere within the Final Environmental Impact Statement (FEIS) as referenced in Volume 1, Appendix 1.0-A, and the text below.

6.2.2 Geology Baseline Environment

The following sections establish the geologic and geochemical setting within the LSA for the Project (Figure 6.1-1). The baseline setting is defined from published work and field investigations.

6.2.2.1 Surficial Geology

In general, the local overburden stratigraphy in the Project area consists of a thin layer of topsoil overlying a layer of silty gravelly sand. Cobbles and boulders are observed throughout the entire site and at various depths in the boreholes. The grain angularity is found mainly to be sub-angular to angular and few are identified as sub-rounded. The bedrock surface at site is encountered between about 2 m to 18 m below the ground surface.

Additional information on the surficial geology in the local Project area, including geotechnical properties, can be found in SD 2-4A 2011 Geotechnical Field Investigation Report and SD 2-4B 2012 Geotechnical Field Investigation Report.

6.2.2.2 Bedrock Geology

The following descriptions are based on information contained in Snowden (2008) and Fingler (2001), unless otherwise noted. Additional information, including regional and local geology maps and geotechnical properties of the bedrock, can be found in FEIS Volume 2 Section 2.6.1.1, Volume 7 Section 7.2.2.1, and SD 2-4C Preliminary Stope Stability Assessment for the Project.

The Project is located within the Archaean Rankin Inlet Greenstone Belt, within the Churchill Structural Province of the Canadian Shield (Figure 6.2-1). The rocks of the Rankin Inlet Greenstone Belt have been subjected to polyphase deformational events and metamorphism. The rocks consist of a sequence of mafic volcanic rocks, felsic pyroclastic rocks, sedimentary rocks and gabbro sills.

The Project area is situated in a region of historically low seismicity. Archaean and Proterozoic deformational events have resulted in an alignment of stratigraphy trending in a northwest to southeast direction which defines the Meliadine trend. To the south of the deposits is the Pyke Fault, a major regional fault zone, which extends over several kilometres and is characterized by multiple foliations and regional shear zones.

The geology of the Tiriganiaq Deposit consists of greywacke and argillite sediments (Sam Formation), iron formation, and mixed iron formation, greywacke, and siltstone (Upper Oxide Formation) in fault contact with underlying mafic volcanic rocks (Wesmeg Formation). The sequence trends in an east/west direction, and dips northward at inclinations greater than about 60 degrees. The stratigraphy is aligned for over 3 km along the mineralized shear direction. The fault contact between the Tiriganiaq and the Wesmeg Formation is referred to as the Lower Fault Zone. A zone of graphitic, mineralized fault gouge (0.5 to 3 m in thickness) commonly occurs over this zone.

The stratigraphy of the F Zone area is dominated by mafic volcanic rocks and the east southeast striking Lower Lean Iron Formation. The deposit area is located north of the Pyke Fault which runs sub-parallel to the Lower Iron Formation. Mineralization of the F Zone is hosted by the Lower Lean Iron Formation and is associated with quartz veins and east striking shear zones.

The stratigraphy of the Discovery area is dominated by a thick package of inter-bedded clastic sedimentary units, chemical sediments (oxide facies iron formations) and minor gabbroic dykes. In the deposit area, the hanging wall to the main gold-bearing iron formation horizon is dominated by a greywacke unit which contains minor interbedded argillaceous units, chemical sediments and gabbroic dykes. Gold mineralization is generally restricted to a folded and variably sheared oxide facies iron formation package, which generally consists of banded chert and magnetite horizons (banding on the millimetre [mm] to centimetre [cm] scale), with lesser interbedded chlorite-rich beds and chert and minor local interbedded greywacke units. The footwall to the main mineralized iron formation horizon consists of a similar succession of clastic sedimentary units as found in the hanging wall. The footwall stratigraphy is dominated by greywacke, with a more argillaceous interval, approximately 20 to 40 m below the mineralized iron formation.

There appears to be two parts to the Wesmeg gold deposit: a northern and southern part. In the northern part, the stratigraphy strikes east-west and dips 65 degrees to the north. The stratigraphy in the southern part strikes northwest-southeast and dips 50 degrees to the north. The host Wesmeg Formation is massive to pillowed basalts and interlayered mafic volcaniclastics, with rare gabbro dykes and some interflow sediments consisting of siltstone, mudstone and minor iron formations.

The stratigraphy in the Pump deposit area strikes northwest-southeast and dips 50 degrees to the north. Similar to the F Zone and Wesmeg deposits, the host rocks at the Pump area are massive to pillowed basalts of the Wesmeg Formation, which are cut by rare gabbro dykes and interflow sediments.

6.2.3 Geochemistry

A detailed assessment of the geochemical characteristics of the rock and overburden in the Project area is presented in SD 6-3 Geochemistry Baseline Report.

A baseline mine waste geochemical characterization program characterized the geo-environmental properties of waste rock, ore, tailings, and overburden from the Tiriganiaq, Pump, Wesmeg, Wolf, F Zone, and Discovery deposits. The objectives of the program were to identify chemicals of environmental interest in the framework of mine water and waste management and probable future mine water quality. This was accomplished through static testing and kinetic testing at various scales, including standard laboratory humidity cells, large leaching columns and larger field scale leaching tests.

The Meliadine properties are located in the Rankin Inlet Greenstone Belt. The Meliadine ore deposits are low-sulphide, gold-quartz vein deposits. The principal lithological units that are likely to be disturbed by mining include turbiditic sedimentary rocks, volcanic-hosted and sediment-hosted iron formation, sericite altered siltstones and graphitic argillite, and schistose and carbonate-altered mafic volcanic rocks.

The waste rock and ore sample selection was completed to obtain a data set that is compositionally and spatially representative of the material to be removed by mining at each deposit. All waste rock, tailings, and overburden samples were subjected to a variety of static testing to evaluate chemical and mineralogical composition, the potential to generate acid rock drainage (ARD), as well as short- and long-term metal leach potential. Acid rock drainage potential was assessed following *Guidelines for Acid Rock Drainage Prediction in the North* (AANDC 1992) for waste rock and tailings. All leach test water quality results were screened against Metal Mining Effluent Regulations (MMER) for effluent quality (DFO 2006).

Most waste rock lithologies are non-potentially acid-generating (non-PAG) except for Discovery greywacke and iron formations that are uncertain (FEIS SD 6-3). The iron formation waste rock from the Pump and F Zone deposits has an uncertain potential to generate ARD; although, these rock units constitute a minor proportion of waste from these deposits (14% and 8% by tonnage, respectively). All other rock types from these deposits have excess buffering capacity such that the overall ARD potential of waste generated from Pump and F Zone as well as from Tiriganiaq, Wesmeg, and Wolf deposits is expected to be non-PAG.

Based both on kinetic testing results completed on all waste rock types and at various scales, and the Mine Site Water Quality Predictions (FEIS SD 2-6), leachate from the WRSFs is expected to meet MMER monthly mean effluent limits. Waste rock from most deposits in most WRSFs does not require means to prevent oxidation, with the possible exception of the Discovery WRSF. However, the Discovery WRSF is not expected to generate acidic drainage in the short-term based on the low reactivity of potentially acid-generating (PAG) rock samples from the kinetic testing results and AEM's experience at the Meadowbank mine where the waste rock pile containing a large portion of PAG iron formation rock froze within the first year of deposition. The long-term ARD potential of Discovery waste rock, and particularly in the active thaw layer on the surface of the waste rock stockpile, is uncertain; it will depend on the availability and reactivity of sulphide minerals and the availability and effectiveness of buffering minerals under site conditions. The ARD characteristics of Discovery waste rock will be monitored during operations and managed accordingly.

Most of the tested tailings samples from the Project have no potential to generate ARD except for Discovery deposit tailings that are PAG. Based on the current mine plan, the bulk of the tailings in the tailings storage facility (TSF) is therefore anticipated to be non acid-generating on an annual basis over most of the mine life except for short periods during operations where the acid generation potential of the bulk tailings may be uncertain to PAG. The tailings over the last 3 years of deposition are non-PAG, which will enable placement of a non-PAG tailings layer over the entire tailings mass to protect the underlying tailings from oxidizing agents. Prolonged exposure of Discovery tailings will be avoided to prevent the development of localized acidification.

The concentrations of most leachate parameters from static leaching tests of whole ore tailings samples (shake flask extraction test) meet mine effluent criteria (MMER; DFO 2002) with the exception of arsenic, which exceeds the MMER average monthly values in F Zone, Pump, and Tiriganiaq tailings; however, results from kinetic testing show decreased concentrations with time. Long-term chemical release from the tailings will be managed by placement of an engineered cover to minimize infiltration of water to the tailings surface.

Process water will be treated to destroy cyanide prior to discharge to the TSF. Tailings water within the TSF is likely to require attenuation of pH, arsenic, cyanide, and suspended solids to meet MMER criteria prior to discharge to the receiving environment. Other parameters may also require treatment for discharge if recycling of the TSF water results in further concentration of the process water.

Overburden from within the pit outlines is non-acid generating and does not require means to prevent oxidation. Leachate concentrations in overburden are generally lower than waste rock and all meet MMER monthly mean limits. Waste rock and overburden have compatible geochemical characteristics such that they could be managed together in the same facility.

6.3 Permafrost and Permafrost Terrain

The Project is located in Nunavut (NU), approximately 25 km north of Rankin Inlet (Figure 6.3-1).

6.3.1 Introduction

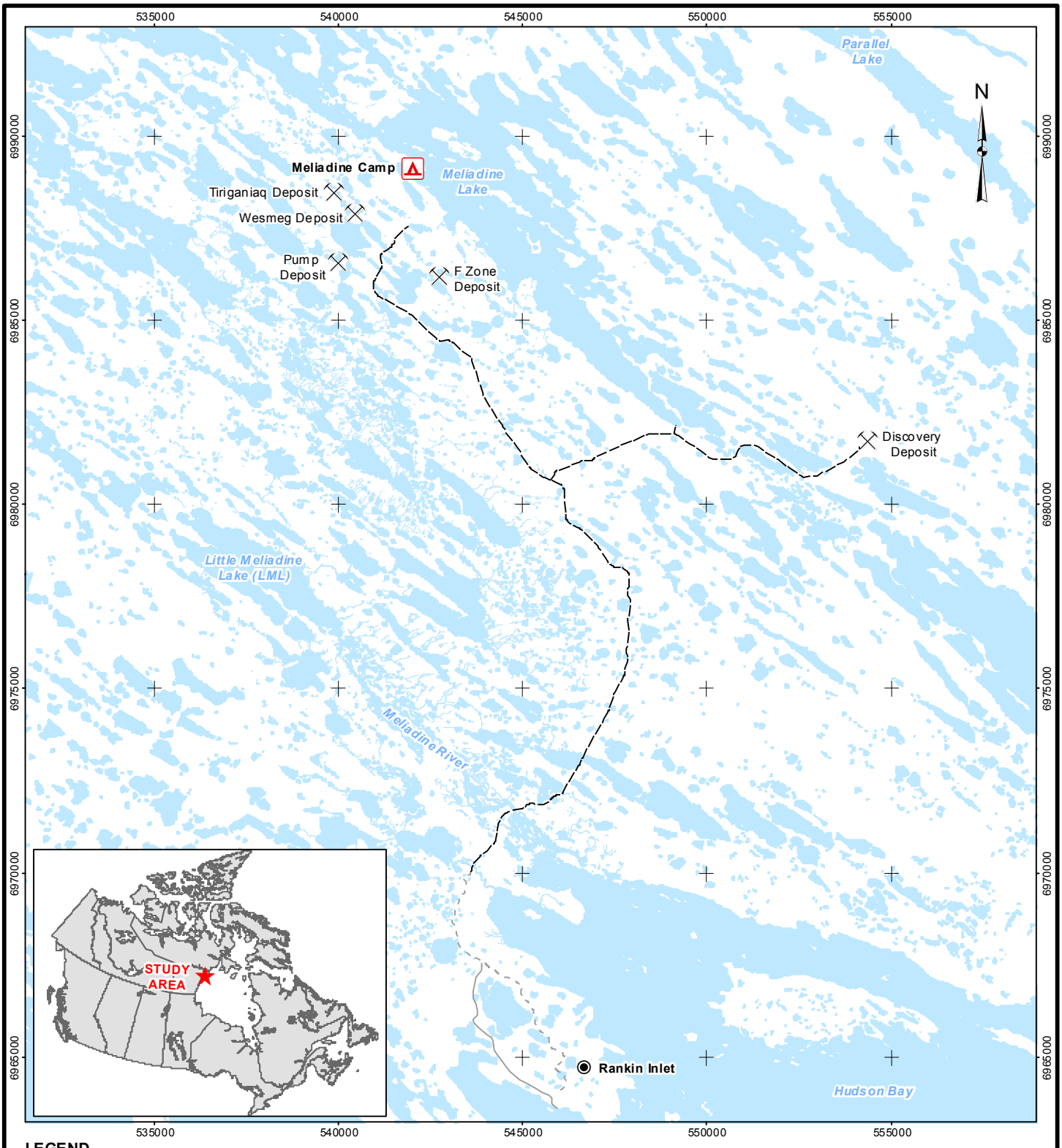
The purpose of this section is to address the Guidelines issued by the NIRB for the Project (NIRB 2012), and specifically those relating to the impact of the Project on the permafrost terrain and environment. Volume 1, Appendix 1.0-A list the specific requirements set out in the guidelines, and relating to the baseline and impact assessment of the permafrost environment.

The Permafrost and Permafrost Terrain section includes an assessment of direct effects to changes to permafrost and permafrost terrain in the study area. The effects assessment evaluates all Project phases, including construction, operation, and closure and reclamation. The effects from the Project must be considered in combination with other developments, activities, and natural factors that influence permafrost within the study area.

6.3.2 Permafrost and Permafrost Terrain Classification Methods

The term ‘permafrost terrain’ in this report refers to the geomorphology, surface geology, and periglacial processes that have shaped the terrain features, both soil and rock, that occurs in the Project area. Permafrost is the state or condition in which the terrain, or terrain materials, continuously exists at a temperature below 0 degrees Celsius (°C) for 2 or more years. This state applies to any material, soil, rock, or water. This is synonymous with perennially cryotic ground, which may be frozen, partially frozen, or non-frozen depending on the ice/water content of the ground, and the salinity of the included water.

The Project is located in the zone of continuous permafrost (Figure 6.3-2).



LEGEND

- Camp
- Proposed Mine Site
- All-weather Access Road (AWAR)
- Road - New
- Road - Existing
- Watercourse
- Waterbody

3000 0 3000
METRES

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).
Datum: NAD 83 Projection: UTM Zone 15

PROJECT
AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

LOCATION PLAN

Golder Associates

PROJECT		10-1373-0076	FILE No.	
DESIGN	JC	26 July 2011	SCALE AS SHOWN	REV. 1
GIS	AL	26 July 2011		
CHECK	JC	28 Jun. 2012		
REVIEW	CJC	28 Jun. 2012		

FIGURE 6.3-1

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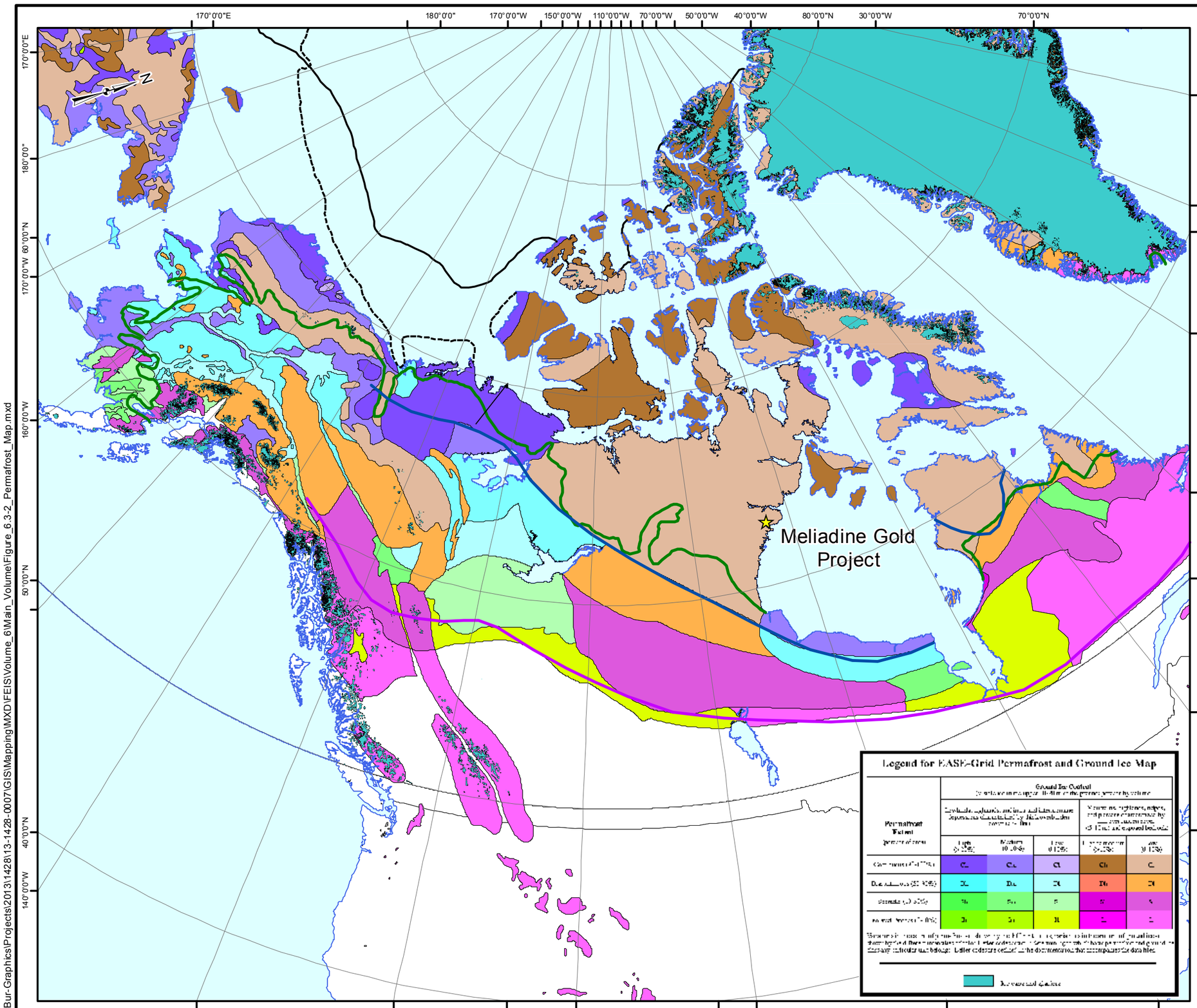

LEGEND

- Meliadine Gold Project
- Southern boundary of continuous permafrost - Present
- Southern boundary of discontinuous permafrost - Present
- Treeline
- Sea-Ice Edge Limit
- Subsea Permafrost Limit

REFERENCE

Brown, J., O.J. Ferrians Jr., J.A. Heginbottom, and E.S. Melnikov. 1998. Circum-Arctic Map or Permafrost and Ground-Ice Conditions. Boulder, Co: National Snow and Ice Data Centre/World Data Centre for Glaciology. Digital Media. Predicted Permafrost Boundaries Based On Woo *et al.*, 1992.

Datum: NAD83 Projection: UTM Zone 15

500 0 500

KILOMETRES

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

PERMAFROST MAP OF CANADA

Golder Associates

PROJECT		10-1373-0076	FILE No.	
DESIGN	JC	27 July 2011	SCALE AS SHOWN	REV. 1
GIS	AL	27 July 2011		
CHECK	JC	28 Jun. 2012		
REVIEW	CJC	28 Jun. 2012		

FIGURE 6.3-2

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6.3.2.1 Permafrost Classification Methods

Baseline studies to characterize the terrain and permafrost thermal regime were initiated at the Meliadine Gold Project site in 1998. Since then, additional studies have been completed to collect baseline information with respect to the site terrain and permafrost conditions.

The studies that have been completed to characterize the permafrost thermal regime at the Project were reported in the permafrost baseline report for the Project (SD 6-1 Permafrost Baseline Report), and included the following activities:

- A review of regional permafrost literature;
- Local permafrost studies, including thermistor installations, to define the permafrost regime and ground temperature profile within the Project area;
- Geotechnical drilling and sampling investigations over a period of several years to sample and describe the permafrost and terrain in the Project area;
- A geomorphological mapping and terrain classification study of the Project area; and
- Permafrost baseline reporting describing the existing permafrost conditions at the site based on the collection of ground temperature data and geotechnical drilling data.

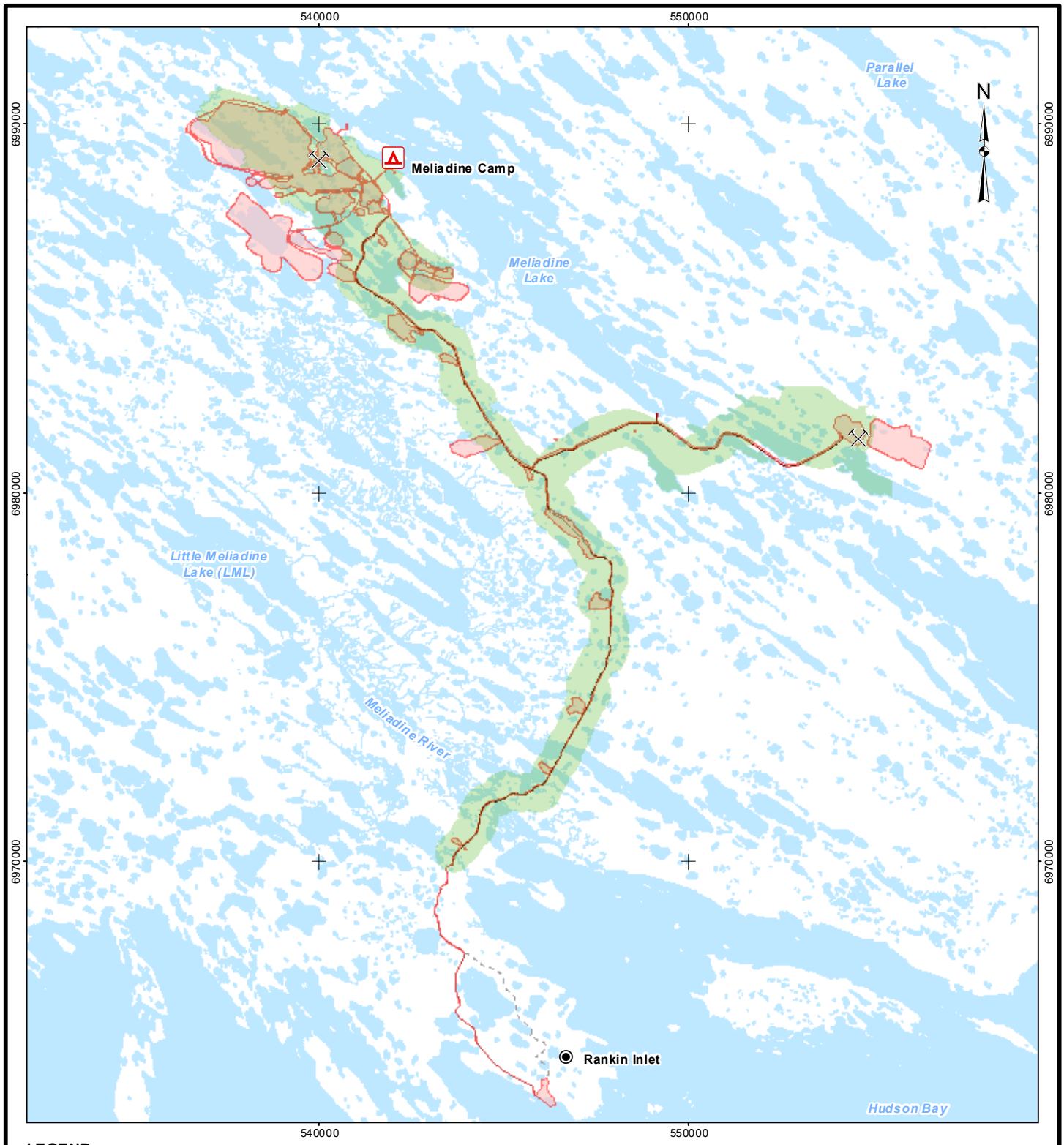
6.3.2.2 Terrain and Surface Geomorphology Classification Methods

The following specific tasks were carried out as part of the classification of the terrain and geomorphology, as described in geomorphology and soils report for the AWAR (Golder 2010a):

- A review was completed of existing and available terrain maps.
- A terrain map of surficial materials, permafrost and periglacial processes, and soil drainage was prepared using 1:10 000 scale black and white and colour air photos. Mapping of the surficial materials and soil drainage followed the methods described for terrain mapping in BC (Resources Inventory Committee 1996). The classification of terrain types, surficial geology, soils, and geomorphic processes followed the classification system developed by Howes and Kenk in BC (Howes and Kenk 1997). The Howes and Kenk classification system encompasses the mapping of the surficial material, the genesis of that surficial material, the morphology of the underlying bedrock surface, and the prevailing geomorphic processes. This classification system evolved from a terrain mapping system originally developed by the Geological Survey of Canada.
- Terrain lines were located using stereoscopic interpretation and drawn by hand on laser photocopies of the 1:10 000 scale air photos. The air photos used were archive copies. It was not possible to obtain and map on original air photos due to the loss of the original photo negatives. Typically laser photocopying, though better than regular photocopying, results in some loss of air photo resolution. Consequently, it should be assumed that the air photo interpretation and terrain mapping is not as accurate as can be achieved with original air photos.

- A series of ground traverses primarily along the proposed access road routes from Meliadine Lake to Rankin Inlet and other sites were used to calibrate and refine the preliminary mapping. The field program for ground confirmation of the mapped surficial materials, periglacial processes, and soils along substantial portions of the route was completed in July 2009. Access to the traverse locations was by helicopter. Weather during the field program varied from sunny days with light winds to cloudy days with moderate winds and occasional rain. Visibility was generally excellent except for occasional fog or low clouds that obscured more distant terrain.
- Following editing of the terrain mapping, the terrain lines were hand transferred to an orthophoto base to document the distribution of surficial material types and terrain conditions. The lines were then digitized and entered into ArcGIS. Orthophoto terrain maps were developed to display the various terrain types (surficial materials) in relation to the Project.
- An assessment matrix was developed linking terrain types and soil drainage class to potential construction-related issues in permafrost terrain. This matrix provides preliminary engineering and hazard interpretations for the various terrain types mapped. A number, or number and letter, is used to identify the terrain type occupying each map polygon.
- The terrain types were classified according to their stability, their respective geomorphologic process, and their soil drainage conditions.
- Maps were prepared to document the spatial distribution of different terrain types and potential terrain susceptibility to freeze/thaw processes. These maps present the different terrain type map units in the Project area as well as interpretation of freeze and thaw induced displacement hazards.

The general area covered by the terrain mapping is shown on Figure 6.3-3.



LEGEND

- Camp
- Approximate Locations For Deposits
- All-weather Access Road (AWAR)
- Road - New
- Road - Existing
- Watercourse
- Project Footprint
- Terrain Coverage
- Waterbody

3 0 3
KILOMETRES

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).
Datum: NAD 83 Projection: UTM Zone 15

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

TERRAIN AND PERMAFROST MAPPING COVERAGE

Golder Associates

PROJECT		10-1373-0076	FILE No.	
DESIGN	CJC	11 Oct. 2012	SCALE AS SHOWN	REV. A
GIS	DSC	12 Oct. 2012		
CHECK	CJC	18 Jan. 2013		
REVIEW	DW	18 Jan. 2013		

FIGURE 6.3-3

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6.3.2.3 Terrain Types

The results of the mapping are presented in the following appendices:

- Appendix 6.3-A – Terrain Unit Descriptions and Interpretations;
- Appendix 6.3-B – Terrain Classification Codes and Terminology;
- Appendix 6.3-C – Terrain Type Map Unit Figures; and
- Appendix 6.3-D – Freeze and Thaw Induced Displacement Hazard Figures.

The Project area is typified by low relief, which is generally gently to moderately sloping with short steep slopes occurring locally on some glaciofluvial, wave-washed bedrock surfaces. The terrain is dominated by veneers and blankets of washed till and shallow lakes.

Marine sediments comprising both beach and deltaic deposits occur locally and are extensive in some areas. Weathered (frost-shattered) bedrock (felsenmeer) and unweathered bedrock outcrops occur locally. There are limited areas of glaciofluvial materials, and shallow, discontinuous organic veneers occur in some poorly and very poorly-drained areas.

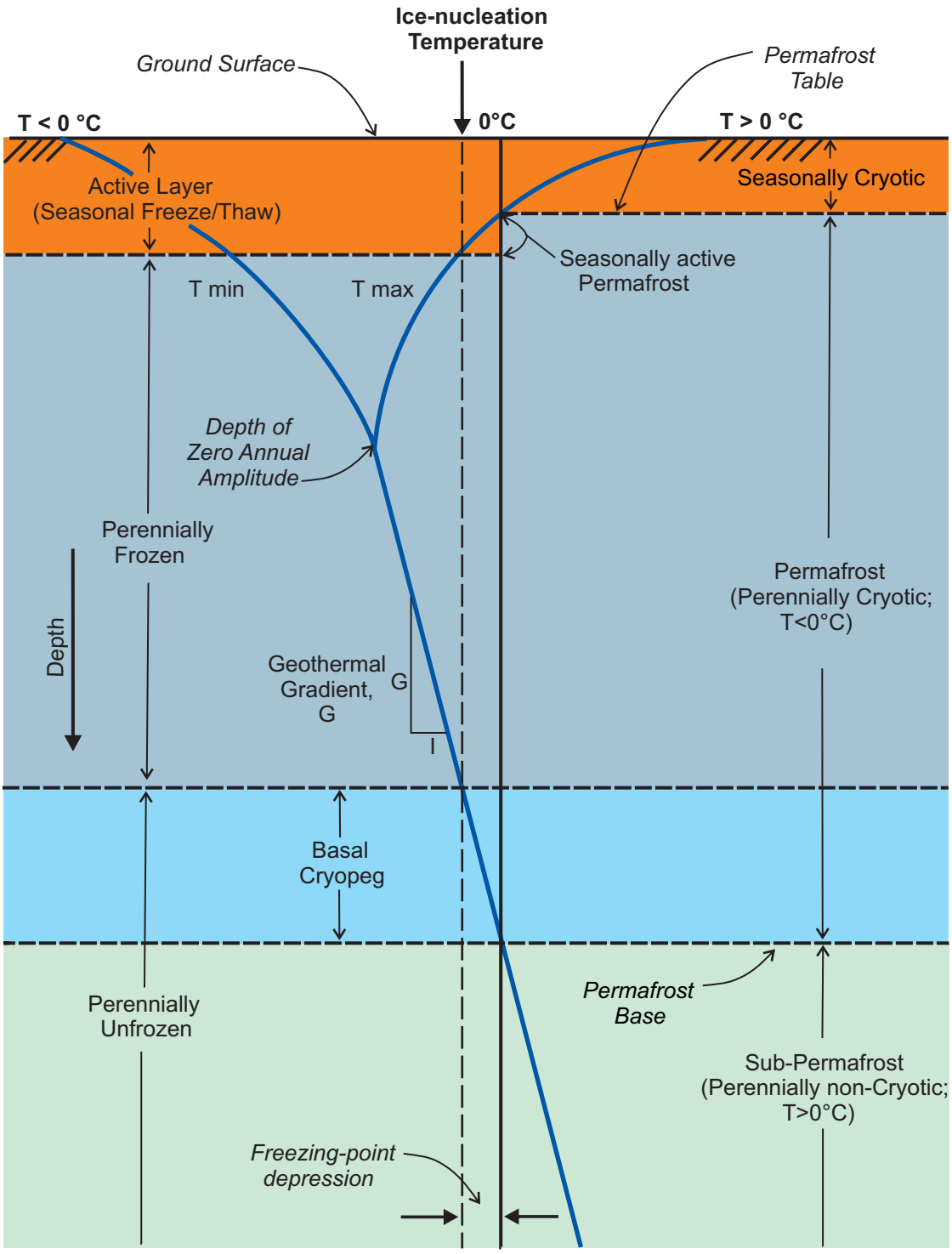
6.3.3 Regional Permafrost Characterization

6.3.3.1 Permafrost Terminology and Characterization Methods

A literature review of the continental and regional permafrost conditions was undertaken to understand the permafrost regime of the Project area.

For descriptive purposes, a typical ground temperature profile in permafrost terrain is shown on Figure 6.3-4 and important permafrost features are shown on Figure 6.3-5. Permafrost is typically described using the following terminologies which are referenced to the figures:

- Active Layer: The active layer is the layer of ground subject to annual freezing and thawing in areas underlain by permafrost. This depth can vary based on material type and water content, presence or absence of vegetation, proximity to water, and general topographic aspect (the direction the slope faces, either north, south, east, or west).
- Permafrost Table: The permafrost table is the upper boundary of permafrost, at the base of the active layer. The ground temperature above the permafrost table is above 0 ºC for at least a portion of each year, and below the permafrost table is less than 0 ºC year round. The ground temperature varies with depth.
- Permafrost Base: The permafrost base is the lower boundary of permafrost, and is an undulating and uneven surface. The ground temperature above the permafrost base is less than 0 ºC and below the permafrost base is above 0 ºC. The depth of the permafrost base varies with latitude, elevation, and with proximity to large bodies of water. The depth of the permafrost base also depends on the thermal history of an area.



REFERENCE:

French, H.M. The Periglacial Environment. Third Edition. England: John Wiley and Sons, Ltd; 2007

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

TYPICAL GROUND THERMAL PROFILE IN PERMAFROST

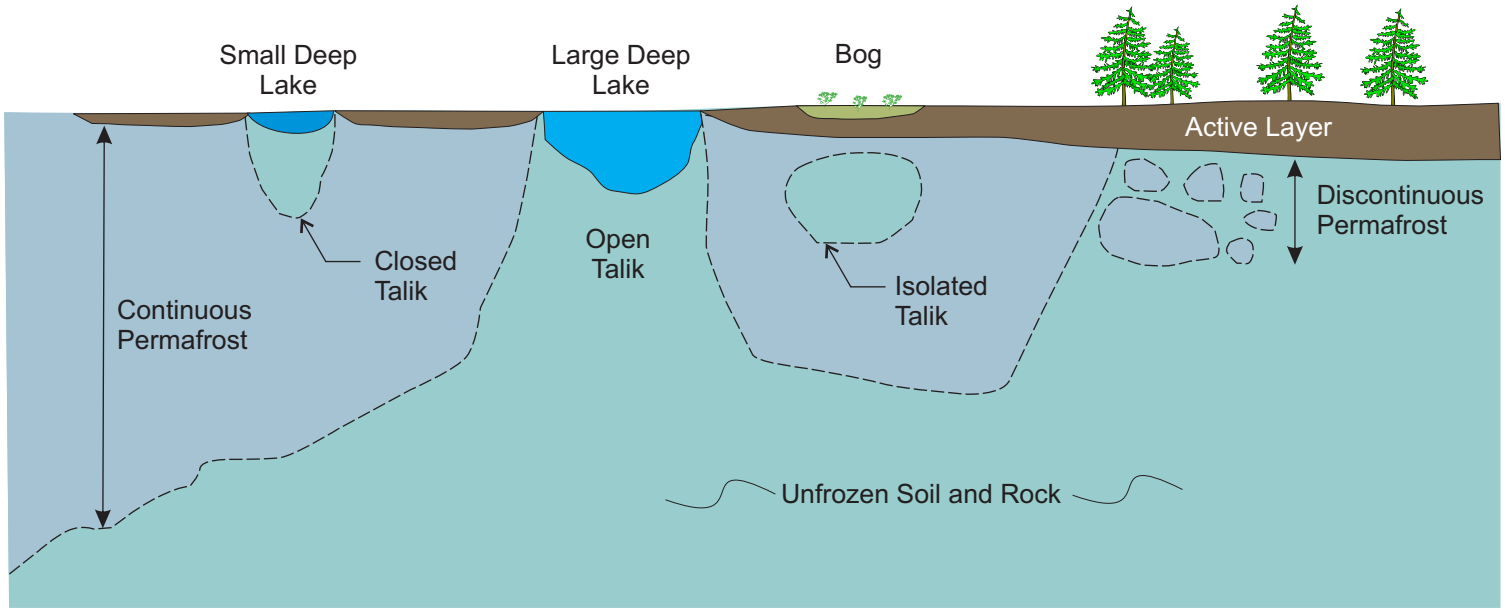
Golder Associates

PROJECT No. 10-1373-0076			PHASE No. 3000	
DESIGN	CJC	31AUG11	SCALE NTS	REV.
CADD	GG	31AUG11		
CHECK	JG	20SEP11		
REVIEW	GRA	20SEP11		

FIGURE 6.3-4

DRAWING DATE: 30-Aug-11 COREL FILE: N:\Bur-Graphics\Projects\20101373\10-1373-0076\Drafting\3000\1013730076-3000-02.cdr

DRAWING DATE: 28-Aug-12 COREL FILE: N:\Bur-Graphics\Projects\2010\1373\10-1373-0076\Drafting\3000\1013730076-3000-07.cdr



Schematic Only
Not to Scale

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

CONTINUOUS AND DISCONTINUOUS PERMAFROST FEATURES

Golder Associates

PROJECT No. 10-1373-0076			PHASE No. 3000-2200	
DESIGN	CJC	28AUG12	SCALE NTS	REV.
CADD	GG	28AUG12		
CHECK	DW	14JAN13	**FIGURE 6.3-5**	
REVIEW	DW	14JAN13		

- Depth of Zero Annual Amplitude: The depth of zero annual amplitude is the depth below ground surface at which there is no variability in ground temperature due to the influence of surface air temperature. It is the depth at which the minimum monthly mean temperature and maximum monthly mean temperatures are equivalent.
- Zero Annual Amplitude Temperature: The temperature at the depth of zero annual amplitude where the minimum monthly temperature and the maximum monthly temperatures are equivalent.
- Geothermal Gradient: The geothermal gradient is the increase in ground temperature with depth below the depth of zero annual amplitude. This is typically a linear relationship. The permafrost base can be estimated if the geothermal gradient is known at a given temperature by projecting the linear relationship down until it crosses from negative ground temperature to positive ground temperature.
- Mean Annual Temperature: The mean annual temperature is the temperature at the ground surface based on a projection upward of the geothermal gradient to intersect the ground surface.
- Sub-permafrost Aquifer: The sub-permafrost aquifer is the deep-permafrost groundwater flow regime near or below the base of permafrost. The top of the sub-permafrost aquifer may or may not coincide with the base of permafrost; if the sub-permafrost aquifer is saline, it is possible that groundwater occurs as a fluid above the base of permafrost (i.e., within permafrost) due to freezing point depression.
- Basal Cryopeg: The layer of perennially cryotic (T<0 °C) but unfrozen ground that forms the base of permafrost. The thickness of this layer is related to the salinity of the groundwater regime which can result in depression of the freezing point several degrees below zero.
- A Talik is defined as a layer or body of unfrozen ground (T>0 °C) in a permafrost area and includes several types based on the relationship to the permafrost and the mechanism related to the unfrozen conditions (Harris et al. 1988). Definitions for the three most common types of talik are presented below:
  - Closed talik: a talik occupying a depression in the permafrost table below a lake or river (also called "lake talik" and "river talik"); its temperature remains above 0ºC because of the heat storage effect of the surface water.
  - Open talik: a talik that penetrates the permafrost completely, connecting a water body above permafrost to the sub-permafrost aquifer (e.g., below large rivers and lakes).
  - Isolated talik: a talik entirely surrounded by perennially frozen ground.

6.3.3.2 Meliadine Permafrost Regime

The Project area is located within the zone of continuous permafrost (Figure 6.3-2) with intervening taliks and thaw bulbs induced by lakes. The ground ice content in the region is expected to be between 0 and 10% (dry permafrost) based on the regional scale compilation data and the Canada Permafrost Map published by Natural Resources Canada (1995). Ice lenses and ice wedges are locally present on land, as indicated by permafrost features such as palsas. These are areas of local ground ice generally associated with low lying areas of poor drainage.

The closest long-term permafrost monitoring station is located at Baker Lake as part of the Circumpolar Active Layer Monitoring (CALM) program. Regionally, ground temperatures have been monitored at Baker Lake since 1997 as part of the CALM program. The location of the CALM station is summarized in the following table.

Table 6.3-1: Baker Lake CALM Location

Site Number	Latitude	Longitude	Elevation (m)	Location
C20	64°19.6'N	95°2.5'W	50	230 km northwest of Meliadine

km = kilometre; m = metre

Mean annual ground temperatures at the Baker Lake CALM site at a depth of 2 m (near top of permafrost) ranged from -6.6 to -8.4°C from 1998 to 2001. Annual active layer thaw depths from 1997 to 2004 are presented in the following table.

Table 6.3-2: Annual Thaw Depth at Baker Lake CALM Site

	Thaw Depth (cm)												Average
Site	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	
Baker Lake C20	120	170	174	189	193	-	-	178	-	-	-	-	171

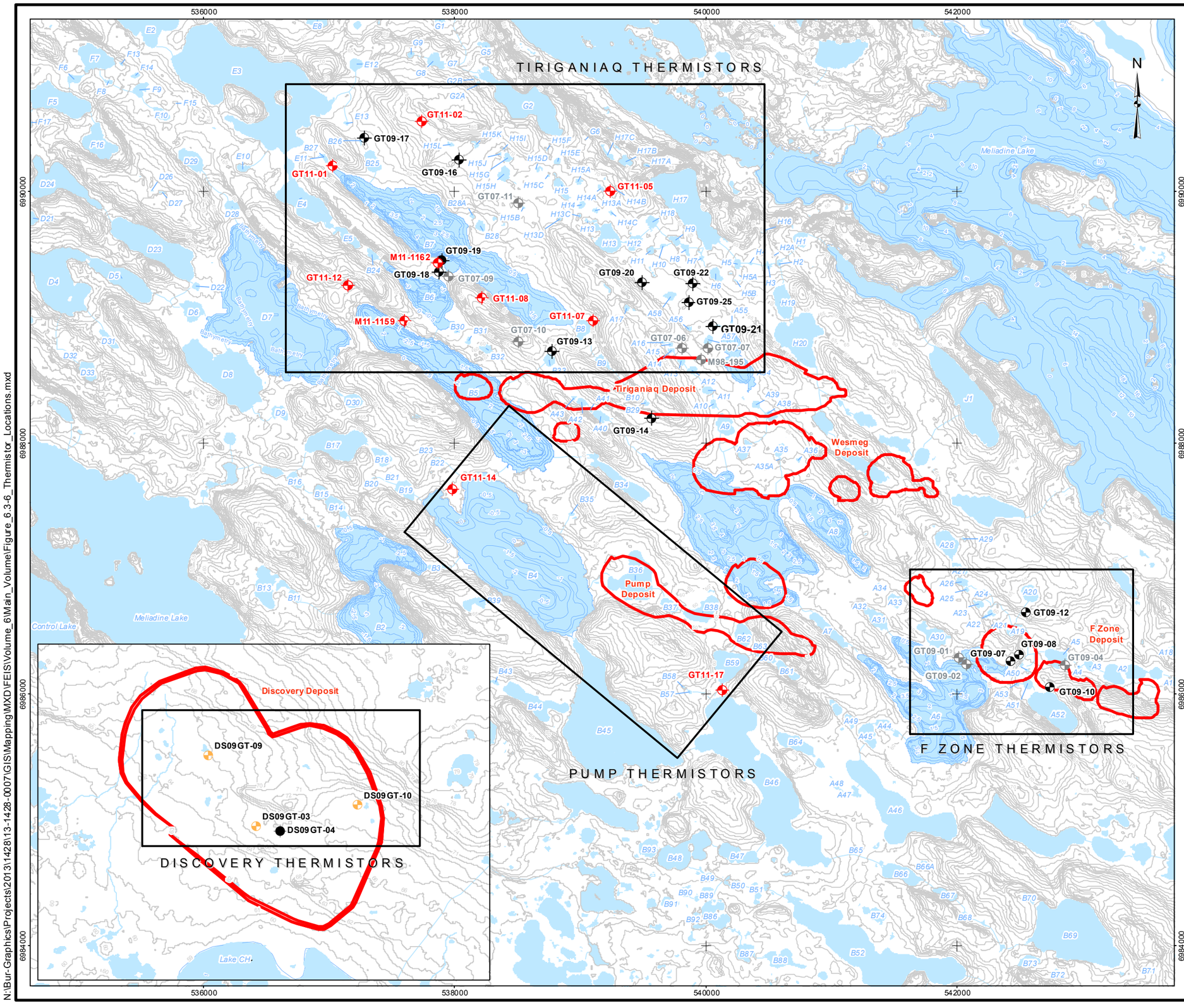
'-' = not reported; data downloaded from CALM website. There are no new data on the CALM website.

The data collection at the Baker Lake CALM site represents a short period of time, and there are no new data from the site. The average thaw depth measured at the Baker Lake CALM site during the period of record is 1.7 m.

6.3.4 Local Permafrost Characterization

6.3.4.1 Permafrost Characterization Methods

In total, 33 thermistors have been installed in the Project area during geotechnical investigations in 1998, 2007, 2009, 2011, and 2012. Figure 6.3-6 shows the locations of the thermistors installed at the Project site. The thermistor installations provide ground temperature data to characterize the existing shallow (near surface) and deep (permafrost base) permafrost regimes to establish baseline conditions for environmental monitoring purposes, as well as to allow the appropriate engineering design of the Project, including the open pits, underground openings, structural fills for facilities, and surface infrastructure.



LEGEND

- Geotechnical Borehole with Thermistor (2011)
- Geotechnical Borehole with Thermistor (2009)
- Hydrogeological Testing Borehole with Thermistor (2009)
- Historic Geotechnical Borehole with Thermistor
- F Zone Geotechnical Borehole with Thermistor (2009)
- Discovery Geotechnical Borehole with Thermistor (2009)
- Deposit Outline
- Topographic Contour (1.0 m Interval Above Sea Level)
- Bathymetric Contour (0.5 m Interval as Depth)
- Watercourse
- Waterbody

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).
Datum: NAD 83 Projection: UTM Zone 15

500 0 500
METRES

PROJECT
AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE
THERMISTOR LOCATION PLAN

PROJECT NO. 10-1373-0076			FILE No.		
DESIGN	JC	28 Sep. 2011	SCALE AS SHOWN	REV.	1
GIS	AL	21 Oct. 2011	**FIGURE 6.3-6**		
CHECK	JC	28 Jun. 2012			
REVIEW	CJC	28 Jun. 2012			

N:\Bur-Graphics\Projects\2013\1428\13-1428-0007\GIS\Mapping\MXD\FEIS\Volume_6\Main_Volume\Figure_6.3-6_Thermistor_Locations.mxd

The thermistors were installed into boreholes that were drilled for either exploration purposes or for specific geotechnical investigation purposes. The depth of each installation varied depending on the desired information to be obtained.

In cases where specific geotechnical boreholes were drilled for the investigation of permafrost, logging of the permafrost soils was carried out using the National Research Council Field Guidelines for the Description of Permafrost (National Research Council Canada 1979).

6.3.4.2 Results

The data collected from the thermistor installations have been used to characterize the baseline permafrost conditions of the Project site, as described in the permafrost baseline report (SD 6-1 Permafrost Baseline Report) along with other important geothermal properties for the various deposit areas. The description of the permafrost soils encountered during drilling includes the identification of the presence or absence of ice. Summaries of the permafrost soils encountered during drilling are presented in the permafrost baseline report (SD 6-1) and include descriptions of ice lenses and stratified ice.

Some important characteristics of the permafrost based on the available data are summarized in the following table from the permafrost baseline report (SD 6-1 Permafrost Baseline Report).

Table 6.3-3: Permafrost Characteristics in the Project Area Based on Available Data

Depth of Zero Annual Amplitude (m)		Zero Amplitude Temperature (°C)			Geothermal Gradient (°C/m depth)			Mean Annual Surface Temperature (°C)			Active Layer Depth (m)			Permafrost Base (mbgs)		
Min.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.
15	35	-7.5	-6.3	-4.8	0.010	0.016	0.020	-8.7	-7.2	-6.0	1.2	2.3	3.2	360	412	495

°C = degrees Celsius; m = metre; min = minimum; max = maximum; avg = average; mbgs = metres below ground surface

Permafrost is sometimes referred to as ‘warm’ or ‘cold’. The actual temperature ranges associated with such naming varies depending on the reference source; however, Hammer et al. (1985) suggests that ‘warm’ permafrost has a temperature range of 0 to -4°C, and ‘cold’ permafrost has a temperature range colder than -4°C. The Project area is in a region of ‘cold’ permafrost, having an average annual surface temperature and zero amplitude temperature less than -4°C. The depth of permafrost and of the active layer varies based on proximity to lakes, soils thickness, vegetation, climate conditions, and slope direction.

The base of the permafrost is expected to be an irregular surface, and so the actual thickness of permafrost will be variable. In the local context of the Project site, the land surface is underlain by continuous permafrost, except under bodies of water too deep to freeze to the bottom during winter. Based on bathymetry data, maximum lake depth varies from 2.5 to 5 m (except Meliadine Lake and Chickenhead Lake), and late winter ice thickness ranges from 1.0 m to 2.3 m averaging approximately 1.7 m. Therefore, lake ice freezes to the lake bottom at depths shallower than approximately 1.0 to 2.3 m. Taliks (areas of unfrozen ground) are to be expected where lake depths are greater than about 1.0 to 2.3 m. Formation of open taliks that penetrate through the permafrost may also be expected for relatively deeper and larger lakes in the Project area.

Analytical solutions suggest that a critical depth beneath a lake to have open-talik formation is related to geothermal gradient, mean annual ground temperature and mean annual lake bottom temperature, but is independent of lake size. Using the critical depth, critical lake sizes for open-talik formation can be estimated. The analytical solutions for the Project area based on assumed mean lake bottom and terrace temperatures result in the following:

- Taliks extending through the permafrost will exist beneath circular lakes having a minimum radius of 290 to 330 m, and beneath elongate lakes having a minimum half width of 160 to 195 m, without considering lake terrace geometries.
- When terrace effects are included in the analyses, the critical radius for a circular lake increases to between 310 and 485 m, and the critical half width for an elongate lake increases to between 170 and 280 m. These are based on assumptions that the terrace is 25 to 75% of the total lake width or diameter.

The salinity level of the deep groundwater in the Project area is elevated which will result in freezing point depression so that the depth of frozen permafrost (depth to the basal cryopeg) is less than the depth of perennially cryotic ground (ground at a temperature less than 0 ^{o}C).

6.3.4.3 Thermal Stability of the Local Permafrost Regime

Site investigations involving permafrost studies for the Project have been carried out since 1998. Thermistor data were collected from thermistor installation M98-195 between 1998 and 2000 (Figure 6.3-6). Following a monitoring gap from 2000 to 2006, investigations with more thermistor installations have been conducted since 2007.

Geothermal properties such as the depth of active layer, the zero annual amplitude depth and the geothermal gradient from installation M98-195 and from other thermistors have been compared. The monitoring period between 2007 and 2011 is considered to be short for evaluating thermal stability of permafrost and lake taliks in the Project area; however, in general the thermistor data to date do not suggest a significant change of the thermal condition of the permafrost in the Project area. Based on the thermistor data collected to date, active layer depths were consistent year over year and permafrost conditions are currently stable in the Project area. No apparent changes of permafrost thermal stability were noted during the monitoring period of 1998 to present.

6.3.4.4 Potential Effects of Long-Term Warming Trends on the Local Permafrost Regime

A climate change assessment has been prepared for the Project (FEIS Volume 5, Section 5.4). The assessment projects the climate in the Project region to be warmer for the 2050s and 2080s time horizons when compared to the observed historic values. The annual average projected climate trend deviations for the 2050s are an increase in temperature of 3 to 3.5 ^{o}C, and in the 2080s an increase of 4.5 to 5 ^{o}C from the observed historic values. These projected climate trend deviations are consistent with the Intergovernmental Panel on Climate Change (IPCC, 2007) predictions under the worst scenario of the climate change model, which projects an increase of the global mean surface air temperature of 2.4 to 6.4 ºC by 2090 to 2099 relative to 1980 to 1999.

Traditional Knowledge of climate change in Nunavut is discussed in FEIS Volume 5, Section 5.4.2.4, and shows that TK observations generally match the historic trend analysis from Baker Lake. IQ

The general effect of a long-term warming in surface temperature on the ground temperature profile is shown on Figure 6.3-7. The potential effect of such a trend on typical permafrost features is shown on Figure 6.3-8. Selected thermistor ground temperature profiles at the Project site have been used to estimate the long-term effect of an average increase in surface air temperature of 4.4 ºC (this is the average of the range predicted by the 2007 IPCC climate change model, and is consistent with the general projected climate trend deviations for the Project site for the 2050s and 2080s noted above) on the current baseline conditions at the site. The results are shown on Figures 6.3-9 through 6.3-13 and are summarized in the following table.

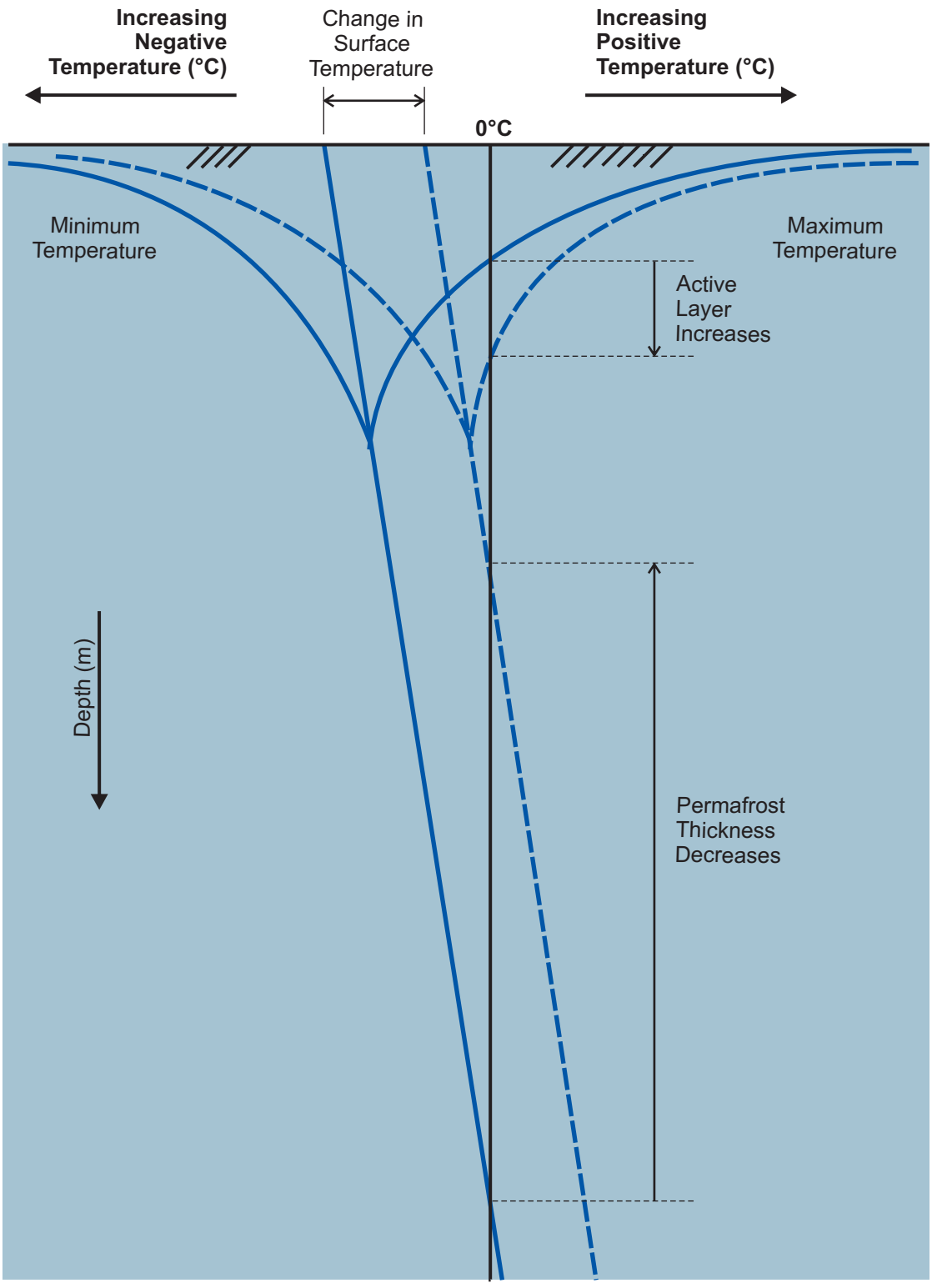
Table 6.3-4: Effect of Long-Term Warming Trend on Ground Temperature Profile after Steady-State Achieved

	M98-195[a]		TE09-01 [a] (DS09GT-03)		TE09-02 [a] (DS09GT-04)		TW09-15 [a] (GT09-08)		TW09-16 [a] (GT09-07)	
	Baseline Condition	**+4.4 °C**	**Baseline Condition**	**+4.4 °C**	**Baseline Condition**	**+4.4 °C**	**Baseline Condition**	**+4.4 °C**	**Baseline Condition**	**+4.4 °C**
Estimated Zero Amplitude Temperature (Deg C)	-7.5	-3.5	-7.0	-2.5	-6.8	-2.3	-6.8	-2.7	-6.6	-2.1
Extrapolated Mean Annual Surface Temperature (Deg C)	-8.7	-4.2	-7.2	-2.8	-7.0	-2.7	-7.0	-2.9	-7.0	-2.5
Estimated Active Layer Thickness (m)	3	4.5	1.3	5.4	1.6	4.6	1.9	4.3	1.8	5.1

[a] Location of thermistor installations shown on Figure 6.3-6.

The simplified figures show that as a consequence of a long-term increase in surface temperature, the thickness of the active layer will gradually increase. Under such conditions the Project site would be considered to be underlain by 'warm' permafrost, having a mean annual surface temperature and zero amplitude temperatures warmer than about -4°C. The thickness of the active layer could increase potentially by 2 to 4 m. Permafrost will still be present beneath the land mass.

Such a long-term increase in surface temperature, and corresponding re-equilibration of the geothermal gradient, would not occur during the operational lifespan of the mine. However, the impact such a scenario would have on the Project infrastructure remaining after closure and decommissioning could include a deepening of the active layer within waste rock piles, and within the cover placed over the tailings storage facility. The foundations of the waste rock piles and the tailings are expected to remain frozen under such a long-term warming trend; however, the longer term closure strategies for the waste rock and tailings will need to consider the potential deepening of the active layer. Decommissioned roads and airstrips will not be significantly impacted by such a long-term warming trend as they will no longer be in use.



REFERENCE:

French, H.M. The Periglacial Environment. Third Edition. England: John Wiley and Sons, Ltd; 2007
Figure 8.1

PROJECT
AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

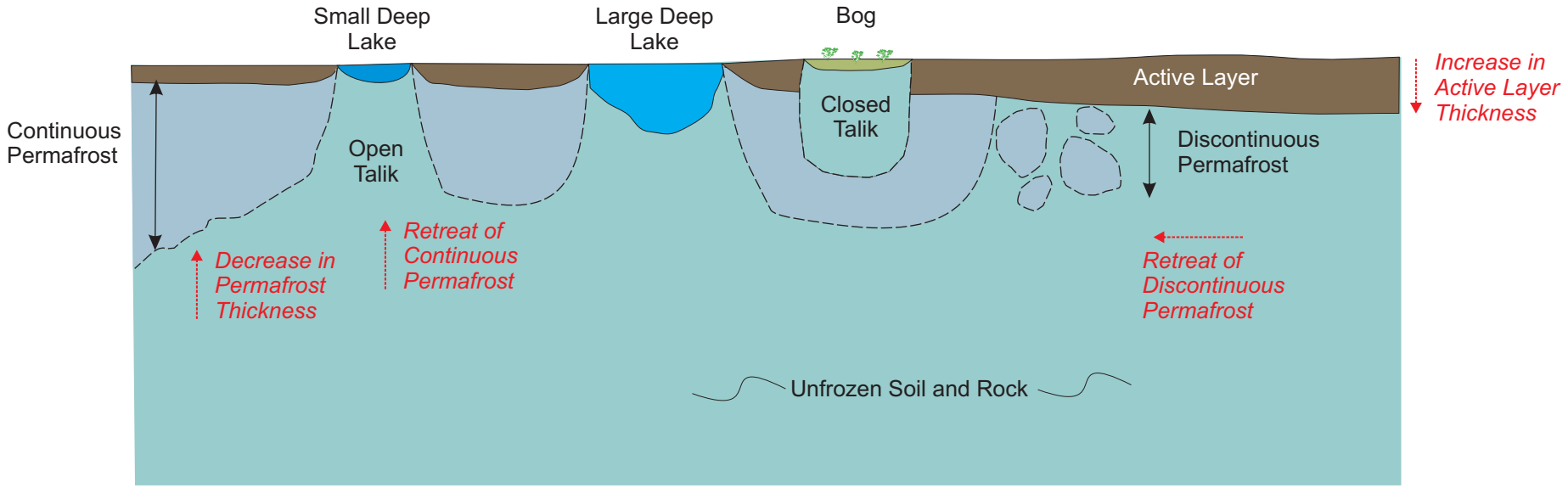
LONG-TERM EFFECT OF WARMING ON THE GROUND TEMPERATURE PROFILE

Golder Associates

PROJECT No. 10-1373-0076			PHASE No. 3000-2200	
DESIGN	CJC	28AUG12	SCALE NTS	REV.
CADD	GG	28AUG12		
CHECK	DW	14JAN13	**FIGURE 6.3-7**	
REVIEW	DW	14JAN13		

DRAWING DATE: 28-Aug-12 COREL FILE: N:\Bur-Graphics\Projects\2010\1373\10-1373-0076\Drafting\3000\1013730076-3000-08.cdr

DRAWING DATE: 04-Oct-12 COREL FILE: N:\Bur-Graphics\Projects\2010\1373\10-1373-0076\Drafting\3000\1013730076-3000-11.cdr



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PROJECT
AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

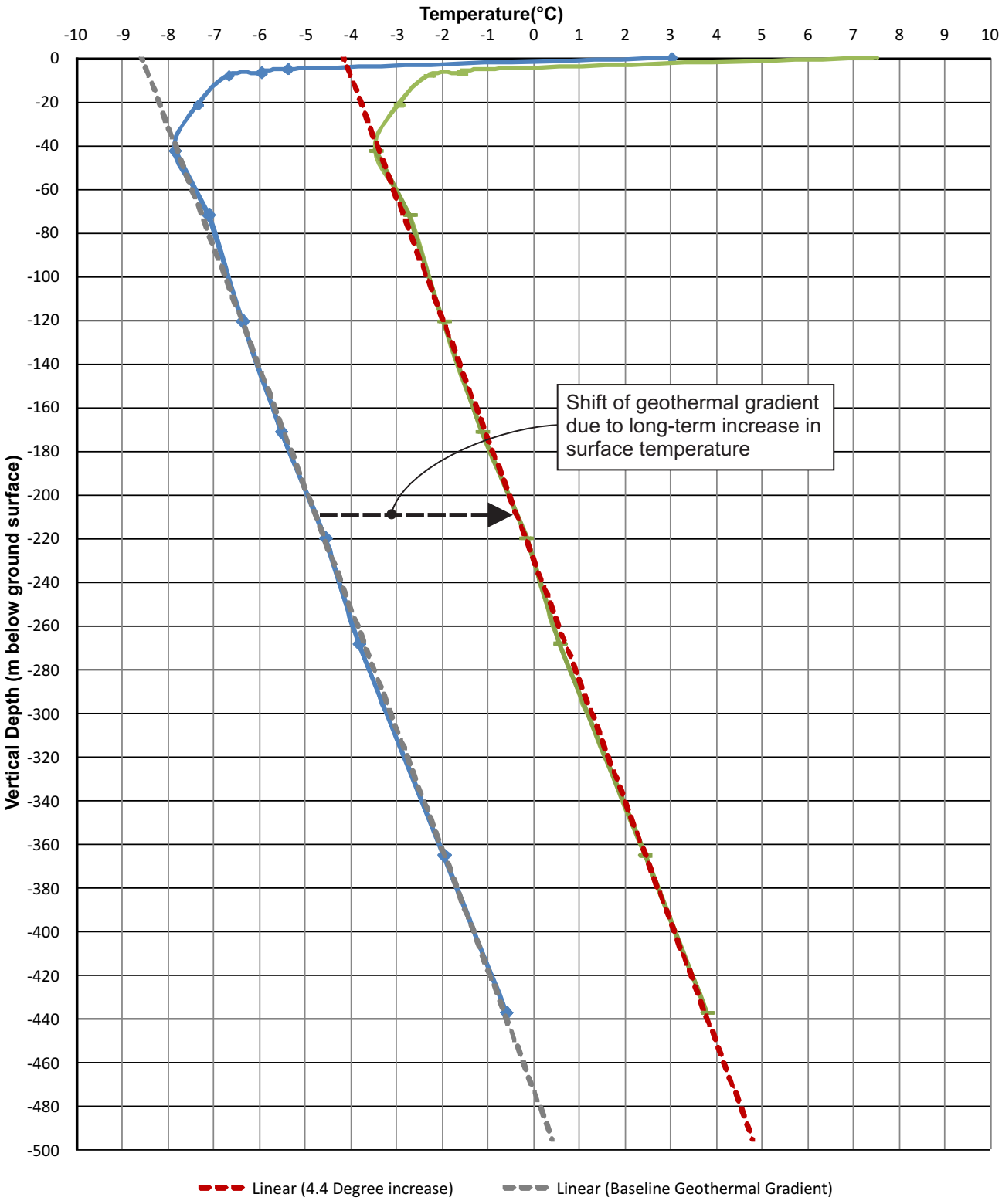
TITLE

CONTINUOUS AND DISCONTINUOUS PERMAFROST FEATURES AFTER LONG-TERM WARMING

Golder Associates

PROJECT No. 10-1373-0076			PHASE No. 3000-2200	
DESIGN	CJC	28AUG12	SCALE NTS	REV.
CADD	GG	28AUG12		
CHECK	DW	14JAN13		
REVIEW	DW	14JAN13		

FIGURE 6.3-8



PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

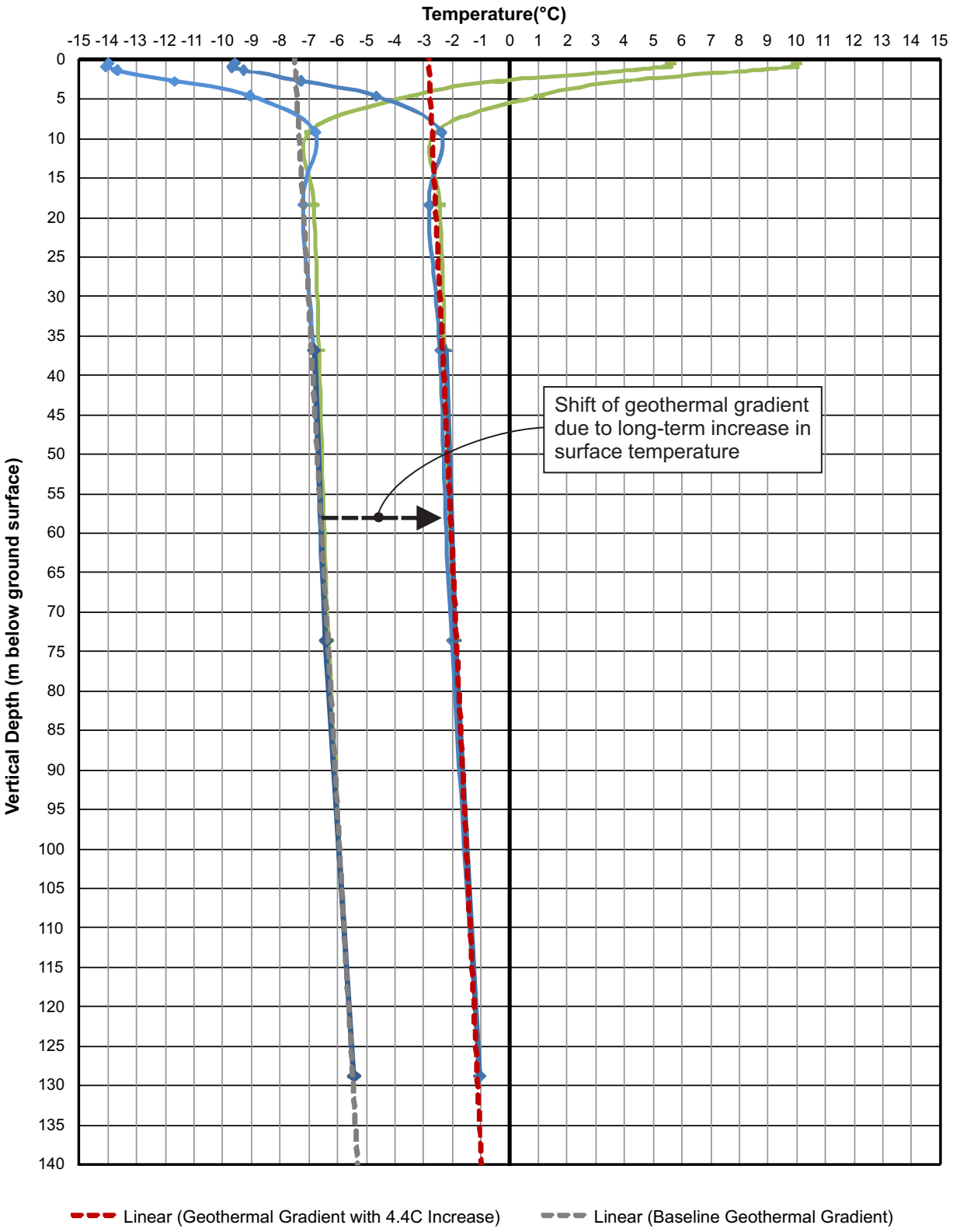
TITLE

BOREHOLE M98-195 - BASELINE GEOTHERMAL GRADIENT AND GRADIENT FOR 4.4°C LONG-TERM INCREASE IN SURFACE TEMPERATURE

Golder Associates

PROJECT No. 10-1373-0076			PHASE No. 3000-2200	
DESIGN	CJC	03OCT12	SCALE NTS	REV.
CADD	GG	03OCT12		
CHECK	DW	14JAN13	**FIGURE 6.3-9**	
REVIEW	DW	14JAN13		

DRAWING DATE: 04-Oct-12 COREL FILE: N:\Bur-Graphics\Projects\2010\1373\10-1373-0076\Drafting\3000\1013730076-3000-10.cdr



PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

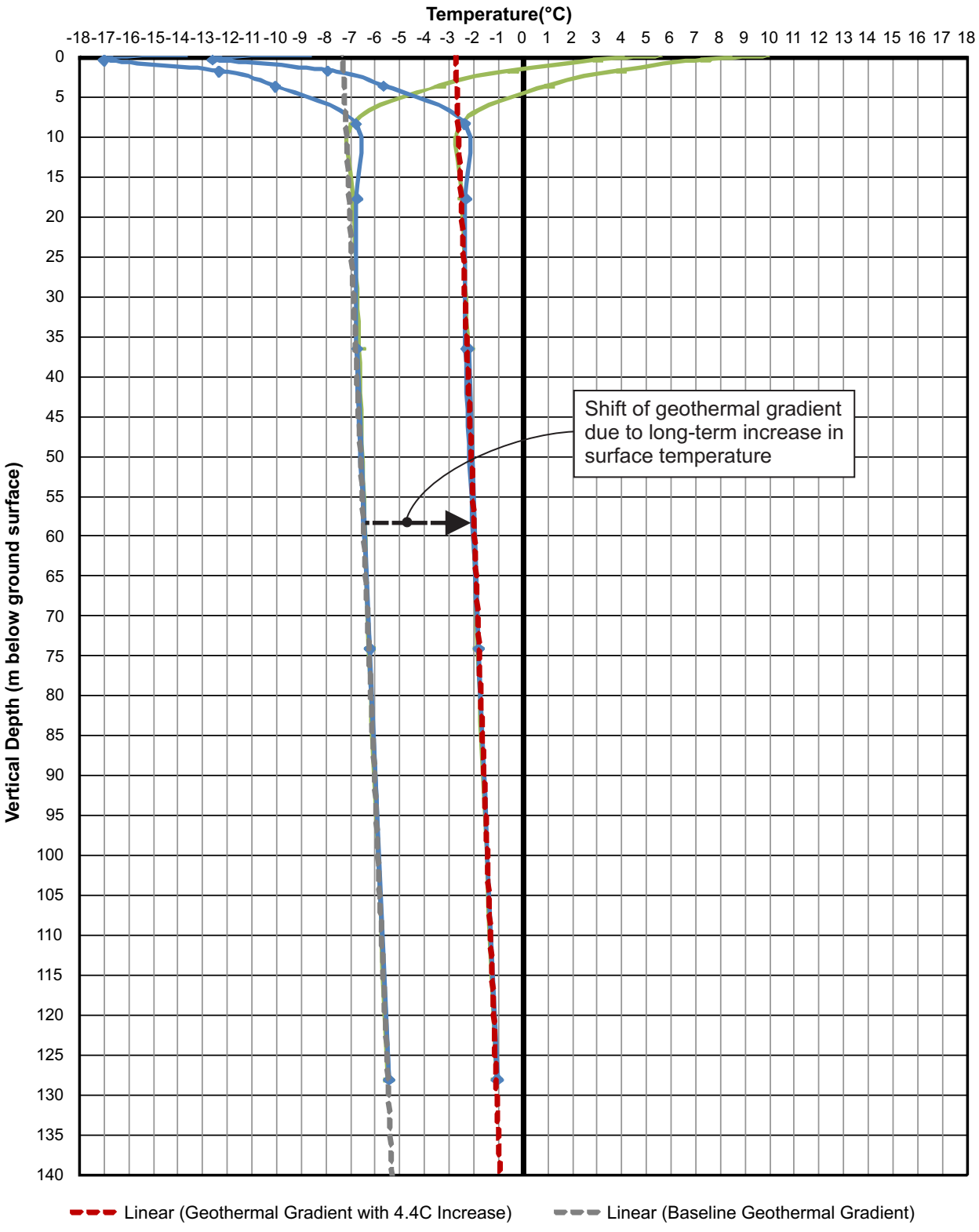
BOREHOLE DS09GT-03 (TE09-01) - BASELINE GEOTHERMAL GRADIENT AND GRADIENT FOR 4.4°C LONG TERM INCREASE IN SURFACE TEMPERATURE

Golder Associates

PROJECT No. 10-1373-0076			PHASE No. 3000-2200	
DESIGN	CJC	03OCT12	SCALE NTS	REV.
CADD	GG	03OCT12		
CHECK	DW	14JAN13		
REVIEW	DW	14JAN13		

FIGURE 6.3-10

DRAWING DATE: 04-Oct-12 COREL FILE: N:\Bur-Graphics\Projects\2010\1373\10-1373-0076\Drafting\3000\1013730076-3000-10.cdr



PROJECT

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MELIADINE GOLD PROJECT
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TITLE

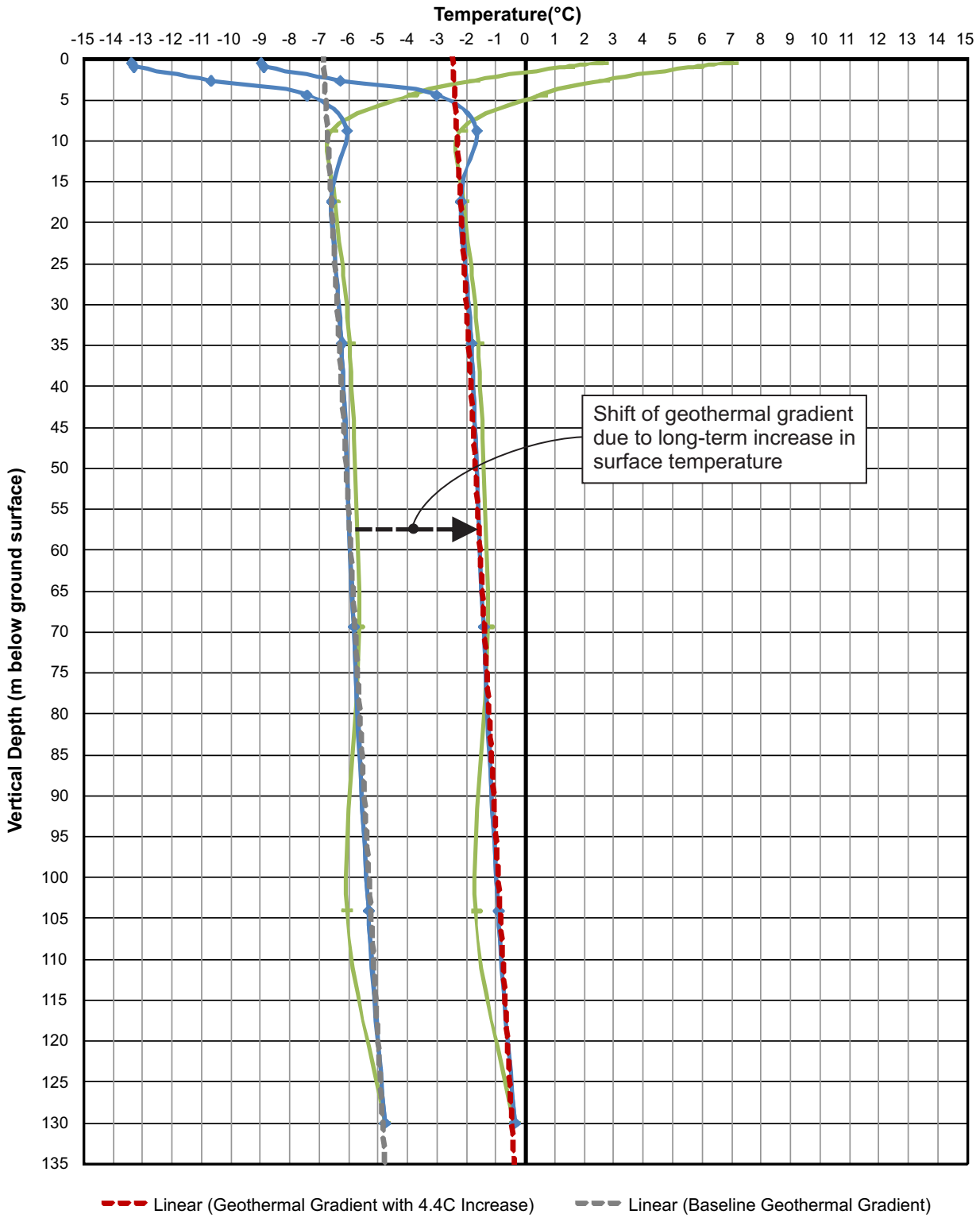
BOREHOLE DS09GT-04 (TE09-02) - BASELINE GEOTHERMAL GRADIENT AND GRADIENT FOR 4.4°C LONG TERM INCREASE IN SURFACE TEMPERATURE

Golder Associates

PROJECT No. 10-1373-0076			PHASE No. 3000-2200	
DESIGN	CJC	03OCT12	SCALE NTS	REV.
CADD	GG	03OCT12		
CHECK	DW	14JAN13		
REVIEW	DW	14JAN13		

FIGURE 6.3-11

DRAWING DATE: 04-Oct-12 COREL FILE: N:\Bur-Graphics\Projects\2010\1373\10-1373-0076\Drafting\3000\1013730076-3000-10.cdr



PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

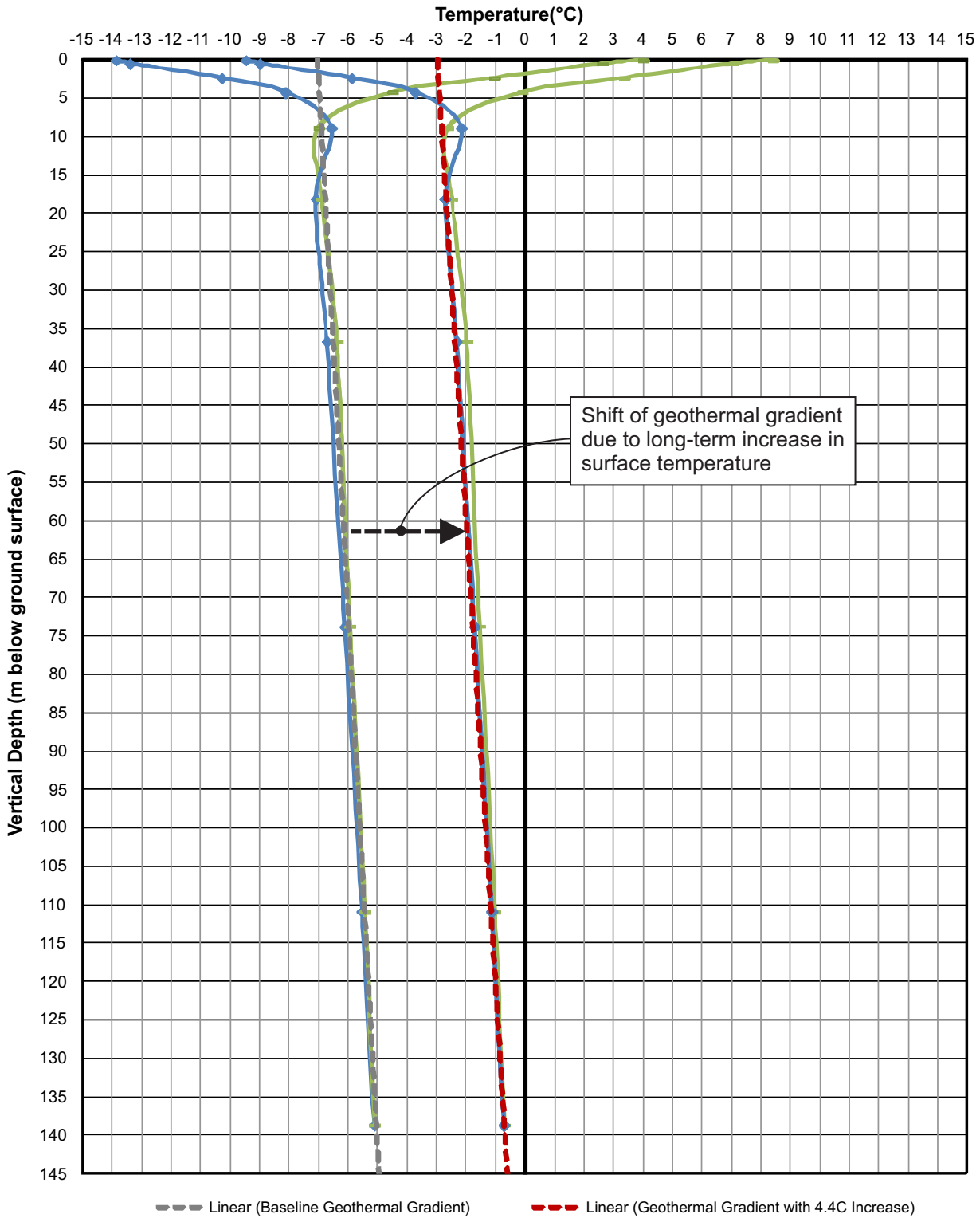
BOREHOLE GT09-07 (TW09-16) - BASELINE GEOTHERMAL GRADIENT AND GRADIENT FOR 4.4°C LONG TERM INCREASE IN SURFACE TEMPERATURE

Golder Associates

PROJECT No. 10-1373-0076			PHASE No. 3000-2200	
DESIGN	CJC	03OCT12	SCALE NTS	REV.
CADD	GG	03OCT12		
CHECK	DW	14JAN13		
REVIEW	DW	14JAN13		

FIGURE 6.3-12

DRAWING DATE: 04-Oct-12 COREL FILE: N:\Bur-Graphics\Projects\2010\1373\10-1373-0076\Drafting\3000\1013730076-3000-10.cdr



PROJECT

AGNICO EAGLE

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MELIADINE GOLD PROJECT
NUNAVUT

TITLE

BOREHOLE GT09-08 (TW09-15) - BASELINE GEOTHERMAL GRADIENT AND GRADIENT FOR 4.4°C LONG TERM INCREASE IN SURFACE TEMPERATURE

Golder Associates

PROJECT No. 10-1373-0076			PHASE No. 3000-2200	
DESIGN	CJC	03OCT12	SCALE NTS	REV.
CADD	GG	03OCT12		
CHECK	DW	14JAN13	**FIGURE 6.3-13**	
REVIEW	DW	14JAN13		

DRAWING DATE: 04-Oct-12 COREL FILE: N:\Bur-Graphics\Projects\2010\1373\10-1373-0076\Drafting\3000\10137300 76-3000-10.cdr

6.3.5 Snow Drift Accumulation

6.3.5.1 Methods

A preliminary assessment of the potential areas for snow build-up along the alignment of the proposed AWAR was completed by Golder (2011a). The snow drift assessment considered snow fall and wind direction data in conjunction with air photo interpretation and topographic contours. The focus of the study was on the AWAR (Phase I); however, the general conclusions relating to the potential locations for snow drift accumulation are applicable to other facilities and infrastructure for the Project.

The preliminary snow drift assessment was based on the information presented in the following table.

Table 6.3-5: Information Sources for Snow Drift Accumulation Study

Data	Source
Meteorological Data	
Annual snowfall data	SD 7-1 2009 Aquatics Synthesis Baseline
Wind direction data	SD 7-1 2009 Aquatics Synthesis Baseline
Snow course data	SD 7-1 2009 Aquatics Synthesis Baseline
Surface Data	
Feasibility level road alignment[a]	Golder 2011b
Topographic maps[a]	Golder 2011b
1:10 000 scale air photos (black and white and colour)	Comaplex Ltd. dated 97/07/19 and 97/07/18
Site photographs taken during a snow course survey in April 2009	SD 7-1 2009 Aquatics Synthesis Baseline

[a] The feasibility level road design used 2 types of topographic data: topographic map data with a 1 m contour interval ("Schlencker Data"); and regular NTS topographic map data with a 7.7 m contour interval.

Topographic data, air photos, site photographs, and site knowledge were used to qualitatively identify potential locations where snow may accumulate along the proposed AWAR alignment.

Air photos were used to identify features along the road alignment indicative of potential locations of snow drifts, such as nivation hollows and changes in vegetative cover, as well as steeper lee slopes.

6.3.5.2 Results

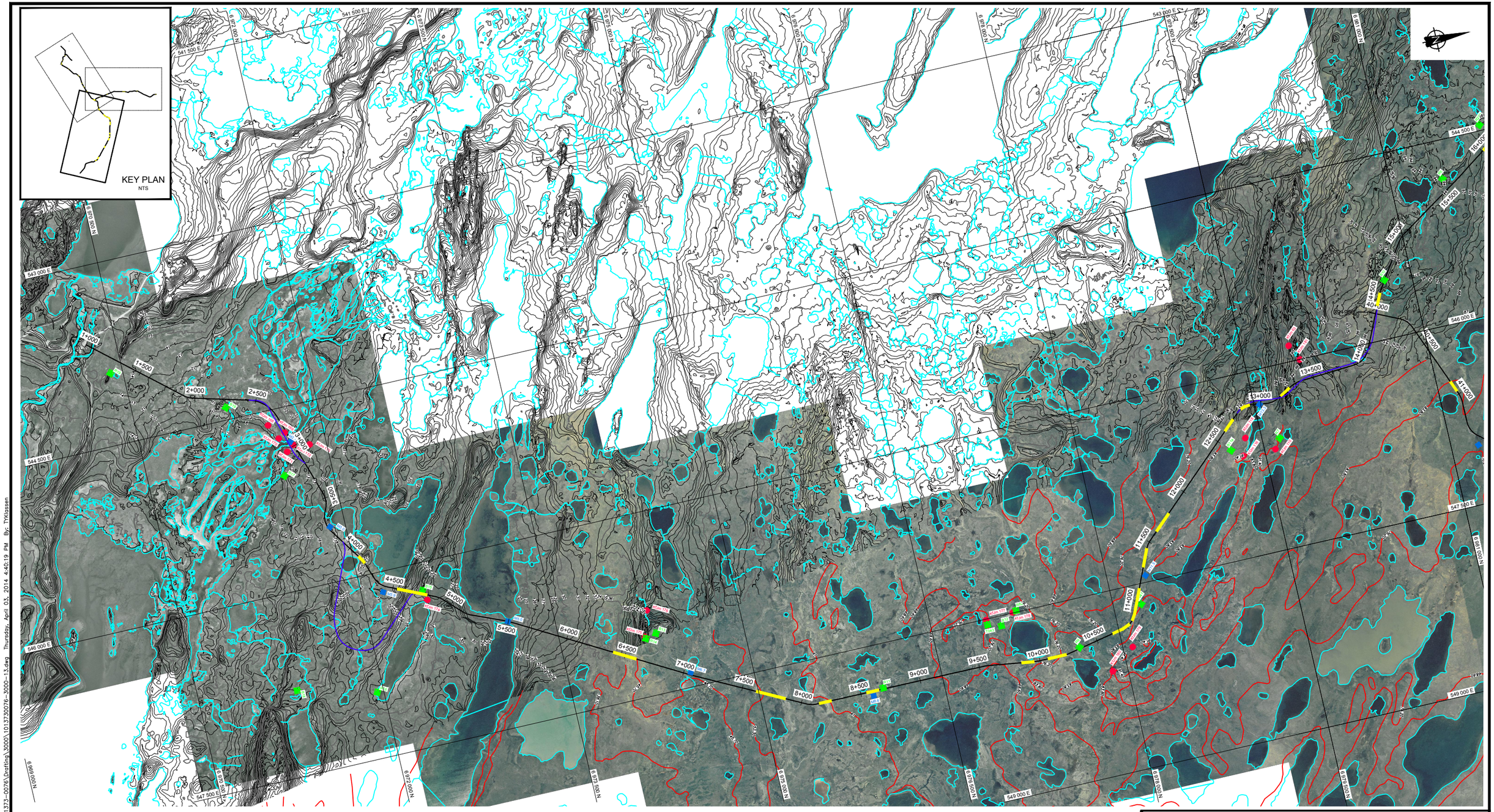
The wind direction data from Rankin Inlet indicate dominant winds from the north-northwest, with sub-dominant winds from the north and, to a lesser degree, from the northwest, suggesting that southeast and south-facing slopes will be the dominant lee slopes. It is anticipated that short, steep, lee slopes (e.g., southeast and southwest facing slopes) and lake shorelines are more likely to accumulate snow than windward slopes and gently sloping hillsides.

Review of the April 2009 snow course site photographs confirmed that ridge crests, crests of gently sloping undulations and upper slopes along some hillsides tend to experience very shallow snow cover. These areas of shallow snow cover often include local areas where soil, rocks, and/or minor vegetation are exposed. Snow depths on gently sloping mid and lower slope hillsides also appear relatively shallow, but deeper than the ridge crests. A few site photographs showed short, steep, lee slopes below ridge crests with relatively deep accumulations of snow.

The proposed AWAR alignment proceeds in a northeast direction from the Char River turnoff to approximately CH 8+600, after which it trends northwest. The road alignment generally follows higher ground and windward slopes. Areas identified along the alignment that may accumulate snow drifts based on topography, wind direction, air photographs, and site photographs are shown on Figures 6.3-14 and 6.3-15.

Facilities and infrastructure will tend to accumulate snow on the leeward side. Depending upon the purpose of the structure or facility, or on access requirements, it may be necessary to actively clear snow during the winter months.

KEY PLAN
NTS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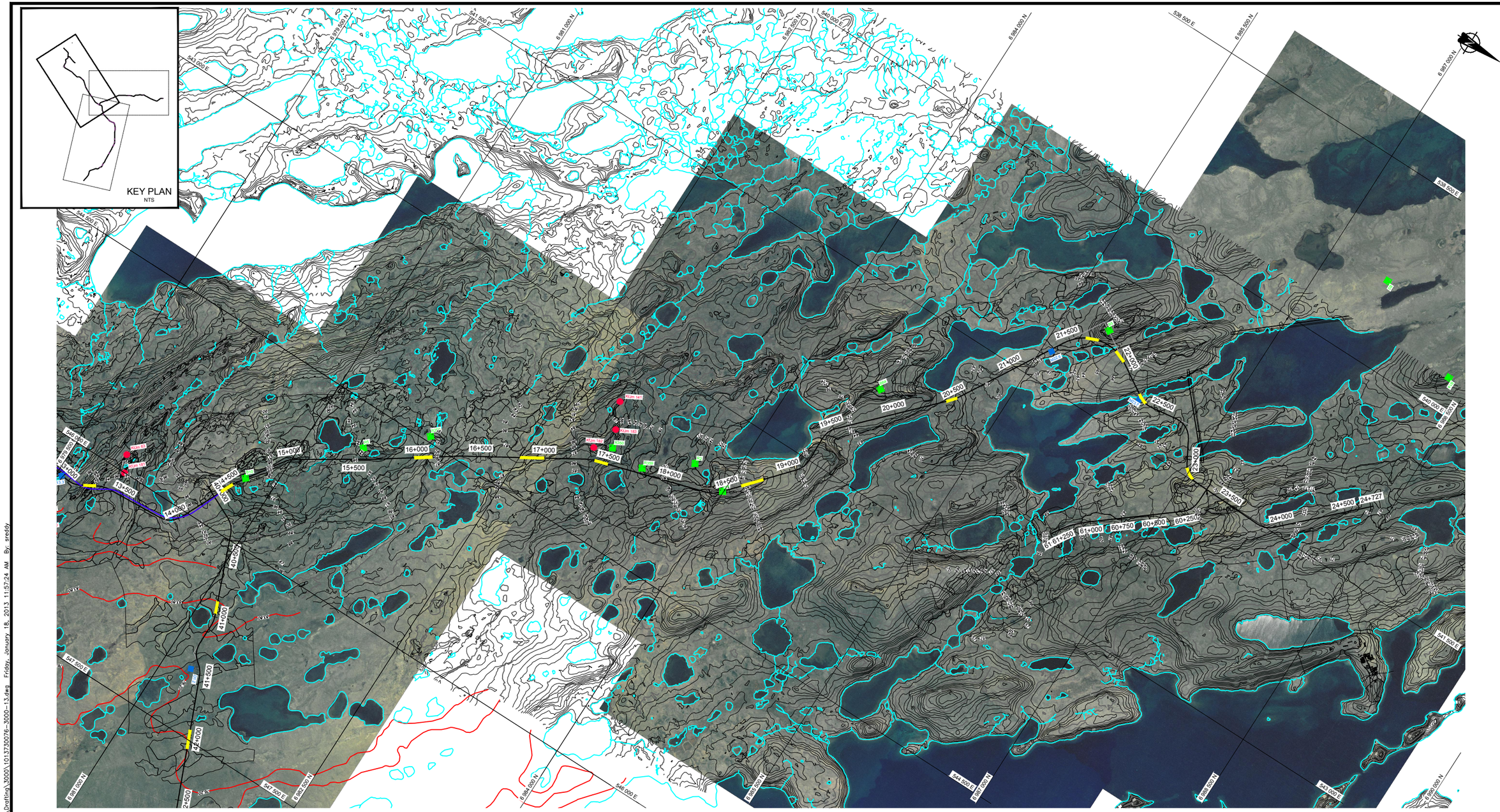

LEGEND

- Archaeology Site
- Potential Quarry Location
- Watercourse Crossing
- Watercourse
- EXISTING MAJOR CONTOUR (5m TOPO - SCHLENCKER DATA)
- EXISTING MINOR CONTOUR (1m TOPO - SCHLENCKER DATA)
- 7.7m EXISTING CONTOUR (NTS MAP SHEET DATA)
- POTENTIAL LOCATION OF SNOW DRIFT ACCUMULATION
- PROPOSED ROAD ALIGNMENT
- ALTERNATIVE ALIGNMENT PROPOSED BY ASSOCIATED ENGINEERING

0 150 300 450 600 750
SCALE IN METRES

NOTES

1. ROAD WIDTH AND FILL ARE NOT SHOWN.
2. ALL DIMENSIONS AND ELEVATIONS ARE IN METRES UNLESS NOTED OTHERWISE.
3. WATERCOURSE CROSSING LOCATIONS TO BE UPDATED DURING DETAILED DESIGN.

REFERENCES

1. BASE DATA OBTAINED FROM COMAPLEX MINERALS CORPORATION. BASE INFRASTRUCTURE AND PITS FROM COMAPLEX 04/12/09 (MELIADINE_PPD_SHAPEFILES_DEC09) AND TIRIGANIAQ PIT IS W24 PIT PROVIDED BY COMAPLEX, FEB 2010. DISPLACEMENT HAZARD MAPPING PROVIDED BY TERRY ROLLERSON (GOLDER, JULY 2009). PROJECTION: UTM ZONE 15 DATUM: NAD 83
2. TOPOGRAPHY PROVIDED BY COMAPLEX AS A COMBINATION OF GOVERNMENT ISSUED NTS MAP SHEETS AND DETAIL AERIAL SURVEY (SCHLENCKER DATA).

PROJECT
AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

POTENTIAL LOCATIONS FOR SNOW DRIFT ACCUMULATION CH. 14+000 TO CH. 24+727

Golder Associates

PROJECT No. 10-1373-0076			PHASE No.	3000	
DESIGN	AS	24MAY11	SCALE AS SHOWN	REV.	
CADD	JH	24MAY11			
CHECK	DW	14JAN13			
REVIEW	DW	14JAN13			

FIGURE 6.3-15

Drawing File: N:\Bur-Graphics\Projects\2010\1373\10-1373-0076\Drafting\3000\10137330076-3000-13.dwg Friday, January 18, 2013 11:52:24 AM By: steddy

6.3.6 Bedrock Geology and Surface Geomorphology of the Project Area

The surface geomorphology and bedrock geology of the Project area are described in detail in Golder (2010a).

The local overburden in the Project area typically consists of silt, sand and gravel deposits of various thicknesses overlying till with cobbles and boulders. A thin layer of organics covers much of the area.

Bedrock types consisting of metavolcanics, gabbro, greywacke, iron formation, siltstone and argillite were encountered during geotechnical field investigations (Golder 2010b and c).

Archean mafic metavolcanics and associated metasediments of the Rankin Inlet Group (Tella 1994) underlie the southern section of the Project area to a point about 2 km northeast of the Meliadine River. From this point north to Meliadine Lake, metamorphic rocks (schists) derived from the Rankin Inlet Group rocks dominate. The proposed AWAR route crosses an east-northeast trending band of Archean felsic to intermediate volcanic and associated metasediments (Tella 1994) a few kilometres north of the Meliadine River, and a west-northwest trending band of Proterozoic granites 13 to 14 km north of Rankin Inlet.

Within the Project area, changes in terrain type, material characteristics, and soil drainage conditions (soil drainage class) can be quite subtle, but highly variable, due to the low relief and subdued nature of the topography. As well, there has been extensive, but sometimes subtle modification of the landscape and surficial materials by complex coastal processes. The entire area was submerged at the end of the last glaciation, and has emerged over time. Consequently, much of the terrain within the study area exhibits relict (emergent) coastline features or materials. These features include relict shore platforms, rocky islets, low coastline scarps, gravelly beach berms or ridges, shell accumulations, and gently sloping mantles (veneers and blankets), or terraces composed of well to poorly sorted sands and gravels. Coarse cobble and/or boulder lags overlying morainal materials can be found vertically and spatially across the landscape. These coarse backshore and foreshore deposits are often found in close proximity to, or spatially intermixed with veneers comprising silty sandy to fine sandy silty diamictons (i.e., marine washed till) likely representative of lower energy, near-shore and/or offshore (below low tide) environments. These silty sandy to fine sandy silty surfaces often, but not always, contain shells.

Permafrost and periglacial processes have further modified these emergent coastal features creating a very complex landscape. Periglacial processes are most evident in areas underlain by morainal deposits and are typical of areas underlain by continuous permafrost. Surface expression is subdued in areas where there is a thin cover of surficial materials over bedrock and in areas of well-drained granular sediments.

A summary of the map units, soil cover types, and ground ice conditions in the Project area based on air photo interpretation and mapping is described in Golder (2010a) and summarized in the following table.

Table 6.3-6: Summary of Terrain Map Units, Soil Cover, and Ground Ice Conditions in the Project Area

Map Unit Type[a]	Soil Cover	Ground Ice
Organic (generally only as a minor component of other terrain units)	Veneers (Ov), humic	Likely present
Marine (W)	Gravelly (can include boulders and/or cobbles) to sandy beach ridges, terraces and veneers. Both beach and deltaic deposits.	Limited near surface, but likely present at depth, especially where till is present under the marine sediments.
Washed Morainal surfaces (washed till) (Mbv-W)	Diamictons. Gravelly to silty sandy to fine sandy silty veneers and possibly blankets (Mbv-W)	Limited near surface but present at depth. Possible excess ice at depth.
Morainal (assumed present under most washed morainal surfaces)	Blankets and likely some veneers, rubbly clasts in a fine grained matrix (M)	Possible excess ice (ice detected in soil)
		Generally wet sites
Glaciofluvial (F^G)	Sand or sand and gravel deposits (F^G)	Material is easy to excavate.
Weathered Bedrock (D) (Felsenmeer)	Rubbly mantles (Db)	Generally limited
	Rubbly veneers (Dx, Dv) with veneers (Ov, Mv)	Generally limited
Bedrock (R)	None	Generally limited
	With blankets (Db, Mb-W)	Possible excess ice
	With veneers (Dv, Mv-W)	Generally limited

[a] Map unit type based on most abundant surficial material interpreted from the air photos. Letter codes correspond to Howes and Kenk (1997).

The terrain in the regional and local study area has been classified in broad terms as thaw-susceptible or thaw-stable, based on its expected response to transitioning between the frozen and thawed state.

Thaw-susceptible soils exhibit a high loss of strength when thawed. These are typically fine grained, saturated to poorly drained or ice-rich soils. Such soils are easily disturbed by construction activities and cannot be used as construction materials.

Thaw-stable soils tend to retain their strength when thawed. These are typically free-draining, coarse grained, or granular soils. Such soils are preferred as construction materials due to their ability to retain strength under a variety of loading and drainage conditions.

The terrain mapping study (Golder 2010a) indicated that freeze and thaw induced displacement of soil can be expected in areas of the Project that are characterized by imperfectly to poorly-drained materials underlain by fine-grained morainal sediments. Physical weathering (frost wedging and frost shattering) is evident on exposed bedrock surfaces and in areas of rubbly, weathered bedrock.

6.3.7 Observed Periglacial Processes

Periglacial processes are most evident in areas underlain by morainal deposits and are typical of areas underlain by continuous permafrost. Surface expression is subdued in areas where there is a thin cover of surficial materials over bedrock and in areas of well-drained granular sediments.

The ground features and patterns observed on the air photos are typical of periglacial processes known to occur in permafrost terrain. The meaning and definition of the various geomorphic features and processes interpreted from the air photos follows the standard definitions given in van Everdingen (1998).

The periglacial processes present in the area fall into 3 main types as follows:

- physical weathering of in situ materials:
  - frost shattering;
  - frost wedging;
- freezing induced displacement of soils:
  - frost creep and creep of frozen ground;
  - frost heave (and cryoturbation in general);
  - frost jacking;
  - frost sorting;
- thaw induced displacement of soils:
  - solifluction is very limited; and
  - thaw consolidation leading to thaw settlement.

The surface expression for these processes in the Project area is locally subdued due to the thin cover of surficial materials and the generally well-drained conditions in shallower surficial materials in some areas.

6.3.7.1 Physical Weathering

Frost wedging and frost shattering occur on exposed bedrock and in coarse-grained block fields (felsenmeer).

6.3.7.2 Freezing Induced Displacement

Evidence of cryoturbation of the marine (W), washed morainal (M-W), weathered bedrock or felsenmeer (D), and glaciofluvial soils (F^{G}) occurs in the form of patterned ground; primarily small, low hummocks; “mud boils”; and cracks. Occasional stone rings have been observed in areas of weathered bedrock or areas of mixed till or marine sediments and weathered bedrock. These terrain features indicate that periglacial processes such as frost sorting, frost heave, and frost creep are acting on the surficial materials within the study area. These processes result in uplift perpendicular to the ground surface during freezing. During thaw, the uplifted material settles vertically leading to some lateral displacement on sloping surfaces.

6.3.7.3 Thaw Induced Displacement

Thaw settlement was not discernible from 1:10 000 scale air photos, but is expected to occur in many areas in the Project area as patterned ground is frequently present, especially in imperfectly and poorly-drained areas. Thaw consolidation leading to thaw settlement would be expected to occur following surface disturbance in areas where the surficial materials are thicker (e.g., greater than 2 m thick) and wetter (e.g., gently sloping or low-lying areas and low-lying areas near surface water). These areas likely will be more prone to thaw settlement than drier, thinner soils where bedrock is near the surface or well-drained, coarse marine sediments.

There is only very limited and localized evidence for rapid mass-movement of slopes through detachment failures or retrogressive thaw slumping visible on the air photos. The likelihood of detachment failures and retrogressive thaw slumping within the Project area appears low.

6.3.8 Susceptibility of Terrain to Periglacial Processes

The terrain units have been classified based on their susceptibility to periglacial processes. The following table summarizes the classifications used to develop displacement hazard plans, which are presented in Appendix 6.3-D.

Table 6.3-7: Susceptibility of Terrain to Periglacial Processes

Active Layer Process	Description	Susceptibility		
		Low	Moderate	High
Physical weathering of in situ materials	Rockfall or Minor Rock Displacement Frost Shattering Frost Wedging	■ Non-bedrock areas. ■ Bedrock areas with slope gradients typically < 60%. ■ Rubbly gravelly beach ridges, platforms, and veneers (gWrv).	■ Bedrock areas with slope gradients typically > 60%.	■ Observed rockfall areas.
Freezing induced displacements of soils	Frost creep Frost Jacking Cryoturbation	■ Felsenmeer (rDb). ■ Bedrock (R). ■ Veneers of wave washed till and/or marine sediments over bedrock. ■ Gravelly to coarse sandy beach ridges, terraces blankets, and veneers. ■ Glaciofluvial deposits.	■ Similar terrain as “High” but with moderately well-drained to imperfectly-drained conditions.	■ Washed morainal veneers over deeper till or complexes of marine and morainal sediments. Imperfectly to poorly drained. ■ Polygons including obvious patterned ground dominated by frost boils and/or low soil hummocks.
Thaw induced displacements of soils	Thaw settlement Thaw Slumping	■ Felsenmeer (rDb). ■ Bedrock (R). ■ Veneers of washed till and/or marine sediments over bedrock ■ Gravelly beach ridges, terraces, blankets, and veneers. ■ Glaciofluvial deposits.	■ Similar terrain as “High” but with moderately well-drained to imperfectly-drained conditions.	■ Washed morainal veneers over deeper till or complexes of marine and morainal sediments. Imperfectly to poorly drained. ■ Polygons including obvious patterned ground dominated by frost boils and/or low soil hummocks.

6.3.9 Pathway and Effects Analysis

A pathway analysis is a method for providing a screening level assessment of potential linkages between the Project and VECs such as physical, biological, cultural, social, and economic properties of the biophysical and human environments that are important to society. The pathway assessment may identify a particular Project activity as having no linkage, minor linkage, or primary linkage to the VECs. These terms are described as follows:

- No linkage – the pathway is removed by environmental design features and mitigation so that the Project results in no detectable environmental change, and no residual effects to a VEC relative to baseline or guideline values;
- Minor – the pathway could result in a measureable, but minor, environmental change but would have a negligible residual effect on a VEC relative to baseline or guideline values; and
- Primary – the pathway is likely to result in a measureable environmental change that could contribute to residual effects on a VEC relative to baseline or guideline values.

No linkage and minor pathways are not predicted to have significant residual effects on VECs and are not considered further in the effects assessment. However, primary pathways require further effects analysis and classification to assess the potential significance of impacts.

For the effects assessment, the Project was considered to have 3 stages: construction, operation, and decommissioning. The following assumptions were made in regards to the construction of the Project:

- During the construction period, construction of the Project will be year-round.
- During the operation period, operation of the Project will be 24-hours per day, year-round.
- Certain facilities and infrastructure may be susceptible to thaw instability, such as site access roads and AWAR, plant site and mill site foundations, and tailings dike foundations, and may be constructed during winter months if necessary to minimize the potential for thaw settlement beneath these structures.
- Where bedrock is near surface for certain thaw-sensitive facilities, stripping of the overburden materials down to sound bedrock, followed by backfilling with structural fill may be used as a construction method to mitigate against thaw settlement for critical structures.
- In most cases structural fill materials used for construction will be placed directly over the existing soil layer without cutting, stripping, or grubbing to avoid disturbing to the subgrade soils, the active layer, and permafrost.
- Structural fill materials will be placed to thicknesses that will promote the aggradation, or growth, of permafrost into the materials. This will promote the stability of the structural fills upon which facility foundations and infrastructure may be built.
- During construction of the AWAR, soils will be disturbed at stream crossings where culverts will be installed under winter frozen conditions, and such disturbance will be minimized to the extent possible by best management practices.

- During construction of the AWAR and the mine site, culverts will be placed to minimize ponding water during spring melt.

6.3.9.1 Results

Impacts on the terrain and permafrost will result from construction of the Project and from the mining activities during the operation of the mine. Some of these activities will result in physical gain of permafrost through permafrost growth into structural fills, as well as to the long term growth of permafrost to encapsulate the tailings storage facility and the various waste rock storage facilities. Other activities will result in physical loss of permafrost and permafrost terrain (soil and rock) due to extraction of rock and soil material for use in construction, and due to the physical mining of the open pits to extract the ore. Flooding of open pits at closure will result in the retreat of permafrost away from the flooded pit areas, and in some cases may result in the formation of through-taliks, connecting the surface hydrological regime with the sub-permafrost hydrogeological regime.

The following table summarizes the main Project activities, the potential effects pathways, and the environmental design features and mitigation strategies that will be utilized to reduce or eliminate impacts.

Table 6.3-8: Potential Pathways for Effects to Terrain and Permafrost

Project Component/Activity	Effects Pathway	Environmental Design Features and Mitigation	Pathway Assessment/ Section for Further Discussion
Construction Activities			
Construction: Earth moving, including excavation, drilling, blasting, grading, trenching, road building, backfilling and dumping; vehicle circulation and helicopter use.	Air emissions, dust deposition, or chemical contamination on the terrain and soils	Use of non-acid generating materials for road fills. Enforcing speed limits will assist in reducing dust emissions. Equipment and fleet equipped with industry-standard emission control systems. Operating procedures will be developed that reduce dust generation and air emissions (e.g., regular maintenance of equipment to meet emission standards). A spill plan will be developed for potential chemical spills, including hydrocarbons.	No Linkage/Section 6.3.9.4
Construction: Blasting activities at site and at quarries.	Degradation of permafrost and terrain (soil and rock) through removal of material.	Minimize depth and footprint area of quarries. Appropriate design of quarries to manage water appropriately and minimize ponding of water within the quarries which will result in a deeper active layer.	Minor/Section 6.3.9.3
Construction: Stripping, grubbing, removal and management of overburden from mine site footprint area and open pit footprint areas.	Degradation of permafrost and terrain (soil and rock) through removal of material and ground disturbance. Physical changes to the permafrost in the area of the mine site footprint.	Minimize footprint areas for stripping and removal of material. Minimize ground disturbance by limiting vehicle circulation and by establishing appropriately designed site access roads.	Minor/Section 6.3.9.3
Construction: Temporary buildings (footprint and height)	Physical changes to permafrost due to temporary building footprint area.	Minimize footprint area and limit exposure time.	No Linkage/Section 6.3.9.4
Construction: Mine site facilities, including power plant, paste plant, mill/process plant, ore stockpile pads, crushers, concrete plant, assay plant, sewage treatment plan, mine maintenance shops, and accommodation complex.	Air emissions, dust deposition, or chemical contamination on the terrain and soils.	Use of non-acid generating materials for road fills. Enforcing speed limits will assist in reducing dust emissions. Equipment and fleet equipped with industry-standard emission control systems. Operating procedures will be developed that reduce dust generation and air emissions (e.g., regular maintenance of equipment to meet emission standards).	No Linkage/Section 6.3.9.4
Construction: Mine site facilities, including power plant, paste plant, mill/process plant, ore stockpile pads, crushers, concrete plant, assay plant, sewage treatment plan, mine maintenance shops, and accommodation complex.	Physical alteration of terrain, soils, and permafrost due to earthworks, facilities construction, and ground disturbance. Gain of permafrost into structural fills used for foundations. Physical removal of permafrost soils and rock where stripping is required.	Use of appropriate engineering design for structural fills and fill thickness to promote permafrost growth. Minimize footprint areas of facilities and infrastructure. Minimize footprint areas and excavation depth of any quarrying for construction materials to limit permafrost degradation. Minimize ground disturbance.	Primary/Section 6.3.9.2

Table 6.3-8: Potential Pathways for Effects to Terrain and Permafrost (continued)

Project Component/Activity	Effects Pathway	Environmental Design Features and Mitigation	Pathway Assessment/ Section for Further Discussion
Construction: AWAR and site roads	Physical alteration of terrain, soils, and permafrost due to earthworks, facilities construction, and ground disturbance. Gain of permafrost in structural fills used to construct AWAR and site roads.	Use appropriately designed structural fill and thickness to promote permafrost growth. Minimize footprint of roads while maintaining safe construction and operation practices. Use appropriate engineering design and construction practices for permafrost environments.	Primary/Section 6.3.9.2
Construction: AWAR and site roads	Use of potential acid generating materials from road building materials can affect terrain and soil quality	Use of non-acid generating material for road construction.	No Linkage/Section 6.3.9.4
Construction: Fuel tank farm	Use of petroleum products, and maintenance of vehicles may result in hydrocarbon spills infiltrating the active layer. Physical loss of permafrost from latent heat of petroleum and fuel oil stored in tank farm.	Appropriate operations and maintenance procedures in place for the operation of the fuel tank farm. Appropriate re-fueling areas and procedures to minimize and capture spills. A spill plan will be developed for potential chemical spills, including hydrocarbons. Appropriate design and construction of fuel tank farm foundations using thaw-stable materials and to thickness' to promote permafrost growth and stability. Appropriate site maintenance buildings for the repair and maintenance of vehicles will be constructed.	No Linkage/Section 6.3.9.4
Construction: Water management (dams, drainage, diversion, intake, discharges and dewatering).	Ponding of water can result in permafrost degradation due to thickening of the active layer. Water diversion and discharge may result in soil erosion.	Minimize ponding of water adjacent to roads, infrastructure, and facilities by promoting drainage and installing appropriate water diversion structures.	Minor/Section 6.3.9.3
Construction: Sewage Treatment and disposal	Physical alteration of terrain, soils, and permafrost due to earthworks, facilities construction, and ground disturbance.	Appropriately designed facility to contain and manage sewage. Minimize ground disturbance. Use appropriate engineering design and construction practices for permafrost environments.	Minor/Section 6.3.9.3
Construction: Waste management (landfill and biopile)	Physical alteration of terrain, soils, and permafrost due to earthworks, facilities construction, and ground disturbance. Physical removal of permafrost soils and rock where stripping is required. Gain of permafrost into waste rock pile foundations.	Minimize stripping of materials. Operate waste management as part of waste rock piles to promote growth of permafrost into the foundation of the piles and promote isolation of waste from the environment.	Minor/Section 6.3.9.3

Table 6.3-8: Potential Pathways for Effects to Terrain and Permafrost (continued)

Project Component/Activity	Effects Pathway	Environmental Design Features and Mitigation	Pathway Assessment/ Section for Further Discussion
Construction: Snow clearing and stockpiling	Stockpiling or clearing of snow can result in the insulation of the active layer and may result in ground instability from thaw subsidence and thickening of the active layer.	Stockpile snow on thaw-stable soils, or in areas that are insensitive to thaw settlement. Use appropriate drainage and water diversion structures to minimize water ponding during thaw.	Minor/Section 6.3.9.3
Construction: Shipping and unloading (marine and land)	Physical alteration of terrain, soils, and permafrost due to earthworks, facilities construction, and ground disturbance. Gain of permafrost into structural fills used to construct lay-down pads and unloading areas.	Use appropriate engineering design for structural fills and thickness to promote growth of permafrost into fill materials.	No Linkage/Section 6.3.9.4
Construction: Use of structural fill pads for facilities; construction of site roads.	Physical changes to the permafrost table and active layer in rock and soils beneath and adjacent to the project footprint resulting from ground disturbance during construction. Placement of fill materials during the summer could insulate warm temperatures in subgrade soils leading to permafrost degradation.	The road alignment has been chosen to avoid areas that are ice-rich and, therefore, more susceptible to disturbance. Thaw-stable construction fills will be used to construct the road. Fill thickness' is designed to preserve the permafrost and promote permafrost growth into the thaw-stable road fills. Road fill material will be placed directly over the existing soil layer without cutting, stripping, or grubbing to avoid disturbing the subgrade soils. Placement of much of the road construction materials during winter will minimize disturbance to the permafrost. Only thick drifted snow greater than 1 m thick will be removed before the road fills are placed.	No Linkage/Section 6.3.9.4
Construction: Quarrying and crushing activities at borrow pits for road fills and surfacing.	Air emissions and dust deposition on the terrain and soils Physical changes to the permafrost table and active layer by quarry excavation. Degradation of rock and soil slopes due to annual freeze-thaw processes.	Minimize quarrying activities and use dust suppression measures where appropriate. Active layer and permafrost table will equilibrate to final quarry shape and profile. Minimize depth of quarrying to limit impact on active layer. Appropriate design of quarry walls to promote stability, and to minimize annual slope degradation. Quarries will be shallow excavations and will be closed on completion using current industry standards and practices.	No Linkage/Section 6.3.9.4
Construction: Quarrying and crushing activities at borrow pits for road fills and surfacing; borrow pit and overburden management, construction of infrastructure and	Use of quarried materials results in rock and soil volume loss in specific quarry locations, and permafrost degradation. Permafrost degradation due to borrow source and quarry development;	Minimize volume of quarried materials required. Quarries will be excavated and sloped for positive drainage. Maximum quarry depths of 3 m are currently planned. The proximity of excavations to watercourses will be to current regulatory standards.	Minor/Section 6.3.9.3

Table 6.3-8: Potential Pathways for Effects to Terrain and Permafrost (continued)

Project Component/Activity	Effects Pathway	Environmental Design Features and Mitigation	Pathway Assessment/ Section for Further Discussion
facilities, use of heavy equipment, vehicle circulation and helicopters	development of closed taliks beneath quarry 'lakes' if quarries are improperly graded and drained	Drainage from quarries will not flow directly into any waterbodies or watercourses; drainage will be directed to swales before runoff can enter watercourses.	
Construction: Quarrying and crushing activities at borrow pits for road fills and surfacing; borrow pit and overburden management, construction of infrastructure and facilities, use of heavy equipment, vehicle circulation and helicopters	Physical loss or permanent alteration of terrain, soils, and permafrost within the quarried areas.	Minimize surface area to be quarried. Use current industry standard practices to close quarry sites to minimize rock and soil cuts and restrict where possible the development of quarry lakes by promoting drainage from sites.	Minor/Section 6.3.9.3
Construction: Quarrying and crushing activities at borrow pits for road fills and surfacing; borrow pit and overburden management, construction of infrastructure and facilities, use of heavy equipment, vehicle circulation and helicopters	Alteration of drainage paths adjacent to quarries may impact permafrost.	Quarries will be excavated and sloped for positive drainage. The proximity of excavations to watercourses will be to current regulatory standards. Drainage from quarries will not flow directly into any water bodies or watercourses; drainage will be directed to swales before runoff can enter watercourses.	No Linkage/Section 6.3.9.4
Operation Activities			
Operation: Open pit mining	Physical loss or permanent alteration of terrain, soils, and permafrost within the mined out areas. Permafrost degradation and retreat due to excavation of open pits. Potential groundwater inflows to the open pit during operations if depth extends below the base of permafrost.	Appropriate design of open pit walls to promote stability, and to minimize annual slope degradation. Management of water inflows to the pit will require sumps and pumps to collect the water for monitoring and, if necessary, treatment before discharge.	Primary/Section 6.3.9.2
Operation: Underground mining	Permafrost degradation and retreat during excavation of underground mine. Potential for extension of mining below the base of permafrost.	Appropriate design of underground workings to promote stability and minimize opening dimensions. Appropriate operations of underground mine to minimize introduction of heated air in to mine openings. Use appropriate back filling methods for the placement of fill material. Initial permafrost retreat that may occur during the placement of backfill may be replaced by permafrost re-establishing within the backfilled areas.	Minor/Section 6.3.9.3

Table 6.3-8: Potential Pathways for Effects to Terrain and Permafrost (continued)

Project Component/Activity	Effects Pathway	Environmental Design Features and Mitigation	Pathway Assessment/ Section for Further Discussion
Operation: Mine site facilities, including power plant, paste plant, mill/process plant, ore stockpiles, crushers, concrete plant, assay plant, sewage treatment plant, mine maintenance shops, and accommodation complex (footprint and height of facilities)	Physical gain of terrain and permafrost within the structural fills used to construct site facilities and infrastructure. Permanent alteration of terrain, soils, and permafrost beneath the structural fills used to construct site facilities and infrastructure.	Use of thaw-stable materials in structural fills to support site facilities and infrastructure. Use appropriate cold regions construction practices for the construction of site facilities and infrastructure to minimize permafrost degradation and to promote permafrost growth. Use of appropriate elevated structures to minimize permafrost degradation.	No Linkage/Section 6.3.9.4
Operation: Waste rock storage facilities	Physical gain of terrain and permafrost within the waste rock piles. Permanent alteration of terrain, soils, and permafrost beneath the waste rock piles.	Design and use of appropriate water management structures to minimize ponding of water adjacent to waste rock piles. Where possible begin construction during winter months, when active layer is frozen. Place waste rock in lifts to promote freezing of pile.	Minor/Section 6.3.9.3
Operation: Tailings area storage facility	Physical gain of terrain and permafrost within the tailings storage facility. Permanent alteration of terrain, soils, and permafrost beneath the tailings storage facility.	Use appropriate design of facility to promote the growth of permafrost into the base of the facility and into the tailings. Use appropriate facilities management methods to reduce the amount of ice trapped within the facility. Use appropriate tailings deposition plan (tailings placed in layers to promote freezing, and maintain a centralized pond).	Primary/Section 6.3.9.2
Operation: Use of heavy equipment, vehicle circulation, and helicopter use	Degradation of permafrost due to traffic frequency, vehicle weight.	Use of appropriate structural fills and thickness for site roads, lay-down areas, and pads.	No Linkage/Section 6.3.9.4
Operation: Fuel tank farm, use of petroleum products, and maintenance of vehicles	Physical gain of terrain and permafrost within the structural fills used to construct fuel tank farms. Permanent alteration of terrain, soils, and permafrost beneath the structural fills used to construct fuel tanks farm. Physical loss of permafrost from latent heat of petroleum and fuel oil stored in tank farm.	Appropriate design and construction of fuel tank farm foundations using thaw-stable materials and to thickness to promote permafrost growth and stability, and to limit permafrost degradation. A spill plan will be developed for potential chemical spills, including hydrocarbons.	No Linkage/Section 6.3.9.4
Operation: Water management (dams, drainage, diversion, intake, discharge, and dewatering)	Ponding of water, or high volume flow during freshet may degrade frozen ground conditions.	Use appropriate water management methods to avoid water ponding and to control high volume potentially erosive flows.	No Linkage/Section 6.3.9.4

Table 6.3-8: Potential Pathways for Effects to Terrain and Permafrost (continued)

Project Component/Activity	Effects Pathway	Environmental Design Features and Mitigation	Pathway Assessment/ Section for Further Discussion
Operation: Waste management (landfill and biopile)	Management of the landfill and biopile may degrade permafrost.	Use appropriate waste management methods to operate the facilities within the proposed waste rock piles, to promote permafrost growth. Operate the landfill and biopile in an area of the waste rock pile that will not result in permafrost degradation.	No Linkage/Section 6.3.9.4
Operation: Shipping and unloading (marine and land)	Permafrost degradation and thaw settlement in the laydown area due to high traffic circulation and loads.	Minimize traffic circulation in the lay down area. Use thaw-stable materials for the construction of the lay-down area.	No Linkage/Section 6.3.9.4
Operation: Snow clearing and stockpiling	Snow clearing and stockpiling may result in insulation of the active layer, incomplete freezing of the active layer, and subsequent thaw settlement.	Stock pile snow on thaw-stable materials. Use snow fencing where appropriate to minimize snow clearing requirements.	Minor/Section 6.3.9.3
Operation: Road use and maintenance activities	Permafrost degradation and thaw settlement along road edges due to 1. snow drifting and snow accumulation in lee of road; 2. snow accumulation along toe of road shoulders from winter plowing; and 3. pooling of water and ice lens growth.	Install culverts to promote drainage. Where possible, construct road along exposed ridge lines to reduce potential snow accumulation. Where possible use thaw-stable road fills for construction. Annual road maintenance as required.	Minor/Section 6.3.9.3
	Freezing and plugging of culverts in the winter may result in 1. inadequate drainage during spring thaw and freshet, 2. over-topping and erosion of road surface releasing silt onto terrain and soils; 3. pooling of water adjacent to road flanks; 4. potential instability and thaw settlement of road shoulders; 5. thaw settlement beneath and adjacent to culverts; and 6. ice lens growth.	Use appropriate culvert design based on the site specific hydraulics. Use of staggered culvert configuration to promote drainage during spring thaw and freshet. Regular inspection of the road to identify any areas where ponding of water along the road represents a risk, and installing additional culverts to alleviate the risk.	No Linkage/Section 6.3.9.4

Table 6.3-8: Potential Pathways for Effects to Terrain and Permafrost (continued)

Project Component/Activity	Effects Pathway	Environmental Design Features and Mitigation	Pathway Assessment/ Section for Further Discussion
Operation: Road use and maintenance activities (continued)	Air emissions, dust deposition, or chemical contamination on the terrain and soils	Dust suppression through regular surface maintenance (e.g., grading, adding coarse top material), and watering where the AEM road supervisor identifies areas prone to high dust levels, or areas where dust may be adversely affecting water quality or fish habitat. Use of non-acid generating materials for road bed and fills. Enforcing speed limits will assist in reducing dust emissions. Equipment and fleet equipped with industry-standard emission control systems. Operating procedures will be developed that reduce dust generation and air emissions (e.g., regular maintenance of equipment to meet emission standards). A spill plan will be developed for potential chemical spills, including hydrocarbons.	No Linkage/Section 6.3.9.4
Decommissioning and Closure Activities			
Decommissioning and Closure: Flooding of pits to form pit lakes	Flooding of pits at closure will result in the creation of a talik beneath the pit lake. The talik may be closed, or it may be open, depending on the depth of the pit and the size of the pit lake that is formed. If an open talik is formed beneath the pit lake, the lake will become either a regional discharge point, or a regional recharge point, for the sub-permafrost groundwater system. If an open talik is formed a hydraulic connection will exist between the pit lakes and the sub-permafrost groundwater system. There will be the potential for constituent transport from the pit lakes into the groundwater system.	Monitor pit lake water quality.	Primary/Section 6.3.9.2
Decommissioning and Closure: Underground mine closure	Backfilling during operations and flooding of underground workings at closure may result in permafrost re-establishing in the areas of the workings not beneath lakes.	Use appropriate mine closure methods to decommission the underground workings and to close the portal. Monitor appropriately.	Primary/Section 6.3.9.2

Table 6.3-8: Potential Pathways for Effects to Terrain and Permafrost (continued)

Project Component/Activity	Effects Pathway	Environmental Design Features and Mitigation	Pathway Assessment/ Section for Further Discussion
	If underground mine workings extend below the base of permafrost, or are located beneath pit lakes large enough to develop an open talik, then there may be a hydraulic connection between the pit lakes, underground workings, and sub-permafrost groundwater system.		
Decommissioning and Closure: Demolition and removal of mine site facilities, including power plant, paste plant, mill/process plant, ore stockpiles, crushers, concrete plant, assay plant, sewage treatment plant, mine maintenance shops, and accommodation complex (footprint and height of facilities)	Physical gain of terrain and permafrost within the structural fills used to construct project components. Ponding of water adjacent to facilities and infrastructure may degrade permafrost.	Use appropriate demolition methods to remove mine site facilities and to render infrastructure impassible. Water management and appropriate drainage and diversion around facilities; infrastructure graded to promote site drainage.	No Linkage/Section 6.3.9.4
Decommissioning and Closure: AWAR and site road network	Ponding of water adjacent to site roads may degrade permafrost. Sediment and contaminant releases during removal of culverts can affect downstream soil and terrain.	Roads will be scarified, and water barred to promote drainage of water. Where possible, in-stream work will be limited to when watercourses are not flowing for ephemeral watercourses or when watercourses are frozen. If any of the culverts need to be removed when the watercourses are flowing, the work will be completed late in the summer, and best management practices for erosion and sedimentation control (e.g., silt curtains, runoff management) will be employed.	No Linkage/Section 6.3.9.4
Decommissioning and Closure Ripping and dozing activities; general decommissioning activities	Ripping of road surface and slopes can result in dust emissions and affect down-wind soil and terrain.	Minimize activity using appropriate equipment and re-establish drainage paths and promote permafrost re-equilibration within the decommissioned road bed. Make road surfaces impassable by vehicular traffic.	No Linkage/Section 6.3.9.4
Decommisioning and Closure: Waste management (landfill and biopile)	Transport of contaminants within the active layer	Use appropriate methods for closing the waste management areas (landfill and biopile) to enhance and promote the growth of permafrost into these materials, and to limit the thickness the active layer.	

Primary pathways require further effects analysis to determine the environmental significance from the Project on terrain and permafrost. Pathways determined to have no linkage to terrain and permafrost or those that are considered minor are not predicted to result in environmentally significant effects on terrain and permafrost. No linkage and minor pathways are summarized in the table above but are not carried through the effects assessment.

The following sections discuss the potential pathways relevant to the terrain and permafrost.

6.3.9.2 Primary Pathways

The following primary pathways are analyzed and classified in the effects assessment.

- **Physical loss or permanent alteration of terrain and soils within the Project footprint.**

Construction of the Project will minimize impact to permafrost, terrain, and soils and will limit potential thaw-settlement of infrastructure due to permafrost degradation. The construction and road fills will be placed directly over existing terrain, including soils and vegetation, without stripping or grubbing to avoid disturbance of the subgrade soils. Construction and road fill thicknesses will be designed to promote the aggradation of permafrost into the thaw-stable fill materials to enhance the stability of the foundations and overlying structural fill materials.

A summary of the general terrain types that will be covered over during the construction of infrastructure and facilities at the Project, and the approximate area loss for the map unit types within the maximum Project footprint area are presented in the Table 6.3-9.

Table 6.3-9: Summary of Terrain Units and Area Affected by Project Footprint

Terrain Code[a]	Terrain Unit[a]	Area (ha)	Cumulative (ha)	Percentage of Total Area Covered by Project Footprint
1	Beach Ridge	9.54	9.54	0.9%
2A	Beach Deposit	30.81	54.98	4.9%
2B		18.60		
2C		1.62		
2D		1.15		
2E		2.80		
3A	Deltaic Terrace, Level, and/or Ridge, Plain	1.14	5.13	0.5%
3B		0.76		
3C		1.44		
3D		1.79		
4A	Marine Sediment and Washed Till	38.75	68.95	6.2%
4B		15.28		
4C		12.42		
4D		2.50		
5A	Blanket and Veneer of Washed Till	15.97	763.94	68.4%
5B		68.77		
5C		90.16		
5D		252.67		

Table 6.3-9: Summary of Terrain Units and Area Affected by Project Footprint (continued)

Terrain Code[a]	Terrain Unit[a]	Area (ha)	Cumulative (ha)	Percentage of Total Area Covered by Project Footprint
5E		185.45		
5F		150.92		
6A	Glaciofluvial Ridge or Slope	5.88	8.44	0.8%
6B		2.56		
7A	Fluvial Level and/or Terrace	0.05	0.18	0.0%
7B		0.13		
8	Weathered Bedrock	1.45	1.45	0.1%
9A	Weathered Bedrock and Washed Till or Marine Sediments, Lesser Bedrock	3.19	3.19	0.3%
10	Weathered Bedrock and Washed Till or Marine Sediments, Minor Bedrock	24.30	24.3	2.2%
11	Bedrock and Weathered Bedrock	10.37	10.37	0.9%
12A	Washed Till and/or Marine Sediment, Weathered Bedrock	6.93	10.98	1.0%
12B		0.60		
12C		3.45		
LAKE	Lake	154.75	154.75	13.9%
Total		**1116.24**		**100%**

[a] Terrain codes and terrain units are described in detail in Appendix 6.3-A and 6.3-B.
ha = hectare

- **Physical loss or permanent alteration of terrain and soils within the Project area.**

Construction materials for site infrastructure will be quarried during pre-development. Construction materials for the AWAR road will be quarried from sites along the proposed route. Depending on the material types overlying the bedrock, and the requirements for road construction, it is possible that much of the terrain and soil types will not be suitable for road construction; consequently such materials will be stripped and spoiled. Some, or all, of the spoil materials may be used to partially backfill quarry areas after quarrying is complete.

Table 6.3-10 summarizes the approximate areas of disturbance for the currently planned quarries, along with the quantities of materials proposed to be quarried from each site.

Table 6.3-10: Approximate Areas of Disturbance for the Proposed Quarries

Quarry	Area (ha)	Primary Map Unit or Terrain Type Code
Rock Quarries		
R19	1.3	11, 3D, 6A
R11	7.6	10, 11, 12C, 5E, 5F
R14	2.6	10, 12A, 5A
R2	2.1	4A, 5C, 5E, 5F
R5	26.1	10, 11, 12A, 12C, 4A, 9A
Eskers, Till/Gravel Pits		
B19	0.8	3B, 3D, 7B
B15	1.8	4A, 5C
B13	2.1	10, 2A, 4A
B12	7.9	11, 2A, 2B, 2C, 2E, 5E, Lake
B11A	17.4	2A, 2B, 4A, 5B, 5C, 5E, 5F, Lake
B10	2.0	10, 11, 12C, 2A, 8, 9A
R350	3.1	
B6A	17.2	2A, 2B, 4A, 4B, 5A, 5B, 5C, 5D, 5E, 5F
B5	18.8	1, 5B, 5C, 5D, 5E, 5F
B1A	24.2	1, 4A, 5A, 5B, 5D, 5F, 8, Lake
Total	**133.7**	

ha = hectare

- **Physical gain of terrain and permafrost within the tailings storage facility; permanent alteration of terrain, soils, and permafrost beneath the tailings storage facility.**

The use of Lake B7 as a tailings storage facility requires draining of the lake water and placing a thickened tailings into the tailings storage basin. This will result in the growth of permafrost into the base of the tailings and the facility as the talik beneath Lake B7 equilibrates with the surrounding permafrost. Over time, the open talik that is currently predicted to exist beneath Lake B7 will freeze, resulting in the formation of continuous permafrost beneath the facility and effectively isolating the tailings and tailings water constituents within the basin.

To evaluate this scenario, a simplified 1-dimensional thermal model was developed. A description of the analytical methodology, input parameters, and results are contained in Appendix 6.3-E. The results are briefly described below.

The 1-d model considered the tailings storage facility to consist of 2 main components:

- The B7 lake basin itself generally consisting of about 6 m thick saturated till overlying a 3 m thick zone of weathered bedrock underlain by 300 m of bedrock; and
- The dry ground surface adjacent to the lake generally consisting of about 2.5 m thick surface layer of sand and gravel, underlain by a 6 m thick till layer, and a 3 m thick zone of weathered bedrock above 300 m of bedrock.

The depth of tailings within the proposed tailings deposit was assumed to be 27 m, which occurs at the deepest portion of the lake at an elevation (El.) of 58 m (tailings assumed at El. 85 m). The tailings placed on dry ground were assumed to have a depth of 21 m, with the ground at El. 64 m and the tailings at El. 85 m.

A minimum 3 m thick rockfill cap is planned to be placed over the tailings at the end of operations, and this layer was included in the models.

Initial Steady State Model

An initial steady state model was run to calculate the current ground conditions, prior to the placement of tailings.

For the scenario where the tailings are placed in the lake basin, constant boundary conditions were set resulting in the ground being initially unfrozen at a constant temperature of 1°C down to El.-250 m.

For the scenario where the tailings are placed on dry ground, a constant ground surface temperature of -7.9°C (the current annual average) and a constant bedrock temperature of -0.5°C at El. -250 m were assumed. This results in the ground being initially frozen down to El.-250 m.

Transient 100 year Model

A transient model was run for a period of 100 years considering instantaneous placement of the tailings to the full capacity of the facility at time zero, and at a temperature of 6°C. This is considered conservative as the tailings would in fact be placed in layers and would freeze progressively throughout the mine life.

To investigate the potential effect of climate change, an additional case with increasing surface temperature was considered for the two scenarios. The climate change model that was considered follows the worst case "high sensitivity" model described by the Intergovernmental Panel on Climate Change (IPCC 2007). This model predicts an increase of 6.4°C in the maximum air temperature by the year 2100 for a site located at 65°N latitude. For the thermal model, the 6.4°C temperature increase is assumed to occur uniformly over the 100 year period, equivalent to an annual increase of 0.064^{o} C. The geothermal gradient is assumed to be constant.

Results

The model results for the two scenarios, assuming tailings placed within the current Lake B7 area and on dry ground adjacent to Lake B7, are presented below.

The results of the thermal model for tailings placed directly in to the Lake B7 basin are presented on Figure 6.3-16. The following table summarizes the length of time required to freeze the tailings and foundation materials for the model scenario with tailings placed into the current Lake B7 basin for both current temperatures and temperatures affected by climate change.

Table 6.3-11: Time to Freeze Tailings and Foundation Within Lake B7

Location in Section	Approximate Time to Freeze (years)	
	Current average temperature	Assuming Climate Change Predictions
Mid-depth of tailings (El. 71.5 m)	12 years	12 years
Base of Tailings (El. 58 m)	28 years	28 years
Bedrock surface (El. 52 m)	40 years	41 years
Bedrock 66 m below tailings surface (El.19 m)	95 years	100 years

The thermal model for the tailings placed in the on-land area around Lake B7 is presented on Figure 6.3-17. The computed number of years required for freezing of the tailings and re-freezing of the foundation for the model scenario with tailings placed on dry ground for both current temperatures and climate change temperatures, are summarized in the following table.

Table 6.3-12: Time required to Freeze Tailings and Foundation – On dry Ground

Location in Section	Approximate Time to Freeze (years)	
	Current average temperature	Assuming Climate Change Predictions
Mid-depth of tailings (El. 74.5 m)	3 years	3 years
Base of Tailings (El. 64 m)	Less than 1 year	Less than 1 year
Bedrock surface (El. 55.5 m)	Remains Frozen	Remains Frozen

The simplified thermal model of the proposed tailings area within Lake B7 indicates that complete freezing of the tailings, foundation soils and bedrock will occur with time even when climate change is considered. The model results also suggest that minimal thawing of the original ground is expected in permafrost areas.

For tailings placed into the drained Lake B7 basin, freezing of the basin is predicted to take approximately 40 years at the bedrock surface. Tailings placed on to dry land are predicted to freeze to the base of the tailings in less than 1 year.

In both the base case, and the modeled climate change case, permafrost eventually is established within the base of the tailings storage facility. Consequently, in the long term it is expected that the talik will close beneath Lake B7.

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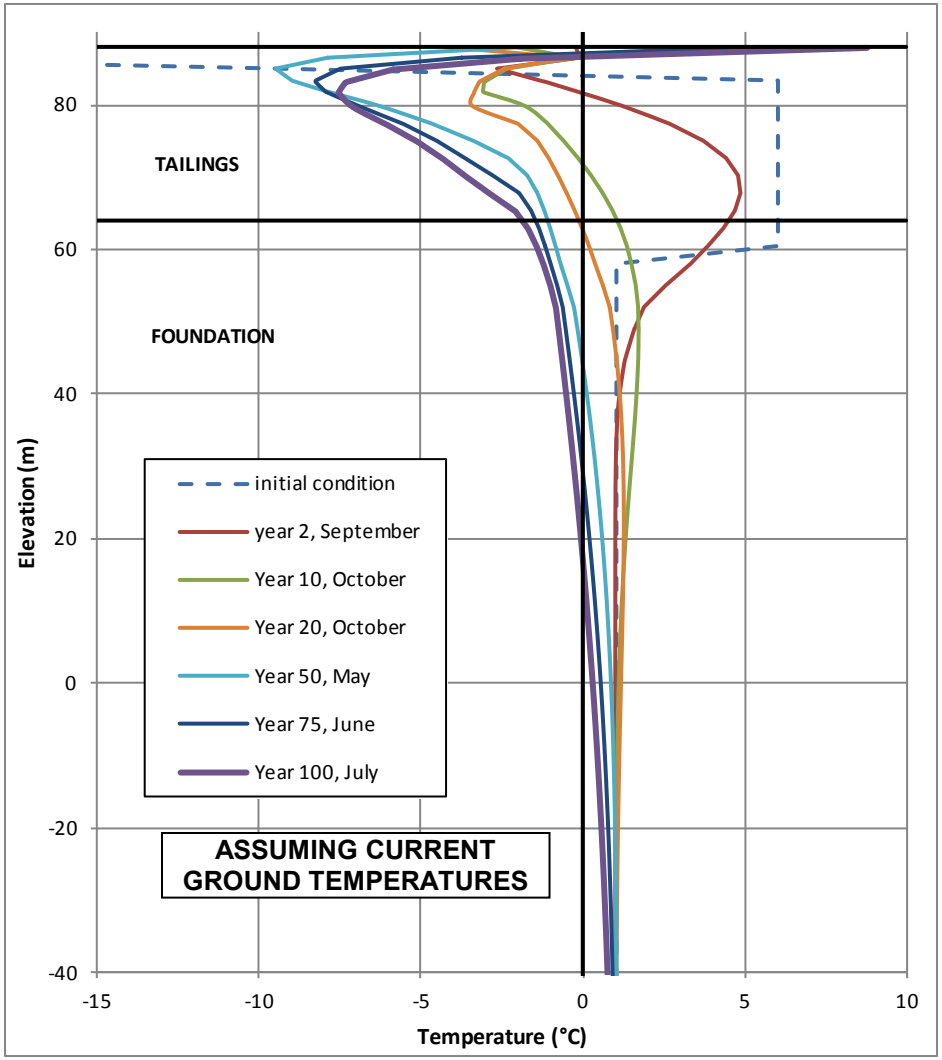

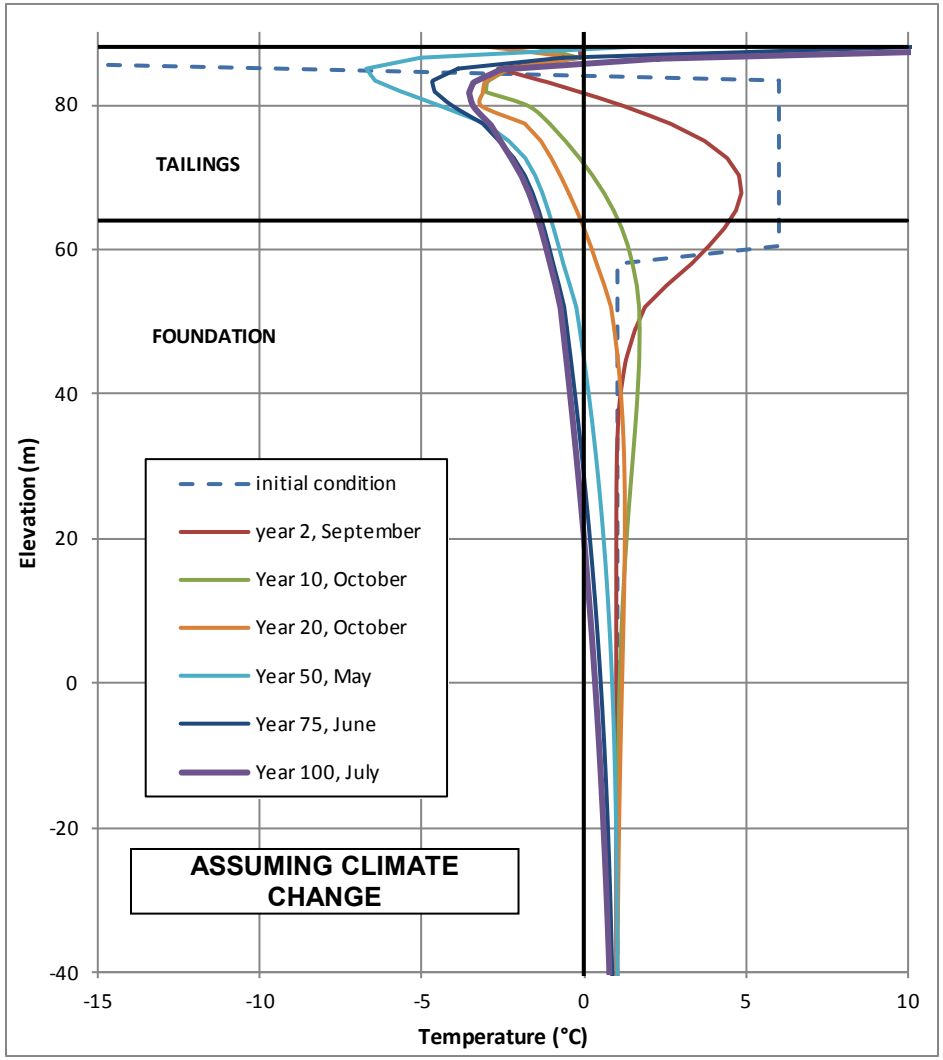

NOTES:

1. Current ground temperatures are based on ground temperatures at a depth of 5 cm measured at Meliadine West Site between 1997 and 2001
2. Climate change assumes a uniform increase in temperature of 6.4°C over the next 100 years (IPCC, 2007 suggest a range of 2.4°C to 6.4°C increase in global average).

PROJECT
AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
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TITLE
1-D THERMAL ANALYSIS TAILINGS STORAGE FACILITY TAILINGS COLUMN WITHIN LAKE B7

Golder Associates

PROJECT No.	10-1373-0076		PHASE No. 8000	
DESIGN	GJ	03OCT12	SCALE NTS	REV.
CADD	GJ	03OCT12	**FIGURE 16.3-16**	
CHECK	DW	14JAN13		
REVIEW	DW	14JAN13		

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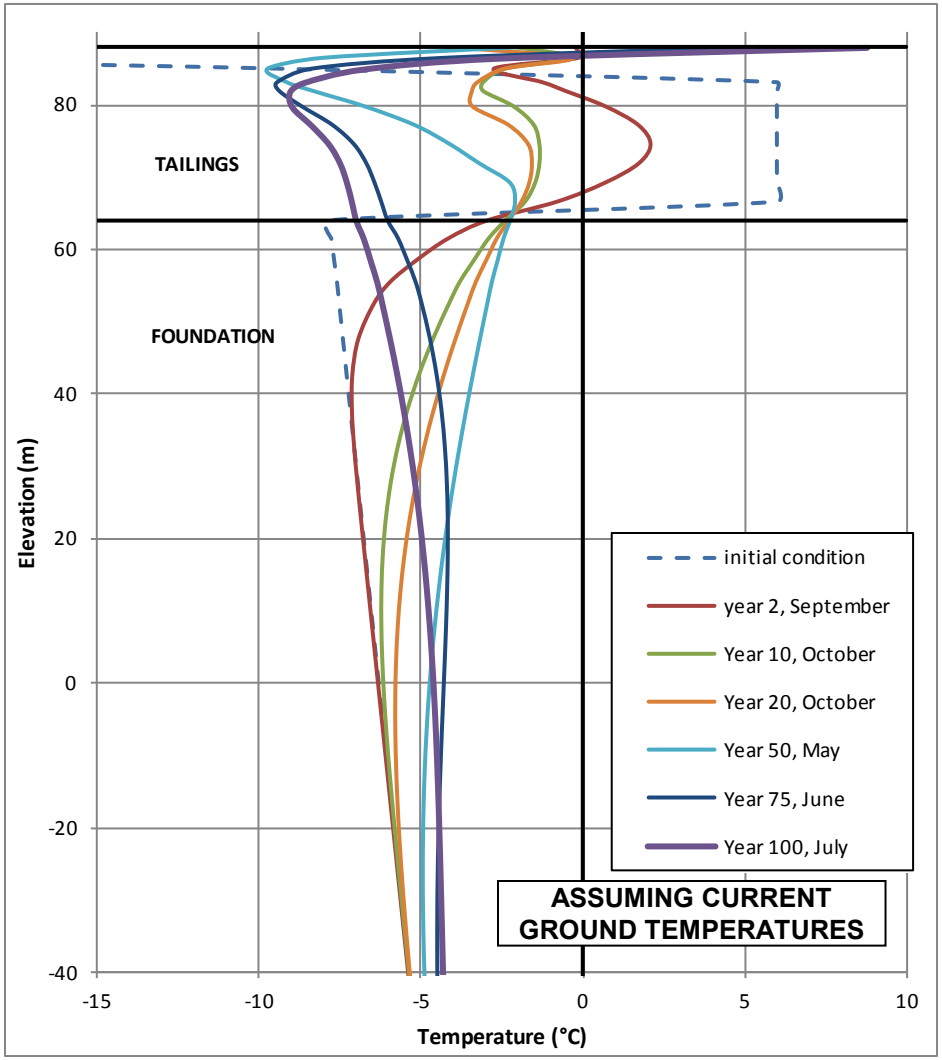

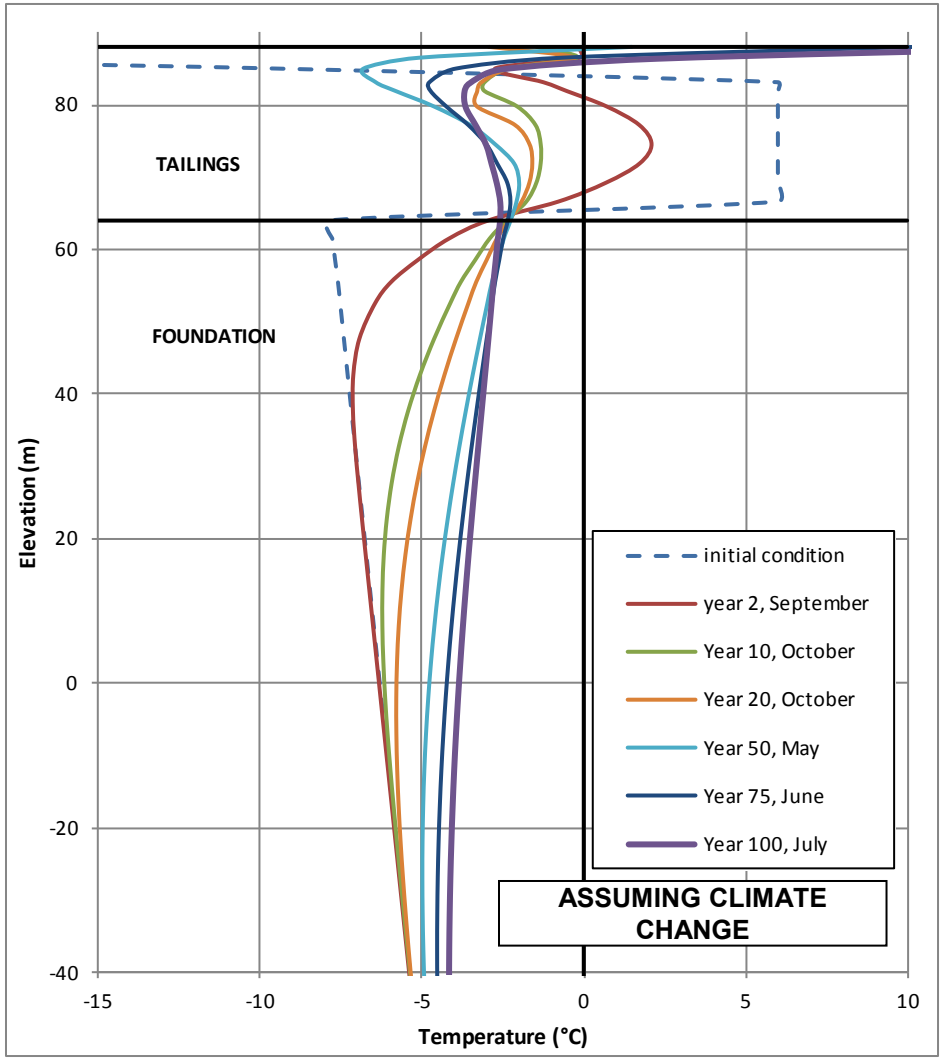

NOTES:

1. Current ground temperatures are based on ground temperatures at a depth of 5 cm measured at Meliadine West Site between 1997 and 2001
2. Climate change assumes a uniform increase in temperature of 6.4°C over the next 100 years (IPCC, 2007 suggest a range of 2.4°C to 6.4°C increase in global average).

PROJECT

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

1-D THERMAL ANALYSIS TAILINGS STORAGE FACILITY TAILINGS COLUMN ON DRY GROUND

Golder Associates

PROJECT No.	10-1373-0076		PHASE No. 8000	
DESIGN	GJ	03OCT12	SCALE NTS	REV.
CADD	GJ	03OCT12		
CHECK	DW	14JAN13		
REVIEW	DW	14JAN13		

FIGURE 6.3-17

- **Physical loss or permanent alteration of terrain, soils, and permafrost within the mined out areas; permafrost degradation and retreat due to excavation of open pits; potential groundwater inflows to the open pit during operations if depth extends below the base of permafrost; flooding of pits will result in creation of talik zones beneath pit lakes; Flooding of underground workings at closure may or may not result in permafrost re-establishing in the areas of the workings.**

The excavation of the open pits will result in minimal retreat of permafrost into the walls and floor of the pit during excavation. Subsequent flooding of these with water at the completion of mining will have an impact on the depth of the base of the permafrost, depending on the location of the pits relative to the surrounding land mass and lakes, and depending on the size of the pits.

The pit lakes can be considered to be analogous to circular and elongate lakes without terraces. The following table summarizes the dimensions of circular and elongate lakes without terraces required for the formation of an open-talik, based on mathematical solutions presented in the baseline permafrost report (SD 6-1 Permafrost Baseline Report).

Table 6.3-13: Critical Radius and Critical Half Width for Lakes without Terraces

Geothermal Gradient[a]	Mean Annual Ground Surface Temperature[b]	Mean Annual Lake (or Central Pool) Bottom Temperature[c]	Critical Depth	Circular Lake Critical Radius	Elongate Lake Critical Half Width
I ^{o}C /m	T_g ^{o}C	T_l (or T_p) ^{o}C	Z m	R_l m	H_l m
0.018	-7.9	2	212	292	161
0.018	-7.9	1	183	332	194

[a] Geothermal gradient based on curve fitting to M98-185 data below a depth of approximately 120 m.
[b] Average of the mean monthly measurements recorded at the site between 1997 and 2001, at a depth of 5 cm below ground surface.
[c] Lake bottom temperature estimates based on site data and published temperatures by others (Burn 2002 and 2005).

Based on the permafrost baseline conditions circular lakes having a diameter of greater than about 580 to 660 m and elongate lakes having widths greater than about 320 to 390 m will have open-taliks connecting the surface hydrological regime to the sub-permafrost hydrogeological flow system. Therefore, it can be presumed that, once flooded, open pits excavated within the permafrost land mass and having geometries and dimensions as described above will result in permafrost retreat over time and the development of open-taliks. Figures 6.3-18 and Figure 6.3-19 show schematically the effect of open pit mining and subsequent flooding of the pits on the permafrost regime for two potential scenarios.

The first scenario presents an open pit with incomplete penetration of the permafrost, resulting in a permafrost boundary remaining beneath the pit floor. If the pit diameter is greater than the geometries described above, then flooding of the pit will result in retreat of the permafrost boundary and the formation of an open-talik. The flooded pit will be either a recharge or discharge source (the figure shows the flooded pit as a potential discharge point for sub-permafrost groundwater). If the pit diameter is less than the geometries described above, then flooding of the pit will result in some permafrost degradation and retreat, but a permafrost boundary will still remain beneath the base of the pit, and a closed talik will form. In this case there will not be a connection between the surface hydrological regime and the sub-permafrost aquifer.

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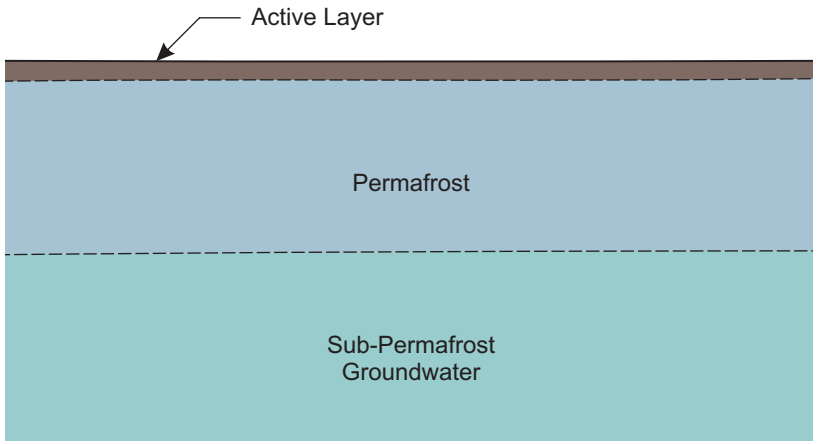
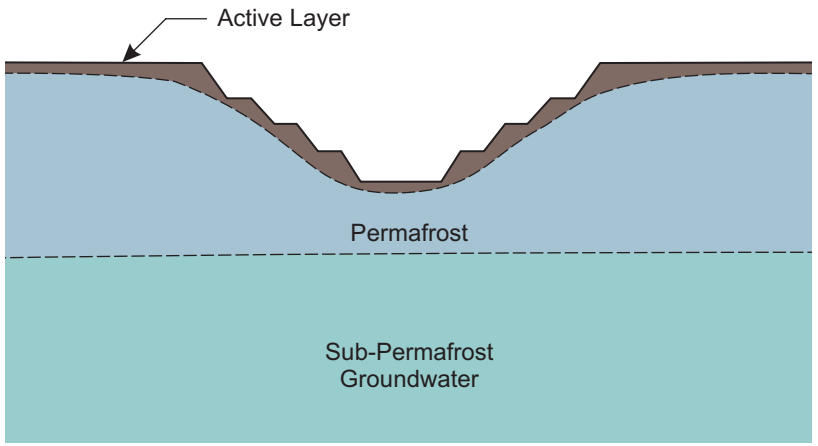
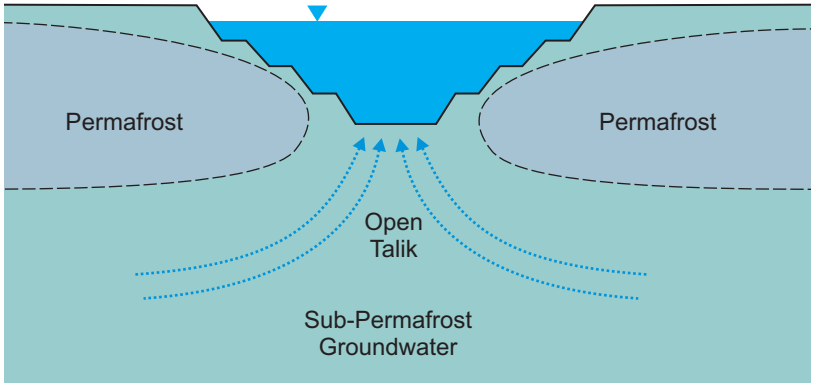


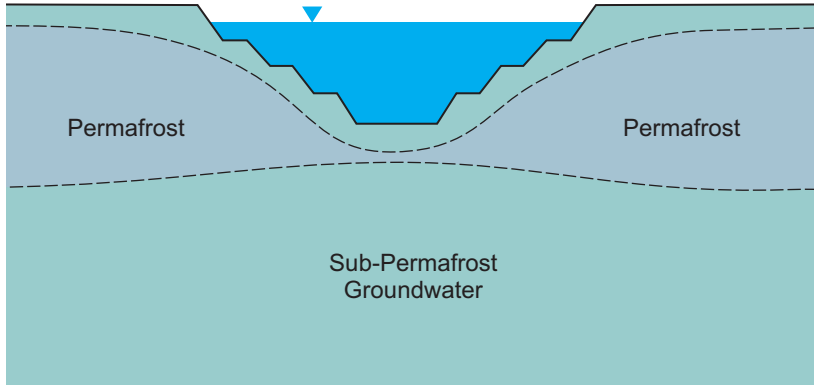
Scenario 1 - Baseline Conditions



Scenario 1 - Incomplete Penetration of Permafrost by Open Pit



Scenario 1 - After Pit Flooding
Pit Dimension Greater than Critical Radius for Open Talik Formation;
Permafrost Retreat and Formation of Groundwater Recharge or
Discharge Point (Discharge Shown)



Scenario 1 - After Pit Flooding
Pit Dimension Less than Critical Radius for Open Talik Formation;
No Hydrological Connection Between Pit Lake and Groundwater System

Schematic Only
Not to Scale

PROJECT
AGNICO EAGLE

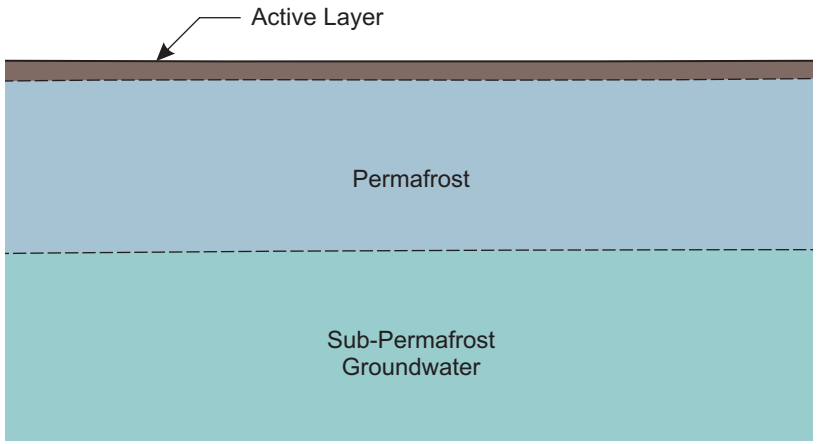
AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE
EFFECTS OF PIT MINING AND FLOODING ON PERMAFROST, SCENARIO 1 - INCOMPLETE PENETRATION OF PERMAFROST BY OPEN PIT

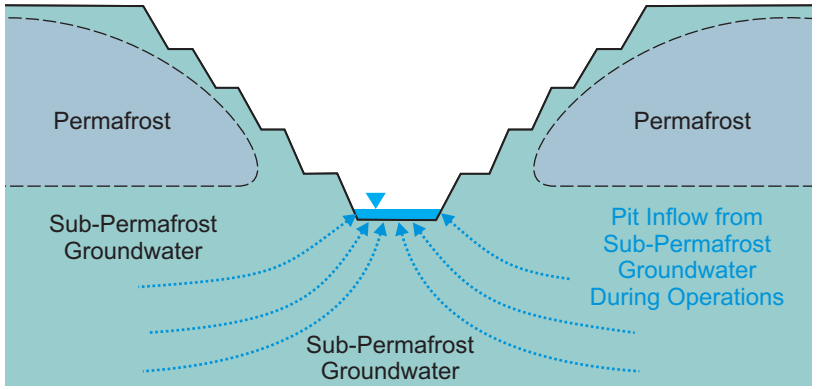
Golder Associates

PROJECT No. 10-1373-0076			PHASE No. 3000-2200	
DESIGN	CJC	04OCT12	SCALE NTS	REV.
CADD	GG	04OCT12	**FIGURE 6.3-18**	
CHECK	DW	14JAN13		
REVIEW	DW	14JAN13		

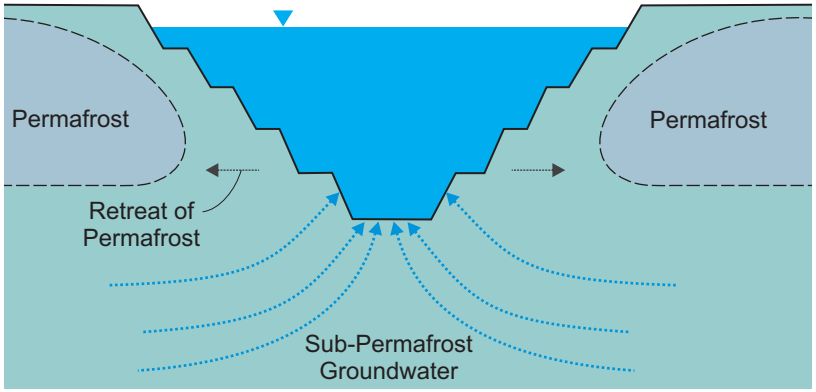
DRAWING DATE: 04-Oct-12 COREL FILE: N:\Bur-Graphics\Projects\2010\1373\10-1373-0076\Drafting\3000\1013730076-3000-12.cdr



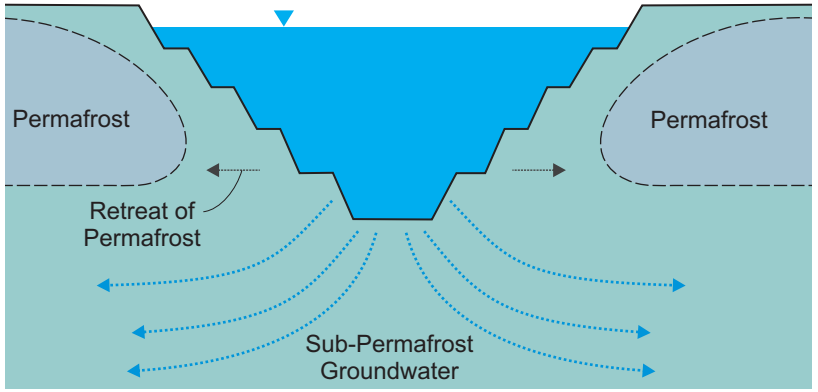
Scenario 2 - Baseline Conditions



Scenario 2 - Complete Penetration of Permafrost by Open Pit



Scenario 2 - After Pit Flooding - Groundwater Discharge if Pit Lake Elevation Less than Surrounding Large Lake



Scenario 2 - After Pit Flooding - Groundwater Recharge if Pit Lake Elevation Greater than Surrounding Large Lake

Schematic Only
Not to Scale

PROJECT

AGNICO EAGLE

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MELIADINE GOLD PROJECT
NUNAVUT

TITLE

EFFECTS OF PIT MINING AND FLOODING ON PERMAFROST, SCENARIO 2 - COMPLETE PENETRATION OF PERMAFROST BY OPEN PIT

Golder Associates

PROJECT No. 10-1373-0076			PHASE No. 3000-2200	
DESIGN	CJC	04OCT12	SCALE NTS	REV.
CADD	GG	04OCT12		
CHECK	DW	14JAN13		
REVIEW	DW	14JAN13		

FIGURE 6.3-19

The second scenario presents an open pit that completely penetrates the permafrost at some stage of the operational life. Once the base of the permafrost has been penetrated, pit inflows from the sub-permafrost groundwater regime will occur, and this hyper-saline water will need to be managed appropriately during operations. Once the pit has been flooded, permafrost will retreat further to some degree due to the latent heat of water in the pit, and the open connection between surface and sub-permafrost waters will remain. The pit lake will become either a recharge or discharge source for the sub-permafrost groundwater, depending on the elevation of the pit lake relative to the surrounding large lakes (e.g. lakes also connected to the sub-permafrost hydrogeological regime) and other hydrological and hydrogeological conditions.

Either of these scenarios is equivalent to the current lake systems in the Project area; these lakes have been formed, or 'excavated', in the landscape over geological time by glacial processes, by physical and chemical weathering processes, and by geological processes, and the rock types that currently form the base of the existing lakes are the same as the rock types that will form the base and the walls of the final open pits. Many of the large lakes in the Project area are sources either of recharge to, or discharge from, the sub-permafrost groundwater system.

The following table indicates the approximate dimensions of each of the pits, and identifies which pits may result in the formation of open taliks over time following flooding.

Table 6.3-14: Pit Dimensions and Potential to Develop Open Talik

Pit	Approximate Length (m)	Approximate Width (m)	Approximate Depth (m)	Pit Lake Elevation (masl) (Ref. Golder 2012d)	Geometry (Circular or Elongate)	Potential to Develop Open Talik under Pit Lake	Recharge or Discharge Point
Tiriganiaq Pit #1	2756	491	195	57.8	Elongate	Yes (connects A38, A39, A54, A10, A11, A12, A13, B10, B29, A41, A42, A43, B5)	
Tiriganiaq Pit #2	298	202	65	57.8	Circular	Yes (within B5)	
Wesmeg #1	216	168	40	59.0	Circular	No	Closed system
Wesmeg #2	1070	592	160	62.2	Circular	Yes (connects A25, A36, A37, A8)	
Wesmeg #3	583	359	100	65.0	Circular	No (connects to unnamed lake)	Closed system
Wesmeg #4	245	159	40	64.0	Elongate	No	Closed system
Wesmeg #5	240	192	50	64.0	Circular	No	Closed system
Pump Pit #1	1766	350	100	62.2	Elongate	Yes (connects B36, B37, B38, and two unnamed lakes)	
Pump Pit #2	486	373	115	60.5	Circular	Yes (within A8)	
F-Zone #1	489	312	45	54.0	Circular	Yes (connects to A6)	
F-Zone #2	493	226	65	55.0	Elongate	No (connects to A5)	Closed system
F-Zone #3	478	448	145	56.0	Elongate	No	Closed system
Discovery	953	600	190	66.0	Circular	Yes	

6.3.9.2.1 Cumulative Effects Assessment of Pit Lake Formation and Underground Flooding at Closure

A cumulative impact (or effect) can be defined as the impact on the environment that results from the incremental impact of the action when added to other past, present and reasonably foreseeable future actions (Tilleman 2005). Cumulative impacts can also result from individually minor but collectively significant actions taking place over a period of time.

As discussed in the previous section, many of the pits will have the required dimensions to form an open talik after a period of time once flooding of the pit has been completed. Furthermore, where underground workings are located beneath the pits having open taliks, or if the workings extend to below the base of permafrost, then these will not freeze, and will become part of the open talik system. Depending on the regional flow regime, and on the elevation of the pit lake, the pit lakes underlain by open taliks may become a local recharge point to the groundwater system, or a local discharge point from the groundwater system. Consequently, chemical constituents that may be present within the pit lakes or flooded underground workings will have the potential to enter the groundwater flow regime through open taliks resulting in a potential cumulative effect on a downstream receptor. Where the pit lakes are not sufficiently large to form open taliks, there will be no physical connection to the groundwater flow regime, and such lakes and closed taliks can be considered minor effects pathways.

Although many of the pit lakes will have the requisite geometry and dimensions to develop open taliks in the long term, resulting in a hydrological connection between the surface hydrological regime and the sub-permafrost aquifer, downstream cumulative effects resulting from the development of an open talik beneath the pit lakes are not expected. This is because the rock types that will be exposed in the pit lake walls are geochemically benign, and are analogous and equivalent to the rock types currently exposed beneath the existing large lake system in the Project area and which have demonstrated no geochemical concerns over geological time.

An objective of the closure and reclamation plan for the Project is to establish chemical stability such that any chemical constituents released from the mine components should not endanger public, wildlife, or environmental health and safety, should not result in the inability to achieve the water quality objectives in the receiving environment, and should not adversely affect soil or air quality into the long term (INAC 2007). As described in above, the waste rock material that will form the walls of the open pits and underground workings will be analogous to those exposed in the current lakes in the Project area. The geochemistry of the waste rock has been characterized and described in SD 6-3 Geochemistry Baseline Report, and is summarized in the following paragraph.

Current test data indicates that the waste rock is non-acid generating. It has an elevated carbonate-mineral buffering capacity and generally low sulphide content. Some metal carbonate minerals (which have no net buffering capacity) are present, but analytical data from current tests demonstrates that the reactive carbonate content provides sufficient buffering capacity to neutralize acid that would be generated. Thus, the waste rock does not require means to prevent oxidation (SD 6-3 Geochemistry Baseline Report).Furthermore, kinetic tests completed on all waste rock types and at various scales show that drainage water quality is expected to meet MMER monthly mean effluent limits, including results for arsenic.

Based on the available information, no net cumulative effects will result from the development of open taliks beneath pit lakes and incorporating underground workings resulting in hydraulic connection between surface waters and the deep groundwater flow regime.

Additional strategies to avoid potential cumulative effects will be used during the closure of the pits and underground facilities, as described in the preliminary closure and reclamation plan for the Project (SD 2-17 Mine Closure and Reclamation Plan), and summarized below.

- Open pits
  - identify unstable areas;
  - check ground conditions to confirm permafrost conditions are being re-established as predicted;
  - sample surface water and profiles of flooded ponds/pits;
  - sample quality of groundwater seeping from pit walls to assess potential for contamination of mine water due to melting permafrost and acid rock drainage/ metal leaching from pit walls;
  - identify and test water management points (including seepage) that were not anticipated;
  - inspect barriers such as berms and inukshuks; and
  - inspect fish habitat in flooded pits where applicable.
- Underground facilities
  - check for surface expression (subsidence) of underground failure;
  - conduct geotechnical assessment of the overall safety and risk within the subsidence zone;
  - install and check thermistors where appropriate to monitor freeze-back in permafrost areas and to confirm that ground thermal regime has not degraded;
  - periodically backfill areas of subsidence as required; and
  - monitor groundwater hydrogeology.

6.3.9.3 Minor Pathways

In some cases, both a source and a pathway exist, but the change caused by the Project is anticipated to result in a minor environmental change, and would have a negligible residual effect on terrain and soils, vegetation, and wildlife relative to baseline or guideline values.

- **Physical changes to the permafrost table and active layer in rock and soils beneath and adjacent to the Project infrastructure, facilities, site roads and AWAR resulting from ground disturbance during construction; physical changes to the permafrost in the area of the mine site footprint**.

The subgrade soils in the Project area are highly variable and are classified by displacement hazard ratings. Low to medium displacement hazard ratings were considered “thaw stable” and included well drained soil, ice poor to frost shattered bedrock material. Medium-high to very high displacement hazard ratings were considered “thaw susceptible” and included poorly-drained, ice-rich, organic, or bog material. The subgrade soil near the toe of site roads and the AWAR road fill, and other structural fills, may experience deeper thaw penetration during each subsequent summer/spring season, which may lead to thaw consolidation. Thaw consolidation in ice rich soil will result in the formation of tension cracks. The road and structural fills placed on ice poor soil, however, are unlikely to be susceptible to bearing capacity failure.

The potential of the subgrade soil to experience ice creep or thaw consolidation is dependent on the ice content of the soil and thaw conditions. Ice rich soils are expected to have high water contents and may experience excess pore water pressures upon thaw. The excess pore water pressures in the thawed soils will contribute to strength loss in the soil, and could result in local bearing capacity failures. Where the terrain is characterized by low lying poorly drained areas of fine grained soils, these are extremely susceptible to ground disturbance and cannot be constructed on during thaw periods. In such areas, the disturbance of the ground cover and formation of localized depressions within the thawed active layer may increase the depth of the active layer leading to thawing of previously frozen soils, ponding of water, and/or growth of ground ice. Construction methodology over poorly drained fine grained soils will be targeted at preserving the permafrost by building over the active layer once it is fully frozen during winter with a pad of sufficient thickness so that the permafrost table migrates upward into the road fill material. This is equivalent to building permafrost into the road base resulting in a stable road section. These sections will have the highest priority for completion of the required road thickness during the winter period.

Where the terrain consists of well drained coarse granular soils, which may occur along ridge crests, these are thaw-stable and can be constructed on during frozen or thawed periods with little to no negative impact to the permafrost table. Depending on the structural fill thickness, the permafrost table may migrate upward into the road section as with the winter construction methods. However, because the underlying ground is thaw-stable, the structural fill thickness for construction in such areas can be thinner than for construction in thaw-susceptible areas.

Where the underlying terrain is rock, then little to no negative impact to the permafrost through the construction of infrastructure and facilities is expected.

Rock and soil materials will be excavated from the quarry areas, transported to the AWAR route, and then used for construction of the AWAR. Consequently, although there is a relocation of rock and soil from quarry to road, there is no net loss of rock and soil volumes due to construction of the AWAR.

- **Ponding of water can result in permafrost degradation due to thickening of the active layer; Permafrost degradation due to snow drifting and melt water; stockpiling or clearing of snow can result in the insulation of the active layer and may result in ground instability or thaw subsidence and thickening of the active layer.**

The active layer and permafrost table can be affected where snow accumulates along the toe of the road side slopes, either by drifting, or by active road clearing during winter. Snow acts as an insulating layer to the active layer, and can restrict the deep penetration of the freezing front through the active layer during winter. Over time, this may result in deepening of the active layer at the toe of the side-slope. Furthermore, melting of the snow in the summer can result in the accumulation of excess water in the toe area, leading to additional thermal erosion and potential thaw subsidence. Water can act as a thermal ‘sink’, retaining heat and contributing to deepening of the permafrost table. The presence of water at the side-slope toe may saturate the soils and provide a source of water for the development of ice lenses and ice layers, further exacerbating thaw-induced settlement along the road edges.

Maintenance will be required during operation to manage snow accumulation locally along the road alignment; however, most of the alignment is located along windward slopes and ridge crests where there should be limited tendency for snow to build-up.

Installation of culverts in low lying areas will reduce the potential for ponding of snow melt water in the spring and summer.

The potential of the subgrade soil to experience ice creep or thaw consolidation is dependent on the ice content of the soil and thaw conditions. Ice rich soils are expected to have high water contents and may experience excess pore water pressures upon thaw. The excess pore water pressures will contribute to strength loss in the soil and could result in local bearing capacity failures.

The subgrade soil near the toe of site roads, the AWAR, and other structural fills may experience deeper thaw penetration during each subsequent summer/spring season, which may lead to thaw consolidation. Thaw consolidation in ice rich soil at the toe of the embankment will result in the formation of tension cracks and small grabens inside the shoulder area. The side slopes of structural fills on ice poor soil are unlikely to be susceptible to bearing capacity failure. Thaw consolidation may result in a measureable, but minor environmental change, and is therefore considered to be a minor pathway.

- **Physical changes to the permafrost table and active layer by quarry excavation.**

The quarries will be excavated through the active layer and into the underlying materials by ripping, drilling, and blasting. The active layer will eventually re-equilibrate with the surrounding permafrost with no residual effects.

- **Potential permafrost degradation due to borrow source and quarry development; development of closed taliks beneath quarry 'lakes' if quarries are improperly graded and drained; degradation of permafrost and terrain (soil and rock) through removal of material and ground disturbance; physical changes to the permafrost in the areas of the open pits and quarries; physical removal of permafrost soils and rock where stripping is required.**

Borrow and quarry development for the AWAR road is likely to occur in areas of low relief due to the generally flat topography along the road alignment. Where possible, the borrow areas and quarries will be graded to provide drainage, but this may not be possible in all areas due to the flat topography. If water collects in the borrow/quarry areas, it could lead to development of local taliks below the quarry 'lakes'. The borrow areas and quarries will be located predominantly within bedrock so the overall impact on the terrain is anticipated to be minor.

Currently, it is planned to excavate the quarries to a depth of 3 m or less. This is in part for ease of excavation, which will be predominantly in the active layer, and in part for ease of water management and closure. It is expected that, in most cases, it will be possible to design and develop the quarries to promote positive drainage from the quarry area, or to minimize the water depths that may accumulate within the quarries. The accumulation of water within the quarries will result in a deepening of the active layer. Provided that the water pool depths are less than approximately 2 to 2.5 m, water accumulating within the quarries will freeze fully during winter, which will limit the degree to which the active layer may be deepened.

Stripping of surficial materials will be minimized, and will be primarily related to foundation preparation for critical facilities that are sensitive to thaw-settlement, such as the process plant. Wherever possible, infrastructure will be constructed directly over existing ground conditions, taking advantage of winter construction in frozen conditions.

- **Permafrost degradation and retreat during excavation and backfilling of underground mine during operations.**

Underground mining activities will involve the development of underground openings within the permafrost. These openings will require forced air circulation at temperatures above 0ºC, and so will result in minor permafrost retreat away from the openings during active mining operations. Once an active area of the mine becomes inactive, and access is no longer required or permitted, ventilation will be terminated. In such cases, permafrost will re-establish itself in the walls of the openings. In some areas of the mine, a backfill product may be used for support. If the product contains cement for strength, then heat will be generated during curing of the cement binder. This heat of hydration will result in some retreat of permafrost, but only temporarily, and once the binding agent has cured, permafrost will re-establish within the backfilled material.

- **Physical gain of terrain and permafrost within the waste rock piles; permanent alteration of terrain, soils, and permafrost beneath the waste rock piles.**

A numerical thermal model was not developed for the waste rock storage facilities. The foundations of the waste rock storage facilities are currently frozen, and so will remain frozen as waste rock is placed. The waste rock piles will also freeze with time, resulting in improved stability. Operational experience gained at sites such as Diavik, Ekati, and Meadowbank has shown that waste dumps developed on flat, frozen ground will remain stable over time with very little maintenance required. This is in contrast to waste dumps developed on mountainous steep terrain and non-frozen soils, which may exhibit instability over time based on the actual site conditions. Ground temperature data were reviewed from the Meadowbank Mine, north of Baker Lake. Two relevant ground temperature profiles are included in Appendix 6.3-G, from Rock Storage Facility 1 (RSF1) at the Meadowbank Mine site. The ground temperature profiles show that permafrost has developed within the facility. An active layer has developed, and the depth of zero annual amplitude can be identified. The ground temperature profiles indicate temperatures within the facility, below the depth of zero annual amplitude to be between approximately -7ºC and -8ºC, which is consistent with local permafrost temperatures.

Even when climate change is considered, the foundations are expected to remain frozen; therefore the potential effects on permafrost are considered negligible. However, under climate change conditions, the depth of the active layer will become thicker. As described previously in Section 6.3.4.4, a long-term warming trend will result in thickening of the active layer. For the long-term closure strategy for the waste rock piles this aspect will have the greatest importance.

Under current conditions, the active layer thickness is on the order of 1.5 to 2.0 m. Under climate change predictions (assuming an average increase in the global mean temperature of 4.4^{o}C) the active layer thickness could increase potentially by 2 to 4 m, as described in Section 6.3.4.4. As a consequence of an increase in active layer thickness, the volume of surface water run-off coming into contact with the active layer material within the waste rock pile may increase. Increased surface temperature will also result in a longer thaw period, again which could contribute to an increase in the volume of water that comes in contact with the waste rock.

6.3.9.4 Pathways with No Linkage

A pathway may have no linkage if the activity does not occur (e.g., effluent is not released), or if the pathway is removed by environmental design features so that the Project results in no detectable (measurable) environmental change and residual effects to the permafrost terrain and soils relative to baseline or guideline values. The following pathways are anticipated to have no linkage to permafrost terrain and soils.

- **Air emissions and dust deposition on the terrain and soils.**

Ripping and dozing of road surfaces and other infrastructure development such as the mine site can result in dust emissions and affect down-wind soil and terrain. Dust may deposit on the tundra down-wind of the construction activities, affecting terrain and soils.

Dust suppression methods will be used to manage potential emissions include watering of the road surface in areas prone to high dust levels during post-winter construction and operation, regular maintenance of the road surface, and enforcing the posted speed limits. These management methods should reduce and control emissions, and subsequent potential effects of dust deposition.

- **Physical changes to permafrost due to temporary building footprint area.**

During the construction phase of the Project it will be necessary to construct certain temporary buildings. These buildings will be removed once construction of the permanent buildings has been completed.

- **Use of potential acid generating materials for facilities and site road building materials can affect terrain and soil quality.**

The materials for constructing the Project components will be quarried from selected rock and soil borrow sources along the proposed AWAR, and from pre-stripping activities at the mine site.

During the geomorphological mapping of the AWAR route, samples of till were taken, and geochemical analyses were completed. The sites chosen for potential quarry and borrow sites along the AWAR alignment were tested for acid rock drainage and metal leaching potential. The results indicated no or very limited acid rock drainage and metal leaching potential for the samples tested.

The Project components will be constructed using non-acid generating fill materials with low metal leaching potential.

- **Use of petroleum products and maintenance of vehicles may result in hydrocarbon spills infiltrating the active layer; physical loss of permafrost from latent heat in petroleum and fuel oil stored at tank farm.**

Petroleum products and fuel oil will be stored in large fuel storage tanks at a fuel tank farm. The fuel tank farm will be designed and constructed using best practices. Appropriate structural fills will need to be placed, and appropriate construction methodology used. The tank farm will have a berm surrounding it to contain any spillage of petroleum products. Re-fueling areas will be appropriately designed to capture spills.

In the case of accidental spills outside of the fuel tank farm and re-fueling areas a spill management plan will be developed that outlines appropriate procedures for collecting spilled products to avoid any detectable environmental change where these spills may occur.

- **Physical alteration of terrain, soils and permafrost due to earthworks, facilities, construction, and ground disturbance at the shipping and marine unloading area; gain of permafrost into structural fills used to construct lay down pads and unloading areas; Permafrost degradation and thaw settlement in the laydown area due to high traffic circulation and loads.**

Unloading of equipment at Itivia Harbour will require the construction of a lay-down area, as well as other infrastructure. The use of thaw-stable structural fills will promote the development of permafrost within the fill materials, and reduce the potential for permafrost degradation of thaw-unstable materials.

- **Placement of fill materials during the summer could insulate warm temperatures in subgrade soils leading to permafrost degradation.**

During the summer months, the active layer may extend down to 2 m depth below the ground surface. If Project components are constructed when the surface soils are thawed, they will likely remain thawed for a period of time because the fills will insulate the subgrade from the cold temperatures during the winter months. Over time the subgrade soils would refreeze.

To the greatest extent possible, the Project components will be constructed in the winter when the subgrade soils are frozen to prevent insulation of thawed subgrade soils. For the AWAR, the rough base would be advanced at the full road width in winter frozen ground conditions. The stream crossing culverts would also be installed in the winter. Once the rough base and stream culverts are installed, the remainder of the construction will be completed by building up the rough base primarily under winter conditions, and placing the final topping materials during the spring and early summer.

The AWAR has been designed with a minimum fill thickness to maintain permafrost conditions within the subgrade soils. Thermal modeling has indicated a minimum road fill thickness of 1 m is required above ice poor subgrade soil to maintain the soil in a frozen condition. Similarly, a minimum road fill thickness of at least 1.3 m is required above ice rich subgrade soils. These road fill thickness are minimum values based on assumptions and generalized conditions.

- **Degradation of rock and soil slopes due to annual freeze-thaw processes; physical changes to the permafrost table and active layer by quarry excavation.**

Physical weathering (frost wedging and frost shattering) is evident on exposed bedrock surfaces and in areas of rubbly, weathered bedrock. Freezing and thaw induced displacement of soil can be expected to occur in poorly-drained materials underlain by fine-grained morainal sediments. Appropriate design and construction methods will be used to prevent against such displacements.

Annual freeze/thaw processes will result in degradation of rock slopes within the quarry sites, however these slopes will not be high, typically less than 3 m, and so material volumes are expected to be small.

Construction of the road bed is planned to occur primarily during winter while soils are frozen, and using thaw-stable fills, to minimize the potential for freezing and thaw induced displacement of the soils. The fills will be placed directly over the existing terrain without cut, stripping, or grubbing to avoid disturbing the subgrade soils. The placement of fills over rock during winter will minimize or reduce degradation of the rock due to annual freeze-thaw processes through aggradation of the active layer into the road fill materials.

- **Freezing and plugging of culverts in the winter; Alteration of drainage paths adjacent to Project components**

The construction of the AWAR will result in alteration of drainage paths adjacent to the road alignment. Culverts will be used to re-direct drainage paths and to convey water from upstream areas to downstream areas across or under the AWAR.

It is expected that annual maintenance and clearing debris from the culverts will be required during the operational period of the road. This is common practice in northern climates. The “offset stacked” culvert configuration will assist in flow conveyance during the spring thaw and ice break-up period.

- **Sediment and contaminant releases during decommissioning and removal of culverts can affect downstream soil and terrain.**

Decommissioning of the AWAR will be accomplished by loosening compacted surfaces (ripping surface with a dozer mounted ripping unit), flattening side slopes, and removing all culverts, bridges (not including the Char River bridge as this would become the property of the Municipality of Rankin Inlet), and other potential obstructions to drainages paths. During these activities there is the potential for release of sediment and contaminants which may be deposited downstream on terrain and soils. To manage such releases, the following activities are planned:

- to the extent possible, in-stream work (e.g., culvert removal) will be limited to when watercourses are not flowing for ephemeral watercourses or when watercourses are frozen; and
- if any of the culverts need to be removed when the watercourses are flowing, the work will be completed late in the summer (and within approved instream work windows), and best management practices for erosion and sedimentation control (e.g., silt curtains, runoff management) will be employed.

- **Ponding of water or high volume flow during freshet may degrade frozen ground.**

Appropriate water management methods will be used to avoid water ponding and to control and convey high volume, potentially erosive flows.

- **Management of the landfill and biopile may degrade permafrost**

The landfill and biopile will be managed and operated within the waste rock storage facility. Permafrost will aggrade into the waste rock facility over time.

- **Physical gain of terrain and permafrost within the structural fills used to construct Project components; Ponding of water adjacent to facilities and infrastructure may degrade permafrost.**

Building components (concrete, steel) will be dismantled, but structural fills will remain behind. Water management and appropriate drainage and diversion structures around facilities and infrastructure will remain as required to promote site drainage.

- **Ponding of water adjacent to site roads may degrade permafrost; sediment and contaminant releases during removal of culverts can affect downstream soil and terrain.**

Site roads and the main AWAR will be decommissioned, including scarifying and water barred, to promote drainage of water, limit ponding, and limit public access. To the extent possible, in-stream work will be limited to when watercourses are not flowing for ephemeral watercourses or when watercourses are frozen. If any of the culverts need to be removed when the watercourses are flowing, the work will be completed late in the summer (and within approved in stream work windows), and best management practices for erosion and sedimentation control (e.g., silt curtains, runoff management) will be employed.

- **Ripping of road surfaces and slopes can result in dust emissions and affect down-wind soil and terrain.**

Ripping and dozing activities will be minimized, and the appropriate equipment will be used to re-establish drainage paths and to promote permafrost re-equilibration within the decommissioned road bed. The road surfaces will be made impassable to vehicular traffic.

6.3.9.5 Effects Summary

Effects to the terrain, including rock, soil, and permafrost, are anticipated to be confined to the footprint area of the Project, which includes the mine site, open pits, waste rock facilities, tailings storage facility, site access roads, and AWAR. The pathway assessment indicates the linkages between the Project and VECs to be minor (minimal but measureable residual effects) or none (e.g. no residual effects). In the case of mining of the open pits, and subsequent flooding, a primary linkage exists to the degradation of permafrost as it is possible that open taliks will be formed beneath pit lakes greater than approximately 600 m in diameter.

The construction of the Project will have minimal, but measureable, effects on the terrain in that soil and rock materials will be directly covered over, or will be excavated and stored elsewhere. The rock and soil along the AWAR route will be covered by fill materials. The thickness of the fill materials is designed to preserve the underlying permafrost in areas of thaw-stable soils, and to promote the aggradation, or building, of permafrost into the road structure in areas of thaw-sensitive soils. Appropriate maintenance of the road during winter will minimize the depth of snow drifting and snow accumulation along the road edges in areas of thaw-sensitive materials. Culverts will be placed in topographically low areas where water may accumulate against the road fills to minimize the potential for thaw settlement.

The development of quarries to provide suitable road construction materials will result in open excavations on the landscape. Once the quarries are developed, permafrost will re-equilibrate to the excavated condition. Where possible the quarries will be designed to promote drainage from the quarries so that no water accumulation occurs. Closure of the quarries may include some backfilling of spoiled material, and re-grading. Nevertheless, these will remain once the AWAR Project has been completed.

The construction of the Project components and infrastructure facilities will have some effects on the terrain components and the permafrost active layer. Infrastructure components are generally insensitive to settlement and heave. Nevertheless, the engineering and construction methods used for the design and construction of the Project infrastructure will avoid areas that are sensitive to ground disturbance, specifically thaw-sensitive soils. Where construction of Project components and facilities is in areas of thaw-sensitive soils, the design and

construction of the Project components will minimize impact to the underlying terrain through the use of appropriate structural fills and thicknesses, and the use of appropriate construction methodologies and scheduling. Thick fills using thaw-stable construction materials will be used to preserve the permafrost or promote permafrost growth, and appropriate drainage measures will be used to control and manage water adjacent to the facilities to prevent ponding of water and minimize the potential for deepening of the active layer leading to potential instability.

Future development scenarios that may include the development of currently undiscovered or under-explored deposits may result in the following future impacts:

- Additional tailings storage may be needed. This may require increasing the height of the planned storage facility by raising the tailings dikes. The tailings storage facility is predicted to freeze in the long term, and so there will be a gain of permafrost within the facility;
- Additional waste rock storage will be needed. This may require increasing the height of existing waste rock storage facilities, or the construction of a new storage facility in the Wolf Deposit area. This will result in a gain of permafrost within the expanded storage facility area, or within any new storage facility area. There will be a permanent alteration of terrain, soils and permafrost beneath the storage facilities;
- An access road will need to be constructed to gain access to the Wolf Deposit area. This may require additional quarry sites to be identified, quarrying of materials from these sites, and road construction over the permafrost. Road construction over the permafrost will result in a gain of permafrost into the road construction fills. The development of quarry sites will result in physical changes to the permafrost table and active layer by the quarry excavation. The development of closed taliks beneath quarry 'lakes' could occur if quarries are improperly graded and drained. Degradation of permafrost and terrain (soil and rock) through removal of material and ground disturbance will occur and physical removal of permafrost soils and rock will occur where stripping is required.
- Any new open pit developments will result in physical loss or permanent alteration of terrain, soils, and permafrost within the mined out areas. Permafrost degradation and retreat due to excavation of open pits may result. Potential groundwater inflows to the open pit during operations may result if the pit depth extends below the base of permafrost or if the pit walls intersect drained lakes. Flooding of pits will result in creation of talik zones beneath pit lakes.

6.3.10 Uncertainty

6.3.10.1 Mapping Uncertainty

In some areas map unit designations for terrain and soil drainage conditions may appear somewhat arbitrary and may not be entirely consistent from place to place due to the complexity of the landscape, the intermixing of different surficial material, and soil moisture conditions, and total differences among and across air photo flight lines. As noted above, the stereoscopic interpretation utilized laser photocopies of the original air photos, consequently there may have been some loss of resolution. As a result, the air photo interpretation and terrain mapping is likely not as accurate as might have been achieved using original air photos.

Small inclusions (i.e., ≤10%) of materials or soil drainage classes (e.g., well- or moderately well-drained beach sediments within a larger area of poorly- to imperfectly-drained wave washed materials) are typically not delineated or identified in the map unit (polygon) symbol, even though they may be visible in the field and/or on air photos. Due to these limitations, surficial materials and soil drainage conditions other than those suggested by the mapping may be encountered in the field.

In most, but not all cases, terrain units occupying slightly less than 1 cm^2 (i.e., ≤one hectare at 1:10 000 scale) on the map are not delineated. Other apparent discrepancies may occur due to changing water levels in shallow ponds and lakes. For example, while not entirely consistent, water levels observed during the July 2009 fieldwork appeared to be slightly lower than those visible on the July 1997 air photos used for the terrain mapping and for the base map orthophoto. It also was noticed that visible changes in water levels were noted in some small ponds following 1 or 2 days of moderate rain.

The mapping uncertainty described above does not restrict the ability to draw conclusions or inferences relating to the material types that are expected to be encountered in the various areas of the Project.

6.3.10.2 Thermal Modeling Uncertainty

The uncertainties in the preliminary thermal modeling of the tailings include the following:

- The use of tabulated thermal properties for materials assumed in the thermal analyses; and
- The uncertainty associated with future climate change predictions.

The model results presented in this report constitute an initial simplified approach to provide general understanding of the freezing process that would develop within tailings deposited on dry ground, and within the lake basin. The model results will be refined during future stages of the Project to incorporate the tailings dike, as well as the impact of the tailings deposition sequence on the freezing process.

6.3.11 Closing Statement

The effects pathways related to permafrost and permafrost terrain are predominantly minor linkages, or have no linkage. The pathways will result in either no detectable environmental change and no residual effects, or measureable but minor environmental change and negligible residual effects.

Although there are primary linkages associated with mining of the pits and underground, and subsequent flooding to create pit lakes, no net cumulative effects are predicted. The effects pathways develop as the result of permafrost retreat and the formation of open taliks beneath certain pit lakes large enough to develop such taliks, and underground workings that extend beneath the permafrost.

6.4 Terrain and Soil

The purpose of the Terrain and Soil section of the FEIS is to meet the Guidelines issued by the NIRB. Volume 1, Appendix 1.0-A

The Terrain and Soil section includes an assessment of direct effects to changes to terrain and soils (e.g., soil quality and erosion) in the study area. The effects assessment evaluates all Project phases, including construction, operation, and closure and reclamation. Indirect and cumulative effects have been incorporated throughout this section, where applicable. The effects from the Project must be considered in combination with other developments, activities, and natural factors that influence terrain and soils within the study area.

Some information from other components of the FEIS, including air quality, water quality, and water quantity as well as information from existing developments, is incorporated in the effects assessment for terrain and soils. More detailed information on the requirements of the Guidelines (NIRB 2012) for this section can be found in Volume 1, Appendix 1.0-A. Impacts to permafrost and sensitive terrain types are outlined in Section 6.3 (permafrost).

6.4.1 Baseline Environment

6.4.1.1 Methods

Terrain and soil mapping was completed to describe and characterize the existing terrain and soil resources, the distribution across the landscape, and associated terrain and soil quality and sensitivities within the LSA. The approach to classifying and describing terrain and soil units involved a review of existing information, soil sampling and analysis, and development of terrain and soil maps in a Geographical Information System (GIS) platform.

Terrain and soil mapping was undertaken for the LSA only as effects to terrain and soil are localized and are not regional issues. The terrain mapping used existing data for most of the LSA, with airphoto interpretation and digital elevation models used to complete the mapping in areas without coverage.

For soil mapping, Ikonos imagery and Landsat Thematic Mapper satellite imagery were used to initially delineate vegetation units for Ecological Landscape Classification (ELC) mapping in the LSA. The ELC vegetation units were then used as part of the mapping process to derive correlations between soil types and the ELC vegetation types. Due to the resolution of the ELC data, many soil map units were presented as complexes to capture the range of soil types on the landscape and minor components of a soil type (i.e., less than 20% representation within a map unit) were not mapped. The soil map unit delineations were inferred from the interpretation of landscape features (i.e., elevation contours and landform), ELC units, without field groundtruthing. Thus, the soil map should be viewed as a predictive model of soil distribution. The information should not be applied for predicting site-specific characteristics without collecting additional field information.

6.4.1.1.1 Soil Quality in the Local Study Area

6.4.1.1.1.1 Soil Erosion Risk

Soil erosion risk from water is generally determined by applying the modified Universal Soil Loss Equation as described by Tajek et al. (1985) and Transportation Association of Canada (TAC 2005). Soil erosion risk from wind was determined based on a dimensionless index described by Coote and Pettapiece (1989). Soil sensitivities to wind and water erosion were determined through an interpretation of soil characteristics (e.g., soil texture, soil structure, and soil moisture) and an evaluation of a soil erodability factor based on texture and slope characteristics associated with each soil type. A final soil erosion sensitivity rating was then assigned to each soil

map unit based on the most limiting erosion factor (i.e., whether it is predominantly a wind or water erosion sensitivity) and modified using professional judgement based on natural factors specific to the LSA, such as organic or shallow soils.

6.4.1.1.1.2 Soil Chemical Parameters

Soil samples were collected in 2008 and 2009 for total metals analysis using ICP to measure background metal concentrations in soils in the LSA. Soil sample collection methods for baseline metal concentrations can be found in the Soil and Vegetation Chemistry Baseline Report (SD 6-2 2009 Terrestrial Synthesis Baseline).

6.4.1.2 Results

6.4.1.2.1 Terrain and Soil Distribution in the Local Study Area

The following soil types were identified in the LSA (Soil Classification Working Group 1998).

Turbic Cryosol

These are Cryosolic soils that have developed primarily in mineral material and have marked evidence of cryoturbation (Harris et al. 1988). They generally occur on patterned ground, which includes such cryogenic forms as sorted and nonsorted circles, nets, polygons, stripes, and steps in stony or coarse-textured material, and nonsorted units such as earth hummocks in medium- and fine-textured materials. Processes include sorting of different-sized particles and mixing of both mineral and organic material from different horizons. Organic (Oy) or organic-rich mineral horizons (Ahy) are characteristically present in the region of the permafrost table (upper surface of permafrost layer), and there is generally a buildup of ice in the upper part of the permafrost layer.

Turbic Cryosols are mineral soils that have permafrost within 2 m of the surface and show marked evidence of cryoturbation laterally within the active layer, as indicated by disrupted or mixed or broken horizons, or displaced material, or a combination of both.

Organic Cryosol

These Cryosolic soils have developed primarily from organic material containing more than 17% organic carbon by weight and are underlain by permafrost within 1 m of the surface. They are greater than 40 cm thick, or greater than 10 cm thick over either a lithic contact or an ice layer that is at least 30 cm thick. Landforms associated with Organic Cryosols include palsas, peat polygons, and high-centre polygons.

Static Cryosol

These Cryosolic soils have developed primarily in coarse-textured mineral parent materials, or in a wide textural range of recently deposited or disturbed sediments where evidence of cryoturbation is still largely absent, or in both. They may have organic surface horizons less than 40 cm thick.

Static Cryosols have permafrost within 1 m of the surface but show little or no evidence of cryoturbation or features that indicate cryoturbation. They may be associated with landforms exhibiting patterned ground features such as polygons.

Regosols

Regosolic soils do not contain a recognizable B horizon at least 5 cm thick and are therefore referred to as weakly developed. The lack of a developed pedogenic B horizon may result from any of a number of factors: youthfulness of the material, recent alluvium; instability of the material, colluvium on slopes subject to mass wasting; nature of the material, nearly pure quartz sand; and climate, dry cold conditions. Regosolic soils are generally rapidly to imperfectly drained. They occur under a wide range of vegetation and climates.

6.4.1.2.2 Terrain and Soil in the Local Study Area

Fifteen terrain units have been defined and mapped for the LSA and include disturbance, unclassified, and water (Figure 6.4-1 and Table 6.4-1). The most common terrain map unit encountered in the LSA is the till blanket/veneer terrain unit (Tbv), which covers 3661 ha (33%) of the LSA. The second most abundant terrain unit is the till and marine sediments (Tm) unit, which covers 1,760 ha (17%) of the LSA. The remaining terrain units compose less than 10% of the LSA each.

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LEGEND

- Local Study Area (LSA)
- Terrestrial Disturbances
- Watercourse
- Waterbody

Terrain Map Units

- Am - Alluvium and marine sediments, undifferentiated
- DL - Disturbed land
- Gh - Glaciofluvial and morainal deposits
- Gk - Ice-contact stratified sediments
- Mm - Nearshore sediments
- Mr - Littoral sediments
- Mt - Tidal flats sediments
- O - Organic Deposits
- R - Volcanic/sedimentary rocks
- R-Mr - Volcanic/sedimentary rocks - littoral sediments
- R-Tw - Volcanic/sedimentary rocks - marine washed till
- Tbv - Till blanket veneer
- Th - Hummocky till
- Tm - Till and marine sediments, undifferentiated
- Tx - Till, modified by glacial meltwater flow
- Water

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METRES

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).
Datum: NAD 83 Projection: UTM Zone 15

2500 0 2500
METRES

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

TERRAIN MAP UNITS IN THE TERRESTRIAL LOCAL STUDY AREA

Golder Associates

PROJECT NO. 10-1373-0076			FILE No.	
DESIGN	DD	31 Jul. 2012	SCALE AS SHOWN	REV. 0
GIS	JW	19 Sep. 2012		
CHECK	DD	18 Jan. 2013		
REVIEW	DW	18 Jan. 2013		

FIGURE 6.4-1

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Table 6.4-1: Area of Terrain Map Units in the Local Study Area

Terrain Map Unit	Terrain Map Unit Description	Total LSA	
		Area (ha)	%
Am	Alluvium and marine sediments	283	3
DL	Disturbed land	4	<1
Gh	Glaciofluvial and morainal deposits	107	1
Gk	Ice contact stratified sediments	113	1
Mm	Nearshore sediments	484	5
Mr	Littoral sediments	428	4
Mt	Tidal flat sediments	86	1
O	Organic	20	<1
R	Bedrock	560	5
R-Mr	Bedrock-littoral sediments	192	2
R-Tw	Bedrock-till	362	3
Tbv	Till blanket/veneer	3,661	33
Th	Till hummicky	437	4
Tm	Till and marine sediments	1,760	17
Tx	Till	30	<1
W	Water	2,203	21
Total		**10,598**	**100**

Note: Numbers are rounded for presentation purposes; therefore, it may appear that the totals do not equal the sum of the individual values.
LSA = local study area; AWAR = All-weather Access Road; NA = not applicable; % = percent; ha = hectare; < = less than.

The 6 soil map units described and mapped for the LSA are summarized in Table 6.4-2 and illustrated on Figure 6.4-2. The most common soil map unit in the LSA are the Turbic Cryosols-Regosols followed by Organic and Turbic Cryosols, which account for 4035 ha (38%) and 2449 ha (23%) of the LSA, respectively. The remaining soil map units collectively represent less than 15% of the LSA each. Water covers 2221 ha (21%) of the LSA.

Table 6.4-2: Area of Soil Map Units in the Local Study Area

Soil Map Unit	Total LSA	
	Area (ha)	%
Bedrock-Regosols	233	2
Disturbed	<1	<1
Organic Cryosols	317	3
Organic and Turbic Cryosols	2,449	23
Static Cryosols	1,341	13
Turbic Cryosols-Regosols	4,035	38
Water	2,221	21
Total	**10,598**	**100**

Note: Numbers are rounded for presentation purposes; therefore, it may appear that the totals do not equal the sum of the individual values.
LSA = local study area; AWAR = All-weather Access Road; NA = not applicable; % = percent; ha = hectare; < = less than.

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LEGEND

- Local Study Area (LSA)
- Terrestrial Disturbances
- Watercourse
- Waterbody

Soil Map Units

- Bedrock-Regosols
- Disturbed
- Organic Cryosols
- Organic and Turbic Cryosols
- Static Cryosols
- Turbic Cryosols-Regosols
- Water

400 0 400
METRES

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).
Datum: NAD 83 Projection: UTM Zone 15

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METRES

PROJECT

AGNICO EAGLE

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TITLE

SOIL MAP UNITS IN THE TERRESTRIAL LOCAL STUDY AREA

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PROJECT NO. 10-1373-0076			FILE No.	
DESIGN	DD	31 Jul. 2012	SCALE AS SHOWN	REV. 0
GIS	JW	19 Sep. 2012		
CHECK	DD	18 Jan. 2013		
REVIEW	DW	18 Jan. 2013		

FIGURE 6.4-2

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6.4.1.2.3 Soil Sensitivity and Quality in the Local Study Area

Soil Erosion Risk

Soil erosion risk is one of the primary concerns for disturbed soils because the limited amount of vegetation cover exposes soil materials to the elements (e.g., wind and water). With continuous exposure to wind or rain, the uppermost portions of the soil profile may be eroded, washed, or blown away, depending on terrain and soil characteristics, resulting in loss of topsoil and subsequent soil quality. Most soil map units in the LSA are rated as having low erosion sensitivity, with the exception of disturbed areas and Cyrosols. Erosion sensitivities for Cryosolic soils (i.e., permafrost soils) are considered to be moderate to reflect the sensitivity of these soils to disturbance and the potential for changes in the thermal regime to de-stabilize soil structure and increase pore water pressures. A summary of soil characteristics and the overall erosion sensitivity for each soil map unit is presented in Table 6.4-3.

Table 6.4-3: Erosion Sensitivity of Soil Map Units in the Local Study Area

Soil Map Unit	Soil Erosion Sensitivity Rating
Bedrock-Regosols	Low
Disturbed	Moderate
Organic Cryosols	Low
Organic and Turbic Cryosols	Low-Moderate
Static Cryosols	Moderate
Turbic Cryosols-Regosols	Low-Moderate
Water	Not Applicable

Reclamation Suitability

Soil reclamation suitability is discussed as an integrator of various soil quality parameters. Reclamation suitability is defined by a set of soil quality parameters that define a soil's capability to support natural plant communities. Criteria applied to the baseline soil data to determine reclamation suitability was based on methods developed in Alberta (Alberta Agriculture 1987) for the Northern Forest Region (Table 6.4-4).

Table 6.4-4: Reclamation Suitability of Soil Map Units in the Local Study Area

Soil Map Unit	Reclamation Suitability Rating
Bedrock-Regosols	Unsuitable
Disturbed	Unsuitable
Organic Cryosols	Organic
Organic and Turbic Cryosols	Organic-Poor
Static Cryosols	Poor-Unsuitable
Turbic Cryosols-Regosols	Poor-Unsuitable
Water	Not Applicable

Based on the criteria for the upper lift (topsoil), the topsoils of mineral soils in the LSA have generally Poor to Unsuitable reclamation suitability due to texture, coarse fragments and metal concentrations. Subsoils were predominantly categorized as Poor and Unsuitable for reclamation. The extensive Organics and Organic Cryosols in the area are not given a rating and are classified as an organic category. However, these materials are valuable in reclamation because of higher nutrient contents and soil moisture holding capacities and may be used as an amendment during reclamation.

6.4.1.2.4 Soil Chemistry

Sampling for baseline metal chemistry of soils was completed in 2008 and 2009. Results from the baseline metal chemistry sampling program can be found in Soil and Vegetation Chemistry Baseline Report (SD 6-2 2009 Terrestrial Synthesis Baseline) and is summarized in Tables 6.4-5 and 6.4-6.

The results from the metal analyses indicate there are areas where naturally occurring arsenic concentrations are high (i.e., above Canadian Soil Quality Guidelines [CCME 2012a]). If these materials are salvaged during Project activities, they will be salvaged separately from materials that are not naturally high in arsenic to prevent cross-contamination of salvaged materials. Additional sampling may be required to better evaluate the spatial extent of soils containing naturally high arsenic concentrations to prevent mixing with soils that do not contain naturally high arsenic concentrations within the Project footprint.

Table 6.4-5: Total Soil Metal Concentrations (mg/kg) Associated with each 2008 Sample Plot

	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Copper	Lead	Mercury	Molybdenum	Nickel	Selenium	Silver	Thallium	Tin	Uranium	Vanadium	Zinc
	(Sb)	(As)	(Ba)	(Be)	(Cd)	(Cr)	(Co)	(Cu)	(Pb)	(Hg)	(Mo)	(Ni)	(Se)	(Ag)	(Tl)	(Sn)	(U)	(V)	(Zn)
Detection Limits	0.2	0.2	5	1	0.5	0.5	1	2	5	0.05	1	2	0.2	1	1	5	2	1	10
2007 CCME Guideline (agricultural)	20	12	750	4	1.4	64	40	63	70	6.6	5	50	1	20	1	5	23	130	200
2008 Soil Sample Plots																			
08-001	<0.2	**51.8**[a]	36	<1	<0.5	32.7	14	31	10	<0.05	<1	38	<0.2	<1	<1	<5	<2	22	50
08-002	<0.2	**59.9**	53	<1	0.5	11.1	9	**66**	8	0.05	<1	48	**1.2**	<1	<1	<5	<2	9	60
08-003	<0.2	**47.3**	93	<1	<0.5	16	19	30	<5	<0.05	2	20	0.4	<1	<1	<5	<2	15	20
08-004	<0.2	**13**	118	<1	<0.5	12.3	6	8	<5	0.16	<1	10	0.2	<1	<1	<5	<2	8	70
08-005	<0.2	**51.1**	117	<1	<0.5	10.7	**45**	**72**	<5	<0.05	7	39	0.8	<1	<1	<5	<2	9	40
08-006	<0.2	**26.9**	22	<1	<0.5	25.6	5	18	7	0.08	<1	20	0.2	<1	<1	<5	<2	15	50
08-007	<0.2	**13.9**	24	<1	<0.5	31.6	5	8	<5	0.09	<1	12	0.2	<1	<1	<5	<2	18	30
08-008	<0.2	**23.3**	31	<1	<0.5	22	6	9	<5	<0.05	<1	13	0.2	<1	<1	<5	<2	15	40
08-009	<0.2	1.2	51	<1	<0.5	5.2	1	5	<5	0.11	<1	4	0.4	<1	<1	<5	<2	4	20
08-010	<0.2	**11.8**	81	<1	0.8	23.1	9	18	<5	0.19	<1	19	0.4	<1	<1	<5	<2	15	60
08-011	<0.2	7	73	<1	<0.5	29.4	10	15	<5	<0.05	<1	24	0.2	<1	<1	<5	<2	39	40
08-012	<0.2	**49.7**	35	<1	<0.5	26.9	15	30	10	<0.05	1	31	<0.2	<1	<1	<5	<2	18	40
08-013	<0.2	5.9	40	<1	<0.5	27.4	7	18	<5	<0.05	1	15	<0.2	<1	<1	<5	<2	29	30
08-014	<0.2	8.4	64	<1	<0.5	29.1	8	29	<5	<0.05	1	24	0.4	<1	<1	<5	<2	25	30
08-015	<0.2	**19.5**	72	<1	<0.5	51.3	11	13	6	<0.05	<1	22	<0.2	<1	<1	<5	<2	38	50
08-016	<0.2	1.3	113	<1	<0.5	32.2	5	8	<5	0.16	<1	13	0.4	<1	<1	<5	<2	30	40
08-017	<0.2	2.7	74	<1	<0.5	31.8	7	7	<5	<0.05	<1	16	<0.2	<1	<1	<5	<2	27	30
08-018	<0.2	1.4	18	<1	<0.5	8.5	2	5	<5	<0.05	<1	5	<0.2	<1	<1	<5	<2	9	20
08-019	<0.2	1.1	22	<1	<0.5	12.7	3	2	<5	<0.05	<1	7	<0.2	<1	<1	<5	<2	14	20
08-020	<0.2	8.3	50	<1	<0.5	23	15	29	<5	<0.05	<1	26	<0.2	<1	<1	<5	<2	23	40

[a] Values in bold and shaded refer to soil metal concentrations that exceed CCME guidelines. Note: mg/kg= milligram per kilogram.

Table 6.4-6: Total Soil Metal Concentrations (mg/kg) Associated with each 2009 Sample Plot

Metal		Detection Limits	2007 CCME Guideline (agricultural)	2009 Soil Sample Plots							
				09-D01	09-D02	09-D03	09-D04	09-D05	09-D06	09-D08	09-D09
Aluminum	(Al)	10	n/a	9,670	9,530	1,240	9,580	6,370	3,550	5,820	8,460
Antimony	(Sb)	0.05	20	<0.050	<0.050	0.113	0.056	<0.050	0.067	<0.050	<0.050
Arsenic	(As)	0.05	12	6.66	**12.6** [a]	4.52	8.91	1.85	1.80	**20.3**	4.03
Barium	(Ba)	0.1	750	71.3	72.7	61.9	73.6	119	99.9	51.7	64.0
Beryllium	(Be)	0.2	4	3.11	3.71	0.24	2.74	1.73	0.92	2.11	2.73
Bismuth	(Bi)	0.3	n/a	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Cadmium	(Cd)	0.5	1.4	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Calcium	(Ca)	10	n/a	5,530	6,760	26,700	1,950	3,270	4,100	7,680	5,810
Chromium	(Cr)	0.5	64	39.3	39.5	2.98	37.0	33.0	10.5	23.2	36.2
Cobalt	(Co)	0.5	40	11.1	18.4	3.75	6.80	4.89	3.68	10.9	8.95
Copper	(Cu)	0.5	63	53.4	42.6	31.1	22.7	13.5	12.9	32.5	19.4
Iron	(Fe)	5	n/a	17,900	21,300	1,700	16,100	10,300	5,170	11,600	15,300
Lead	(Pb)	0.1	70	5.31	4.35	5.29	3.98	2.92	2.87	4.06	3.67
Lithium	(Li)	0.5	n/a	12.0	13.1	0.83	9.40	3.24	1.45	7.16	12.6
Magnesium	(Mg)	5	n/a	6,740	6,550	1,060	5,200	3,850	1,770	4,520	7,080
Manganese	(Mn)	0.2	n/a	238	425	271	90.6	138	50.9	237	251
Mercury	(Hg)	0.01	6.6	0.113	0.023	0.202	0.169	0.180	0.161	0.015	0.025
Molybdenum	(Mo)	0.05	5	0.679	0.688	1.34	0.648	0.484	0.322	0.297	0.244
Nickel	(Ni)	0.5	50	26.8	33.0	20.6	16.3	10.5	6.97	17.2	16.9
Phosphorus	(P)	20	n/a	658	672	939	885	1070	872	619	596
Potassium	(K)	100	n/a	2,670	1,970	1,090	1,330	2,300	680	1,110	2,530
Selenium	(Se)	1	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Sodium	(Na)	100	n/a	320	310	130	<100	120	100	210	230
Strontium	(Sr)	0.3	n/a	31.5	41.2	195	19.4	17.8	29.8	32.2	28.6
Thallium	(Tl)	0.03	1	0.174	0.214	0.066	0.106	0.137	0.043	0.090	0.124
Tin	(Sn)	0.2	5	0.47	0.42	0.28	0.25	0.30	0.25	0.31	0.37
Titanium	(Ti)	0.5	n/a	824	945	67.6	446	666	300	574	878
Uranium	(U)	0.01	23	1.97	1.37	0.634	0.647	0.592	0.353	0.527	0.688
Vanadium	(V)	0.5	130	27.7	26.1	3.67	16.3	19.2	6.91	17.7	26.6
Zinc	(Zn)	0.5	200	46.7	48.9	53.5	39.7	44.7	32.5	32.3	36.3

[a] Values in bold and shaded refer to soil metal concentrations that exceed CCME guidelines. Note: mg/kg= milligram per kilogram; <= less than.

Metals concentrations for the collected soil samples were assessed relative to the Canadian Council of Ministers of the Environment (CCME) (2012a) agricultural guidelines for contaminated soils to determine if any metals exceeded the guidelines under the existing baseline conditions. The soil quality guidelines for agricultural sites were used, as the site in its current state is considered natural at baseline.

The majority of soil metal concentrations in 2008 sample plots were within acceptable guidelines, with the exception of arsenic, which exceeded CCME limits on 10 plots (Table 6.4-6). Most of these plots were found in the immediate vicinity of the main mine site or along the proposed road near the mine site. The exception was plot 08-015, which was located southwest of the main mine site near the proposed road leading to Discovery. One plot, 08-010, had borderline values for arsenic at 11.8 milligram per kilogram (mg/kg). Cobalt, copper, and selenium also exceeded CCME agricultural criteria on 2 sites (Table 6.4-6). Soil plot 08-002 had high levels of copper and selenium, whereas plot 08-005 had levels of cobalt and copper above CCME criteria. Both sites are located near the main mine site. For the 2009 samples, only soil plots 09-D02 and 09-D08 had elevated levels of arsenic at 12.6 mg/kg and 20.3 mg/kg respectively, compared to the CCME guideline value of 12 mg/kg (Table 6.4-7). All other soil metal concentrations in the 2009 sample plots were below applicable CCME guidelines (Table 6.4-7).

6.4.2 Pathway Analysis

6.4.2.1 Methods

Pathway analysis identifies and assesses the linkages between Project components or activities, and the correspondent potential residual effects to terrain and soils. Potential pathways through which the Project could affect terrain and soils were identified from a number of sources including:

- review of the development description and scoping of potential effects by the environmental and engineering teams for the Project;
- scientific knowledge and experience with other mines in NU;
- engagement with the public, Aboriginal people, communities, and government; and
- consideration of potential effects identified from the Guidelines for the Project.

The first part of the analysis was to produce a list of all potential effects pathways for the Project (Section 6.4.2.2). Each pathway was initially considered to have a linkage to potential effects on terrain and soils. This step was followed by the development of environmental design features and mitigation that can be incorporated into the development description to remove a pathway or limit (mitigate) the effects to terrain and soils. Environmental design features include Project design elements, environmental best practices, management policies and procedures, and social programs. Environmental design features were developed through an iterative process between the Project's engineering and environmental teams to avoid or mitigate effects.

Knowledge of the ecological system and environmental design features and mitigation was then applied to each of the pathways to determine the expected amount of Project-related changes to the environment, and the associated residual effects (i.e., effects after mitigation) on terrain and soils. Changes to the environment can alter measurement endpoints such as soil chemistry and quantity. For an effect to occur there has to be a source

(Project component or activity) that results in a measurable environmental change (pathway) and a correspondent effect on terrain and soils.

Project activity → change in environment → effect to terrain and soils

Pathway analysis is a screening step that is used to determine the existence and magnitude of linkages from the initial list of potential effects pathways for the Project. This screening step is largely a qualitative assessment, and is intended to focus the effects analysis on pathways that require a more comprehensive assessment of effects on terrain and soils. Pathways are determined to be primary, minor, or as having no linkage using scientific and traditional knowledge, logic, and experience with similar developments and environmental design features. Each potential pathway was assessed and described as follows:

- no linkage – pathway is removed by environmental design features and mitigation so that the Project results in no detectable environmental change and residual effects to terrain and soils relative to baseline or guideline values;
- minor – pathway could result in a measurable and minor environmental change, but would have a negligible residual effect on terrain and soils relative to baseline or guideline values; or
- primary – pathway is likely to result in a measurable environmental change that could contribute to residual effects on terrain and soils relative to baseline or guideline values.

Primary pathways require further effects analysis from the Project on terrain and soils. Pathways with no linkage to terrain and soils or that are considered minor are not analyzed further in the EA because environmental design features and mitigation will remove the pathway (no linkage) or residual effects to terrain and soils can be determined to be negligible through a simple qualitative evaluation of the pathway. Pathways determined to have no linkage to terrain and soils or those that are considered minor are not predicted to result in environmentally significant effects on terrain and soils. All primary pathways are assessed in the EA.

6.4.2.2 Results

Potential pathways through which the Project could affect terrain and soils are presented in Table 6.4-7. Environmental design features and mitigation incorporated into the Project Description (FEIS Volume 2, Section 2.0) to remove a pathway or limit the effects to terrain and soils are listed, and pathways are determined to be primary, minor, or as having no linkage. The following section discusses the potential pathways relevant to the terrain and soil environment.

Table 6.4-7: Potential Pathways for Terrain and Soil

Project Component/Activity	Effect Pathways	Environmental Design Features and Mitigation	Pathway Assessment/ Section for Further Discussion
Mine infrastructure footprint (e.g., open pit, site roads) Project Access Road Rankin Inlet Infrastructure	Physical loss or alteration of terrain and soil from the Project footprint and AWAR	Compact infrastructure arrangement is designed to reduce the overall project footprint. Roads are designed as narrow as possible, while maintaining safe construction and operation practices, and meeting legislated requirements. Minimum haul road widths are defined under the Mine's Act.	Primary/Section 6.4.2.3
Mine infrastructure footprint (e.g., open pit, site roads) Project Access Road Rankin Inlet Infrastructure	Loss or alteration of local flows, drainage patterns (distribution), and drainage areas from the Project footprint and AWAR can cause changes to soils, vegetation, and wetlands	Use of design features (i.e. dams, drainages, dykes and diversions) that reduce changes to local flows, drainage patterns, and drainage areas. Mitigation measures will be based on results from the 2012 shoreline erosion baseline surveys (in progress at the time of preparing this document), mitigation measures based on adaptive management, or a combination of both. Where practical, natural drainage patterns will be used to reduce the use of ditches or diversion berms	Minor/Section 6.4.2.2.2
Water Management (dams, drainage, diversion, intake, discharge and dewatering)	Process and potable water requirements during Construction and Operations from the Project may decrease drainage flows and surface water levels, and affect soil, vegetation, wetlands, and wildlife habitat.	A Site Water Management Plan will be developed. Contact water will be monitored and managed through the attenuation ponds. Surface runoff and talik water seeping into the open pits will be collected in in-pit sumps. The collected water will be used for dust control and/or managed as contact water (collected, contained, monitored and treated if required to meet water license discharge standards before release). Underground water with high salinity will be collected, contained, monitored and treated in a water treatment plant or used in the milling process.	No Linkage/Section 6.4.2.2.1
Water Management (dams, drainage, diversion, intake, discharge and dewatering)	Cross-drainage structures for the mine site roads, AWAR, and Rankin Inlet Road may alter stream hydraulics and geomorphology, and can alter soils, vegetation, and wildlife habitat	Pumped discharge to receiving lake will only occur while water quality discharge criteria are met. pumped discharge will be directed to the lake environment, and not directly to outlets, to attenuate flow changes. Mitigation measures will be based on results from the 2012 shoreline erosion baseline surveys (in progress at the time of preparing this document), mitigation measures based on adaptive management, or a combination of both. where practical, natural drainage patterns will be used to reduce the use of ditches or diversion berms	No Linkage/Section 6.4.2.2.1
Water Management (dams, drainage, diversion, intake, discharge and dewatering)	Dewatering of lakes, Project footprint, and diversion of water, may change downstream flows, water levels, and affect soils, vegetation, and wildlife habitat.	Pumped discharge to receiving lake will only occur while water quality discharge criteria are met. Pumped discharge will be directed to the lake environment, and not directly to outlets, to attenuate flow changes. Mitigation measures will be based on results from the 2012 shoreline erosion baseline surveys (in progress at the time of preparing this document), mitigation measures based on adaptive management, or a	Minor/Section 6.4.2.2.2

Table 6.4-7: Potential Pathways for Terrain and Soil (continued)

Project Component/Activity	Effect Pathways	Environmental Design Features and Mitigation	Pathway Assessment/ Section for Further Discussion
		combination of both. Where practical, natural drainage patterns will be used to reduce the use of ditches or diversion berms	
General construction and operation of mine and supporting infrastructure	Air emissions and dust deposition can cause changes to chemical properties of surface water, soils, vegetation, and wetlands	Dust will be actively suppressed from roads (water and/or other dust suppressants). Potential use of chemical dust suppressants in accordance with the Environmental Guidance for Dust Suppression published by the Government of Nunavut Department of Environment. Enforcing speed limits will assist in reducing dust. Road surfaces will be maintained through grading and the addition of granular material. Equipment and vehicles will comply with relevant non-road emission criteria at that time of purchase. Regular maintenance of equipment and vehicles will be conducted to meet emission standards	Minor/Section 6.4.2.2.2
General construction and operation of mine and supporting infrastructure	Spills on the mine site or along the AWAR can affect surface water quality, soils, and vegetation	Equipment will be re-fueled, serviced, and washed away from stream crossings and on impermeable pads wherever possible. There will be a wash bay in the maintenance shop. Emergency response and spill contingency plans have been developed and will be implemented. Vehicles properly loaded and loads appropriately covered where necessary. Hazardous materials and fuel will be stored according to regulatory requirements to protect the environment and workers (i.e., Materials and Waste Management Plan). Individuals working on site and handling hazardous materials will be trained in the Transportation of Dangerous Goods and Hazmat. Biopile will be constructed to treat soils and rock contaminated by light hydrocarbons. The biopile will have a low permeability liner. Soils from petroleum spill areas will be excavated and placed into the biopile. Soils contaminated with heavy hydrocarbons will be segregated, packaged and shipped to the south from the mine site for proper treatment and disposal. Fuel storage tanks will be situated in a lined and bermed containment area capable of containing 110 per cent of the contents of the largest tank. The storage tanks and fuel-dispensing systems will be constructed in accordance with current regulatory requirements and fire regulations. Fuel will be transported year-round by double-walled tanker trucks to the Meliadine tank farm. Construction and mining equipment, machinery, and vehicles will be regularly maintained.	No Linkage/Section 6.4.2.2.1

Table 6.4-7: Potential Pathways for Terrain and Soil (continued)

Project Component/Activity	Effect Pathways	Environmental Design Features and Mitigation	Pathway Assessment/ Section for Further Discussion
General construction and operation of mine and supporting infrastructure	Surface water runoff from the mine facilities area can affect surface water quality, soil, and vegetation	The site Water Management Plan will contain contact water on-site. Runoff and seepage from waste rock management areas will be collected in sedimentation ponds located around the perimeter in low topographic points. This water will be monitored for water quality and if necessary transferred to the mine attenuation pond for treatment prior to discharge. Surface runoff and talik water seeping into the open pits will be collected in in-pit sumps. The collected water will be used for dust control and/or managed as contact water (collected, contained, monitored and treated if required to meet water license discharge standards before release). Natural construction materials will be tested before they are used to confirm that they are not potential acid draining or potential sources of metal leaching.	No Linkage /Section 6.4.2.2.1
Operation of Mine and supporting infrastructure	Leaching of dissolved metals from waste rock in the waste rock/overburden storage facilities may cause changes to groundwater and surface water quality and soils, which may affect vegetation	Waste rock management procedures developed for potentially problematic waste rock/overburden material. Use of non-acid generating and non-metal leaching material at all watercourses. Any PAG or high metal leaching waste rock will be segregated at source and placed into designated areas within the waste rock dumps. PAG and high metal leaching waste rock will be encapsulated with non -PAG rock and low metal leaching rock. Over time potential PAG and high metal leaching rock will become permanently frozen with an active cover layer of non-PAG rock.	Minor/Section 6.4.2.2.2
Post-closure	Residual ground disturbance can cause permanent loss and alteration of terrain and soil	Limited Project footprint size. Implement a Closure and Reclamation Plan.	Primary/Section 6.4.2.3
	Long-term seepage from the facilities can change groundwater and surface water quality, which can affect soils and vegetation	Sewage treatment plant will remain active during the first 2 years of decommissioning. Landfill will be covered with waste rock pile.	Minor/Section 6.4.2.2.2

6.4.2.2.1 Pathways with No Linkage

A pathway may have no linkage if the pathway is removed by environmental design features and mitigation so that the Project results in no detectable environmental change and no residual effects to terrain and soils relative to baseline or guideline values. The pathways described in the following bullets have no linkage to terrain and soils, and will not be carried through the effects assessment.

- **Process and potable water requirements during Construction and Operations from the Project may decrease drainage flows and surface water levels, and affect soil, vegetation, wetlands, and wildlife habitat.**

The Project will withdraw freshwater for dust suppression, potable water, and plant operations from Meliadine Lake. The source of potable water for the camp will be Meliadine Lake. Freshwater requirements for potable water are estimated at 50 000 cubic metres per year (m^3/y), during construction and operations. Supply volumes are small in comparison to median monthly and annual outflow volumes from Meliadine Lake. In comparison, mean monthly water levels are expected to decrease by less than 0.050 m during closure under average climate conditions, during which approximately 17 100 000 m^3/y will be pumped out of Meliadine Lake over a compressed schedule of four months per year to accelerate pit refilling. Thus, the effects on soils, vegetation and wildlife habitat from the potential alteration of process and potable water requirements are expected to be negligible.

- **Surface water runoff from the mine facilities area can affect surface water quality, soil, and vegetation.**

In accordance with SD 2-6 Surface Water Management Plan, contact water will be collected and monitored on-site. Runoff and seepage from waste rock dumps will be collected in local sumps sited in low topographic points. This water will be monitored for water quality and if necessary transferred to the mine contact water management pond for treatment before discharge. Surface runoff and groundwater seeping into the open pits will be collected in in-pit sumps. The collected water will be used for dust control or pumped to the tailings storage facility for re-use as process water. Sumps will be sized to hold water running off the waste rock/overburden management areas and the ore stockpiles and open pits. Construction materials will be clean and contaminant free. Sewage will be treated in packaged multi-stage rotary biological contactor sewage treatment plant.

- **Cross-drainage structures for the mine site roads, AWAR, and Rankin Inlet Road may alter stream hydraulics and geomorphology, and can alter soils, vegetation, and wildlife habitat.**

The installation of cross-drainage structures to prevent roads from impeding water flow can result in the loss and alteration of aquatic and shoreline habitat. The loss of stream and shoreline habitat may be permanent; however, the amount of habitat altered is expected to be minimal. Cross-drainage structures will be implemented in such a way that they provide a design conveyance for 1:25 year event without overtopping the roadway, which will result in minor changes in stream velocity, and prevent channel aggradation, degradation, erosion, or changes to bankfull width or depth. The implementation of appropriate cross-drainage structures is expected to result in minor changes to stream flow velocity in the vicinity of the structures relative to baseline conditions and have negligible residual effects on water quantity and geomorphology. Thus, the effects on terrain and soil from the potential alteration of stream hydraulics and geomorphology are expected to be negligible.

- **Spills on the mine site, mine site roads or along the AWAR can affect surface water quality, soils, and vegetation.**

Chemical spills on other northern mine sites are usually localized (Tahera 2008; BHP Billiton Diamonds Inc. 2010; Diavik Diamond Mines Inc. 2010; De Beers 2010). Mitigation identified in the Emergency Response Plan (SD 2-15) and Spill Contingency Plan (SD 2-16) and environmental design features will be in place to limit the frequency and extent of spills that result from Project activities (Table 6.4-7). Hazardous materials and fuel will be stored according to regulatory requirements to protect the environment and workers (i.e., SD 2-13 Hazardous Materials Management Plan). Smaller storage tanks (e.g., engine oil, hydraulic oil, waste oil, and coolant) will be double walled, and located in lined and bermed containment areas. Individuals working on site and handling hazardous materials will be trained in the Transportation of Dangerous Goods. Emergency spill kits will be available wherever toxic materials or fuel are stored and transferred.

The implementation of the Emergency Response and Spill Contingency Plan and environmental design features are anticipated to reduce the frequency, spatial extent, and severity of spills on the environment. Thus, spills in the mine area and on the AWAR are predicted to result in low to negligible changes to soil quality. Consequently, this pathway was determined to have no linkage to effects on soils.

6.4.2.2.2 Minor Pathways

In some cases, both a source and a pathway exist, but the change caused by the Project is anticipated to result in a minor environmental change, and would have a negligible residual effect on terrain and soils relative to baseline or guideline values (Table 6.4-7). The pathways described in the following bullets are expected to be minor and will not be carried through the effects assessment:

- **Dewatering of lakes and alteration of flow paths may change flows, water levels, and channel/bank stability in receiving and downstream waterbodies, and affect water quality and quantity, and can cause changes to soils, vegetation and wetlands.**

Pumped discharge to receiving lakes will only occur while water quality discharge criteria are met. In addition, pumped discharge will be directed to the lake environment, and not directly to outlets, to attenuate flow changes. Mitigation measures will be based on results from the 2012 shoreline erosion baseline surveys (in progress at the time of preparing this document), mitigation measures based on adaptive management, or a combination of both. Where practical, natural drainage patterns will be used to reduce the use of ditches or diversion berms.

- **Vertical and lateral seepage (dissolved metals) from facilities may cause changes to groundwater and surface water quality and soils, which may affect vegetation. Long-term seepage from the facilities can change groundwater and surface water quality, which can affect soils and vegetation.**

During the life of the Project there is the potential for leachate (e.g., metals) from the Tailings and Waste Rock Piles to seep into the surrounding environment. Additionally, there is potential for arsenic as well as other metals (i.e., aluminum, arsenic, cadmium, cobalt, lead, selenium, and uranium) to be present in the leachate. Such water-borne elements could adversely affect soils through surface water runoff and seepage. Environmental design features and mitigation have been incorporated into the Project to reduce the potential for water to contact metal leaching Mine Rock, tailings, and potentially acid generating rock and thus, reducing potential effects to the environment from surface water runoff and seepage from the facilities (Table 6.4-7).

The tailings and waste rock is expected to not have significant quantities of potentially acid generating and metal leaching rock. Runoff and seepage will not be released directly to the environment during construction, operations, closure, and post closure. Runoff and seepage will report to seepage collection ponds.

After construction, all releases from the Project site into waterbodies will be subject to monitoring. Overall, release of runoff and long-term seepage from the Project is not expected result in a detectable change to soils relative to baseline conditions. Consequently, these pathways were determined to have only minor linkages to soils.

- **Air emissions and dust deposition can cause changes to the chemical properties of soils**

Accumulation of dust (i.e., particulate matter [PM] and total suspended particulate [TSP] deposition) and concentrations of air emissions produced from the Project may result in a local indirect change on the quality of soil within the LSA. Air quality modelling was completed to predict the spatial extent of dust deposition and air emissions from the Project (FEIS Volume 5, Section 5.2). Sources of dust deposition and air emissions modelled in the application case (maximum effect case) include blasting activities, haul roads, the Plant, activities at the Open Pit and other ancillary facilities, and vehicle traffic along the AWAR. Environmental design features and mitigation have been incorporated into the Project to reduce potential effects from dust deposition (Table 6.4-7). For example, the watering of roads and laydown areas during the non-winter period will facilitate dust suppression. In addition, programs will be implemented to review power and heat use to reduce energy use. Although these environmental design features and mitigation should reduce dust deposition and air emissions, assumptions incorporated into the model are expected to contribute to conservative estimates of emission concentrations and deposition rates (FEIS Volume 5, Section 5.2). Maximum predicted emissions presented by the air quality model scenario (or Case) are summarized in Table 6.4-8.

Table 6.4-8: Maximum Predicted Air Emissions Project

Compound	Units	Maximum Deposition Prediction Outside of Project Disturbance Areas[a]						
		Case1	Case2	Case3	Case4	Case5	Case6	Overall
DUST	(g/m²/yr)	1.57E-01	2.05E-01	5.43E-01	2.55E-01	3.30E-01	2.05E-01	**5.43E-01**
PAI	(keq/ha/yr)	0.23	0.27	0.38	0.25	0.23	0.26	**0.38**
Arsenic	(g/m²/yr)	1.74E-05	2.28E-05	6.03E-05	2.83E-05	3.67E-05	2.28E-05	**6.03E-05**
Copper	(g/m²/yr)	1.11E-05	1.45E-05	3.85E-05	1.81E-05	2.34E-05	1.45E-05	**3.85E-05**
Cobalt	(g/m²/yr)	4.20E-06	5.49E-06	1.46E-05	6.83E-06	8.85E-06	5.50E-06	**1.46E-05**
Selenium	(g/m²/yr)	1.88E-07	2.45E-07	6.50E-07	3.05E-07	3.95E-07	2.46E-07	**6.50E-07**

[a] Refer to FEIS Volume 5, Section 5.2 for further details.

Trucks travelling on the AWAR have the potential to transfer dust from vehicles and loads (e.g., dust deposited on wheels and undercarriage while at the Project). However, the relative contribution of these loads to the overall dust accumulation in the area along the roads is considered to be negligible (FEIS Volume 5, Section 5.2). Similarly, dust generation from Project vehicles along the AWAR and mine roads would occur annually, but would likely be higher during the non-winter period and not continuous (i.e., would occur less frequently during wet and cool conditions).

Arsenic is one of the metals which is elevated under baseline conditions. After 15 years of operation, the maximum arsenic deposition as the result of air emissions is estimated to be 0.0000347 mg/kg, which would represent less than 0.0003% of the CCME criteria value of 12 mg/kg.

Air emissions from vehicles along the AWAR and site roads were included in the operations case. In general, emissions from the roads will be small, and if extended over the whole year, a negligible effect from annual depositions is predicted (FEIS Volume 5, Section 5.2). Annual emissions from the Project are anticipated to result in no detectable changes to soils.

Acid deposition from air emissions includes the deposition of sulphur oxides, nitrogen oxides, hydrogen, and metals (Rusek and Marshall 2000) onto soil. Potential acid input from air emissions can change the chemical properties of soil. Air quality modelling results indicate maximum deposition rates of 0.38 kiloequivalent per hectare per year (keq/ha/y) within the Project Lease Boundary (Table 6.4-8). While the 0.38 keq/ha/y maximum potential acid input (PAI) is predicted to be above the critical load of 0.25 keq/ha/y of sensitive soils (CASA 1996), it is expected that sensitive soils would likely not be affected by acid deposition relative to baseline conditions due to the short duration of emissions (15 years). Short-term occurrences above the critical loads will not necessarily result in measurable effects on soil ecosystems, but the risk of impacts increases with time (Maynard 1996). Therefore, metal emissions and PAI effects to soil are expected to be negligible.

6.4.2.3 Primary Pathways

The following primary pathways are analysed in the effects assessment:

- **site clearing, contouring, and excavation can cause admixing, compaction, and increase erosion potential, and change terrain;**
- **soil disturbance can change physical, biological, and chemical properties of soils, and increase erosion potential;**
- **permanent loss or alteration of soils from the Project footprint; and**
- **residual ground disturbance can cause permanent alteration of terrain and soils**.

6.4.2.3.1 Effects to Terrain and Soils

6.4.2.3.1.1 Effects to Terrain Units, Soil Quantity, and Distribution

Site clearing and construction for the Project, particularly through the processes of soil stripping and storage, will result in changes to soil quantity and distribution, and changes to terrain. Soil removal will occur mainly during the construction phase of the Project, and to a much lesser extent during operation (i.e., as Open Pit blasting activities will occur primarily on bare bedrock). During closure and reclamation, the soil (i.e., growth media) will not be re-constructed as outlined in the Mine Closure and Reclamation Plan (SD 2-17).

Areas that are expected to be reclaimed at closure by allowing natural revegetation include the Plant site, Borrow Sites, mine site access roads, and AWAR. These areas will be scarified to allow natural revegetation to take place. However, terrain and soil can be altered or lost through the following Project components and activities:

- wind and water erosion during construction and reclamation phases;
- changes to terrain during blasting and excavation of the Underground Mine and Open Pits; and
- permanent residual ground disturbance from Project components.

Methods

Changes to terrain and soil (i.e., terrain and soil map units) were assessed for the maximum predicted point of development of the Project footprint (operations case). Changes to terrain and soil distribution directly affected by the Project were quantified by GIS analysis using the following process:

- GIS quantified areas of terrain and soil map units within the LSA for the baseline case, operations case, and closure; and
- the net changes in terrain and soil map unit distribution were calculated between the baseline case and closure.

6.4.2.3.2 Effects to Terrain and Soil Units and Distribution

Closure is the period during the decommissioning and reclamation phase of the Project when infrastructure is dismantled and initial reclamation of the Project surface footprint is completed, which will involve scarification of the soil surface. Areas that are expected not to be reclaimed include the Open Pit, Waste Rock Piles and Tailings. Following closure, it is anticipated that all plant site structures will be dismantled or demolished and removed.

- With appropriate reclamation techniques terrain can be contoured, to the extent practical, to blend the residual footprint with the surrounding landscape.

The maximum amount of terrain and soil disturbance area from the Project footprint from the Operations Case is predicted to be approximately 2950 ha (28% of the LSA) (Table 6.4-9).

The largest disturbances to terrain will be to the till blanket/veneer (Tbv) map unit with 1,574 ha (15% of LSA), followed by water with 571 ha (5% of LSA). The remaining terrain map unit disturbances represent less than 2% of the LSA each. Of potentially sensitive terrain, the hummocky till (Th) unit will lose about 104 ha (1 % of LSA). Following closure there will be new terrain features created including extra lakes, waste rock piles and tailings disposal areas for a total of 2378 ha (22% of the LSA).

The area of net change for each soil map unit is described in relation to the LSA (Table 6.4-10). For example, approximately 2950 ha (28%) of the soil map units within the LSA will be disturbed. The soils within the Turbic Cyosols-Regosols soil map unit will be disturbed the most (1250 ha, 12 % of LSA) with the Organic and Turbic Cryosols disturbed by 592 ha (6% of LSA). The remaining soil map units represent 3% or lower of the LSA. The area of permanent ground disturbance (i.e., flooded open pits, Tailings Storage Facility, Waste Rock Storage) is predicted to be approximately 1373 ha (13% of the LSA) as these areas will not be reclaimed at closure (Table 6.4-10).

Table 6.4-9: Comparison of Terrain Map Unit Distribution between the Baseline and Closure Case in the Local Study Area

Terrain Map Unit	Baseline Case		AWAR		Operations Case		Closure		Closure Net Change (ha)	
	Area (ha)	(%)	Area (ha)	(%)	Area (ha)	%	Area (ha)	%	Area (ha)	%
Alluvium and marine sediments (Am)	283	3	5	<1	49	<1	234	2	49	<1
Disturbed land (DL)	4	<1	1	<1	0	0	4	0	0	0
Glaciofluvial and morainal deposits (Gh)	107	1	7	<1	16	<1	91	1	16	<1
Ice contact stratified sediments (Gk)	113	1	3	<1	7	<1	106	1	7	<1
Nearshore sediments (Mm)	484	5	16	<1	63	1	421	4	63	1
Littoral sediments (Mr)	428	4	48	<1	77	1	351	3	77	1
Tidal flat sediments (Mt)	86	1	3	<1	4	<1	82	1	4	<1
Organic (O)	20	<1	<1	<1	1	<1	19	0	1	<1
Bedrock (R)	560	5	25	<1	188	2	372	4	188	2
Bedrock-littoral sediments (R-Mr)	192	2	2	<1	9	<1	183	2	9	<1
Bedrock-till (R-Tw)	362	3	14	<1	40	<1	322	3	40	<1
Till blanket/veneer (Tbv)	3,661	33	176	2	1,594	15	2,067	20	1,594	15
Till hummicky (Th)	437	4	<1	<1	104	1	333	3	104	1
Till and marine sediments ™	1,760	17	73	1	225	2	1,535	14	225	2
Till (Tx)	30	<1	0	0	<1	<1	30	0	<1	<1
Water (W)	2,203	21	0	0	571	5	2,068	20	571	5
Reclaimed Terrain	0	0	0	0	0	0	2,378	22	0	0
Total	**10,596**	**100**	**419**	**4**	**2,950**	**28**	**10,596**	**100**	**2,950**	**28**

Note: Numbers are rounded for presentation purposes; therefore, it may appear that the totals do not equal the sum of the individual values.

[c] areas of residual disturbance are those areas that will not be reclaimed

LSA = Local Study Area; AWAR = All-weather Access Road; na = not applicable; ha = hectare; % = percent; < = less than.

Table 6.4-10: Comparison of Soil Map Unit Distribution between the Baseline Case and Closure Case in the Local Study Area

Soil Map Unit[a]	Baseline Case		AWAR		Operations Case		Closure		Net Change	
	Area (ha)	% LSA	Area (ha)	% LSA	Area (ha)	% LSA	Area (ha)	% LSA	Area (ha)	% LSA
Bedrock-Regosols	233	2	5	<1	43	<1	190	2	43	<1
Disturbed	<1	<1	<1	<1	0	0	0	<1	0	0
Organic Cryosols	317	3	8	<1	111	1	206	2	111	1
Organic and Turbic Cryosols	2,449	23	89	1	592	6	1,857	18	592	6
Static Cryosols	1,341	13	99	1	323	3	1,018	10	323	3
Turbic Cryosols-Regosols	4,035	38	178	2	1,250	12	2,785	26	1,250	12
Water	2,221	21	41	<1	631	6	1,590	15	631	6
Reclaimed Soil (Scarified)	0	0	0	0	0	0	1,579	15	0	0
Permanent Soil loss	0	0	0	0	0	0	1,373	13	0	0
Total	**10,598**	**100**	**419**	**4**	**2,950**	**28**	**10,598**	**100**	**2,950**	**28**

Note: Numbers are rounded for presentation purposes; therefore, it may appear that the totals do not equal the sum of the individual values.
Disturbance = anthropogenic disturbance; Unclassified = unclassified due to cloud, haze, and shadow
[a] areas of residual disturbance are those areas that will not be reclaimed
LSA = Local Study Area; AWAR = All-weather Access Road; na = not applicable; ha = hectare; % = percent; < = less than.

6.4.2.3.2.1 Effects to Soil Quality

Site clearing and construction for the Project, particularly through the processes of soil stripping and storage, may result in changes to soil quality. Changes to soil quality may influence the ability of soil to support natural plant communities following closure. Soil removal will occur mainly during the construction phase of the Project, and to a lesser extent during operation (i.e., as Open Pit blasting activities are occurring). During decommissioning and reclamation, the soil (i.e., growth media) will be not re-constructed as outlined in the Mine Closure and Reclamation Plan (SD 2-17).

Soil quality can be altered during salvage and construction operations through the following processes:

- physical, biological, and/or chemical changes during salvage, stockpiling, and transport; and
- admixing and compaction of soil through site clearing, contouring, excavation, and decommissioning and reclamation.

Methods

The effect on soil quality is discussed qualitatively by evaluating the potential for soil admixing, soil compaction, erosion, and reclamation suitability rating changes. Individual characteristics within each soil map unit are assessed to determine overall soil quality, and thus, the ability of a soil to sustain the capability to support natural plant communities. The effect of Project activities on soil quality is determined from an analysis of each of the individual soil parameters and is based on studies reported in the literature and baseline data collected in the LSA (Section 6.4.1.2).

Results

Changes to Soil Physical, Biological, and/or Chemical Properties

Stripping and stockpiling topsoil during construction can cause physical changes to soil such as disturbing soil structure. Loss of soil structure can result in a reduction in the amount of soil organic matter and soil organic carbon present within the soil (Wick et al. 2009). Soil structure influences the bulk density, pore size distribution, microbial community structure, and resistance of soil to erosion (Wick et al. 2009). The most considerable change in soil chemistry in stockpiled soil is changes in organic matter content, especially in sandy textured soil (Abdul-Kareem and McRae 1984). Soil organic matter content influences the rates of microbial decomposition and nutrient availability for plant uptake (Wick et al. 2009). Therefore, direct loss of soil organic matter and soil organic carbon can decrease the ability of soil to support vegetation. Although soil structure begins to recover following storage in stockpiles for a period of time, Wick et al. (2009) found that subsequent movement of the soil caused the structure to break apart more than the initial disturbance, resulting in more fine particles that are more susceptible to erosion.

Biological changes can also arise from stripping and stockpiling soil. There is a large decrease in soil microbial activity, microbial biomass, and mycorrhizal fungi following initial stripping of topsoil (Abdul-Kareem and McRae 1984; Stark and Redente 1987; Wick et al. 2009). Stockpiling topsoil has been known to have adverse effects on earthworm populations, microbial biomass, soil microbiological activities, and mycorrhizal fungi populations over time (Abdul-Kareem and McRae 1984). Stockpiles tend to become anaerobic over time, although the depth at which this occurs is dependent on soil texture (Abdul-Kareem and McRae 1984). For example, sandy textured soil tends to remain aerobic to a greater depth when compared to loam or clay textured soil. The pH also tends to decrease in stockpiled soil, mostly due to the buildup of ammonia as a result of anaerobic conditions (Abdul-Kareem and McRae 1984). The adverse effects on soil microbiological activities and mycorrhizal fungi may result in decreased rates of nutrient cycling, and reduced nutrient availability, although this is dependent on the depth of the stockpile, length of time soil remains in the stockpile, and whether the stockpile has been revegetated (Abdul-Kareem and McRae 1984; Stark and Redente 1987; Wick et al. 2009). Vegetation maintained on stockpiles tends to maintain populations of bacteria and fungi over time at the surface of the stockpile.

Chemical changes to soil include changes to extractable nutrients in topsoil storage piles over time (Abdul-Kareem and McRae 1984). As oxygen decreases in the bulk of a topsoil stockpile, it becomes anaerobic, which inhibits the nitrogen cycle, thereby increasing ammonium-nitrogen (Williamson and Johnson 1994) with depth (Abdul-Kareem and McRae 1984). In some studies, extractable potassium, phosphorus, and magnesium increased in clayey stockpiles, and decreased in sandy and loamy textured stockpiles (Abdul-Kareem and McRae 1984). Other studies have found that the nutrient status of topsoil in stockpiles declined over time, which is likely a result of the loss of clays and silts to erosion (Kundu and Ghose 1997). Nitrogen, phosphorus, and potassium levels tend to decrease with increasing age of a stockpile (Ghose 2001).

The above mentioned physical, biological, and chemical changes can decrease the ability of a soil to support natural plant communities following reclamation. Effects from stripping topsoil are difficult to mitigate simply because moving soil initially causes changes to soil. However, the benefit of salvaging soils outweighs the negative effect from initially moving it. Naeth et al. (2006) reported that topsoil is the most effective way to establish vegetation cover in northern mine sites. Mitigation to reduce the adverse effects of storage of

stockpiled soil includes maximizing the surface area of the stockpile to minimize biological and chemical changes, and allowing natural revegetation of the stockpiles to:

- maintain biological activity and populations of soil bacteria and fungi;
- protect the stockpiles from wind and water erosion;
- promote soil structure formation during storage; and
- reduce nutrient leaching.

By implementing these mitigation practices, the change in local soil quality from soil stripping and subsequent storage is anticipated to be within the range of baseline values. The residual change from soil stripping and storage on local soil quality is predicted to be reversible at the end of closure.

Soil Admixing

Admixing of topsoil with subsoil during soil stripping and salvage operations may cause soil profile integrity to be compromised, especially if clear distinctions are not apparent between the topsoil and subsoil. This is often the case when topsoil thickness is highly irregular over the area of the lift. The depth of the surface layer that will be salvaged from mineral soils will vary according to landscape position and soil drainage conditions.

The primary concerns of soil profile admixing are changes in texture and structure, and dilution of nutrients and organic carbon, which can directly affect soil physical, biological, and chemical characteristics. Changes in soil texture could arise from admixing, particularly in those soils with large textural differences between topsoil and subsoil horizons. However, in the LSA, differences in texture between soil horizons does not occur or textures differ by one soil texture class, but are within the same particle size class. Differences in soil texture between topsoil and subsoil only occur in some localities (i.e., subsoil becomes gravelly at depth at some locations). Consequently, the main concern regarding admixing is the dilution of nutrients and organic matter content of the topsoil. Admixing of subsoil materials into topsoil can dilute organic matter and organic carbon in the topsoil, which can negatively influence microbiological activity, and reduce rates of nutrient cycling (Wick et al. 2009). The reduction of nutrients and organic material content of the soil can decrease the ability of a soil to support natural plant communities.

The residual change from admixing on local soil quality can be reversible at the end of closure if topsoil is salvaged and stored properly.

Compaction

Compaction of soil influences drainage, structure, porosity, aeration, permafrost, and potential susceptibility to erosion, all of which affect soil quality. Compaction from heavy equipment or repeated passes of lighter equipment can break down soil structure, thereby decreasing macro-pore volume and increasing the volume proportion of solids. Compaction can influence the depth of thaw in areas of permafrost, but not as much as where the vegetation is removed (Lawson 1986). Compaction may result in different degrees of change to thaw depth, depending on the soil properties and the ice content of permafrost in an area. Compaction will result in immediate effects on surface drainage in an area (Lawson 1986).

A soil's capability to support natural plant communities can be reduced if the soil becomes compacted. Soil compaction can also influence the success of reclamation by decreasing plant establishment and subsequent plant growth. Compaction of topsoil and subsoil can lead to a decrease in long-term productivity (Heuer et al. 2008; Blouin et al. 2008). The decrease in long-term productivity is a result of increases in soil bulk density and soil strength, reductions in soil aeration (i.e., less soil oxygen), reduced water infiltration and available soil water, restricted root growth, reductions in soil microbiological activity, and influences on nutrient uptake.

The susceptibility of soils to compaction depends on several factors including soil texture, organic matter content, and soil moisture conditions. In general, the higher the clay content, the higher the susceptibility to compaction, especially when soils are moist or wet. For example, well-drained, medium-textured soils (loams, sandy loams, silt, and silt loams) are less prone to compaction than fine-textured soils (silty clay loam, silty clay, clay loam, and clay) under the same soil moisture conditions. In addition, variability in soil particle size tends to offset compaction, such that soils with homogenous texture (i.e., clay, silt) are more prone to compaction than are soils of mixed particle size (Pritchett and Fisher 1987).

Soils developed on coarse to moderately coarse-textured glacial till and glaciofluvial deposits, commonly overlying bedrock at shallow depths (less than 1 m), characterize the Project footprint. Areas prone to compaction are limited to low-lying, poorly drained areas where the clay content of soils are slightly higher than in upland soils.

Topsoil stripping while the soil is not excessively wet will reduce risk of compaction and limit damage to soil structure (Ghose 2001). Topsoil stripping under frozen conditions can also reduce the risk of compaction. If construction is completed under frozen or dry conditions, then compaction is less likely to have an influence on soil quality and suitability for reclamation.

Mitigation to reduce the risk of compaction during construction includes the following:

- a pre-construction site-specific survey to better evaluate soil sensitivity to compaction;
- construction in winter to the extent practical to reduce the potential for compaction;
- discontinue construction during excessively wet periods to the extent practical; and
- limit vehicle traffic and similar activities to designated areas.

By implementing these mitigation practices, the change in local soil quality and suitability for reclamation from compaction is anticipated to be within the range of baseline values, and reversible at the end of closure.

Erosion

Erosion is a concern within the Project footprint during soil salvage and stockpiling due to removal of the vegetation cover. Also, stockpiles maintained through the operation phase may be susceptible to erosion due to factors such as absence of vegetation, steep slopes, and desiccation. Soil quality can be affected because erosion can remove finer particles and organic materials from bulk soil. The removal of organic particles and clays from soil can reduce the overall nutrient content and water holding capacity. Vegetation on storage stockpiles helps to protect the stockpiles from wind and water erosion (Stark and Redente 1987; Ghose 2001). Plant cover shields soils from rainfall erosion, reduces run-off velocity, disperses surface flows, and improves

soil permeability, thus reducing potential effects from erosion. Plant cover will also act to physically bind soil particles, and further reduce the effects from erosion.

Overall, most soil map units in the LSA are rated as having low erosion sensitivity, with the exception of those with special management concerns (i.e., organic or shallow soils, and permafrost). Erosion sensitivities for Cryosolic soils were rated as moderate to reflect the sensitivity of these soils to disturbance and the potential for changes in the thermal regime to de-stabilize soil structure and increase pore water pressures. The soil erosion ratings represent the maximum effect potential based on the disturbance of the soil profile and no mitigation to control soil loss. Since erosion is a concern mainly with respect to disturbed soils, the effect will be confined to the Project footprint. Environmental design features and mitigation (i.e., erosion control practices) will be applied to control wind and water erosion on topsoil and overburden stockpiles (Table 6.3-6). Mitigation will include the implementation of erosion and sedimentation control structures, creation of a stable and favourable landscape that will encourage natural colonization, as outlined in SD 2-17 Mine Closure and Reclamation Plan. Applying appropriate mitigation is expected to reduce the residual effects of local soil erosion (i.e., decreases in soil quality) to within the range of baseline values.

The following general mitigation will be applied to limit erosion:

- salvage topsoil and store on the site away from sensitive areas or areas of high potential erosion;
- construct temporary cross ditches to redirect surface run-off; and
- construct roads so natural drainage patterns are not impeded, where possible, and in a manner that runoff to road ditches enters natural drainage systems or contoured containment areas.

6.4.3 Impact Prediction

No impact predictions are made for terrain and soil as impacts to these components will be captured in other sections including vegetation, wildlife habitat and hydrology. For example, terrain and soil provide the basic form for the terrestrial environment such that vegetation can grow which in turns creates wildlife habitat. Changes in terrain or soils by itself can only be evaluated in context to how it changes the other components such as vegetation and wildlife habitat.

6.4.4 Cumulative Effects

No cumulative effects assessment was done for terrain and soil as effects to these components are localized and will not interact with other disturbances regionally.

6.4.5 Uncertainty

There is a high degree of confidence that surficial materials will be moved, excavated, and re-contoured and soil will be disturbed within the Project footprint. The areas affected have been determined based on the current Mine Plan. However, there is uncertainty associated with the location of ice-rich permafrost within the Project footprint, and site-specific investigations will be undertaken prior to construction to reduce this uncertainty.

Several aspects of soil quality were examined. The effects from soil removal, storage, and other Project activities on soils were assessed. The main processes are biological, chemical, and physical changes during storage in stockpiles, soil admixing, compaction, and erosion, and the associated reclamation suitability. Minor changes in quality due to these processes are predicted with moderate certainty. Admixing, compaction, and erosion effects are expected to be localized. Storage effects are not well known for soils in northern climates. Prediction of a low effect is based on appropriate stockpile design, vegetating the stockpiles, and storage being mainly under frozen conditions; however, there is little background information in subarctic environments to support this assumption. There is uncertainty associated with the distribution of soil containing high concentrations of naturally occurring arsenic (i.e., above Canadian Soil Quality Guidelines [CCME 2012a]). To reduce this uncertainty, additional soil samples will be collected for analysis during salvaging of soils to limit or prevent mixing of materials containing high arsenic with materials that do not contain high arsenic concentrations.

Uncertainty was addressed in the assessment by incorporating information from available and applicable literature, and using past experience in similar areas. In addition, the application of environmental design features and mitigation, and the Mine Closure and Reclamation Plan (SD 2-17) will mitigate effects to soil and the ability of soil to support plant communities during construction, operation, and reclamation. Finally, a conservative approach was used when information was limited so that effects are typically overestimated. For example, for erosion sensitivities of soils, the highest sensitivity (i.e., wind or water erosion) was applied to each soil map unit.

6.4.6 Monitoring and Follow-Up

Monitoring programs implemented during the life of the Project may be a combination of environmental monitoring to track conditions and implement further mitigation as required (e.g., monitoring for soil erosion during construction), and follow-up monitoring to verify the accuracy of effect predictions and adaptively manage and implement further mitigation as required.

Terrain stability and soil quantity and quality would be assessed during the construction and operations phases of the Project, and during closure and post-closure as part of reclamation. Soil conditions may be monitored to estimate reclamation success, and on-going terrain stability monitoring is anticipated after closure. Other soil quality issues such as erosion, admixing, and compaction will be visually assessed as part of this task. Results from this program will be used to support adjustments to the reclamation and closure plan and incorporated into the ongoing reclamation activities. Mine closure requires input from regulatory agencies and communities to identify closure objectives and strategies, so the precise monitoring required is unknown at this time.

6.5 Vegetation

6.5.1 Introduction

The purpose of this section is to describe the baseline conditions for vegetation and assess the effects of the Project on vegetation. This assessment includes potential changes resulting from Project-related components and associated activities, including air quality, water quality, water quantity, and terrain and soils. The effects assessment will evaluate all Project phases, including construction, operation, and temporary, final, and post-closure. Indirect and cumulative effects have been incorporated throughout this section, where applicable. Volume 1, Appendix 1.0-A list the specific requirements set out in the guidelines relating to the baseline and the impact assessment of the vegetation environment.

6.5.2 Valued Components

Valued ecosystem components and VSECs represent physical, biological, cultural, social, and economic properties of the environment that are either legally, politically, publically, or professional recognized as important to a particular region, community, or by society as a whole. Valued ecosystem components and VSECs were selected based on their role in the ecosystem, and value placed on them by humans for traditional use and cultural connection, where appropriate. Three VECs were selected for vegetation to assess Project related effects on the terrestrial environment (Table 6.5-1).

Table 6.5-1: Vegetation Valued Ecosystem Components

Valued Ecosystem Component	Rationale for Selection
Plant populations and communities	Characterized within Ecological Landscape Classification (ELC) types, especially those with restricted distribution that may be disproportionately affected by the Project; important for support of ecosystem processes and services, ecosystem resiliency, and spiritual and aesthetic values
Listed (rare) plant species	Plant species listed as “At Risk”, “May be at Risk” or “Sensitive” in Nunavut or by Committee on the Status of Endangered Wildlife in Canada (COSEWIC); which therefore, may be disproportionately affected by Project activities
Traditional use plant species	Plants used in Nunavut primarily by aboriginal persons, including edible plants, medicinal plants, and plants used for construction or other purposes

Factors considered when selecting VECs included the following (Salmo 2006):

- biophysical components identified by NIRB during Project scoping and AEM community and stakeholder consultation;
- represent important ecosystem processes;
- territorial (CESCC 2011) and federal listed (COSEWIC 2012; *SARA* 2012) species;
- communities or species that reflect the interests of regulatory agencies, First Nations groups, and communities;
- can be measured or described with one or more practical indicators (measurement endpoints);
- allow cumulative effects to be considered; and
- current experience with environmental assessments and effects monitoring programs in NU and the NT.

Plant populations and communities, including plant species identified as country foods, are important to the people of NU. All issues related to vegetation identified through public consultation, including those listed in the NIRB Guidelines are captured under the VECs for vegetation and addressed in this assessment.

Assessment endpoints represent the key properties of the VEC that should be protected for their use by future generations, while measurement endpoints are quantifiable (i.e., measurable) expressions of changes to assessment endpoints. Assessment and measurement endpoints for vegetation VECs are presented in Table 6.5-2.

Table 6.5-2: Summary of the Valued Ecosystem Components, Assessment, and Measurement Endpoints for Vegetation

Valued Ecosystem Component	Assessment Endpoints	Measurement Endpoints
• Plant populations and communities • Listed (rare) plant species • Traditional use plants	• Maintenance of population abundance and distribution of plant populations and communities. • Maintenance of population abundance and distribution of plant species at risk. • Continued opportunity for use of traditional plants.	• Relative abundance and distribution of plant species • Presence of invasive species • Availability of plants for traditional use.

6.5.3 Baseline Environment

6.5.3.1 Methods

Ecological Landscape Classification

Regional Study Area

A regional ELC classification map was developed using satellite imagery, remote sensing software, and a GIS to determine the abundance and distribution of primary land cover classes within the RSA and LSA for vegetation. The regional ELC classification was based on cloud-free coverage using LANDSAT 5 satellite spectral imagery with a 30 × 30 m pixel size that was captured on the 23 July 2005. A reconnaissance survey completed in July 2008 was used to verify and finalize the regional ELC classification.

The image classification for the RSA satellite imagery is at a coarser scale (e.g., 30 x 30 m pixel data from satellite spectral imagery) than was used for the LSA, which uses fine scale data (aerial photography interpretation at a 1:10 000 scale), resulting in a more broadly defined vegetation classification. Classification of satellite imagery at this scale for the RSA is an accepted standard practice for regional vegetation resource mapping, and can be integrated with the LSA classification for a seamless product.

Local Study Area

A preliminary vegetation classification system was developed and mapped for the Project area in 1998 using 1:10 000 colour aerial photographs, and expanded in 2008 and 2009 to include the AWAR, Discovery pit, and F Zone pit regions. In 2012, the Project area expanded and additional areas within the LSA that were not previously mapped (including the southern portion of the AWAR and the laydown area) were classified and mapped in a GIS environment using ortho-rectified imagery. To reduce confusion, the classification system developed in 1998 was used for all subsequent vegetation mapping, though modifications were made to account for inclusions of any new community types or associations.

Plant community types represent mappable units at a scale of 1:10 000 and correspond to major vegetation units that are often associated with distinct terrain features. Within each plant community type, a series of subgroups, or plant associations, have been described that are based on field level observations. These units are not mappable, but have been described and are included in Appendix A of the SD 6-2 2009 Terrestrial Synthesis Baseline report to provide additional information on the level of natural variability associated with each plant community type.

Detailed Vegetation and Listed Plant Field Surveys

Baseline vegetation surveys were carried out in the summer of 1998 over 3 survey periods (9 to 11 June, 9 to 11 July, and 16 to 23 August) to collect baseline vegetation data for the main Project area. In the summer of 2008 (29 to 31 July and 1 to 6 September) and 2009 (27 to 30 August), additional vegetation surveys were completed in the F Zone pit area, and along the AWAR from the Project site to Rankin Inlet and to the Discovery area. In the summer of 2012 (15, 17 to 19, 21, 26 to 27 August and 7 September), additional vegetation surveys were completed along the southern portion of the AWAR and the laydown area. In total, 456 plots were established, including 337 plots in 1998, 59 plots in 2008, 20 plots in 2009, and 40 plots in 2012 (Figure 6.5-1).

Listed plant species were assessed as part of the baseline vegetation surveys. The studies were designed to collect baseline data within the terrestrial study area, including the proposed Project footprint and the proposed AWAR corridor. Detailed vegetation inventory surveys were completed in the vicinity of the Project development and aerial reconnaissance surveys in the broader regional area.

Prior to undertaking the field surveys, a review of relevant vegetation studies completed in and around Rankin Inlet and the Arctic in general was completed to provide a perspective of available information including the following:

- federal and territorial status documents;
- vascular plant checklists for the NT (Porsild and Cody 1980); and
- other public rare plant species reports for the NT (McJannet et al. 1995).

Field survey methods followed previously established protocols that were developed for the Diavik Project (Burt 1997) and other projects, including the Meadowbank Gold Project and the Baffinland Iron Mines Mary River Project (unpublished data). Prior to undertaking the vegetation surveys, preliminary plot locations were identified through a review of 1:50 000 topographical and 1:10 000 airphotos. Vegetation plots were established in a representative location within a given plant association type and care was taken to avoid transitional areas.

530000 540000 550000 560000

6990000 6980000 6970000

N

Parallel Lake

Meliadine Lake

Little Meliadine Lake (LML)

Meliadine River

Rankin Inlet

400 0 400
SCALE 1:20000 METRES

LEGEND

- Local Study Area (LSA)
- Watercourse
- Waterbody
- Proposed Project Infrastructure
- All-weather Access Road (AWAR)
- Road - New
- Road - Existing
- Soil and Plant Tissue Sampling Plot
- 1998 Vegetation Sampling Plot
- 2008 Vegetation Sampling Plot
- 2009 Vegetation Sampling Plot
- 2012 Vegetation Sampling Plot

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).
Datum: NAD 83 Projection: UTM Zone 15

2500 0 2500
METRES

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

DISTRIBUTION OF VEGETATION SAMPLING PLOTS IN THE LOCAL STUDY AREA

Golder Associates

PROJECT NO. 10-1373-0076			FILE No.		
DESIGN	LV	09 Nov. 2012	SCALE AS SHOWN	REV.	0
GIS	CDB	14 Nov. 2012			
CHECK	LV	17 Jan. 2013			
REVIEW	DW	17 Jan. 2013			

FIGURE 6.5-1

N:\Bur-Graphics\Projects\2013\1428\13-1428-0007\GIS\Mapping\MXD\FEIS\Volume_6\Main_Volume\Figure_6.5-1_Distribution_Vegetation_Sample_Plots_LSA.mxd

Traditional Use Plant Species

Information for traditional use plant species, which includes plant based country foods, was gathered through a review of existing literature, secondary data collection, and field studies as described in FEIS Volume 9, Section 9.1.2. The literature review considered Inuit Qaujimajatuqangit (IQ) and Traditional Land Use (TLU) activities within the LSA and RSA. Interviews were completed during the summer of 2010 with Elders from Rankin Inlet, Chesterfield Inlet, and Whale Cove and results are documented in the FEIS Volume 9, Section 9.3, and Appendix 9.3-A. Additional information on country foods was gathered through focus groups, as described in FEIS Volume 9, Section 9.1.1

Baseline Metals Assessment in Soils and Plant Tissue

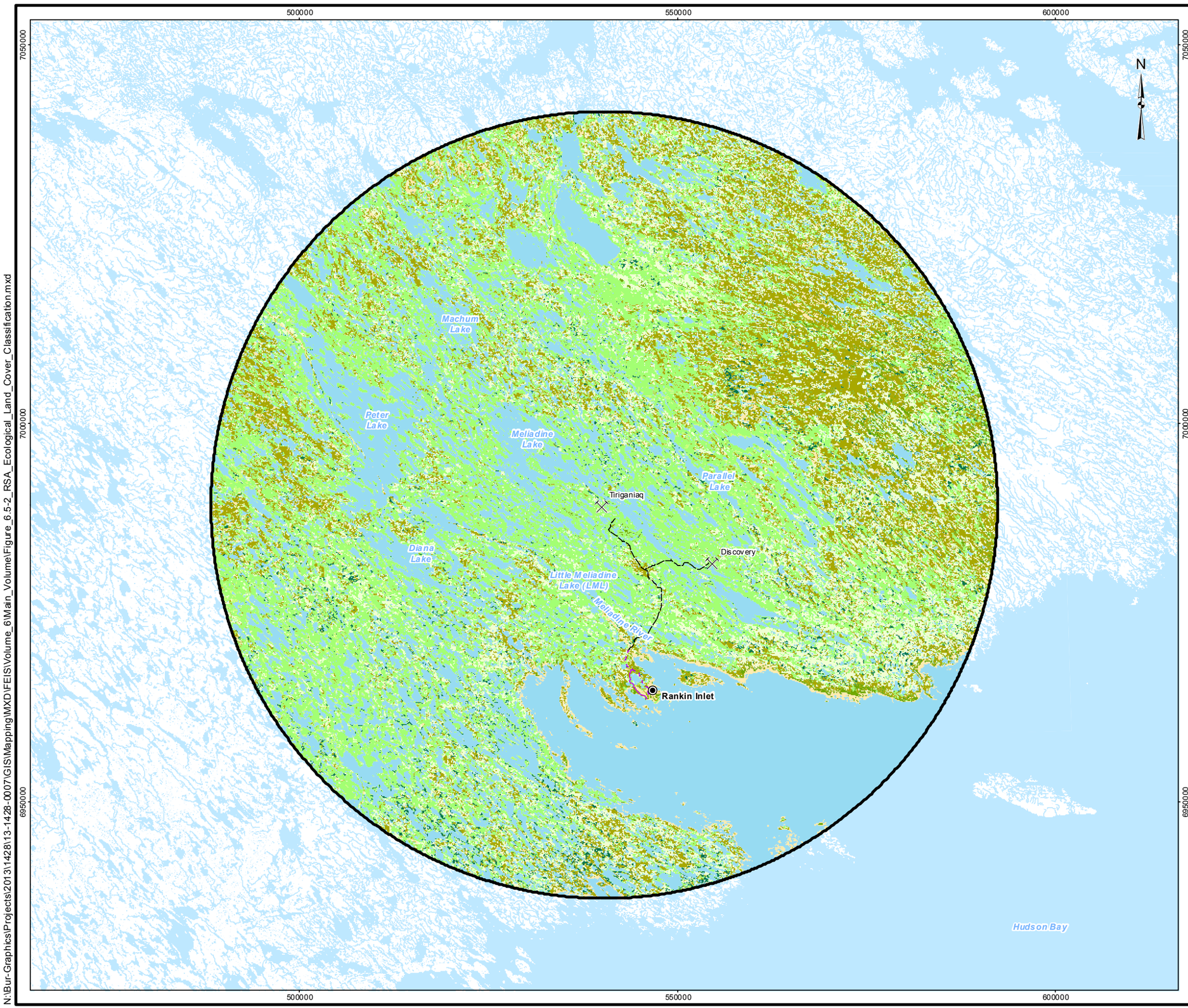
Vegetation sampling for plant tissue (i.e., leaves) chemistry was completed in fall of 2009. Soil samples were also obtained from the vegetation sampling locations. Sample sites were selected to represent the range of vegetation types in the vicinity of the proposed mine site and road. Seventeen permanent sampling sites were established in the vicinity of the proposed mine site and along the proposed AWAR, and an additional 12 sites were established along the road to the Discovery area. Tissue samples from at least 2 different plant species and a soil sample were collected from each site. Two equal sub-samples of soil were taken from the rooting zone and combined into one composite sample of approximately 200 grams (g). Plant species for tissue analysis samples were selected based on a high relative abundance in the area and their importance to human or wildlife consumption.

6.5.3.2 Results

Ecological Landscape Classification

Regional Study Area

The RSA covers 246 300 hectares (ha) and is classified into 8 land cover classes, including 4 heath classes, 2 wetlands and riparian classes, and 2 miscellaneous land cover classes (Table 6.5-3, Figure 6.5-2). Heath vegetation encompasses 142 562 ha (58%) of the RSA, while wetlands and riparian areas are distributed over 29 177 ha (12%) of the RSA (Table 6.5-3). The remaining 74 561 ha (30%) of the RSA are classified as water, predominantly lakes and the tidal basin of Hudson's Bay, and a small percentage of bare ground and rock outcrops. Detailed descriptions of land cover classes mapped within the RSA are provided in SD 6-2 2009 Terrestrial Synthesis Baseline, Section 4.2.



LEGEND

- Proposed Mine Site
- All-weather Access Road (AWAR)
- Road - New
- Road - Existing
- Watercourse
- Waterbody
- Terrestial Regional Study Area (RSA)

RSA Ecological Land Cover Classification

- Bare Ground (Rock Outcrop)
- Heath Boulder
- Heath Lichen - Cetraria
- Heath Lichen - Hair Lichen
- Heath Tundra
- Low Shrub
- Tussock - Hummock
- Water

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).
Datum: NAD 83 Projection: UTM Zone 15

10 0 10
KILOMETRES

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

REGIONAL STUDY AREA ECOLOGICAL LAND COVER CLASSIFICATION

Golder Associates

PROJECT NO.	10-1373-0076		FILE No.	
DESIGN	LV	09 Nov. 2012	SCALE AS SHOWN	REV. 0
GIS	DSC	14 Nov. 2012		
CHECK	LV	17 Jan. 2013		
REVIEW	DW	17 Jan. 2013		

FIGURE 6.5-2

N:\Bur-Graphics\Projects\2013\1428\13-1428-0007\GIS\Mapping\MXD\FEIS\Volume_6\Main_Volume\Figure_6.5-2_RSA_Ecological_Land_Cover_Classification.mxd

Table 6.5-3: Total Area and Percent Cover of Land Cover Classes within the Regional Study Area

Regional Land Cover Class	Regional Land Cover Class Description	Total Area of RSA (ha)	Total Percent of RSA
Heath			
Heath boulder	occurs on rapidly to well-drained sites that contain a high proportion of boulder deposits in association with bedrock outcrop	26 499	11
Heath lichen - hair lichen	typically associated with eskers and the crests and upper slopes of small ridges with poorly developed, rapidly drained soils	4 503	2
Heath lichen - *Cetraria*	typically occurs on the lower slopes of ridges and eskers or as veneers over flat rocky plains characterized by frost boils	1 733	1
Heath tundra	occurs on well-drained soils	109 826	45
	Heath vegetation subtotal	***142 562***	**58**
Wetlands/Riparian			
Low shrub	associated with imperfectly to poorly drained soils characteristic of riparian areas and depressions	3 478	1
Tussock-hummock	typically found in flat to low-lying areas, where soils are poorly to very poorly drained	25 699	10
	Wetlands /riparian subtotal	***29 177***	**12**
Miscellaneous			
Bare ground (rock outcrop)	represents areas with limited to no vegetation cover and is typically associated with eskers, steep sandy slopes, and the tidal and inter-tidal beaches along Hudson's Bay	5 263	2
Water	associated with rivers and lakes, as well as portions of Hudson's Bay	69 298	28
	Miscellaneous subtotal	***74 561***	**30**
	Total	**246 300**	**100**

Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.

ha= hectares; RSA = regional study area

Local Study Area

Plant species information is summarized at the plant community level within the LSA, rather than at the individual species level, as it is more meaningful from an ecological context and can be directly tied to wildlife habitat. Additionally, each plant community type is defined by a number of principle plant species that are characteristic of a specific community type. Thus, for the purposes of this assessment, baseline and potential effects are discussed in terms of the distribution (e.g., percentage) of plant community types in the LSA. However, principle plant species that are of concern (e.g., territorially or federally listed plant species), or are considered important to people as traditional use plants, are discussed separately.

The LSA covers 10 598 ha and is classified into 10 plant community types, including 4 heath vegetation classes, 3 wetlands classes, and 3 un-vegetated classes (Table 6.5-4, Figures 6.5-3a and b). Heath vegetation encompasses 5429 ha (51%) of the LSA, with the heath tundra community type dominating the landscape at 4036 ha (38%). Wetlands are distributed over 2767 ha (26%) of the LSA and are predominately comprised of the sedge community, which accounts for 2449 ha (23%). The remaining 2403 ha (23%) of the LSA are classified as un-vegetated units that are predominantly composed of waterbodies and rivers (Table 6.5-4). Disturbance features and un-vegetated sand areas represent <1% and 2% of the total LSA, respectively (Table 6.5-4).

Detailed descriptions of plant community types mapped within the LSA are provided in Section 4.3 of SD 6-2 2009 Terrestrial Synthesis Baseline, while correlations with soil units are provided in Section 6.4.

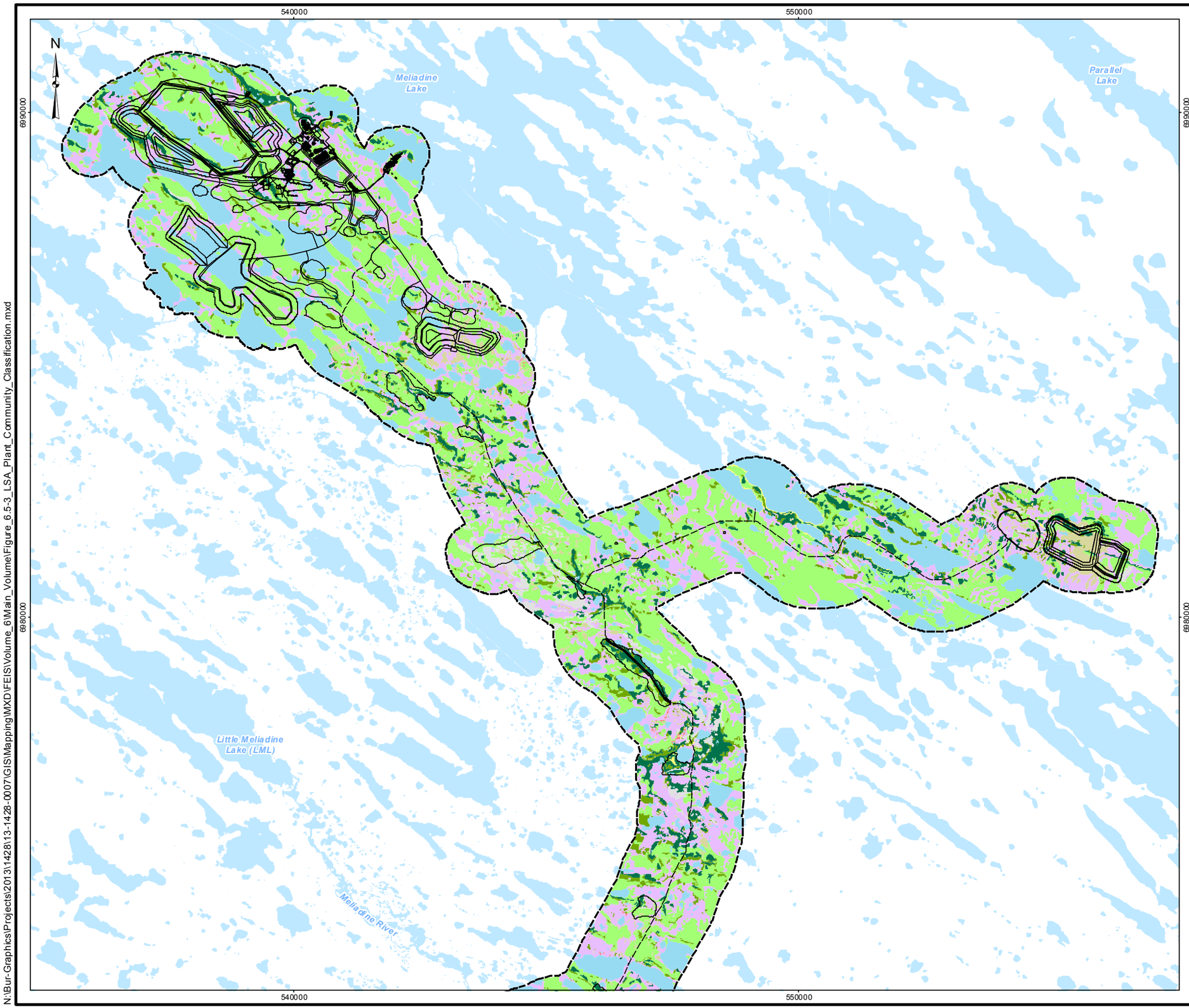
Table 6.5-4: Total Area and Percent Cover of Plant Community Types within the Local Study Area

Map Code	Plant Community Type	Plant Community Type Description	Total Area of LSA (ha)	Total Percent of LSA
Heath				
LR	Lichen-Rock Community	characterized by crustose lichens growing on the boulders or rocks that predominate on eskers or rocky plateaus	233	2
LHc	Lichen-Heath (*Cetraria* Lichen)	occurs on lower slope positions, often below the lichen-health – hair lichen community, on more rapidly drained sandy substrates	601	6
LHh	Lichen-Heath (Hair Lichen)	occurs almost exclusively on the higher ridges of slopes and on drumlin and esker crests, where the ground cover consists of a high percentage of black and green hair lichens	560	5
HT	Heath Tundra Community	occurs on uplands and slopes of most ridges characterized by gently rolling to undulating terrain with rapidly to well-drained soils	4 036	38
		Heath subtotal	***5 429***	***51***
Wetlands/Riparian				
SC	Sedge Community	occurs adjacent to lakes and streams on very poorly drained soils and in low-lying areas	2 449	23
BS	Birch Seep	occurs on imperfectly to poorly drained soils, such as the edges of solifluction lobes, on the slopes of some eskers, in stream valleys and along transitions to some sedge associations	305	3
RW	Riparian Willow or Birch	typically occurs along the banks of stream courses; characterized by imperfectly drained, nutrient enriched soils	12	<1
		Wetlands/ Riparian subtotal	***2 767***	***26***
Un-vegetated				
U	Un-vegetated (Sand)	associated with steep sandy slopes and the margins of rivers and lakes; limited to no vegetation cover	182	2
W	Water	associated with waterbodies and watercourses	2 221	21
DS	Disturbed	cleared areas and access roads associated with the Project as well as various natural disturbance features	<1	<1
		Un-vegetated subtotal	***2 403***	***23***
		Total	**10 598**	**100**

Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.

ha= hectares; LSA = local study area

A total of 146 vascular plant species were identified within the LSA, including 22 woody species, 83 forbs, and 41 graminoids. As no bryophyte or lichen collections were obtained during the field studies, no estimates of species numbers are provided, though there is potential for 20 species of bryophytes and 47 species of lichens to be present in the LSA.



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LEGEND

- Local Study Area (LSA)
- Waterbody

Plant Community Classification

- Birch Seep
- Disturbed
- Heath Tundra Community
- Lichen-Heath (Cetraria Lichen)
- Lichen-Heath (Hair Lichen)
- Lichen-Rock Community
- Riparian Willow or Birch
- Sedge Community
- Unvegetated (Sand)
- Water
- Proposed Project Infrastructure
- All-weather Access Road (AWAR)
- Road - New
- Road - Existing
- Watercourse

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).
Datum: NAD 83 Projection: UTM Zone 15

1500 0 1500
METRES

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

LOCAL STUDY AREA PLANT COMMUNITY CLASSIFICATION - NORTH

Golder Associates

PROJECT NO. 10-1373-0076			FILE No.	
DESIGN	LV	31 Jul. 2012	SCALE AS SHOWN	REV. 0
GIS	CDB	31 Jul. 2012		
CHECK	LV	17 Jan. 2013		
REVIEW	DW	17 Jan. 2013		

FIGURE 6.5-3a

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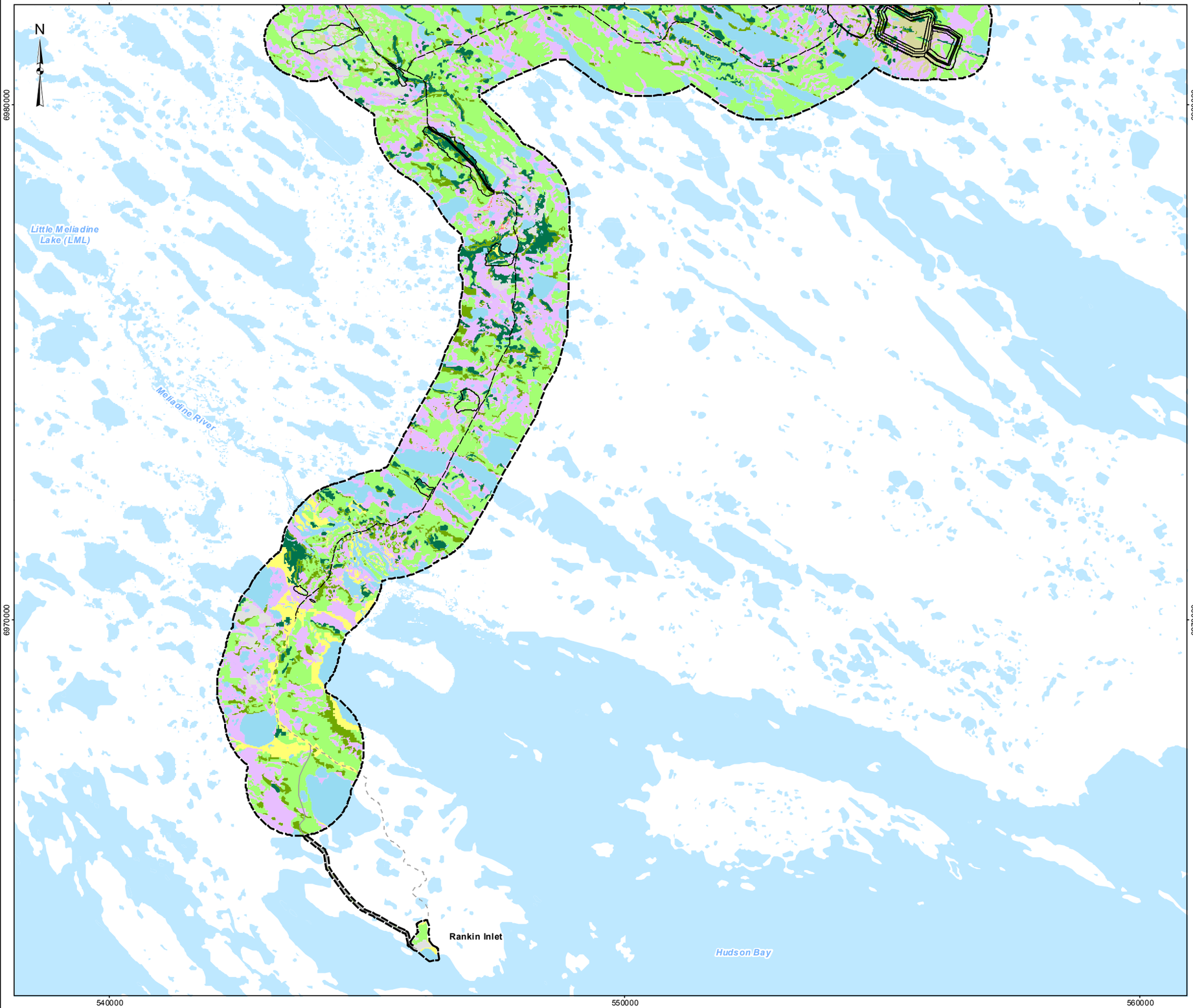


LEGEND

- Local Study Area (LSA)
- Waterbody

Plant Community Classification

- Birch Seep
- Disturbed
- Heath Tundra Community
- Lichen-Heath (Cetraria Lichen)
- Lichen-Heath (Hair Lichen)
- Lichen-Rock Community
- Riparian Willow or Birch
- Sedge Community
- Unvegetated (Sand)
- Water
- Proposed Project Infrastructure
- All-weather Access Road (AWAR)
- Road - New
- Road - Existing
- Watercourse

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).
Datum: NAD 83 Projection: UTM Zone 15

1500 0 1500
METRES

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

LOCAL STUDY AREA PLANT COMMUNITY CLASSIFICATION - SOUTH

Golder Associates

PROJECT NO. 10-1373-0076			FILE No.	
DESIGN	LV	31 Jul. 2012	SCALE AS SHOWN	REV. 0
GIS	CDB	31 Jul. 2012		
CHECK	LV	17 Jan. 2013		
REVIEW	DW	17 Jan. 2013		

FIGURE 6.5-3b

Listed Plant Species

Three listed plant species designated as "Sensitive" in NU (CESCC 2011) were observed within the LSA during the 1998, 2008, 2009, and 2012 field programs (Table 6.5-5). No federal listed species (COSEWIC 2012; *SARA* 2012) were identified as occurring within the LSA or RSA. However, a number of territorial listed plant species have the potential to occur in habitats that are present in both the LSA and RSA. These include 5 listed vascular plant species and 6 listed non-vascular plant species not encountered during the 1998, 2008, 2009, and 2012 surveys (Table 6.5-6). All of these species are listed as "Sensitive" in NU (CESCC 2011), though none are federally listed (COSEWIC 2012; *SARA* 2012). All of the vascular plant species that are listed as sensitive, with the exception of *Woodsia alpina* (Northern woodsia), are associated with wetland or riparian habitats such as meadows, seeps, and marshes that are associated with the Riparian Willow/Birch, Birch Seep, and Sedge Community plant community types.

It is important to note that the absence of listed plant observations does not preclude the potential for listed plants to inhabit the area. Therefore, a survey for listed plant species cannot confirm the absence of listed plants or listed plant communities; it can only confirm their presence.

Table 6.5-5: Listed Plants Observed within the Local Study Area

Scientific Name	Common Name	Habitat	Rank		
			Nunavut[a]	COSEWIC[b]	Nature-Serve[c]
Salix tyrrellii	Tyrrell's willow	Moist, riparian areas	Sensitive	Not listed	G5T2
Arctanthemum arcticum	Arctic daisy	Moist, saline meadows, moist gravel, seashores	Sensitive	Not listed	G5
Pinguicula villosa	Hairy butterwort	Found only in Sphagnum moss, in small hillside seeps	Sensitive	Not listed	G4

[a] CESCC (2011)
[b] COSEWIC (2012)
[c] NatureServe (2012)

Table 6.5-6: Listed Plants that may Occur in the Local or Regional Study Areas

Scientific Name	Common Name	Habitat	Rank		
			Nunavut[a]	COSEWIC[b]	Nature-Serve[c]
Forbs					
Ranunculus cymbalaria	Alkali or shore buttercup	Seashores, mudflats	Sensitive	Not listed	G5
Ranunculus pallasii	Pallas' buttercup	Brackish meadows, coast	Sensitive	Not listed	G5
Woodsia alpina	Northern woodsia	Uncommon, rock crevices, calcareous rocks	Sensitive	Not listed	G4
Grasses					
Calamagrostis deschampsioides	Circumpolar reedgrass	Littoral, damp tundra, low seacoasts	Sensitive	Not listed	G4
Puccinellia deschampsioides (also *P. nuttaliana)*	Polar alkali grass	Littoral, coastal	Sensitive	Not listed	G3
Bryophytes					
Sphagnum	Sphagnum moss	Wetlands	Sensitive	Not listed	G5

Table 6.5-6: Listed Plants that may Occur in the Local or Regional Study Areas (continued)

Scientific Name	Common Name	Habitat	Rank		
			Nunavut[a]	COSEWIC[b]	Nature-Serve[c]
fimbriatum					
Lichens					
Cladonia borealis	Boreal pixie-cup	n/a	Sensitive	Not listed	G5
Cladonia crispata	Organ-pipe lichen	n/a	Sensitive	Not listed	G3G5
Cladonia squamosa	Dragon-funnel	n/a	Sensitive	Not listed	G5
Peltigera didactyla	Alternating dog-lichen	n/a	Sensitive	Not listed	G5
Stereocaulon tomentosum	Gray mealy lichen	n/a	Sensitive	Not listed	G5

[a] CESCC (2011)
[b] COSEWIC (2012)
[c] NatureServe (2012)
n/a = not available

Traditional Use Plant Species

IQ

The use of traditional use plant species as country foods is an important practice, and activities such as berry picking was, and continues to be, an important fall activity throughout the Meliadine valley and the wider RSA, and typically occurs wherever there are low slopes with heath tundra, and in hummocky areas at the edges of wetlands. The most commonly picked berries include the following:

- paungait (black berry) or crowberry (*Empetrum nigrum*);
- kigutangirnaq or blueberry (*Vaccinium uliginosum*); and
- kakautit or lingonberry (*Vaccinium vitis-idaea*).

Lesser quantities of the highly-desired aqpik or cloudberry (*Rubus chamaemorus*) and kablautitit or bearberry (*Arctostaphylos alpina*) are also picked. Mahok or liquoriceroot (*Hedysarum alpinum*) grows abundantly in the floodplain of rivers. The plant is highly valued for its roots, and is a source of nutrition in the fall, tasting vaguely like carrots (FEIS Volume 9, Appendix 9.3-B).

A list of traditional plants applicable to the Project is provided in Table 6.5-7. More details on local and regional use of these plants can be found in FEIS Volume 9, Section 9.3 and Appendix 9.3-B of Volume 9. This list also includes the plant community types associated with these species that represent the most probable plant community types for traditional use where these plant species occur with sufficient abundance. Many traditional use plants, such as crowberry, blueberry, lingonberry, and bearberry are common in a number of different plant community types. However, there are a few traditional use species such as moss campion (*Silene acaulis*) and large-flowered wintergreen (*Pyrola grandiflora*) that tend to only be associated with a single plant community type that has a more restricted distribution (e.g., Birch seep), though they may be locally abundant within that plant community type.

Table 6.5-7: Traditional Use Plant Species Identified During the Elders' Workshop, 2010

Local Name	Common Name	Scientific Name	Traditional Use	Lichen-Rock Community	Lichen-Heath (*Cetraria* Lichen)	Lichen-Heath (Hair Lichen)	Heath Tundra Community	Sedge Community	Birch Seep	Riparian Willow or Birch	Un-vegetated (Sand)	Disturbed
kanguujait	single-flowered Arctic cotton	*Eriophorum scheuchzeri*	wick for the qulliq					•	•			
pualunnguat	multiple-flowered Arctic cotton	*Eriophorum angustifolium*	wick for the qulliq					•	•			
Ivit, iviksukat, ivialuit, ivigjuag	beach ryegrass	*Leymus mollis*	food									
avaalaqqiat	dwarf birch	*Betula nana*	firewood, mats, use in storage caches				•		•	•		
suputiit	Arctic willow	*Salix arctica*	firewood, food, medicine; seeds used for wick for the qulliq, tinder, wound dressing				•					
avaalaqiat or suputiit	felt-leaf willow	*Salix calcicola*	firewood, use in storage caches, ribs for kayak, tender for the qulliq; seeds used from wick for the qulliq, tinder					•		•		
airaq	moss campion	*Silene acaulis*	food	•								
maliksuagaiit	seabeach sandwort	*Honckenya peploides*	food								•	
tuqlak	bistort	*Polygonum viviparum* or *Persicaria vivipara*	food				•	•		•		

Table 6.5-7: Traditional Use Plant Species Identified During the Elders' Workshop, 2010 (continued)

Local Name	Common Name	Scientific Name	Traditional Use	Lichen-Rock Community	Lichen-Heath (*Cetraria* Lichen)	Lichen-Heath (Hair Lichen)	Heath Tundra Community	Sedge Community	Birch Seep	Riparian Willow or Birch	Un-vegetated (Sand)	Disturbed
qunguliit, siirnat	mountain sorrel	*Oxyria digyna*	food								•	
malikkaat, isurramuat	mountain avens	*Dryas integrifolia*	wick for the qulliq, tinder		•	•	•					
aqpik or aqpiit	cloudberry	*Rubus chamaemorus*	food					•	•	•		
uqkaujat (leaves); kigutauja (flowers)	large-flowered wintergreen	*Pyrola grandiflora*	food						•			
airaq or airait	bell's crazyweed	*Oxytropis arctica var. bellii*	food				•					
airaq or airait	Hudson Bay crazyweed	*Oxytropis hudsonica*	food				•					
airaq	yellow crazyweed	*Oxytropis maydelliana*	food				•					
masu, mahok	liquoriceroot	*Hedysarum alpinum*	food				•					
airaq	wooly lousewort	*Pedicularus lanata*	food				•					
paunait (plant); kakkautit (leaves)	dwarf fireweed	*Chamerion latifolium*	food								•	•
aupilattunguat	purple mountain saxifrage	*Saxifraga oppositifolia*	food				•					
kakilarnaq	prickly saxifrage	*Saxifraga tricuspidata*	food, dog medicine and dog bedding	•	•	•						

Table 6.5-7: Traditional Use Plant Species Identified During the Elders' Workshop, 2010 (continued)

Local Name	Common Name	Scientific Name	Traditional Use	Lichen-Rock Community	Lichen-Heath (*Cetraria* Lichen)	Lichen-Heath (Hair Lichen)	Heath Tundra Community	Sedge Community	Birch Seep	Riparian Willow or Birch	Un-vegetated (Sand)	Disturbed
iksutit	white Arctic heather	*Cassiope tetragona*	bedding, firewood, emergency fuel		•	•	•					
qisiqtuutitq	Labrador tea	*Ledum palustre* ssp. *groenlandicum*	firewood, emergency fuel, tea, medicine			•	•		•			
kakautit	lingonberry	*Vaccinium vitis-idaea*	food, tobacco substitute	•	•	•	•		•	•		
kablaqutit	bearberry	*Arctous alpina* or *Arctostaphylos alpina*	food	•	•	•	•					
kigutangirnaq	blueberry	*Vaccinium uliginosum*	food			•	•		•	•		
pauungait	crowberry	*Empetrum nigrum*	food, firewood, bedding		•	•	•		•	•		
uqjuk	grey moss	*Racomitrium lanuginosum*	bedding	•								
maniq	cushion or lamp moss	several species	wick for the qullik, medicine					•		•		
tingaujait	black hair lichen	*Alectoria nigricans*	tinder		•	•	•					
nirnait	snow lichen	*Flavocetraria nivalis*	food for caribou		•	•	•					

Baseline Metals Assessment in Soils and Plant Tissue

Soil Metal Concentrations

Metals concentrations for the collected soil samples were assessed relative to the CCME (CCME 2007) criteria for contaminated soils to determine if any metals exceeded acceptable limits for agricultural sites under the existing baseline conditions. The soil quality guidelines for agricultural sites were used, as the site in its current state is considered unaltered at baseline.

The majority of soil metal concentrations in 2008 sample plots were within CCME guidelines, with the exception of arsenic, which exceeded CCME limits on 10 plots (see Section 4.3.3; Table 4-10 of SD 6-2 2009 Terrestrial Synthesis Baseline). Most of these plots were found in the immediate vicinity of the proposed Meliadine main site or along the proposed road near the main site. The exception was plot 08-015, which was located southwest of the main mine site near the proposed Discovery area road. One plot, 08-010, had borderline values for arsenic at 11.8 mg/kg. Cobalt, copper, and selenium also exceeded CCME agricultural criteria at 2 sites. Soil plot 08-002 had high levels of copper and selenium, whereas plot 08-005 had levels of cobalt and copper above CCME criteria. Both sites are located near the proposed Meliadine main mine site.

For the 2009 samples, only soil plots 09-D02 and 09-D08 had elevated levels of arsenic at 12.6 mg/kg and 20 mg/kg, respectively, compared to the CCME guideline value of 12 mg/kg. All other soil metal concentrations in the 2009 sample plots were below applicable CCME guidelines.

Plant Tissue Metal Concentrations

The results of the plant tissue (i.e., leaves) metals analyses for 2008 and 2009 indicate that there was a wide variability in the range of metal concentrations (see Section 4.3.3; Tables 4-12 and 4-13 of SD 6-2 2009 Terrestrial Synthesis Baseline Report). Bearberry and snow lichen tissue were found to have some of the highest concentrations of aluminium and iron in both 2008 and 2009 sample plots, with crowberry also showing high levels of aluminium in the 2009 plots. In the 2008 samples, nickel concentrations were found to be highest in *Oxytropis arctica* var. *bellii*, whereas flat-leaved willow and lingonberry had some of the highest levels for zinc and manganese, respectively. This is in contrast to the 2009 samples taken along the proposed Discovery Road alignment, which showed high levels of nickel. The highest levels of arsenic were found in bearberry, along with water sedge on 2 plots located near the proposed Meliadine main site.

It is not known if these metal levels are of concern for these particular species, as there is limited literature available on the levels of metals that would be toxic to the specific plant species selected. At the time of sampling, there were no indications of vegetation disease or toxicity symptoms observed in the areas studied, with the exception of a fungus infection called “rust” affecting swamp birches. This condition is seen throughout the mainland arctic (P. Burt, 2008, pers. comm.), and is not particular to this area.

Further discussion on metal concentrations related to aspects of human and wildlife health can be found in FEIS Volume 10, Sections 10.1 and 10.2.

6.5.4 Pathway Analysis

6.5.4.1 Methods

Pathway analysis identifies and assesses the linkages between Project components or activities, and the correspondent potential residual effects to vegetation. The first part of the analysis is to produce a list of all potential effects pathways for the Project (FEIS Volume 4, Section 4.3). Each pathway is initially considered to have a linkage to potential effects on vegetation. This step is followed by the development of environmental design features and mitigation that can be incorporated into the development description to remove a pathway or limit (mitigate) the effects to vegetation. Environmental design features include Project design elements, environmental best practices, management policies and procedures, and social programs. Environmental design features are developed through an iterative process between the Project's engineering and environmental teams to avoid or mitigate effects.

Pathway analysis is a screening step that is used to determine the existence and magnitude of linkages from the initial list of potential effects pathways for the Project. This screening step is intended to focus the effects analysis on pathways that require a more comprehensive assessment of effects on vegetation. Pathways are determined to be primary, minor, or as having no linkage using scientific and traditional knowledge, logic, and experience with similar developments and environmental design features. Each potential pathway is assessed and described as follows:

- no linkage – pathway is removed by environmental design features and mitigation so that the Project results in no detectable environmental change and residual effects to vegetation relative to baseline or guideline values;
- minor – pathway could result in a minor environmental change, but would have a negligible residual effect on vegetation relative to baseline or guideline values; or
- primary – pathway is likely to result in a measurable environmental change that could contribute to residual effects on vegetation relative to baseline or guideline values.

Primary pathways require further effects analysis to determine the environmental significance from the Project on vegetation. Pathways determined to have no linkage to vegetation or those that are considered minor are not predicted to result in environmentally significant effects on vegetation. No linkage and minor pathways are summarized, but not carried through the effects assessment.

Potential pathways through which the Project could affect vegetation are presented in Table 6.5-8. Environmental design features and mitigation incorporated into the design of the Project to remove a pathway or limit the effects to vegetation are listed, and pathways are determined to be primary, minor, or as having no linkage. The following section discusses the potential pathways relevant to vegetation.

Table 6.5-8: Potential Pathways for Effects to Vegetation

Project Activity	Effect Pathways	Environmental Design Features and Mitigation	Pathway Analysis/Section for Further Discussion
Mine infrastructure footprint (e.g., open pit, site roads), Project Access Road, Rankin Inlet Infrastructure	Physical loss or alteration of vegetation from the Project footprint and AWAR	Compact infrastructure arrangement is designed to reduce the overall Project footprint Design roads as narrow as possible, while maintaining safe construction and operation practices, and meeting legislated requirements. For example, minimum haul road widths are defined under the *Mine Health and Safety Act*.	Primary/Section 6.5.4.4
Mine infrastructure footprint (e.g., open pit, site roads), Project Access Road, Rankin Inlet Infrastructure	Loss or alteration of local flows, drainage patterns (distribution), and drainage areas from the Project footprint and AWAR can cause changes to soils, vegetation, and wetlands	Use of design features (i.e. dams, drainages, dykes and diversions) that reduce changes to local flows, drainage patterns, and drainage areas. Shoreline areas susceptible to extensive erosion will be addressed by appropriate erosion protection measures, mitigation measures based on adaptive management, or a combination of both, to reduce erosion and associated re-suspension of fine sediment. Where practical, natural drainage patterns will be used to reduce the use of ditches or diversion berms.	Minor/ Section 6.5.4.3
Mine infrastructure footprint (e.g., open pit, site roads), Project Access Road, Rankin Inlet Infrastructure	Physical loss or alteration of permafrost from the Project footprint can lead to changes in vegetation ecosystem structure and composition	Compact infrastructure arrangement is designed to reduce the overall project footprint Mine site infrastructure (buildings) foundations will be built on bedrock or pillars to minimize Project induced thawing of permafrost. Design roads as narrow as possible, while maintaining safe construction and operation practices and meeting legislated requirements. For example, minimum haul road widths are defined under the *Mine Health and Safety Act*. Design and construct roads using thaw-stable construction fills to minimize frost effects.	Minor/Section 6.5.4.3

Table 6.5-8: Potential Pathways for Effects to Vegetation (continued)

Project Activity	Effect Pathways	Environmental Design Features and Mitigation	Pathway Analysis/Section for Further Discussion
Water Management (dams, drainage, diversion, intake, discharge, and dewatering)	Process and potable water requirements for the Project may decrease drainage flows and surface water levels, and affect vegetation and wetlands	Develop a Site Water Management Plan (SD 2-6). Contact water will be monitored and managed through the Attenuation Ponds. Surface runoff and groundwater seeping into the open pits will be collected in in-pit sumps. The collected water will be used for dust control and as process water. Underground water will be re-cycled for re-use underground, where possible. Underground water with high salinity will be treated. Discharge quality will meet MMER at end of pipe from AP01 and will meet CCME aquatic life standards within a 100 m wide mixing zone of the diffuser in Meliadine Lake. The rotary biological contactor sewage treatment plant for the camp facilities will be designed to meet the Nunavut effluent guidelines for wastewater discharge.	No Linkage/Section 6.5.4.2
Water Management (dams, drainage, diversion, intake, discharge and dewatering)	Cross-drainage structures for the mine site roads, AWAR, and Rankin Inlet bypass road may alter stream hydraulics and geomorphology, and can alter soils and vegetation	Cross-drainage structures will be designed for a 1:25 year precipitation event without overtopping the roadway. Use of staggered culvert configuration, and removal of snow at the culvert inlet and outlet prior to the freshet to promote drainage during spring thaw and freshet. Regular inspection of the road to identify any areas where ponding of water along the road represents a risk, and installing additional culverts to alleviate the risk.	Minor/ Section 6.5.4.3

Table 6.5-8: Potential Pathways for Effects to Vegetation (continued)

Project Activity	Effect Pathways	Environmental Design Features and Mitigation	Pathway Analysis/Section for Further Discussion
Water Management (dams, drainage, diversion, intake, discharge, and dewatering)	Dewatering of lakes and alteration of flow paths may change flows, water levels, channel/bank stability in receiving and downstream waterbodies, affect water quality and quantity, and can cause changes to soils, vegetation, and wetlands	Pumped discharge to receiving lake will only occur while water quality discharge criteria are met. Pumped discharge will be directed to the lake environment, and not directly to outlets, to attenuate flow changes. Shoreline areas susceptible to extensive erosion will be addressed by appropriate erosion protection measures, mitigation measures based on adaptive management, or a combination of both, to reduce erosion and associated re-suspension of fine sediment. Where practical, natural drainage patterns will be used to reduce the use of ditches or diversion berms.	Minor/Section 6.5.4.3
General construction and operation of mine and supporting infrastructure	Air emissions and dust deposition can cause changes to chemical properties of surface water, soils, vegetation, and wetlands	Dust will be actively suppressed from roads (water and/or other dust suppressants). Potential use of chemical dust suppressants in accordance with the Environmental Guidance for Dust Suppression published by the Government of Nunavut Department of Environment. Enforcing speed limits will assist in reducing dust. Road surfaces will be maintained through grading and the addition of granular material. Equipment and vehicles will comply with relevant non-road emission criteria at that time of purchase. Regular maintenance of equipment and vehicles to meet emission standards.	Minor/Section 6.5.4.3
General construction and operation of mine and supporting infrastructure	Dust deposition may cover vegetation and lead to physical and/or physiological damage		
General construction and operation of mine and supporting infrastructure	Spills on the mine site or along the AWAR can affect surface water quality, soils, and vegetation	Equipment will be re-fueled, serviced, and washed away from stream crossings and on impermeable pads wherever possible. There will be a wash bay in the maintenance shop.	No Linkage/Section 6.5.4.2

Table 6.5-8: Potential Pathways for Effects to Vegetation (continued)

Project Activity	Effect Pathways	Environmental Design Features and Mitigation	Pathway Analysis/Section for Further Discussion
		Emergency response and spill contingency plans will be developed and implemented. Ready access to an emergency spill clean-up kit for cleaning-up any spills. Hazardous materials and fuel will be stored according to regulatory requirements to protect the environment and workers (i.e., SD 2-13 Hazardous Materials Management Plan). As necessary, individuals working on-site and handling hazardous materials will be trained, notably in the Transportation of Dangerous Goods and Hazmat. A biopile will be constructed to treat soils and rock contaminated by light hydrocarbons. Soils contaminated with heavy hydrocarbon oil spills will be excavated, placed into appropriate containers and transported for remediation at a certified hazardous materials treatment site and disposed of appropriately. Fuel storage tanks will be situated in a secondary containment area capable of containing 110% of the contents of the largest tank. The storage tanks and fuel-dispensing systems will be constructed in accordance with current regulatory requirements and National Fire Code. Fuel reconciliation will be conducted and structural integrity will be routinely inspected. Construction and mining equipment, machinery, and vehicles will be regularly maintained.	

Table 6.5-8: Potential Pathways for Effects to Vegetation (continued)

Project Activity	Effect Pathways	Environmental Design Features and Mitigation	Pathway Analysis/Section for Further Discussion
General construction and operation of mine and supporting infrastructure	Surface water runoff from the mine facilities area can affect surface water quality, soil, and vegetation	Contact water will be contained on-site for monitoring, re-use, and/or treatment, if required, prior to release to the environment (SD 2-6 Site Water Management Plan). Runoff and seepage from waste rock management areas will be collected in sedimentation ponds located around the perimeter in low topographic points. This water will be monitored for water quality and if necessary transferred to the mine attenuation pond before discharge Surface runoff and talik water seeping into the open pits will be collected in in-pit sumps. The collected water will be used for dust control and/or managed as contact water (collected, contained, monitored, and treated if required to meet water license discharge standards before release). Natural construction materials will be tested before they are used to confirm that they are not potential acid draining or potential sources of metal leaching.	No Linkage/Section 6.5.4.2
General construction and operation of mine and supporting infrastructure	Introduction of non-native plant species can affect native vegetation	Inspection of newly shipped equipment/vehicles and clean as required. Enforce DOE guidelines regarding non-native plant species and incorporate protocols for monitoring non-native plant species.	Minor/Section 6.5.4.3
Operation of Mine and supporting infrastructure	Leaching of dissolved metals from waste rock in the waste rock/overburden storage facilities may cause changes to groundwater and surface water quality and soils, which may affect vegetation	Design waste rock management procedures for potentially problematic waste rock/overburden material. Use of non-acid generating and non-metal leaching material at all watercourses. Any PAG or high metal leaching waste rock will be segregated at source and placed into designated areas within the waste rock storage facilities. PAG and high metal leaching waste rock will be encapsulated with non -PAG rock and low metal leaching rock. Over time potential PAG and high metal leaching rock will become permanently frozen with an active cover layer of non-PAG rock.	No Linkage/Section 6.5.4.2

Table 6.5-8: Potential Pathways for Effects to Vegetation (continued)

Project Activity	Effect Pathways	Environmental Design Features and Mitigation	Pathway Analysis/Section for Further Discussion
Operation of Mine and supporting infrastructure	Vertical and lateral seepage from facilities may cause changes to groundwater and surface water quality and soils, which may affect vegetation	A biopile will be constructed to treat soils and rock contaminated by light hydrocarbons with any leachate captured sedimentation ponds. Landfill will not contain any putrescible organic matter so seepage is not expected.	No Linkage/Section 6.5.4.2
Closure and Post-closure	Residual ground disturbance can cause permanent loss and alteration of vegetation	Limit size of Project footprint. Implement a Closure and Reclamation Plan (SD 2-17).	Primary/Section 6.5.4.4
	Long-term seepage from the facilities can change groundwater and surface water quality, which can affect soils and vegetation	Sewage treatment plant will remain active during the first 2 years of decommissioning. Landfill will be covered with waste rock. Implement a Closure and Reclamation Plan (SD 2-17).	No Linkage/Section 6.5.4.2

6.5.4.2 Pathways with No Linkage

A pathway may have no linkage if the pathway is removed by environmental design features and mitigation so that the Project results in no detectable environmental change and residual effects to vegetation relative to baseline or guideline values. The pathways described in the following bullets have no linkage to vegetation and will not be carried through the effects assessment.

- **Spills on the mine site, mine site roads or along the AWAR can affect surface water quality, soils, and vegetation.**

A Risk Management and Emergency Response Plan (SD 2-15), Spill Contingency Plan (SD 2-16), and Fuel Management Plan (part of SD 2-13) will be developed and implemented to minimize the likelihood of accidental spills, or if they do occur, to quickly respond and clean up any spills. AEM will not permit the deposit of chemicals, sediment, wastes, or fuels into any waterbody. During construction, equipment will be re-fueled, serviced, and washed away from stream crossings and on impermeable pads wherever possible. There will be a wash bay in the maintenance shop where water will be managed appropriately. Hazardous materials and fuel will be stored according to regulatory requirements to protect the environment and workers, and hazardous materials will be stored at the mine site in a dedicated waste management building and handled according to the Hazardous Materials Management Plan (SD 2-13). As necessary, individuals working on the Project and handling hazardous materials will be trained, notably in the Transportation of Dangerous Goods. Emergency spill kits will be readily available. A biopile will be constructed to treat soils contaminated by light hydrocarbons, and soils contaminated with heavy hydrocarbon oil spills will be excavated, placed into appropriate containers, undergo remediation at a certified hazardous material treatment site and disposed of appropriately. Construction and mining equipment, machinery, and vehicles will be regularly maintained.

Accidental spills (e.g., fuel) have occurred at AEM's Meadowbank project, but most of the spill volumes have been small, and clean-up has occurred with only minor effects to the environment (AEM 2011a). Out of 78 spills at Meadowbank since the start of construction, 73 were within the mine site boundary, and 5 were along the access road outside of the mine boundary. There were 10 spills greater than 1 000 L, one of which was outside the mine boundary. Contaminated material from the larger spill outside the mine boundary was completely recovered (AEM 2011a). All of the spills inside and outside the mine boundary were contained and cleaned-up (AEM 2011b). In NIRBs 2011 annual report (NIRB 2011), it was noted that Meadowbank was kept in an impressively clean state with no apparent spills on location.

The implementation of the Risk Management and Emergency Response Plan (SD 2-15), and environmental design features, including proper equipment maintenance and driver training, are expected to reduce the frequency and severity of spills. It is acknowledged that accidental spills, including vehicular accidents, have the greatest potential to affect soils and vegetation. However, in the event of a spill, contaminated materials will either be collected and treated on-site, or shipped off-site for treatment and disposal. Thus, spills are not predicted to result in detectable changes to soil and vegetation relative to baseline conditions. Consequently, this pathway was determined to have no linkage to the maintenance of plant population abundance and distribution of plant populations and communities, including listed plant species and the opportunity for traditional and non-traditional use of plant species.

- **Process and potable water requirements for the Project may decrease drainage flows and surface water levels, and affect vegetation and wetlands.**

The Project will withdraw freshwater from Meliadine Lake for potable water, underground operations and plant operations. Freshwater requirements are estimated at a maximum of approximately 1 130 000 m^3/y during construction and operations. Supply volumes are small in comparison to median monthly and annual outflow volumes at Meliadine Lake (Table 6.5-9), and residual effects on water levels are expected to be negligible. In comparison, mean monthly water levels are expected to decrease by less than 0.050 m during closure under median conditions, during which approximately 17 100 000 m^3/y will be pumped out of Meliadine Lake over a compressed schedule of four months per year to accelerate pit refilling.

Table 6.5-9: Median Annual Outflow Volumes at the Outlet of Meliadine Lake during Baseline and Closure

Snapshot	Median Mean Monthly and Annual Outflow Volume (m^3)						
	May	Jun	Jul	Aug	Sep	Oct	Annual
Baseline	1 790 000	41 800 000	20 100 000	8 520 000	6 580 000	2 570 000	84 700 000
Closure	1 400 000	34 800 000	16 800 000	6 190 000	4 170 000	1 520 000	67 600 000

m^3= cubic metre

Water requirements for the Project are not expected to decrease drainage flows and surface water levels below baseline conditions (FEIS Volume 7, Section 7.3), and should result in a minor change to vegetation and wetlands. Therefore, this pathway is expected to have negligible residual effects to the maintenance of plant population abundance and distribution of plant populations and communities, including listed plant species and the opportunity for traditional and non-traditional use of plant species.

- **Leaching of dissolved metals from waste rock in waste rock/overburden storage facilities may cause changes to groundwater and surface water quality and soils, which may affect vegetation;**
- **Vertical and lateral seepage from waste rock storage facilities and tailings containment facilities may cause changes to groundwater and surface water quality and soils, which may affect vegetation; and**
- **Long-term seepage from the facilities can change groundwater and surface water quality, which can affect soils and vegetation.**

During the life of the Project, there is the potential for leachate, runoff, and seepage (e.g. metals) from the facilities developed for storage of tailings and waste rock. All waste rock is currently categorized as non-potentially acid generating (PAG) type. Separate waste management procedures are proposed for the PAG and non-PAG material should any PAG waste rock be found in continuing studies. All PAG and high metal leaching potential waste rock generated by open pit mining will be segregated at source and placed into designated areas within the waste rock storage facilities. This rock will then be encapsulated with non-PAG and low metal leaching potential waste rock so that the risk of contaminant release is significantly reduced and/or eliminated to prevent potential contamination of surrounding waterbodies, soils, and vegetation.

Runoff and seepage from the waste rock storage facilities will not be released to the environment during construction or operations. The on-land facilities will have ditch systems to collect seepage and runoff, and all

water collected will be monitored and treated, when necessary, prior to release to the environment. Attenuation ponds for the storage of contact water from the Project site have been designed to accommodate the total volume of runoff under the 1-in-100 wet year freshet event, and to limit the potential for seepage. Tailings are expected to have arsenic concentrations that are over MMER and CCME guidelines; therefore, a provision will be made for treating tailings supernatant water to remove arsenic during the life of mine operation prior to discharge to the TSF.

Short-term water leach test results of waste rock and ore yield concentrations that meet the MMER chemical criteria in all samples tested with the exception of arsenic in one Tiriganiaq greywacke/siltstone sample and 3 ore samples from Discovery and Tiriganiaq. However, short-term leach tests are considered a conservative estimate of arsenic leachability. Large column and field cell tests, conducted at low water-to-rock ratios that are more appropriate to site conditions, generate leachate concentrations well below MMER criteria. Scale up studies further support this conclusion, as do on-site surface water quality samples representing waste rock contact water (operations pad made of Tiriganiaq greywacke run of mine rock).

Permafrost conditions are present under the waste rock storage facilities and over time will penetrate into the facility. The permafrost is anticipated to limit seepage from waste rock storage facilities over the long-term. The aggradation of permafrost into the facility is expected to occur under both current climate and future climate change scenarios.

Currently, there is a talik in Lake B7 that could be a pathway for constituents to enter the groundwater. However, it is anticipated that the talik will be replaced with permafrost prior to the release of constituents. Groundwater modelling suggests it would take 500 to 1000 years for the groundwater under the tailings facility to reach Meliadine Lake (Section 7.2.3.3).

At closure, the TSF will be dewatered. The tailings storage facility will be covered with non-metal leaching and non-PAG rock. The rock will be tested prior to use on the tailings storage facility. The ditches and sumps and water treatment facilities will be maintained until it is confirmed that the runoff from the waste rock and tailings storage facilities will meet CCME guidelines for the protection of aquatic life.

The environmental design features and mitigations reduce the potential risk of contact between vegetation and contaminants from waste rock. Overall, release of runoff and long-term seepage from the TSF and waste rock storage facilities, as well as leachate from waste rock is not expected to occur and so there is not expected to be a detectable change to vegetation outside of the Project footprint area, relative to baseline conditions. Therefore, these pathways were determined to have no linkage to effects on the maintenance of plant population abundance and distribution of plant populations and communities, including listed plant species and the opportunity for traditional and non-traditional use of plant species.

- **Surface water runoff from the mine facilities area can affect surface water quality, soil, and vegetation.**

Surface water runoff from areas of the mine facilities could potentially affect vegetation. However, these facilities incorporate several environmental design features to prevent release of untreated site water into the receiving environment.

During the construction and operations phases, all surface water runoff from the areas of the mine facilities or that has been in contact with any mine facilities or processes will be captured through a series of collection ditches and sumps. Contact water from open pits will be pumped to the TSF, while surface water from the remaining facilities will be pumped to Attenuation Pond 1. Any excess water in the TSF will be treated and discharged to Attenuation Pond 1. Furthermore, water from underground workings will be collected and treated, then directed to Attenuation Pond 1. Water collected at Attenuation Pond 1 will be discharged as an effluent into Meliadine Lake through a diffuser outfall. The diffuser will be configured to promote mixing of the effluent in the lake ambient water, in order to meet water quality standards established from the CCME guidelines for protection of aquatic life.

During the closure phase, contact water will be directed to Attenuation Pond 1 until it meets the water quality standards, upon which Attenuation Pond 1 and water treatment facilities will be decommissioned. The TSF will be dewatered and covered with a rockfill cover over a graded tailings surface. Runoff will be monitored to confirm that it meets the water quality standards before being discharged to the environment or Tiriganiaq pit to assist with pit reflooding. Dewatering of the open pits will cease at the end of operations and the open pits will be actively filled with water over a period of approximately 10 years. When flooded, and water quality criteria have been achieved, outflows from the pits will naturally drain toward adjacent lakes and eventually reach Meliadine Lake. It is expected that the water quality in the open pits will meet the water quality standards from the CCME guidelines for protection of aquatic life. Contact water ditches and sumps enclosing waste rock facilities will be removed and a layer of non-potentially acid generating rock will be placed over any sediment in the sumps to prevent dusting and erosion.

Implementation of these environmental design features is expected to result in no detectable changes to vegetation from the Project. Therefore, this pathway was determined to have no linkage to effects on the maintenance of plant population abundance and distribution of plant populations and communities, including listed plant species and the opportunity for traditional and non-traditional use of plant species.

6.5.4.3 Minor Pathways

In some cases, both a source and a pathway exist, but the change caused by the Project is anticipated to result in a minor environmental change, and would have a negligible residual effect on terrain and soils, vegetation, and wildlife relative to baseline or guideline values. The following pathways are anticipated to be minor, and will not be carried through the effects assessment.

- **Dust deposition may cover vegetation; and**
- **Air emissions and deposition can cause changes to chemical properties of surface water, soils, vegetation, and wetlands.**

Accumulation of dust (i.e., particulate matter and TSP deposition) and concentrations of air emissions produced from the Project may result in a local indirect change on the quality of vegetation within the LSA. Air quality modelling was completed to predict the spatial extent of dust deposition and air emissions from the Project (FEIS Volume 5, Section 5.2). Sources of dust deposition and air emissions modelled in the Project case (maximum effect case) include blasting activities, haul roads, the processing plant, activities at the open pits and other ancillary facilities, and vehicle traffic along the AWAR. Environmental design features and mitigation have

been incorporated into the Project to reduce potential effects from dust deposition (Table 6.5-8). For example, the watering of roads and laydown areas during the non-winter period will facilitate dust suppression. In addition, programs will be implemented to review power and heat use to reduce energy use. Although these environmental design features and mitigation should reduce dust deposition and air emissions, assumptions incorporated into the model are expected to contribute to conservative estimates of emission concentrations and deposition rates (FEIS Volume 5, Section 5.2).

Deposition of dust onto vegetation can result in a variety of physiological and chemical effects, including reduced water content, increased conductivity, reduced chlorophyll content, reduced respiration, reduced reception of radiation or photosynthesis, and reduced carbon uptake (Spatt and Miller 1981). In some cases visible symptoms such as chlorosis or necrosis of the leaves (e.g., brown or black spots) may occur in affected plants, but in general, there is in overall reduction in plant productivity. Lichens, mosses, and other plants that derive some of their moisture and nutrient requirements from the atmosphere are especially sensitive to the effects of dust (Farmer 1993). Auerbach et al. (1997) found that although plant species composition may change and aboveground biomass is reduced by dust deposition, ground cover is still maintained. Some species such as cloudberry (*Rubus chamaemorus)*, willow, and cottongrass (*Eriophorum spp*.) were observed to be more abundant as a result of dust deposition, as these species have a higher tolerance to dust and may be able to out-compete less tolerant species (Forbes 1995).

Trucks travelling on the AWAR and site roads have the potential to transfer dust from vehicles and loads (e.g., dust deposited on wheels and undercarriage while at the Project and in Rankin Inlet); however, the relative contribution of dust transfer (as opposed to dust generation) to the overall dust accumulation in the area along the roads is considered to be negligible (FEIS Volume 5, Section 5.2). Dust generation due to Project vehicles travelling along the AWAR would occur annually, but would likely be higher during the non-winter period and not continuous (i.e., would occur less frequently during wet and cool conditions).

Dust deposition is expected to result in minor and localized changes to vegetation along the right-of-ways for the AWAR. For example, Walker and Everett (1987) and Everett (1980) reported that effects were confined to a 50 m buffer on either side of a road. Moreover, Meininger and Spatt (1988) found that most of effects occurred within 5 to 50 m of a road, with less obvious effects observed between 50 m and 500 m from a road. Therefore, dust deposition from vehicles along the AWAR is predicted to result in negligible residual effects to the maintenance of plant population abundance and distribution of plant populations and communities, including listed plant species and the opportunity for traditional and non-traditional use of plant species.

Air emissions from vehicles along the AWAR were included in the air quality modelling completed for the Project and assumed that the AWAR would be open all year round. In general, emissions from the roads are small, and if extended over the whole year, a negligible effect from annual depositions was predicted (FEIS Volume 5, Section 5.2). Annual emissions from vehicles on the roads are anticipated to result in no detectable changes to soils (Section 6.4.2.2) and are expected to have no detectable effects to vegetation relative to baseline conditions.

The results of the air quality modelling predicted that the maximum annual dust deposition resulting from the Project is 1.83 grams per square metres per year ($g/m^2/y$) within the Project disturbance areas, and 0.54 $g/m^2/y$ outside of the Project disturbance areas (Table 6.5-10). The major sources of dust will be associated with the open pit and haul roads. The strongest effects from dust are expected to be generally confined to the immediate area adjacent to the dust source, such as roads (per Walker and Everett 1987 and Everett 1980).

Table 6.5-10: Maximum Air Emission Deposition Rates for the Project

Compound	Units	Criteria[a]	Maximum Deposition Prediction Outside of Project Disturbance Areas						
			Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Overall
Dust	(g/m²/yr)	none	0.16	0.20	0.54	0.26	0.33	0.21	0.54
PAI	(keq/ha/yr)	0.25	0.23	**0.27**	**0.38**	0.25	0.23	0**.26**	**0.38**
Nitrate	(kg/ha/yr)	none	13.73	16.52	23.16	15.11	14.03	15.74	23.16

Note: Bolded values exceed criteria

[a] Criteria based on Clean Air Strategic Alliance (CASA 1999)

PAI = potential acid input; m = metre; $g/m^2/y$ = grams per square metre per year; keq/ha/y = kiloequivalent per hectare per year; kg/ha/yr=kilogram per hectare per year

Acid deposition from air emissions includes the deposition of sulphur oxides, nitrogen oxides, hydrogen, and metals (Rusek and Marshall 2000) onto soil and vegetation. Potential acid input from air emissions can change the chemical properties of soil and water, which can affect vegetation and wildlife habitat. Air quality modelling results showed that maximum PAI deposition rates reached 0.38 keq/ha/y within the Project Lease Boundary (FEIS Volume 5, Section 5.2; Table 6.5-10). While the 0.38 keq/ha/y maximum PAI is predicted to be above the critical load of 0.25 keq/ha/y for sensitive soils (CASA 1999), it is expected that sensitive soils would likely not be affected by acid deposition relative to baseline conditions due to the short duration of emissions. This in turn should result in only minor changes to vegetation. Although short-term occurrences above the critical loads will not necessarily result in measurable effects on soil and vegetation ecosystems, the risk of impacts increases with time (Maynard 1996).

The air emission modelling results show that the predicted maximum concentrations for sulphur dioxide and nitrogen dioxide outside of the Project disturbance areas are below Nunavut Ambient Air Quality guidelines (Department of Environment 2011) for all model scenarios (FEIS Volume 5, Section 5.2; Table 6.5-11). Annual TSP concentrations outside of the Project disturbance areas are predicted to be below recommended guidelines, reaching a maximum of 14.6 $\mu g/m^3/y$ (Table 6.5-11).

Table 6.5-11: Summary of Predicted 1-hour, 24-hour, and Annual Air Quality Concentrations from the Project

Substance	Averaging Period	Criteria ($\mu g/m^3$)[a]	Maximum Concentration Prediction Outside the Project Disturbance Areas					
			Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
Nitrogen Dioxide	1-hour	400	270.7	273.1	272.0	273.5	271.0	273.2
	24-hour	200	119.4	120.0	119.8	120.2	119.5	120.2
	Annual	60	25.9	27.7	27.0	27.3	26.2	27.4
Sulphur Dioxide	1-hour	450	2.5	2.6	2.6	2.5	2.5	2.6
	24-hour	150	1.0	1.1	1.0	1.0	1.0	1.0
	Annual	30	0.0	0.0	0.1	0.0	0.0	0.0
TSP	24-hour	120	18.2	62.1	**212.5**	101.8	**134.7**	81.0
	Annual	60	1.7	3.3	14.6	3.8	6.0	3.2

Note: Bolded values exceed criteria.

[a] Criteria based on Nunavut Ambient Air Quality guidelines (Department of Environment 2011).

$\mu g/m^3$ = micrograms per cubic metre; TSP = total suspended particulate

Although concentrations are predicted to be above baseline conditions for some parameters (i.e., PAI), the anticipated changes to vegetation are localized and considered minor, which should have a negligible effect on plant populations and communities. Maximum reported values are, in part, a consequence of local topography as deposition patterns depend mainly on local topography and plant cover (Rusek and Marshall 2000). The deposition predictions are considered to be conservative, and therefore the presented deposition rates are likely overestimated. Overall, changes in vegetation (including listed plant species) due to dust deposition and air emissions are anticipated to be minor relative to baseline conditions. Consequently, residual effects to plant population abundance and distribution of plant populations and communities, including listed plant species and the opportunity for traditional and non-traditional use of plant species from dust deposition and air emissions are predicted to be negligible.

- **Cross-drainage structures for the mine site roads, AWAR, and Rankin inlet bypass road may alter stream hydraulics and geomorphology, and can alter soils and vegetation.**

The installation of cross-drainage structures to prevent roads from impeding water flow can result in the loss and alteration of shoreline vegetation. The loss of shoreline vegetation may be permanent. Cross-drainage structures will be designed to withstand a 1:25 year precipitation event without overtopping the roadway. The implementation of appropriate cross-drainage structures is expected to result in minor changes to stream flow velocity in the vicinity of the structures relative to baseline conditions and have negligible residual effects on water quantity and geomorphology. Thus, the effects on the maintenance of plant population abundance and distribution of plant populations and communities, including listed plant species and the opportunity for traditional and non-traditional use of plant species are expected to be negligible

- **Dewatering of lakes, Project footprint, and diversion of water, may change downstream flows, water levels, and affect soils, vegetation, and wetlands.**
- **Loss or alteration of local flows, drainage patterns (distribution), and drainage areas from the Project footprint and AWAR can cause changes to soils, vegetation, and wetlands**

Potential increases in peak annual water levels from the alteration of watershed configuration due to the Project footprint and diversions will be mitigated by engineered diversion channels (e.g., B5-C-02) and enhanced lake outlet channels. Dewatering rates and schedule will also be managed so that peak annual water levels, which typically occur in June, do not increase from baseline conditions. Water levels will be increased during the low flow season (i.e., July to October) but are expected to remain below the baseline peak annual water level. In addition, to attenuate flow changes, pumped discharge from dewatering of lakes will be directed to the lake environment, and not directly to outlets. At closure, pumping rates will be managed to minimize potential effects on the water levels of Meliadine Lake during refilling of the pits (FEIS Volume 7, Section 7.3), and effects on water levels in Meliadine Lake are expected to be negligible.

The implementation of the above environmental design features are expected to maintain flows and water levels within the range of baseline conditions and so changes to downstream vegetation are expected to be minor. Thus, the effects on the maintenance of plant population abundance and distribution of plant populations and communities, including listed plant species and the opportunity for traditional and non-traditional use of plant species are expected to be negligible.

- **Physical loss or alteration of permafrost from the Project footprint can lead to changes in vegetation ecosystem structure and composition.**

Permafrost within the RSA is described as continuous with intervening taliks and thaw bulbs induced by lakes (Section 6.2). Freeze induced displacement of soil (i.e., frost jacking) and thaw induced displacement of soil (i.e., subsidence) are the main vegetation issues related to permafrost degradation (i.e., loss and alteration). Changes to thaw penetration and thickness of the active layer can influence vegetation and surface stability through thaw settlement, frost heave, and bearing capacity, as well as slope stability (Tarnoicai et al. 2004). Changes to the permafrost active layer can also affect vegetation by altering local hydrology, soil moisture, and nutrient availability conditions. A more detailed summary of the analysis of effects to permafrost is provided in Section 6.2.

Mitigation and environmental design features to reduce the potential for permafrost melting and subsequent subsidence on areas include the following:

- use culverts to maintain surface drainage and reduce pooling of water at the surface;
- limit the mine footprint disturbance area;
- limit the road footprint disturbance area, while maintaining safe construction and operation practices;
- use thaw-stable construction fill for road construction and other facilities to minimize frost effects;
- insulate infrastructure, where possible; and
- building foundations will be built on bedrock or pillars to minimize thawing of permafrost.

By implementing these mitigation practices and environmental design features, the change to permafrost from the Project is anticipated to be minor relative to baseline conditions; therefore, the residual effects to plant populations and communities, and the maintenance of plant population abundance and distribution of plant populations and communities, including listed plant species and the opportunity for traditional and non-traditional use of plant species are predicted to be negligible.

- **Introduction of non-native plant species can affect native vegetation.**

The construction and operation of the Project and its supporting infrastructure have the potential to introduce non-native plant species and disrupt native plant communities (Mack et al. 2000; Truscott et al. 2008). Non-native invasive plant species, or weeds, may alter nutrient cycling, competition, and the energy budget of an ecosystem, which may lead to a decrease in native plant community structure and species diversity (Jager et al. 2009), and lower native species survival and abundance (Mack et al. 2000). Non-native invasive plant species are those species whose rapid establishment and spread can adversely affect ecosystems, habitats and/or other species (Haber 1997). The main contributor to the introduction of non-native invasive plants and noxious weeds is human transport (Mack et al. 2000).Non-native invasive plant species are not a common occurrence in the north, which is in part due to the extreme ecological conditions (e.g., short growing season, harsh winters) that are outside the optimal range for most plant species that are not adapted to Arctic conditions. However, with increasing development and changing climate, there is increased potential for non-native invasive plant species to become established in Arctic environments (Lassuy and Lewis 2010).

Ground disturbances associated with construction activities such as disturbed road edges, quarry sites, or other cleared areas, can create the type of habitat favoured by non-native invasive plant species. However, transportation corridors to and from construction areas provide the primary means of ingress for invasive plant species. This can include roads, as well as other indirect means of transportation, such as aircraft and shipping, which are used to transport goods and materials. Vehicles and machinery that are transported to a site serve as a dispersal mechanism for plant propugules (seeds and/or vegetative parts) that can get lodged in tires, the undercarriage, or mud on the surface of the vehicle. Ships or aircraft can also act as dispersal mechanisms for non-native invasive plant species through the direct spread of plant propugules from ballast disposal (i.e., aquatic plant species), or indirectly through the transport of goods and materials that contain non-native invasive plant species propugules.

Effective mitigation strategies are required early in the Project planning to address the introduction, spread, and effects of non-native invasive plant species on the environment (Haber 1997). Preventing non-native invasive plant species from entering an area is often more efficient and cost effective than dealing with their removal once established (Clark 2003; Polster 2005; USDA 2006; Carlson and Shephard 2007). No non-native invasive plant species were noted to occur in the LSA, though specific surveys aimed at searching for non-native invasive plant species were not completed during baseline surveys; however, had they been present within vegetation plots they would have been recorded.

To mitigate the transport and introduction of non-native plant species into native plant communities, newly shipped equipment and vehicles will be inspected and cleaned as required, particularly before moving into sensitive vegetation areas. Protocols for monitoring non-native invasive plant species will be implemented as part of the Terrestrial Environment Monitoring Program (TEMP) and will follow DOE guidelines for reporting on non-native invasive plant species.

The implementation of mitigation and environmental design features is anticipated to result in minor changes in the abundance and distribution of native plant species relative to baseline conditions. Therefore, the residual effect to the maintenance of plant population abundance and distribution of plant populations and communities, including listed plant species and the opportunity for traditional and non-traditional use of plant species is predicted to be negligible.

6.5.4.4 Summary of Primary Pathways

The following primary pathways were determined for linking Project-related activities to effects on vegetation and will be carried through the effects analysis:

- **Physical loss or alteration of vegetation from the Project footprint; and**
- **Residual ground disturbance can cause permanent loss and alteration of vegetation**.

6.5.5 General Approach to Primary Pathways

The effects analysis considers all primary pathways that result in expected changes to the abundance and distribution of vegetation VECs, after implementing environmental design features and mitigation. Thus, the analysis is based on the residual effects from the Project. Residual effects to vegetation are analyzed using

measurement endpoints (FEIS Volume 4, Section 4.2.3 and Table 4.2-1) and are expressed as effects statements, including the following:

- effects to plant populations and communities as expressed by changes in plant community types;
- effects to listed plant species and high rare plant habitat potential; and
- effects to traditional use plants.

The magnitude, spatial extent, and duration of changes in measurement endpoints (e.g., persistence of plant populations and communities) from the Project and other developments are expected to be similar to or greater than the actual effects to the abundance and distribution of populations. The analyses of residual effects from the Project on vegetation were quantitative, where possible, and included data from field studies, scientific literature, monitoring programs at existing mines, government publications, and personal communications. Traditional knowledge and community information were incorporated where available. Due to the amount and type of data available, some analyses were qualitative and included professional judgement or experienced opinion.

6.5.6 Effects to Plant Populations and Communities

6.5.6.1 Methods

Due to the inherent sensitivity of the subarctic environment to disturbance, all vegetation ecosystems and associated plants were included in the analysis of effects. Particular emphasis was placed on the effects of the Project (including the Phase 2 AWAR) in relation to plant community types or plants considered especially sensitive to disturbance (e.g., wetlands or shrub communities), those plant community types with a restricted distribution in the study area, plant species listed as being “at risk”, and plant species identified from traditional use studies. The effects to plant populations and communities were assessed quantitatively using land cover information developed for the LSA, field survey data, and the expected Project footprint. Effects to biodiversity were assessed at the community level, both directly in terms of number of plant communities that are affected and indirectly through quantification of the amount of area of each plant community type that is affected by the Project.

Changes to vegetation are assessed for the maximum predicted Project footprint, which should have the largest magnitude and geographic extent of effects to vegetation. The maximum predicted Project footprint includes the Phase 2 AWAR and all other project infrastructure (i.e., mine and camp infrastructure, tailings and waste rock storage facilities, site access roads). The Phase 2 AWAR is not assessed as a separate component of the Project as the Phase 2 AWAR footprint is the same as the Phase 1 AWAR and the Phase 1 AWAR was previously assessed under the Phase 1 – Meliadine All-weather Access Road Project Description and Environmental Assessment.

Changes to plant community types directly affected by the Project were quantified by GIS analysis using the following process:

- the areas of plant community types within the LSA were quantified for the baseline case, AWAR case, Project case, and post-closure; and
- the net change in plant community types were calculated between baseline case and post-closure.

6.5.6.2 Results

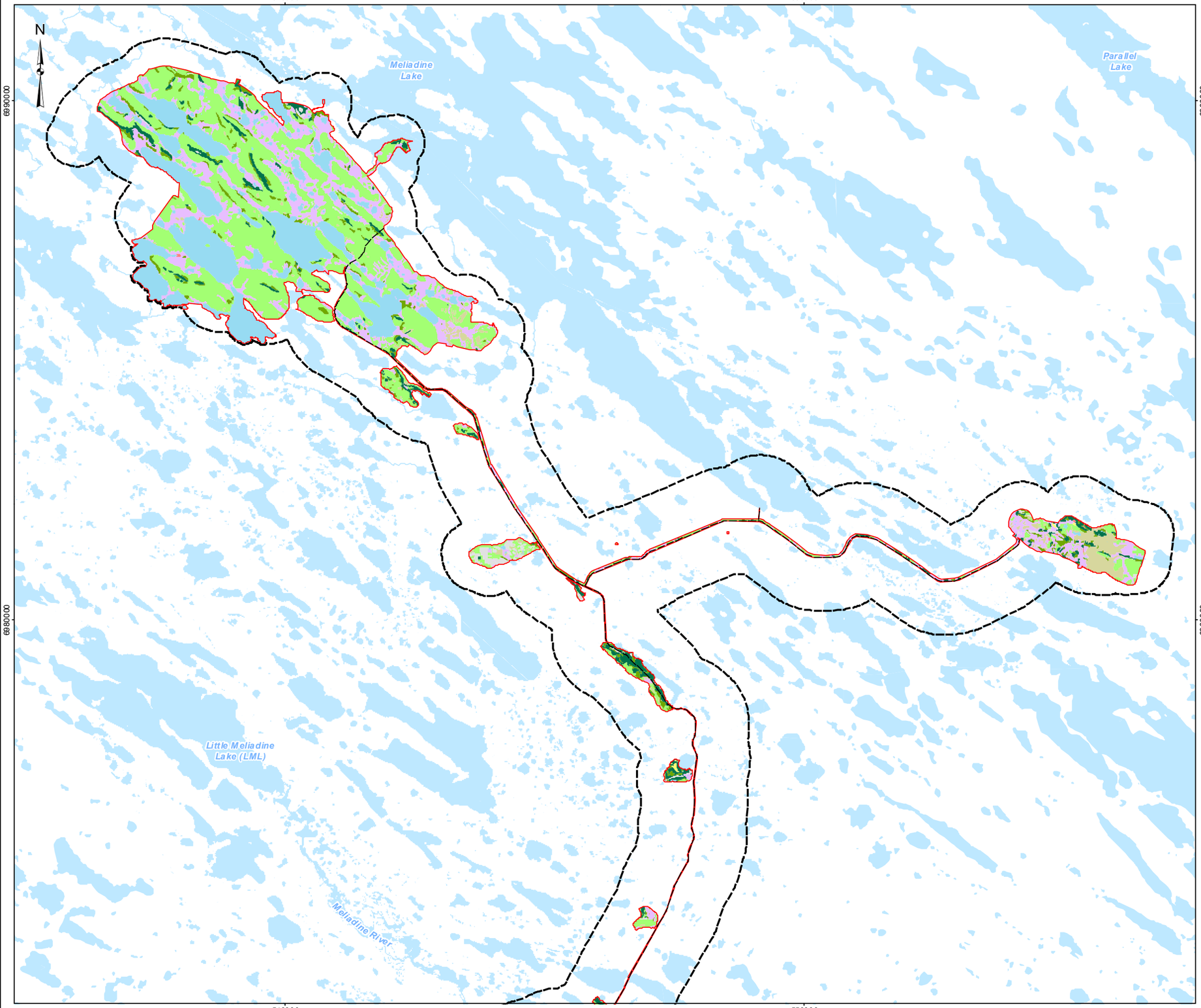
Construction and operation of the Project (including the Phase 2 AWAR) will result in a maximum disturbance of 2950 ha (28%) of the LSA including 1581 ha of vegetated heath types and 702 ha of vegetated wetlands/riparian types (Table 6.5-12 and Figures 6.5-4a and b). All plant community types will be affected by the Project, resulting in net changes to all types; however, there will be no complete loss of any one plant community type. Of the vegetated heath types, the Heath Tundra and Lichen-Heath (Hair Lichen) communities will experience the largest net change at 845 ha (22% of this map unit; 8% of the LSA) and 131 ha (24% of this map unit; 1% of the LSA), respectively. Vegetated Wetlands/Riparian types will experience a net change of 502 ha (5% of the LSA), with the largest net change in area occurring in the Sedge Community at 408 ha (17% of this map unit; 4% of the LSA). Heath Tundra and Sedge Community types are the most abundant plant community types in the LSA, and are widely distributed throughout the RSA.

Following closure, approximately 511 ha (5%) of the LSA will be reclaimed to a scarified natural revegetation type (Figures 6.5-5a and b). Test plots will be implemented as part of the mitigation and monitoring program to acquire knowledge during operations regarding natural revegetation processes in disturbed areas. At this time, reclaimed lands have not been assigned to specific target plant community types, as it is not known how quickly these areas will be revegetated and to which community they will return to. The area of residual disturbance, which includes Reclaimed Waterbodies and the Reclaimed Lichen-Rock Community is predicted to be approximately 1373 ha (13% of the LSA), as these areas will not be reclaimed to a vegetated unit at closure (Table 6-5-12).

Table 6.5-12: Distribution of Plant Community Types Between the Baseline Case and Post-Closure Case in the Local Study Area

Plant Community Types	Baseline Case		Phase 1 AWAR		Project Case[a]		Post-Closure Case (ha)	Post-Closure Net Change (ha)	Post-Closure Net Change (% unit)	Post-Closure Net Change (% LSA)
	Area (ha)	Proportion of LSA (%)	Area (ha)	Proportion of LSA (%)	Area (ha)	Proportion of LSA (%)				
Vegetated Heath										
Lichen-Rock Community	229	2	5	<1	43	<1	189	-40	-17	-<1
Lichen-Heath (Cetraria Lichen)	542	5	48	<1	131	1	446	-96	-18	-1
Lichen-Heath (Hair Lichen)	555	5	19	<1	156	1	424	-131	-24	-1
Heath Tundra Community	3 868	36	178	2	1 250	12	3 023	-845	-22	-8
vegetated heath subtotal	***5 194***	***49***	***250***	***2***	***1 581***	***15***	***4 082***	***-1 113***	***-21***	***-10***
Vegetated Wetlands/Riparian Units										
Sedge Community	2 368	22	89	1	592	6	1 960	-408	-17	-4
Birch Seep	297	3	8	<1	109	1	205	-93	-31	-1
Riparian Willow or Birch	12	<1	<1	<1	2	<1	11	-1	-12	-<1
vegetated wetlands/riparian subtotal	***2677***	***25***	***97***	***1***	***702***	***7***	***2175***	***-502***	***-19***	***-5***
Non-vegetated										
Un-vegetated (Sand)	150	1	31	<1	36	<1	115	-35	-23	-<1
Water	2 180	21	41	<1	631	6	1 707	-473	-22	-4
non-vegetated subtotal	***2 331***	***22***	***72***	***1***	***666***	***6***	***1822***	***-508***	***-22***	***-5***
Disturbance										
Disturbance	396	4	<1	<1	0	0	635	239	60	2
disturbance subtotal	***396***	***4***	***<1***	***<1***	***0***	***0***	***635***	***239***	***60***	***2***
Following Closure										
Scarified Natural Revegetation	0	0	0	0	0	0	511	511	100	5
Reclaimed Lichen-Rock Community[b]	0	0	0	0	0	0	916	916	100	9
Reclaimed Waterbodies[b]	0	0	0	0	0	0	457	457	100	4
Total	**10 598**	**100**	**419**	**4**	**2 950**	**28**	**10 598**	**0**	**n/a**	**0**

Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.
[a] Maximum amount of disturbance during the Project.
[b] Residual Disturbances.
LSA = Local Study Area; ha = hectare; % = percent; < = less than; n/a = not applicable.



LEGEND

- Local Study Area (LSA)
- Terrestrial Disturbance
- All-weather Access Road (AWAR)
- Road - New
- Road - Existing
- Watercourse
- Waterbody

Plant Community Classification

- Birch Seep
- Disturbed
- Heath Tundra Community
- Lichen-Heath (Cetraria Lichen)
- Lichen-Heath (Hair Lichen)
- Lichen-Rock Community
- Riparian Willow or Birch
- Sedge Community
- Unvegetated (Sand)
- Water

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).
Datum: NAD 83 Projection: UTM Zone 15

1500 0 1500
METRES

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

PLANT COMMUNITY CLASSIFICATION AT MAXIMUM DISTURBANCE - NORTH

Golder Associates

PROJECT NO. 10-1373-0076			FILE No.	
DESIGN	LV	27 Jul. 2012	SCALE AS SHOWN	REV. 0
GIS	CDB	27 Jul. 2012		
CHECK	LV	17 Jan. 2013		
REVIEW	DW	17 Jan. 2013		

FIGURE 6.5-4a

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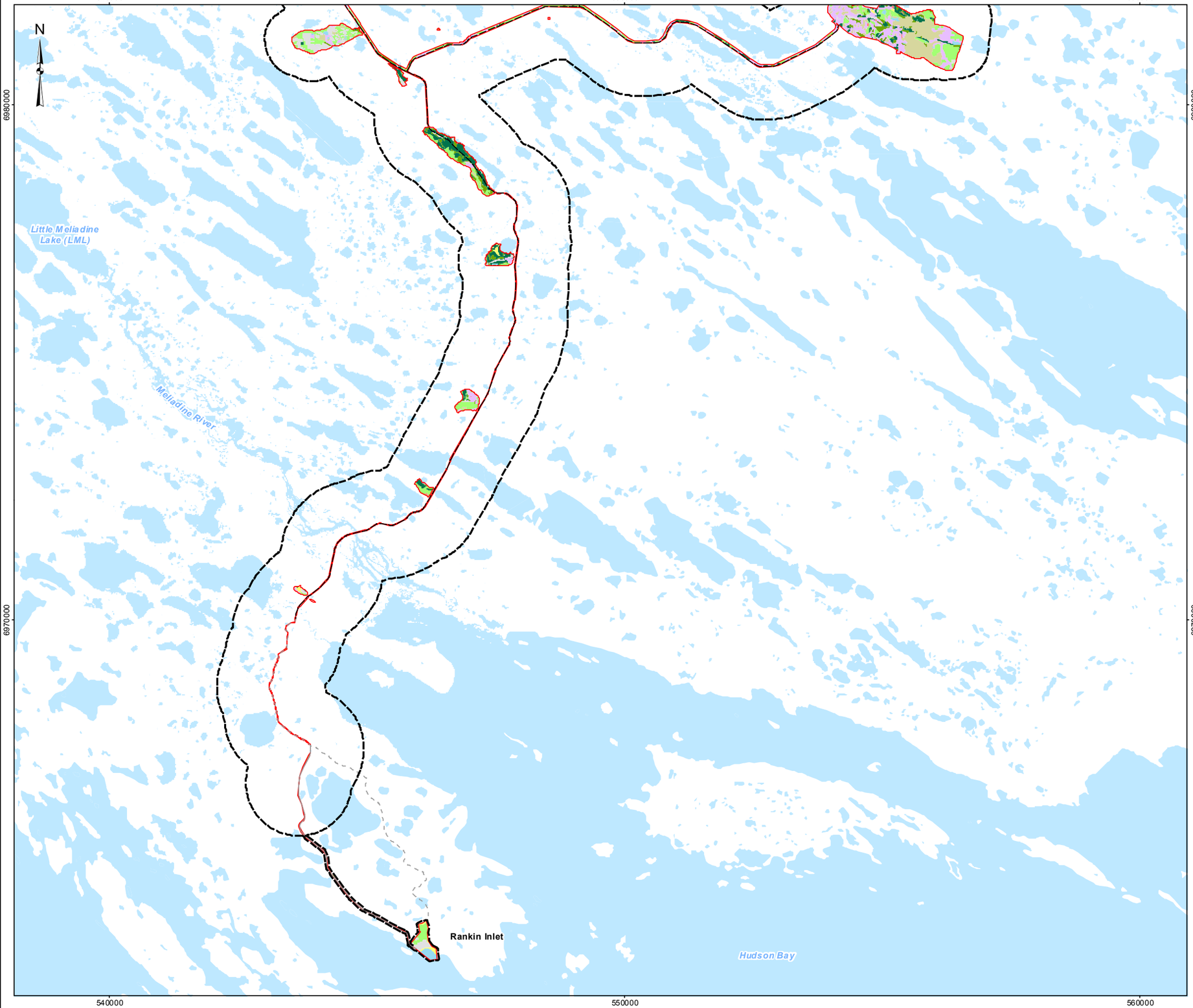

LEGEND

- Local Study Area (LSA)
- Terrestrial Disturbance
- All-weather Access Road (AWAR)
- Road - New
- Road - Existing
- Watercourse
- Waterbody

Plant Community Classification

- Birch Seep
- Disturbed
- Heath Tundra Community
- Lichen-Heath (Cetraria Lichen)
- Lichen-Heath (Hair Lichen)
- Lichen-Rock Community
- Riparian Willow or Birch
- Sedge Community
- Unvegetated (Sand)
- Water

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).
Datum: NAD 83 Projection: UTM Zone 15

1500 0 1500
METRES

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

PLANT COMMUNITY CLASSIFICATION AT MAXIMUM DISTURBANCE - SOUTH

Golder Associates

PROJECT NO. 10-1373-0076			FILE No.	
DESIGN	LV	27 Jul. 2012	SCALE AS SHOWN	REV. 0
GIS	CDB	27 Jul. 2012		
CHECK	LV	17 Jan. 2013		
REVIEW	DW	17 Jan. 2013		

FIGURE 6.5-4b

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535000 540000 545000 550000 555000

6990000 6985000 6980000 6975000

N

Meliadine Lake

Parallel Lake

Little Meliadine Lake (LML)

LEGEND

- Local Study Area (LSA)
- Terrestrial Disturbance
- Municipal Boundary
- All-weather Access Road (AWAR)
- Road - New
- Road - Existing
- Watercourse
- Waterbody

Reclamation Class

- Reclaimed Lichen-Rock Community
- Reclaimed Waterbody
- Scarified Natural Revegetation

Plant Community Classification

- Birch Seep
- Disturbed
- Heath Tundra Community
- Lichen-Heath (Cetraria Lichen)
- Lichen-Heath (Hair Lichen)
- Lichen-Rock Community
- Riparian Willow or Birch
- Sedge Community
- Unvegetated (Sand)
- Water

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).
Datum: NAD 83 Projection: UTM Zone 15

1500 0 1500
METRES

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

PLANT COMMUNITY CLASSIFICATION FOLLOWING MINE CLOSURE - NORTH

Golder Associates

PROJECT NO. 10-1373-0076			FILE No.	
DESIGN	LV	09 Nov. 2012	SCALE AS SHOWN	REV. 0
GIS	MH	14 Nov. 2012		
CHECK	LV	17 Jan. 2013		
REVIEW	DW	17 Jan. 2013		

FIGURE 6.5-5a

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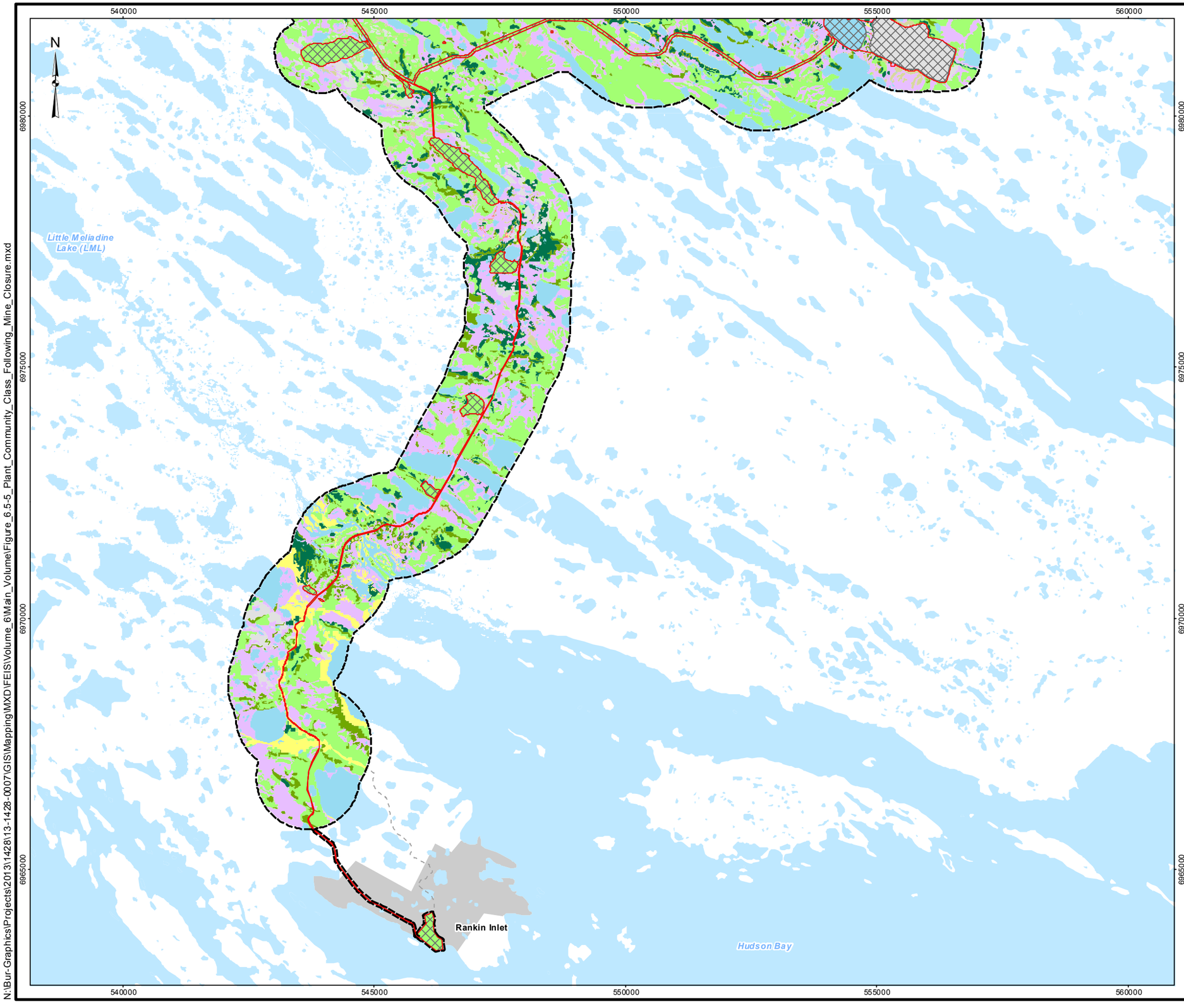


LEGEND

- Local Study Area (LSA)
- Terrestrial Disturbance
- Municipal Boundary
- All-weather Access Road (AWAR)
- Road - New
- Road - Existing
- Watercourse
- Waterbody

Reclamation Class

- Reclaimed Lichen-Rock Community
- Reclaimed Waterbody
- Scarified Natural Revegetation

Plant Community Classification

- Birch Seep
- Disturbed
- Heath Tundra Community
- Lichen-Heath (Cetraria Lichen)
- Lichen-Heath (Hair Lichen)
- Lichen-Rock Community
- Riparian Willow or Birch
- Sedge Community
- Unvegetated (Sand)
- Water

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).
Datum: NAD 83 Projection: UTM Zone 15

1500 0 1500
METRES

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

PLANT COMMUNITY CLASSIFICATION FOLLOWING MINE CLOSURE - SOUTH

Golder Associates

PROJECT NO. 10-1373-0076			FILE No.	
DESIGN	LV	09 Nov. 2012	SCALE AS SHOWN	REV. 0
GIS	MH	14 Nov. 2012		
CHECK	LV	17 Jan. 2013		
REVIEW	DW	17 Jan. 2013		

FIGURE 6.5-5b

6.5.7 Effects to Listed Plant Species

6.5.7.1 Methods

Effects to listed plant species were assessed quantitatively and qualitatively using available data, literature and professional knowledge. The wetlands/riparian plant community types were used as a proxy to quantify high listed (rare) habitat potential, as all known locations of listed plant species are associated with these habitat types. Changes to these plant community types were quantified following the same methods as described in Section 6.5.8.1.

6.5.7.2 Results

Construction and operation of the Project (including the Phase 2 AWAR) will result in a maximum disturbance of 2950 ha (28%) of the LSA. The area of maximum disturbance due to the Project includes 702 ha (7% of the LSA) of wetlands/riparian plant community types containing a moderate to high potential for listed plant species. Following closure, approximately 511 ha (5%) of the LSA will be reclaimed to a scarified natural revegetation type (Table 6.5-12). At this time it is unknown what the potential of these lands to support listed plant species will be once re-vegetated. At post-closure, 1373 ha (13%) of the LSA of residual ground disturbance (i.e., Reclaimed Waterbodies and the Reclaimed Lichen-Rock Community) will not be reclaimed to a vegetated unit with any potential to support listed plants, resulting in a net loss of 502 ha (5% of LSA) of wetlands/riparian types (Table 6.5-13).

Table 6.5-13: Distribution of Wetlands/Riparian Plant Community Types with Potential to Contain Listed Plant Species between the Baseline Case and Post-Closure Case in the Local Study Area

Wetlands/ Riparian Plant Community Types	Baseline Case		Phase 1 AWAR		Project Case		Post-Closure Case (ha)	Post-Closure Net Change (ha)	Post-Closure Net Change (% unit)	Post-Closure Net Change (% LSA)
	Area (ha)	Proportion of LSA (%)	Area (ha)	Proportion of LSA (%)	Area (ha)	Proportion of LSA (%)				
Sedge Community	2368	22	89	1	592	6	1960	-408	-17	-4
Birch Seep	297	3	8	<1	109	1	205	-93	-31	-1
Riparian Willow or Birch	12	<1	<1	<1	2	<1	11	-1	-12	-<1
Total	**2677**	**25**	**97**	**1**	**702**	**7**	**2175**	**-502**	**-19**	**-5**

Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.

[a] Maximum amount of disturbance during the Project.

LSA = Local Study Area; ha = hectare; % = percent; < = less than; n/a = not applicable.

No confirmed listed plant species identified as “At Risk” or “May be at Risk” in NU (CESCC 2011), or federal listed species (COSEWIC [2012] or *SARA* [2012]), were found in the LSA during the 1998, 2008, 2009, and 2012 field surveys. Three occurrences of listed plant species identified as “Sensitive” in NU (CESCC 2011) were identified in the LSA and all of these species were associated with wetland or riparian habitats such as meadows, seeps, and marshes that are associated with the Riparian Willow/Birch, Birch Seep, and Sedge Community plant community types.

These results do not however, preclude the potential for other listed plant species to be present in the LSA and disturbing habitat that may support higher numbers of listed plant species may negatively affect existing populations. The identification of possible listed plant occurrences within the Project footprint will be further addressed through the follow-up monitoring under the TEMP. Appropriate mitigation practices and protocols will also be implemented should any listed plants be identified during monitoring.

6.5.8 Effects to Traditional Use Plant Species IQ

6.5.8.1 Methods

Traditional plant use potential was assessed by grouping plant community types into high, medium, and low categories using available information on the number of traditional plant species that may occur in each plant community type, and professional judgement (Table 6.5-14). Water and disturbance plant community types were considered to have low traditional plant potential as these areas do not typically contain a diversity of vegetation.

6.5.8.2 Results

There are approximately 32 traditional use plants species known to occur within the LSA based on IQ studies (FEIS Volume 9, Section 9.3 and Appendix 9.3-B). The maximum amount of disturbance from the Project is predicted to be 2950 ha (28%) of the LSA, affecting 977 ha (9% of the LSA) of plant community types with a high traditional plant potential, and 598 ha (6% of the LSA) of moderate traditional plant potential plant community types (Table 6.5-14). Within the high traditional plant potential group, the Heath Tundra community type will have the greatest loss or alteration to traditional use plants with a net change of 845 ha (22% of this map unit; 8% of the LSA). Although 511 ha (5%) of the LSA is expected to be reclaimed to a scarified natural revegetation type, it is not known what the traditional use potential will be on these lands once they are fully re-vegetated. Additionally, residual ground disturbance (i.e., Reclaimed Waterbodies and the Reclaimed Lichen-Rock Community) representing 1373 ha (13% of the LSA) will not be reclaimed to a vegetated state at post-closure, resulting in a loss of habitat with a low potential to support traditional use plants.

The IQ studies identified that plants and berries are harvested through the LSA and RSA, including areas overlapping with the Project footprint (FEIS Volume 9, Section 9.3 and Appendix 9.3-B). Berry picking is common throughout the Meliadine valley and along many of the slopes and eskers that are found throughout the LSA (FEIS Volume 9, Section 9.3 and Appendix 9.3-B).

Table 6.5-14: Change in Traditional Plant Use Potential between the Baseline Case and Closure Case in the Local Study Area

Plant Community Types	Baseline Case		Phase I AWAR		Project Case[a]		Post-Closure Case (ha)	Post-Closure Net Change of Unit (ha)	Post-Closure Net Change (% unit)	Post-Closure Net Change (% LSA)
	Area (ha)	Proportion of LSA (%)	Area (ha)	Proportion of LSA (%)	Area (ha)	Proportion of LSA (%)				
High Traditional Plant Potential										
Heath Tundra Community	3 868	36	178	2	1,250	12	3 023	-845	-22	-8
Lichen-Heath (Hair Lichen)	555	5	19	<1	156	1	424	-131	-24	-1
high traditional plant potential subtotal	***4 423***	***42***	***197***	***2***	***1,407***	***13***	***3,447***	***-977***	***-22***	***-9***
Moderate Traditional Plant Potential										
Lichen-Heath (*Cetraria* Lichen)	542	5	48	<1	131	1	446	-96	-18	-1
Birch Seep	2 368	22	89	1	592	6	1 960	-408	-17	-4
Sedge Community	297	3	8	<1	109	1	205	-93	-31	-1
Riparian Willow or Birch	12	<1	<1	<1	2	<1	11	-1	-12	-<1
moderate traditional plant potential subtotal	***3 220***	***30***	***145***	***1***	***833***	***8***	***2,621***	***-598***	***-19***	***-6***
Low Traditional Plant Potential										
Lichen-Rock Community	229	2	5	<1	43	<1	189	-40	-17	-<1
Un-vegetated (Sand)	150	1	31	<1	36	<1	115	-35	-23	-<1
Water	2 180	21	41	<1	631	6	1 707	-473	-22	-4
Disturbance	396	4	<1	<1	0	0	635	239	60	2
low traditional plant potential subtotal	***2 956***	***28***	***77***	***1***	***710***	***7***	***2,647***	***-309***	***-10***	***-3***
Following Closure										
Scarified Natural Revegetation	0	0	0	0	0	0	511	511	100	5
Reclaimed Lichen-Rock Community[b]	0	0	0	0	0	0	916	916	100	9
Reclaimed Waterbodies[b]	0	0	0	0	0	0	457	457	100	4
Total	**10 598**	**100**	**419**	**4**	**2 950**	**28**	**10 598**	**0[c]**	**n/a**	**0[c]**

Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.
[a] Maximum amount of disturbance during the Project.
[b] Residual Disturbances.
[c] **Post-closure net change does not change overall landscape area, therefore total values are zero**
LSA = Local Study Area; ha = hectare; % = percent; < = less than; n/a = not applicable.

6.5.9 Related Effects to Wildlife and People

Related effects to wildlife address wildlife habitat and associated loss of habitat (e.g., plant community types) as a result of the Project, and is described in detail in Section 6.6. Pollution (i.e., dust and air emissions, and spills) can have indirect effects on the use of habitat (e.g., plant community types) by terrestrial and marine wildlife due to potential alteration of plant community types. These effects are described in detail in Section 6.6.3.1 (no linkage pathway effects related to spills) and Section 6.6.3.2 (minor pathway effects related to dust and air emissions) for terrestrial wildlife, and in FEIS Volume 8, Sections 8.3.4.3 and 8.3.6.5 for marine wildlife. Potential impacts from noise do not effect vegetation, athough it can have a sensory effect that alters use of habitat (e.g., plant community types) by terrestrial and marine wildlife as discussed in Sections 6.6.4.2 and 6.6.5.2, and FEIS Volume 8, Sections 8.3.6.2.2, 8.3.6.3.2 and 8.3.6.4.2, respectively.

Related effects to people addresses the use of plants as a resource (e.g., traditional use plants). Berry-picking is practiced by families, including grandparents and children, wherever berry habitat is accessible from Rankin Inlet by ATV. There are many areas along the ridges over which the proposed road will pass that are rich in crowberries. These are considered productive berry-picking areas. Most flat terrace, drumlin, or esker ridges offer abundant crowberry habitat. Participants in an IQ workshop hosted in 2010 believe that the presence of a road would make this area much more accessible to those who wish to pick berries (FEIS Volume 9, Appendix 9.3-A). The Project footprint (including the AWAR) will alter 2950 ha (28%) of the LSA, including 977 ha (9%) of plant community types with a high traditional plant potential (Table 6.5-14). The overall effect from the Project on the use of vegetation resources is expected to be within the range of baseline conditions, as traditional use plants are associated with a range of plant community types that are locally and regionally abundant. Effects from dust deposition and air emissions on vegetation are also expected to be mostly confined to the immediate area around the anticipated mine footprint and the right-of-way along the AWAR and associated mine haul roads. Detailed information on human health risks associated with dust deposition and air emissions, as well as potential bioaccumulation effects are described in FEIS Volume 10, Section 10.2.

6.5.10 Residual Effects Summary

The effect from the Project (including the AWAR) on plant community type distribution will be confined to the Project footprint. The type and degree of change consists of the spatial extent of change and the shape of the landscape. The area that will be disturbed during construction and operation is 2950 ha (28%) of the LSA including 1581 ha of vegetated heath types, 702 ha of wetlands/riparian types and 666 ha of unvegetated types. In the post-closure landscape, 511 ha (5%) of the LSA will be reclaimed to a scarified natural revegetation type, while 1373 ha (13%) of the LSA will not be reclaimed to a vegetated state. Non-vegetated land is associated with residual disturbances including Reclaimed Waterbodies and Reclaimed Lichen-Rock. Thus, at this time, reclaimed lands have not been assigned to specific plant community types. Impacts to biodiversity are minimal as the diversity of plant community types is maintained (i.e., no plant communities are lost as a result of the Project development) and sufficient habitat is retained within each plant community type to support the range of plant species that typically occur.

No confirmed federally or territorially listed plant species identified as “At Risk” or “May be at Risk” were found in the LSA, though three plant species listed as “Sensitive” in NU were found in the LSA. A total of 702 ha (7% of the LSA) of wetlands/riparian plant community types containing a moderate to high potential for listed plant species will be directly disturbed by the Project, relative to the baseline case. Although 511 ha (5%) of the LSA

will be reclaimed to a scarified natural revegetation type in the post-closure period, it is unknown what the potential of these lands to support listed plant species will be once re-vegetated. An additional 1373 ha (13% of the LSA) of residual disturbances will not be reclaimed to a vegetated unit with any potential to support listed plants, resulting in a net loss of 502 ha (5% of LSA) of potential habitat for listed plant species.

The effect to traditional use plants includes the disturbance of 977 ha (9% of the LSA) of plant community types with high traditional plant potential. Although 511 ha (5% of the LSA) will be reclaimed following closure it is not known what the nature and availability of traditional use plants will be in these reclaimed areas once they are re-vegetated. Additionally, 1373 ha (13% of the LSA) that may contain traditional use plants will be lost due to residual disturbances.

6.5.11 Residual Impact Classification

6.5.11.1 Methods

The following criteria suggested in the Guidelines for the Project (NIRB 2012) are used to assess the residual impacts from the Project.

- direction or nature of the impacts;
- magnitude and complexity;
- geographic extent;
- frequency;
- duration;
- reversibility; and
- likelihood or probability of effects.

The term “effect”, used in the effects analyses and residual effects summary, is regarded as an “impact” in the residual impact classification; therefore, in the residual impact classification, all residual effects are discussed and classified in terms of impacts to vegetation.

Generic definitions have been provided for each of the impact criteria in the Assessment Approach (FEIS Volume 4, Section 4.5.4). For criteria such as geographic extent, duration, frequency, and likelihood, the definitions can be applied consistently across all terrestrial VECs. Similarly, reversibility is defined as the likelihood and time required for a component (e.g., population) to recover after removal of a stressor and is a function of resilience. Definitions for each criterion are provided in Table 6.5-15.

The approach used to classify the magnitude of changes in measurement endpoints (and related impacts) was based on scientific literature and professional opinion, and incorporated conservatism. Other environmental assessments often use the universal effect size approach for categorizing magnitude such as negligible changes (0 to 10%), small changes (10 to 25%), and medium changes (25 to 40%) (Munkittrick et al. 2009). Ideally, effect threshold values would be known, and measurement endpoints could be quantified accurately with a high degree of confidence; however, little is known about ecological thresholds, and biological parameters are typically associated with large amounts of natural variation. Therefore, the classification of magnitude included a level of conservatism so that the impacts would not be underestimated.

Table 6.5-15: Definitions of Terms Used in the Residual Impact Classification

Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility[a]	Likelihood
Negative: less favourable relative to baseline values **Positive:** an improvement over baseline values or conditions	**Negligible:** no predicted detectable change from baseline values **Low:** impact is predicted to be within the range of baseline values **Moderate:** impact is predicted to be at or slightly exceed the limits of baseline values **High:** impact is predicted to be beyond the upper or lower limit of baseline values so that there is likely a change of state from baseline conditions	**Local:** small-scale direct and indirect impacts from the Project (e.g., footprint, and dust deposition) **Regional:** the predicted maximum spatial extent of combined direct and indirect impacts from the Project that exceed local-scale effects (can include cumulative direct and indirect impacts from the Project and other developments at the regional scale) **Beyond Regional:** cumulative local and regional impacts from the Project and other developments extend beyond the regional scale	**Short-term:** impact is reversible at end of construction **Medium-term:** impact is reversible at end of closure **Long-term:** impact is reversible within a defined length of time beyond closure **Unknown**: Impact may be reversible however the length of time cannot be defined **Permanent**: impact will last into perpetuity	**Isolated:** impact confined to a specific discrete period **Periodic:** impact occurs intermittently but repeatedly over the assessment period **Continuous:** impact will occur continually over the assessment period	**Reversible:** Impact will not result in a permanent change of state of the population compared to "similar" environments not influenced by the Project **Irreversible:** impact is not reversible (i.e., duration of impact is unknown or permanent)	**Unlikely:** the impact is likely to occur less than once in 100 years **Possible:** the impact will have at least one chance of occurring in the next 100 years **Likely:** the impact will have at least one chance of occurring in the next 10 years **Highly Likely:** the impact is very probable (100% chance) within a year

[a] "similar" implies an environment of the same type, region, and time period.

The definition of magnitude provided in Table 6.5-15 is applicable for more qualitative results (e.g., related impacts to people). For quantitative analyses and results (e.g., loss of plant community types and associated effects to plant populations and communities), the following definition for magnitude is applied:

- negligible: less than a 1% change from the Project relative to baseline values;
- low: 1 to 10% change from the Project relative to baseline values;
- moderate: greater than 10 to 20% change from the Project relative to baseline values; and
- high: more than 20% change from the Project relative to baseline values.

The scale is consistent with, and is below thresholds identified in a recent review by Swift and Hannon (2010) who found that most empirical studies demonstrated negative effects on insects, plants, birds, and mammals when remaining habitat cover ranged from 10 to 30% (i.e., more than 70% habitat loss).

6.5.11.2 Results

Direct impacts to vegetation from the Project (including the AWAR) are local in geographic extent (Table 6.5-16). The impacts to vegetation include associated impacts to listed plant species and traditional use plants. Approximately 28% of the existing plant community types in the LSA will be impacted by the Project footprint, where 5% of this area will be altered following reclamation. However, the incremental change of each plant community type relative to baseline conditions is predicted to be between 12% and 31%. The Project is predicted to impact less than 1% to 4% of plant community types that have a high potential for containing listed plant species and no confirmed federally or territorially listed plant species identified as “At Risk” or “May be at Risk” were found in the LSA, though three plant species listed as “Sensitive” in NU were found in the LSA. A total 977 ha (9 % of the LSA) of plant community types with high traditional plant potential will be impacted by the Project.

Therefore, at the local scale, the magnitude of impacts from the Project footprint on plant communities and populations as defined by plant community types is predicted to be moderate to high for all plant community types (Table 6.5-16). The magnitude of impacts to listed plant species and plant community types with the potential to contain listed plant species is low. The magnitude of impacts to traditional use (e.g., traditional use species) is expected to be moderate.

The frequency of direct impacts from the Project to vegetation, including plant populations and communities, listed plant species, and traditional use species, are considered to be periodic during the life of the Project (i.e., clearing of land during construction activities will occur during the first few years of the Project). The frequency of residual ground disturbance following reclamation is considered continuous. Although reclamation will be integrated into mitigation and management plans for the Project, subarctic terrestrial ecosystems are slow to recover following disturbance; therefore, the duration of these changes should be long-term, but given adequate time, the impacts are predicted to be reversible. Research on arctic ecosystems has shown that it can take from 20 to 75 years for vegetation to recover following disturbance (Forbes et al. 2001; Walker and Everett 1991). However, it is not known what the abundance and distribution of plant species and plant community types will be in reclaimed areas following revegetation. It is not certain that rare plants and traditional use plants will be

present in the reclaimed landscape in the same proportion and abundance as they are in a future environment that is not influenced by the Project.

Table 6.5-16: Summary of Residual Impact Classification of Primary Pathways for Effects from the Project on Vegetation

Pathway	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Likelihood
Physical loss or alteration of vegetation from the Project footprint affecting plant populations and communities	Negative	Moderate	Local	Long-term	Periodic	Reversible	Highly Likely
Physical loss or alteration of vegetation from the Project footprint affecting listed plant species	Negative	Low	Local	Long-term	Periodic	Reversible	Highly Likely
Physical loss or alteration of vegetation from the Project footprint affecting availability of traditional use plant species	Negative	Moderate	Local	Long-term	Periodic	Reversible	Highly Likely
Residual ground disturbance can cause permanent loss and alteration of vegetation (including listed and traditional use plant species)	Negative	Moderate	Local	Unknown/ Permanent	Continuous	Irreversible/ Reversible	Highly Likely

Not all the areas for the Project will be reclaimed to a revegetated state; 13% of the impacted vegetation communities will be lost. The Reclaimed Waterbodies and Reclaimed Lichen Rock Community will be permanent non-vegetated features on the landscape, covering approximately 1373 ha. Therefore, at the local scale, the magnitude of the impact from residual ground disturbance on plant populations and communities, including listed plant species, and traditional use species, is moderate. The duration of this change is permanent and irreversible for the Reclaimed Waterbodies, and unknown and potentially reversible for the Reclaimed Lichen Rock Community (Table 6.5-16).

6.5.12 Environmental Significance

6.5.12.1 Methods

The classification of residual impacts on primary pathways provides the foundation for determining environmental significance from the Project on vegetation assessment endpoints. However, significance is only determined for assessment endpoints, and not individual pathways, as assessment endpoints represent the

ultimate ecological properties and services of plant populations and communities that should be protected for use by future human generations (Section 4). Magnitude, geographic extent, and duration are the principal criteria used to predict significance. Duration of impacts, which includes reversibility, is a function of ecological resilience, and these ecological principles are applied to the evaluation of significance. Other criteria, such as frequency and likelihood are used as modifiers (where applicable) in the determination of significance.

The evaluation of significance for plant populations and communities considers the entire set of pathways that influence a particular assessment endpoint (e.g., persistence of listed and traditional use plant populations). The relative contribution of each pathway is then used to determine the significance of the Project on assessment endpoints. For example, a pathway with a high magnitude, large geographic extent, and long-term duration would be given more weight in determining significance relative to pathways with smaller scale effects.

Environmental significance is used to identify predicted impacts that have sufficient magnitude, duration, and geographic extent to cause fundamental changes to plant populations and communities. The following definitions are used for assessing the significance of impacts on the persistence of plant populations and communities, including listed plant species and the associated continued opportunity for traditional use of plants.

Not significant – impacts are measurable at the local or individual level, and strong enough to be detectable at the population level, but are not likely to decrease the resilience and increase the risk to population persistence.

Significant – impacts are measurable at the population level and likely to decrease the resilience and increase the risk to population persistence. A number of high magnitude and irreversible impacts at the population level (regional scale) would be significant.

The evaluation of significance uses scientific and ecological principles, to the extent possible, but also involves professional judgement and experienced opinion.

In summary, the following information is used in the evaluation of the significance of impacts from the Project on vegetation assessment endpoints.

- Results from the residual impact classification of primary pathways.
- Magnitude, geographic extent, and duration of the impact as principal criteria, with frequency and likelihood as modifiers.
- Application of professional judgment and ecological principals, such as resilience, to predict the duration and associated reversibility of impacts.

6.5.12.2 Results

For all primary pathways influencing plant populations and communities assessment endpoints, the geographic extent of impacts was determined to be local (Table 6.5-16). The impacts are highly likely to occur for all Project pathways. The frequency of impacts to plant populations and communities is anticipated to be periodic and limited to discrete periods throughout the life of the Project. At the local scale, the magnitude of the impact to plant populations and communities from the Project is predicted to be moderate. Impacts from the residual ground disturbances that will not be reclaimed to a vegetated state are considered permanent and irreversible for the Reclaimed Waterbodies, and unknown and potentially reversible for the Reclaimed Lichen Rock

Community, while areas expected to be reclaimed are predicted to be reversible in the long-term (Table 6.5-16). Based on the impacts from the Project on plant populations and communities, it is predicted that the magnitude of impacts to traditional use of plants will be moderate.

Participants in an IQ workshop hosted in 2010 stated that the presence of the AWAR would make this area much more accessible to those who wish to pick berries (Appendix 9.3-A), thereby supporting continued traditional use. The results indicate that the Project should not result in significant adverse impacts to the persistence of plant populations and communities, including listed plant species, and the use of traditional plants. Changes from the Project are predicted to result in moderate, local-scale impacts to plant populations and communities, and should be reversible in the long-term (i.e., 50 to 75 years following closure) for those areas that will be reclaimed (i.e., scarified and left to naturally re-vegetate). IQ

6.5.13 Cumulative Effects

6.5.13.1 Methods

Incremental and cumulative effects analysis was conducted at the RSA-scale providing an environmentally conservative statement on the impacts to plant populations and communities as expressed by changes in regional land cover classes. Direct effects from human disturbance were used to quantify changes in the relative availability of different regional land cover classes, under each development case: reference, baseline, Phase 1 AWAR, Project (project and AWAR), and future case. Reference conditions represent the initial period of baseline conditions (as far back as data are available), while the baseline case includes all previous, existing, and approved developments up to 2012.

The following proposed projects have been selected as a suite of major developments that may occur in the foreseeable future:

- The Manitoba to Nunavut Road – This major project has received ongoing support from the governments of Nunavut and Manitoba. Although no permit applications have yet been filed, a preferred alignment has been selected, and the project would change the face of development in the Kivalliq region.
- The Churchill Diamonds Project – This project is currently in the exploration phase and applications have not been made to advance to mining, but it was included as a likely project to be induced by the Manitoba to Nunavut Road, and was identified in the Manitoba to Nunavut Road route selection study as such.
- The Ferguson Lake Project – This project is currently in the exploration phase and applications have not been made to advance to mining, but a scoping study has investigated the possibility of advancing to mining. This project was included as a likely project to be induced by the Manitoba to Nunavut Road, and was identified in the Manitoba to Nunavut Road route selection study as such.
- The Kiggavik Uranium Project – This project is currently undergoing review to become a uranium mine.

The Wolf deposit, located north-west of the Tiriganiaq deposit, is currently known, but still requires some exploration work to be better defined and included in the mine plan. Currently, the Wolf deposit does not have sufficient proven reserves to be economically mined and so was not included as a development, or as part of the

Project. An environmental impact assessment (including a cumulative effects analysis) for the Wolf deposit will be completed in the future if the deposit becomes economically feasible to be developed.

The following equations were used to estimate the relative change in the amount of regional land cover classes in the RSA for different conditions on the landscape.

- Existing Cumulative Effects = (Baseline Case area – Reference Case area) / Reference Case area x 100;
- Phase 1 AWAR Incremental Effects = (Phase 1 AWAR Case area – Baseline Case area) / Baseline Case area x 100;
- Project Incremental Effects = (Project Case area – Phase 1 AWAR area) / Baseline Case area x 100;
- Future Incremental Effects = (Future Case area – Project Case area) / Project Case area x 100; and
- Future Cumulative Effects = (Future Case area – Reference Case area) / Reference Case area x 100.

6.5.13.2 Results

The RSA currently supports the hamlet of Rankin Inlet (and associated infrastructure), one territorial campground, 2 active exploration camps (one of which is on the AEM property), one active quarry, and one inactive quarry. Linear developments include an all-season road extending for 15 km between the community and a nearby territorial campground, as well as about 58 km of active winter roads between Rankin Inlet and active exploration camps.

Under baseline conditions the existing development footprint in the RSA covers about 790 ha or 0.32% of the RSA. The incremental direct effect of the Phase 1 AWAR will increase the existing footprint area by 27 ha from the baseline case, or 0.01% of the RSA (Table 6.5-17), as much of the AWAR overlaps with existing disturbances. The direct effect of the Project (e.g., Project Case) will incrementally increase the footprint area by 2 526 ha from the Phase 1 AWAR case, or 1.03% of the RSA, while the total cumulative direct effects of development measured as development footprints under the future scenario will be about 3 493 ha relative to the reference case, or 1.42% of the RSA (Table 6.5-17).

The cumulative incremental change of each regional land cover class in the RSA relative to reference conditions is predicted to be between 0.05% and 6.76% (Table 6.5-17). As there is limited development in the RSA in the future scenario, the overall cumulative direct and indirect effects to vegetation, including effects to listed plant species and traditional use plant species, are predicted to be negligible to low.

Table 6.5-17: Incremental and Cumulative Loss or Alteration to Regional Land Cover Classes

Regional Land Cover Class	Reference Case (ha)	% of RSA	Baseline Case (ha)	Percent Incremental Change Reference to Baseline Case	Phase 1 AWAR Case (ha)	Percent Incremental Change Baseline to AWAR Case	Project Case (ha)	Percent Incremental Change AWAR to Project Case	Future Case (ha)	Percent Incremental Change Application to Future Case	Cumulative Percent Change Reference to Future Case
Heath											
Heath Boulder	26 499	11	26 417	-0.31	26 412	-0.02	26 342	-0.27	26 323	-0.07	-0.67
Heath Lichen - hair lichen	4 503	2	4 494	-0.22	4 493	-0.01	4 472	-0.47	4 469	-0.07	-0.77
Heath Lichen - Cetraria	1 733	1	1 698	-2.03	1 696	-0.11	1 617	-4.67	1 616	-0.06	-6.76
Health Tundra	109 826	45	109 534	-0.27	109 520	-0.01	107 912	-1.47	107 851	-0.06	-1.80
Heath vegetation subtotal	*142,562*	*58*	*142,143*	*-0.29*	*142,122*	*-0.01*	*140,342*	*-1.25*	*140,259*	*-0.06*	*-1.62*
Wetlands/Riparian											
Low Shrub	3 478	1	3 476	-0.08	3 475	-0.01	3 461	-0.40	3 461	-0.02	-0.50
Tussock – Hummock	25 699	10	25 633	-0.26	25 627	-0.02	25 441	-0.73	25 413	-0.11	-1.11
Wetlands /riparian subtotal	*29,177*	*12*	*29,109*	*-0.23*	*29,103*	*-0.02*	*28,903*	*-0.69*	*28,873*	*-0.10*	*-1.04*
Miscellaneous											
Bare ground	5 263	2	5 017	-4.68	5 017	-0.01	4 984	-0.64	4 983	-0.02	-5.31
Water	69 298	28	69 242	-0.08	69 242	-<0.01	68 727	-0.74	68 692	-0.05	-0.87
Miscellaneous subtotal	*74,561*	*30*	*74,259*	*-0.40*	*74,258*	*-<0.01*	*73,712*	*-0.74*	*73,675*	*-0.05*	*-1.19*
Total	**246 300**	**100**	**245 510**	**-0.32**	**245 483**	**-0.01**	**242 957**	**-1.03**	**242 807**	**-0.06**	**-1.42**

Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.
LSA = Local Study Area; ha = hectare; % = percent; < = less than; n/a = not applicable.

6.5.14 Uncertainty

Like all scientific results and inference, residual impact predictions must be tempered with uncertainty associated with the data and current knowledge of the system. The confidence in impact predictions is related to the adequacy of baseline data for understanding current conditions, accuracy of the local and regional scale ecological landscape classification and plant community mapping, the validity of models (e.g., to predict the extent of air emission and dust deposition) and understanding of project-related impacts on the system. The primary sources of uncertainty surrounding the identification of potential effects to subarctic vegetation ecosystems and plants are largely associated with the degree to which effects may occur (e.g., magnitude and duration). It is understood that development activities will disturb plant populations and communities; however, the ecological trajectory and rate at which these communities will recover is somewhat uncertain.

A critical aspect of this assessment is based on plant community types that have been interpreted using high resolution satellite imagery. The listed plant potential and traditional plant distributions within these plant community types were also estimated and qualitatively assessed as insufficient empirical data were available to derive numerical models. The plant community type classification was developed from data collected in the field, supporting literature, aerial photograph interpretation, as well as professional judgement. In general, this classification represents an accurate interpretation of ground conditions, especially at the local scale. The effects associated with air emissions and dust deposition, have not been extensively studied in subarctic environments and anticipated effects have been extrapolated from studies completed in more temperate climates. The identified sources of uncertainty affect the magnitude and duration components of the predictions. Where uncertainty exists, conservative estimates were used so that impacts were not underestimated.

Uncertainty can be reduced by collecting additional data, which can be used to validate models, and describe previously undocumented processes that are associated with effects from the Project. Monitoring programs for the Project will be designed, implemented, reviewed and updated on a regular basis to reduce uncertainty of the predicted effects related to changes from the Project.

6.5.15 Monitoring and Follow-Up

Construction of the Project will lead to the direct loss and alteration of vegetation and other natural features across a range of plant community types. These changes will predominantly occur during construction, and continue at a much slower rate and smaller spatial extent throughout the period of operations.

It is anticipated that monitoring of revegetation success will be required during the Project, but the objectives, measurement endpoints, and methods of revegetation will need to be determined with input from regulators and the communities. Analyzing and assessing the success of revegetation success would likely be a component of the TEMP, and will provide input into the Mine Closure and Reclamation Plan (SD 2-17). It is anticipated that test plots will be implemented as part of the TEMP to acquire knowledge during operations regarding natural revegetation processes in disturbed areas. Environmental monitoring would also include protocols for monitoring non-native invasive plant species, which will be implemented as part of TEMP and will follow DOE guidelines for reporting on non-native invasive plant species.

The Project is anticipated to affect air quality through the release of combustion emissions and fugitive dust, which may influence vegetation and have indirect impacts to wildlife and human health. An air quality monitoring program will be implemented to determine if changes in air and dust emission parameters from the Project are

within concentrations predicted from air dispersion modelling (FEIS Volume 5, SD 5-1). As part of the air quality monitoring program, dust monitoring sites may be established at varying distances around the Project. A corresponding vegetation monitoring program, in which plant samples of importance to wildlife and humans (e.g., lichens or berries) are collected and tested for metal concentrations, would be implemented in the vicinity of the dust fall devices. The plant species selected for metals analysis will be the same as those species collected on sites for the baseline data and will follow the same data collection protocols. Based on the results of the vegetation and dust fall monitoring programs, mitigation and changes to mine operation may be suggested to reduce emissions and fugitive dust. Should additional issues related to vegetation be raised during the public consultation process in the future, they will be considered and addressed as part of AEMs adaptive management approach.

6.6 Terrestrial Wildlife and Wildlife Habitat

6.6.1 Introduction

6.6.1.1 Purpose and Scope

Based on the Guidelines for the Project (NIRB 2012), terrestrial wildlife and wildlife habitat is represented by terrestrial wildlife migration routes and crossings, and terrestrial mammals including: caribou (*Rangifer tarandus groenlandicus*) (including habitat, migration, and behaviour), muskoxen (*Ovibos moschatus)*, wolverine (*Gulo gulo*), brown bears (*Ursus arctos*), polar bears (*Ursus maritimus*), wolves (*Canis lupus arctos*), and less conspicuous species that may be maximally exposed to contaminants. Grizzly bear (*Ursus arctos horribilis*) is the only species of brown bear that may be exposed to the project development.

The purpose of the assessment is to evaluate direct and indirect effects of the Project on terrestrial wildlife and wildlife habitat. The effects assessment evaluated all aspects of the Project, including construction, operation, and closure and post-closure. Indirect and cumulative effects were incorporated, where applicable. Information from other components, including air quality, water quality and quantity, and traditional and non-traditional land use, as well as information from existing developments, were incorporated in the effects assessment for terrestrial valued ecosystem components (VECs). Volume 1, Appendix 1.0-A list the specific requirements set out in the Guidelines issued by the NIRB in their Guidelines for the Project (NIRB 2012) relating to the baseline and the impact assessment for terrestrial wildlife and wildlife habitat.

6.6.1.2 Valued Components

Valued ecosystem components and VSECs represent physical, biological, cultural, social, and economic properties of the environment that are either legally, politically, publically, or professionally recognized as important to a particular region, community, or by society as a whole. Several wildlife VECs were selected to assess Project-related effects on the terrestrial wildlife and wildlife habitat (Table 6.6-1). The only wildlife species for which concern was raised during public consultation was caribou (SD 3-1).

Table 6.6-1: Wildlife and Wildlife Habitat Valued Ecosystem Components

	Valued Component		Rationale for Selection
Wildlife	Ungulates	Barren-ground Caribou	important subsistence, cultural, and economic species; migratory species with extensive range requirements; may be affected by disturbance during seasonal movements; primary prey species for large carnivores in northern environments
	Carnivores	Gray Wolf	large home range size linked to caribou migrations; top predator in ecosystem, can be attracted to human disturbance; long generation time means one individual may be affected by disturbance over multiple years resulting in potential regional population effects; important subsistence and cultural species
		Polar Bear	large home range size; top predator in ecosystem, can be attracted to human disturbance; long generation time means one individual may be affected by disturbance over multiple years resulting in potential regional population effects; listed as "Sensitive" in Nunavut (CESCC 2011), "Special Concern" in Canada (COSEWIC 2012), "Sensitive" on Schedule 1 of SARA (2013), and "Vulnerable" by the IUCN (Schliebe et al. 2008).

COSEWIC = Committee on the Status of Endangered Wildlife in Canada
CESCC = Canadian Endangered Species Conservation Council
IUCN - International Union for Conservation of Nature

Factors considered when selecting wildlife VECs included the following criteria (Salmo 2006):

- biophysical components identified by NIRB during Project scoping and AEM community and stakeholder consultation and as outlined in the project Guidelines (NIRB 2012);
- represent important ecosystem processes;
- territorially and federal listed species (COSEWIC 2012; *SARA* 2012, CESCC 2001), as well as internationally listed by the IUCN (www.IUCNredlist.org);
- communities or species that reflect the interests of regulatory agencies, traditional use, and communities;
- can be measured or described with measurement endpoints;
- allow cumulative effects to be considered; and
- current experience with environmental assessments and effects monitoring programs in NU and the NT.

Grizzly bear, muskox, and wolverine were also considered as VECs, but not selected because the core part of their distributional range does not overlap with the Project (GN 2011). In addition, there have been either no, or very few, observations of these animals in close proximity to the Meliadine camp. There are few wolverines, or grizzly bears harvested by the Rankin Inlet community (Priest and Usher 2004).

Concerns were raised during the review process of the Draft Environmental Impact Statement regarding future impacts to muskox populations. The distribution of muskox is changing in NU, thus muskox may increase in abundance and distribution during the life of the Project. Although not include as a VEC for the reasons stated above, future distribution was considered to guide monitoring and potential mitigation in the future. The historic range of muskox once overlapped the Project area; however hunting pressure resulted in extirpation of muskox from much of its southern range (Jenkins *et al* 2011). Elders noted that while muskoxen were present in the time of their ancestors, there were no muskox when they were young. As a result, muskox hunting fell out of

common Inuit practice. Paricipants in consultation regarding the AWAR noted that muskoxen are increasing in numbers in the Rankin Inlet area, and there is much more hunting of muskox than before. Participants also said that muskoxen are being hunted near Diana River (Volume 9, Section 9.3.1.3.2.1). The muskox population was reduced to a few scattered herds by the early 20th century; however, most of the historical range was re-colonized by the 1990s (Barr 1991, Fournier and Gunn 1998).The current distribution lies west of the Project area (Campbell et al. 2012). In the early 2000s, Kivalliq Hunting and Trapping Organizations (HTOs), as well as the Kugaaruk, Taloyoak and Gjoa Haven HTO's reported seeing muskox increase in abundance and expanding their range (Campbell 2007). Information provided by the Arviat, Whale Cove, Rankin Inlet and Baker Lake HTOs supported evidence of this range expansion (Campbell 2007). Observations in the RSA are limited to one in 2008, a group of 26 in 2009 and a group of 18 in 2010 (Section 6.6.2.5; J. Witteman, AEM, 2012, pers. comm.; FEIS Volume 9, Section 9.3). Annual hunting quotas are low (~ 5) and according to community feedback on hunter harvest surveys, muskox are not always taken (Priest and Usher 2004). Hunters report having to travel large distances to harvest muskox and in 2009, when 35 tags were issued by the HTO for muskox harvest, hunters went north of the Regional Study Area (RSA) (i.e., Peter's Lake) to fill their tags (Priest and Usher 2004; N. Ford, Director of the Kangiqliniq HTO, 2012, pers. comm.).The region near Diana River, which is southwest of the RSA, was also identified as a muskox hunting region (FEIS Volume 9, Section 9.3). Thus, muskox presence and abundance still appears to be low in the RSA.

Muskox range expansion towards the RSA and the LSA was estimated based on the distributional change in the Kivalliq muskox population between 2000 and 2012 (Campbell et al. 2012). An annual rate of change was determined by averaging the distance between the 2000 and 2012 range fronts immediately west of the RSA, identified in Figure 6.6-1 as "region used to estimate muskox range expansion". This region roughly corresponds to the area of highest muskox density and the area that has experienced the most change (Campbell et al. 2012). The annual expansion rate, estimated at 12.75 km/year, was projected forward until the RSA was fully contained within the predicted distribution. Based on the process described above, the Kivalliq muskox range is predicted to extend into the LSA in the year 2015 and will fully contain the RSA in the 2019 (Figure 6.6-1).

Muskox distribution reflects the environmental conditions that support these animals, with the northern and coastal extents of their range supporting the highest density (Sly et al. 2001). Forage requirements for muskox vary seasonally and broadly include sedges (Carex spp.), grasses, and deciduous shrubs; especially willows (Salix spp.), birch (Betula spp.), crowberry (Empetrum nigrum), and bilberry (Vaccinium myrtillus) (Larter and Nagy 1997; Klein 1992). Muskox forage habitat within the Project RSA has not been surveyed. The range projection makes the conservative assumption that forage habitat is widely available for muskox throughout the RSA and LSA and that muskox will use all regions equally.

Muskox do not undertake long migrations; however, in some areas, winter and summer ranges are distinct, and distances travelled can be over 160 km between these seasonal habitats. Seasonal movements typically depend on landscape and terrain features, forage availability, and snow characteristics (Gunn and Adamczewski 2003). Daily movements are constrained in spring and summer during the calving period; at this time herds seek out ridges that are free of snow to provide better opportunity for protection from predators (Gunn & Fournier 2000). During late winter, movement is primarily driven by foraging requirements and muskox can be found on eskers and plateaus where the vegetation has been exposed by wind (Sly et al. 2001), or by the warm spring sun. Snow depth has been reported to be one of the most important factors distinguishing usable versus unusable winter muskox habitat (Reynolds et al 2002). The range projection does not account for predator

distribution, snow depth or microhabitat (i.e. eskers) which could affect the presence, abundance, and distribution of muskox that may populate the RSA and LSA. The rate and direction of range expansion will be affected by distribution of habitat features and predators.

Abundance across species distributions generally follows a pattern of higher density at the core, and fewer individuals at the periphery (Brown 1984, Fournier and Gunn 1998). Expansion then tends to occur with a few individuals dispersing and expanding the range front, resulting in declining abundance behind the colonizing front (Gunn et al; Reynolds et al 2002). Population density may also influence dispersal of muskox and range expansion (Gunn and Fournier 2000). Muskoxen live together in loosely organized herds, averaging 15 animals (ENR 2008). Herd size and composition vary with season, range conditions, and the number of bulls in the population (ENR 2008). After the rut, the herds increase as bulls and/or mixed groups join together. In severe winter conditions, large herds may break apart as a result of limited forage. While the rate of expansion was estimated for the region east of the area with highest density, where expansion is expected to occur most quickly, the range projection does not consider muskox density explicitly, as data were not available.

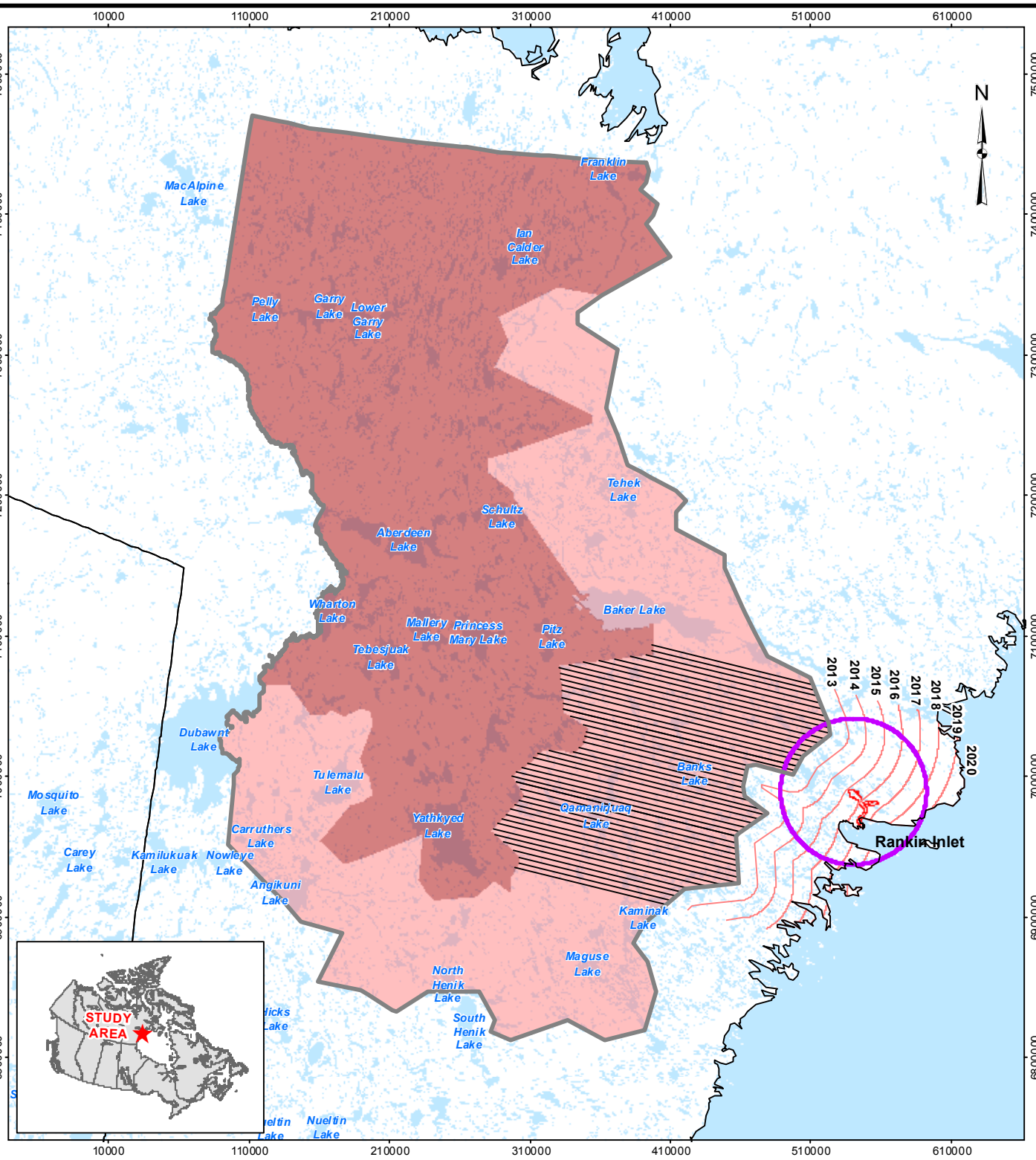
The range expansion projection assumes even yearly range expansion and does not consider factors such has forage potential, predator density, or hunting pressure, which could limit the rate and direction of future muskox range expansion. The estimation provides a coarse view of potential range expansion based on spatial and temporal change only, likely resulting in a conservative projection. The relatively sedentary nature of muskox (daily movements typically 5km/day) and small home range size may result in relatively slow range expansion (Reynolds et al 2002). Muskoxen are also energetically conservative and focus movements on accessing forage material and avoiding predators (Reynolds et al 2002). The estimated annual range expansion rate is slightly faster than observed in the Northwest Territories where it was estimated at less than 10 km/year (Fournier and Gunn 1998).

If the muskox distribution expands into the Project area, potential effects from the Project may include human-wildlife conflict, increased hunting pressure, and sensory disturbance. However, sensory disturbances would occur during the expansion process, and may serve to deter muskox from entering the Project area. The management measures related to human-wildlife conflict and increased hunting pressure outlined in the TEMMP (SD 6-4) are expected to mitigate these Project-related effects to muskox. It is also important to note that a range front projection, as given here, is associated with presence rather than abundance, and often represents the few individuals that disperse and colonize new areas at the periphery of a species range. Thus, potential interactions with the Project are expected to be with a few individuals, not with the core of the population. Effects from the Project to the maintenance of muskox populations and the continued opportunity for traditional and non-traditional use of muskox are predicted to be negligible. AEM will communicate closely with GNDoE biologists to understand the range expansion of muskox. Considerations will be made to adapt the TEMMP (SD 6-4) to include detection surveys for muskox, if deemed necessary.

Arctic fox (*Vulpes lagopus*) was also considered as a VEC, but was not selected because the species is listed as secure or common by governmental agencies, and can thrive in and around human developments.

Any potential impacts from the Project on grizzly bear, wolverine, muskox, and Arctic fox populations are predicted to be negligible. Although the Project may influence the movement or behaviour of an occasional individual(s), the effect would likely not change the demographic performance (i.e., reproduction and survival) of the breeding population as the core of the breeding population for muskox, wolverine, and grizzly bear travelling within the RSA is located farther west or near the treeline, and would not be influenced by the Project. In addition, Elders in Rankin Inlet suggest that wolverines and other carnivores have not been negatively affected

by mining in the past, and remained in the region even while mining was taking place. However, AEM commits to undertake a grizzly bear den survey prior to construction of Project infrastructure and Phase II of the road should the Project be allowed to proceed. In addition, AEM will include management strategies for the management, mitigation and monitoring of grizzly, muskox, wolverine and Arctic fox within the TEMMP (SD 6-4), specifically as part of the human-wildlife conflict management plan and the wildlife protection and response plan.



LEGEND

- Muskox Distribution
- Muskox Expansion 2000-2012
- Regional Study Area (RSA)
- Local Study Area (LSA)
- Waterbody
- Estimated Muskox Expansion (1 Year Increments)
- Region Used to Estimate Muskox Range Expansion
- Watercourse

REFERENCE

Base data obtained from ESRI, Agnico Eagle Mines Ltd. (AEM), and Natural Resources Canada
Wildlife data obtained from the Government of Nunavut
Datum: NAD 83 Projection: UTM Zone 15

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

ESTIMATION OF MUSKOX RANGE EXPANSION INTO THE PROPOSED MELIADINE GOLD MINE PROJECT AREA

Golder Associates

PROJECT	13-1428-0007		PHASE 7000/7300	
DESIGN	KD	05 Mar. 2014	SCALE AS SHOWN	REV. 0
GIS	SGR	06 Mar. 2014		
CHECK				
REVIEW				

FIGURE 6.6-1

N:\Bur-Graphics\Projects\2013\1428\13-1428-0007\GIS\Mapping\MXD\FEIS\Volume_6\Main_Volume\Figure_6.6-1_Estimated_Muskox_Expansion.mxd

6.6.2 Baseline Environment

6.6.2.1 Methods

Baseline terrestrial wildlife studies at the Project were initiated by Arc Wildlife Services Ltd. in May 1998 and continued through 2000. Further studies were completed in 2008 and 2009 by Golder Associates Ltd. (Golder) (Table 6.6-2). The 2008 and 2009 wildlife studies were designed to update and augment the existing baseline data for barren-ground caribou. The studies were designed to collect baseline data within the RSA, including the proposed Project footprint and the proposed All-weather Access Road (AWAR) corridor. The objectives of wildlife studies were to provide baseline data to assess the potential effects of the Project on caribou and other wildlife species, including species of concern (Table 6.6-3), and to develop a wildlife management and monitoring plan (SD 6-4 Terrestrial Environment Management and Monitoring Plan [TEMMP]) utilizing standardized methods to allow for measurement of cumulative effects. The baseline environment included a description of traditional knowledge for VECs, where this information was available. A full report on baseline studies for the Project can be found in the 2009 Terrestrial Synthesis Report (SD 6-2).

Fox den surveys were conducted in 1998 to determine the locations of Arctic fox den sites and monitor for occupancy and productivity. Because Arctic fox were not included as a VEC, these surveys were not summarized in the DDEAR, but are summarized in the 2009 Terrestrial Synthesis Report (SD 6-2). However, the fox den surveys provided the opportunity for incidental sightings of other wildlife species, which are included in the DDEAR. Fox den surveys were conducted on foot, and focused on collecting data near the perimeter of the Project footprint.

Table 6.6-2: Summary of Work Completed for Wildlife Species

Surveys	1998	1999	2000	2008	2009
Caribou – aerial surveys	√	√	√	√	√
Fox dens – ground surveys	√				
Incidental wildlife observations	√	√	√	√	√

Table 6.6-3: Mammal Species of Concern in the Regional Study Area

Common Name	Scientific Name	COSEWIC Status[a]	*SARA* Status[b]	Nunavut Status[c]	Record of Presence in the Regional Study Area
Polar bear	*Ursus maritimus*	Special Concern	Schedule 1	Sensitive	Observed within Project RSA (1998, 1999, 2000, 2007, 2008, 2010, 2012)
Wolverine	*Gulo gulo*	Special Concern	Schedule 3	Sensitive	Not observed
Grizzly bear	*Ursus arctos*	Special Concern	Schedule 3	Sensitive	Not observed
Gray wolf (arctic)	*Canis lupus arctos*	Data Deficient	Not Listed	Sensitive	Observed within Project RSA (2008, 2011)
Barren ground caribou	*Rangifer tarandus groenlandicus*	Not at Risk	Not at Risk	Sensitive	Observed within Project RSA (1998, 1999, 2000, 2008, 2009. 2011, 2012)

[a] COSEWIC Status: Committee on the Status of Endangered Wildlife in Canada. http://www.cosewic.gc.ca/eng/sct1/searchform_e.cfm, accessed August 2012

[b] SARA Status: *Species at Risk Act*. http://www.sararegistry.gc.ca/default_e.cfm, accessed June 24, 2013

[c] CESCC: Canadian Endangered Species Conservation Council. 2011. Wild species 2010: the general status of species in Canada. National General Status Working Group: 302 pp

6.6.2.1.1 Barren-ground Caribou Aerial Surveys

The objective of the barren-ground caribou aerial surveys was to document the seasonal distribution, behaviour, habitat associations, and abundance of caribou within the RSA. Although recent work suggests the potential ZOI for caribou affected by mining activities is 14 km (Boulanger et al. 2012), Johnson et al. (2005) suggested the ZOI for caribou extended up to 30 km from development. Baseline studies were complete prior to 2012, consequently the study area was based on the Johnson et al. (2005) defined ZOI in 2008 and 2009. A larger study area was designed to capture potential mine-related effects on caribou (i.e., includes the ZOI) and provide control data outside the ZOI. Surveys were classified, based on the time of year, as either 'spring migration and calving', 'post-calving through to fall migration and rut', or 'early winter.' This is based on the Qamanirjuaq caribou annual life history phases (Table 6.6-4; BQCMB 1999; J. Shaw, Caslys Consulting, 2012, pers. comm.).

From 1998 to 2000, fixed wing and helicopter aerial surveys were completed within a 121 400 ha area encompassing the Project site, covering 25% of this area. In 2008 and 2009, the surveys were completed over an 849 500 ha area (i.e., within a 52 km radius of the Project site), resulting in 15% coverage of this area.

Table 6.6-4: Qamanirjuaq Barren-Ground Caribou Herd Life History Periods

Life Cycle Period	Dates	Remarks on Timing and Location
Spring migration	1 April to 25 May	May be delayed if snow is deep. Timing depends on distance travelled. Route taken depends on winter distribution.
Calving	26 May to 25 June	Condition of cows affects timing. Most calves are born between 5 and 15 June. The same general area is used for calving each year, but the specific place where calves are born varies from year to year.
Post-calving	26 June to 31 July	Animals gather in large groups to reduce harassment by mosquitoes on calm days. Habitat used for escaping insects (e.g., sand, gravel, hills, lakeshore) is important. The post-calving period ends when caribou migrate south to near tree line.
Late summer	1 August to 15 September	Groups break up when harassment by mosquitoes decreases and that by warble flies and nose bots increases. Caribou begin to regroup in late August and September. Little is known about movement patterns.
Fall migration and rut	16 September to 31 October	Migration timing is influenced by weather, particularly early snowfall and ice formation. Rut occurs in late October.
Early winter	1 November to 31 December	Rapid movements occur in some years. Animals generally move away from areas with deep snow.
Late winter	1 January to 31 March	Movements decrease as snow deepens. Caribou wintering on tundra seek range where the snow is relatively shallow, such as on the tops of hills.

Source: BQCMB 1999; J. Shaw, Caslys Consulting, 2012, pers. comm.

Caribou observed during aerial surveys were counted, and locations and time were recorded. In some years, large congregations of barren-ground caribou were photographed and later counted. In these cases, at least 3 photographs were taken of each congregation and the highest count was used.

During the 2008 and 2009 surveys, the habitat type of each location was recorded. Habitat type was classified based on land cover classification as defined in Matthews et al. (2001). Matthews et al. (2001) classified vegetation within the Kitikmeot/Slave Geological Province. Although the Project study area falls outside of the Kitikmeot/Slave Geological Province, this classification encompasses the Southern Arctic ecozone and the RSA

is located in that ecozone. Therefore, this classification is representative of the vegetation that occurs within the RSA.

During all surveys, barren-ground caribou observed off-transect were recorded as incidental observations, with the number of individuals and a waypoint recorded. More detailed methods can be found in the 2009 Terrestrial Synthesis Report (SD 6-2). When other species were observed, species, number of individuals, and location of observation were recorded.

In addition, spatial boundaries for annual and seasonal home ranges of the Qamanirjuac and Lorillard caribou herds were obtained from the Nunavut Department of Environment (DoE) (Nagy et al. 2011).

6.6.2.1.2 Incidental Wildlife Observations

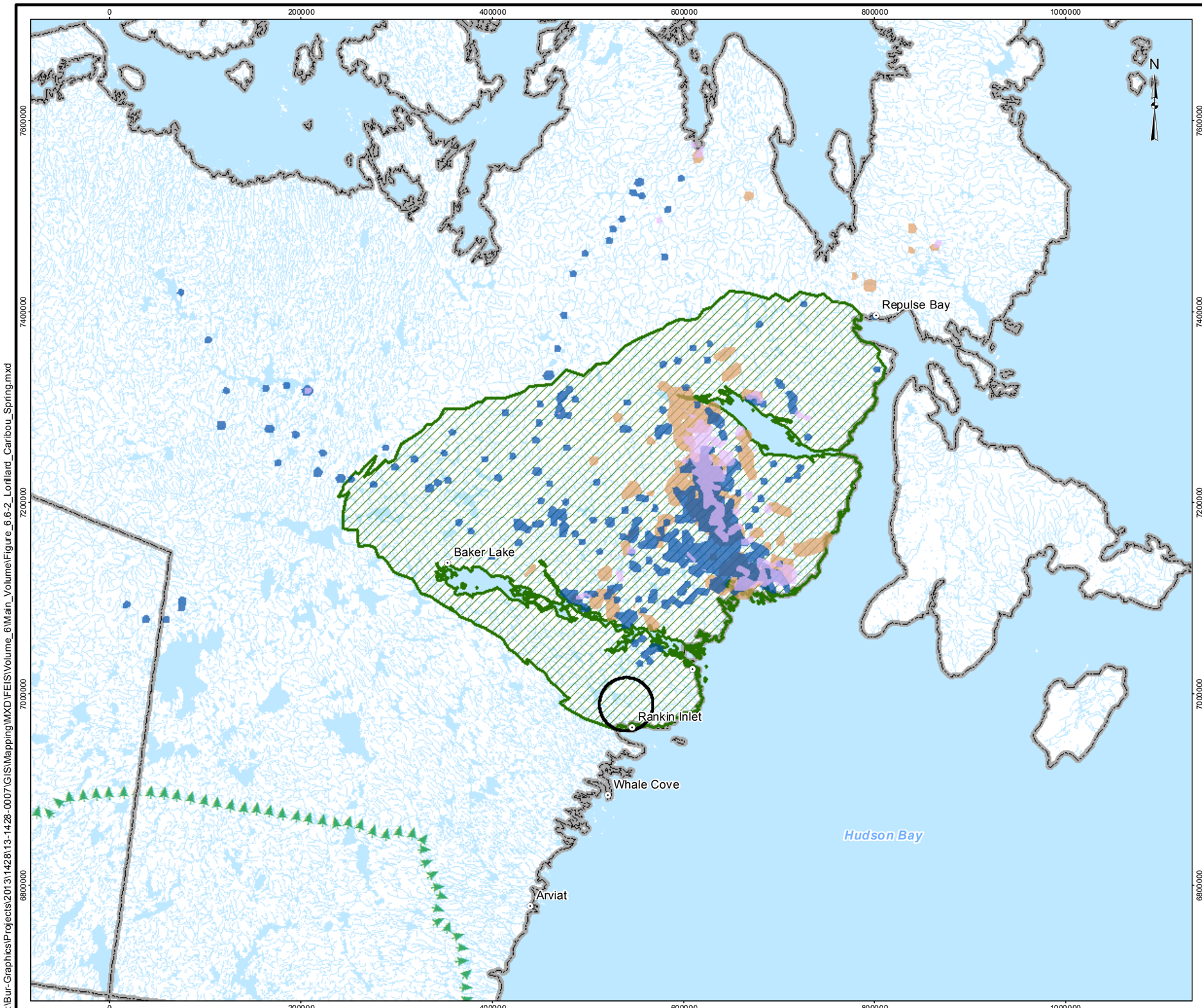
The objective of incidental observations was to document wildlife occurrence within the RSA. Incidental wildlife observations were recorded during all Golder visits to the Project area. During all aerial and ground surveys, observations of non-target species were recorded including global positioning system (GPS) coordinates, number of individuals, habitat use and group composition, if applicable.

Between 1998 and 2000, Western Mining Corporation International Ltd. environmental staff and Project staff completed a wildlife sightings log, which provided additional incidental wildlife data. In 2008 and 2009, personal communications of wildlife observations by Project staff (non-biologists) were recorded and then compiled by Golder personnel. Sightings logs were completed in 2011 and 2012, and incidental observations were recorded during Golder site visits in 2012.

6.6.2.2 Barren-ground Caribou

6.6.2.2.1 Population Status and Distribution

Annual home ranges mapped by Nunavut DoE show that the Project may lie within the annual home ranges of the Lorillard and Qamanirjuaq Caribou Herds (GN 2011; Campbell et al. 2012; Figures 6.6-2 to 6.6-5). However, the Lorillard caribou are non-migratory and generally distributed north of Chesterfield Inlet, based on radio-telemetry data collected by the DoE and the location of their historical calving grounds (Campbell et al. 2012; Figure 6.6-2). The likelihood of animals of this herd occurring in the RSA is very low. Baseline survey data documenting the distribution of barren-ground caribou during early winter, spring migration and calving, and post-calving through fall migration and rut periods suggest that the RSA is within the seasonal range of the Qamanirjuaq (Kaminuriak) barren-ground caribou herd (Jalkotzy 1999, 2000a, 2000b; SD 6-2 2009 Terrestrial Synthesis Report) (Figure 6.6-4 and 6.6-5).



LEGEND

- Development - Point
- Regional Study Area (RSA)
- Lorillard Annual Home Range
- Spring Migration Home Range
- Calving Home Range
- Post-Calving Home Range
- Provincial/Territorial Boundary
- Treeline
- Watercourse
- Waterbody

REFERENCE

Caribou home range shapefiles obtained from the Department of Environment (Government of Nunavut) and Caslys Consulting Ltd. Base data obtained from ESRI and Natural Resources Canada.
Datum: NAD 83 Projection: UTM Zone 15

80 0 80
KILOMETRES

PROJECT
AGNICO EAGLE
AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE
LORILLARD CARIBOU SPRING MIGRATION, CALVING AND POST-CALVING HOME RANGES (AS DEFINED BY THE GOVERNMENT OF NUNAVUT)

Golder Associates

PROJECT NO. 10-1373-0076			FILE No.	
DESIGN	CS	13 Sep. 2011	SCALE AS SHOWN	REV. 0
GIS	CDB	13 Sep. 2011		
CHECK	CS	16 Sep. 2011	**FIGURE 6.6-2**	
REVIEW	GRA	20 Sep. 2011		

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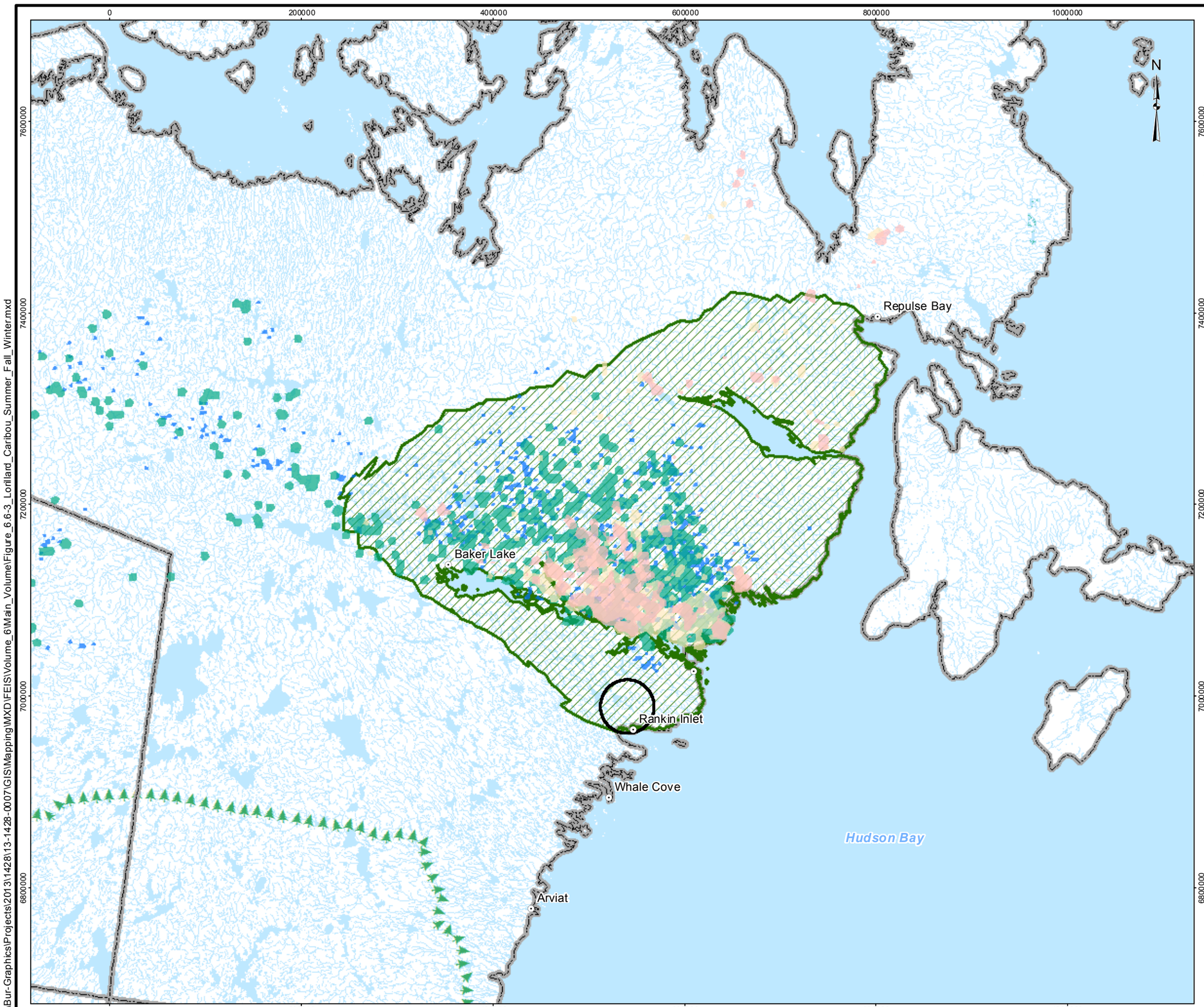

LEGEND

- Community
- Regional Study Area (RSA)
- Lorillard Annual Home Range
- Summer Home Range
- Late Winter Home Range
- Early Winter Home Range
- Fall Home Range
- Provincial/Territorial Boundary
- Treeline
- Watercourse
- Waterbody

REFERENCE

Caribou home range shapefiles obtained from the Department of Environment (Government of Nunavut) and Caslys Consulting Ltd. Base data obtained from ESRI and Natural Resources Canada.
Datum: NAD 83 Projection: UTM Zone 15

80 0 80
KILOMETRES

PROJECT
AGNICO EAGLE
AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE
LORILLARD CARIBOU SUMMER, FALL, AND EARLY/LATE WINTER HOME RANGES (AS DEFINED BY THE GOVERNMENT OF NUNAVUT)

Golder Associates

PROJECT NO. 10-1373-0076			FILE No.	
DESIGN	CS	13 Sep. 2011	SCALE AS SHOWN	REV. 0
GIS	CDB	13 Sep. 2011		
CHECK	CS	16 Sep. 2011		
REVIEW	GRA	20 Sep. 2011		

FIGURE 6.6-3

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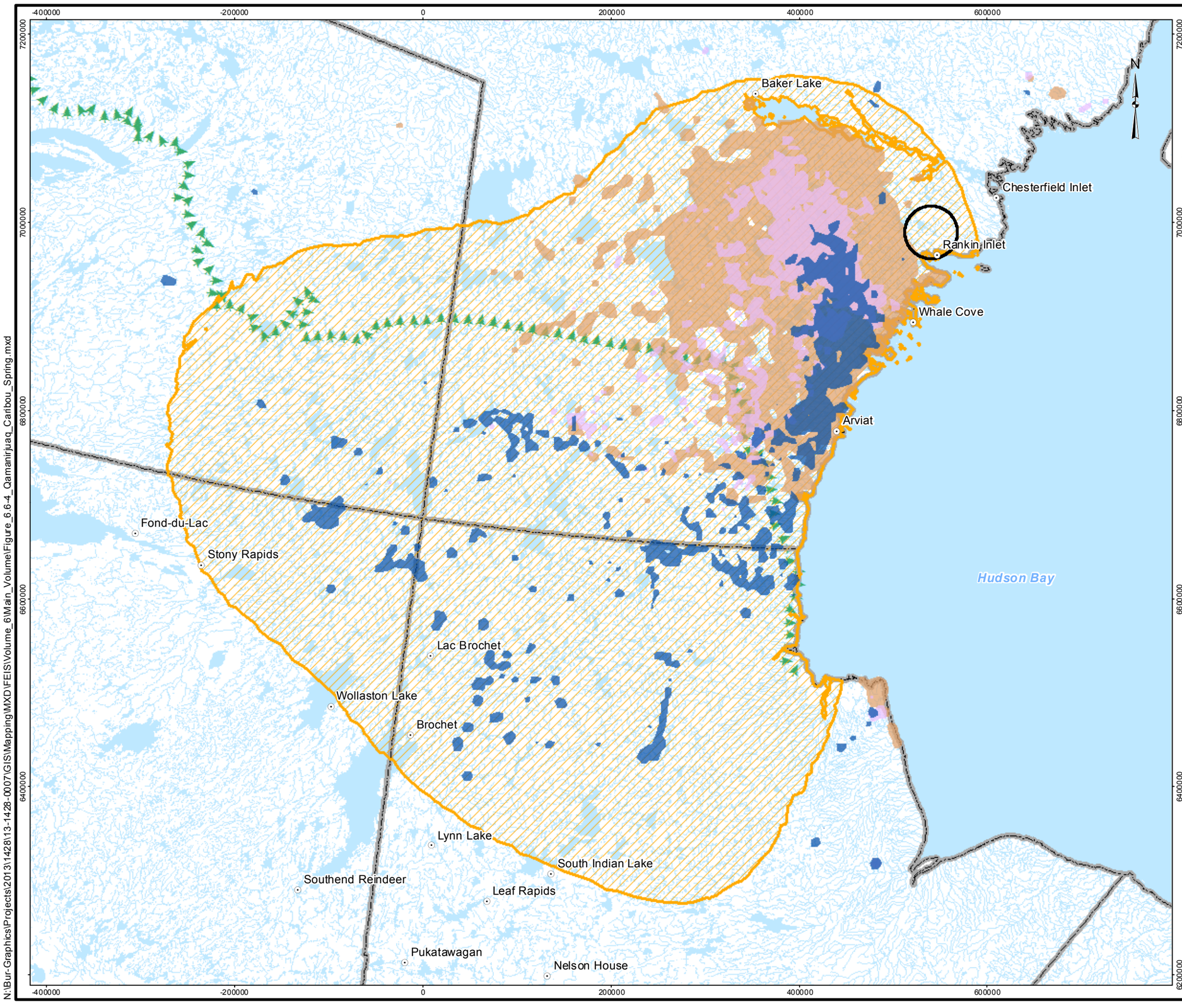

LEGEND

- Community
- Regional Study Area (RSA)
- Qamanirjuaq Annual Home Range
- Post-Calving Home Range
- Calving Home Range
- Spring Migration Home Range
- Provincial/Territorial Boundary
- Treeline
- Watercourse
- Waterbody

REFERENCE

Caribou home range shapefiles obtained from the Department of Environment (Government of Nunavut) and Caslys Consulting Ltd. Base data obtained from ESRI and Natural Resources Canada.
Datum: NAD 83 Projection: UTM Zone 15

80 0 80
KILOMETRES

PROJECT
AGNICO EAGLE
AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE
QAMANIRJUAQ CARIBOU SPRING MIGRATION, CALVING AND POST-CALVING HOME RANGES (AS DEFINED BY THE GOVERNMENT OF NUNAVUT)

Golder Associates

PROJECT NO. 10-1373-0076			FILE No.	
DESIGN	CS	13 Sep. 2011	SCALE AS SHOWN	REV. 0
GIS	CDB	13 Sep. 2011		
CHECK	CS	16 Sep. 2011		
REVIEW	GRA	20 Sep. 2011		

FIGURE 6.6-4

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-400000 -200000 0 200000 400000 600000

7200000 7000000 6800000 6600000 6400000 6200000

Baker Lake
Chesterfield Inlet
Rankin Inlet
Whale Cove
Arviat
Fond-du-Lac
Stony Rapids
Lac Brochet
Wollaston Lake
Brochet
Lynn Lake
South Indian Lake
Southend Reindeer
Leaf Rapids
Pukatawagan
Nelson House
Hudson Bay

N

LEGEND

- Development - Point
- Regional Study Area (RSA)
- Qamanirjuaq Annual Home Range
- Summer Home Range
- Fall Home Range
- Early Winter Home Range
- Late Winter Home Range
- Provincial/Territorial Boundary
- Treeline
- Watercourse
- Waterbody

REFERENCE

Caribou home range shapefiles obtained from the Department of Environment (Government of Nunavut) and Caslys Consulting Ltd. Base data obtained from ESRI and Natural Resources Canada.
Datum: NAD 83 Projection: UTM Zone 15

80 0 80
KILOMETRES

PROJECT
AGNICO EAGLE
AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE
QAMANIRJUAQ CARIBOU SUMMER, FALL, AND EARLY/LATE WINTER HOME RANGES (AS DEFINED BY THE GOVERNMENT OF NUNAVUT)

Golder Associates

PROJECT NO. 10-1373-0076			FILE No.	
DESIGN	CS	13 Sep. 2011	SCALE AS SHOWN	REV. 0
GIS	CDB	13 Sep. 2011		
CHECK	CS	16 Sep. 2011		
REVIEW	GRA	20 Sep. 2011		

FIGURE 6.6-5

N:\Bur-Graphics\Projects\2013\1428\13-1428-0007\GIS\Mapping\MXD\FEIS\Volume_6\Main_Volume\Figure_6.6-5_Qamanirjuaq_Caribou_Summer_Fall_Winter.mxd

The annual range of the Qamanirjuaq herd occupies an area from northern Manitoba and Saskatchewan in the south, to southwestern NU and southeastern NT (BQCMB 1999; Campbell et al. 2012; Figure 6.6-4, 6.6-5). Barren-ground caribou are migratory, and movements and range use varies annually (Wakelyn 1999). The annual distribution and life history of this population has been previously documented (Banfield 1954; Kelsall 1968; Thomas 1969; Parker 1972; Heard 1983). A portion of the Qamanirjuaq herd may pass through the RSA in summer but in some years they may linger from late October through March (Hubert and Associates 2007). Thus, impacts to the Qamanirjuaq herd due to the Project have the potential for transboundary effects.

Migration of the Qamanirjuaq herd from the southern winter range to the calving grounds occurs mid-March to late May (BQCMB 1999). Arviat hunters noted that habitat near Whale Cove and Rankin Inlet provides caribou wintering grounds (Kendrick and Manseau 2008).The traditional calving grounds of the Qamanirjuaq herd are located west of the RSA, and south of Baker Lake (BQCMB 2008; Figure 6.6-4). Specific calving areas can vary from year to year; however, the traditional calving grounds have historically remained in the same general location (BQCMB 2008). After calving in early June, barren-ground caribou form post-calving aggregations. It is during this time, the post-calving period, when the herd may interact with the proposed Project (Campbell et al. 2012; Figure 6.6-4).

The Project does not occur within Caribou Protected Areas as indicated in BQCMB (2004). These areas were designated according to the traditional calving grounds for the Beverly and Qamanirjuaq caribou herds. However, mobile caribou protection measures, as designated by BQCMB (2004), would apply to the Project. The herds occupy the calving ground and post-calving areas until the end of July when a rapid summer migration to the treeline occurs. The timing of the fall migration south of the treeline occurs from October to December (BQCMB 2008) (Figure 6.6-5). Aboriginal elders from Arviat have observed that the caribou now migrate from the northwest towards Arviat whereas historical movements were from the southeast (Kendrick and Manseau 2008). Elders of Rankin Inlet have noted that caribou populations have decreased due to changes in migration resulting from previous mine development (North Rankin Nickel Mine) and settlement (Volume 9 Section 9.3.1.4.2.1).

In total, 195 groups of barren-ground caribou were observed during 16 aerial surveys, comprising a total of 10 254 individual animals (Table 6.6-5. Less than 20 caribou were observed during at least 8 of the aerial surveys. The mean density of barren-ground caribou observed across aerial surveys was estimated to range from 0 to 13 caribou per square kilometre (km^2). The highest density was observed during the spring migration/calving survey in 2000 (32.34 caribou/1000 ha) (Table 6.6-5). Although large numbers were observed during the post-calving survey in 2009 (5920 caribou, July 2008), the study area was much larger, reducing the calculated mean density of barren-ground caribou (Table 6.6-5). It is highly likely that the observed caribou were of the Qamanirjuaq herd based on government deployed collars that monitor movements of barren-ground caribou in the region.

Barren-ground caribou were most frequently observed in heath tundra, but were also observed in esker habitat during baseline surveys. Barren-ground caribou of the Bathurst herd were found to select lichen heath and moist shrub vegetation on calving grounds, while Johnson et al. (2005) found them to select lichen veneer and low shrub habitat types.

Table 6.6-5: Barren-ground Caribou Aerial Survey Observations, 1998 to 2000, 2008, and 2009

Period	Month	Year									
		1998		1999		2000		2008		2009	
		# Caribou Observed	Density (caribou/ 1000 ha)	# Caribou Observed	Density (caribou/ 1000 ha)	# Caribou Observed	Density (caribou/ 1000 ha)	# Caribou Observed	Density (caribou/ 1000 ha)	# Caribou Observed	Density (caribou/ 1000 ha)
Late winter	March	-	-	0	-	3926	32.34	-	-	-	-
Spring migration/calving	April	-	-	0	-	-	-	-	-	-	-
	May	19	0.16	-	-	-	-	-	-	4	<0.01
Calving/post-calving	June	15	0.12	3	0.02	-	-	36	0.04	-	-
								81	0.10		
Post-calving	July	4	0.03	162	1.33	-	-	5920	6.97	-	-
Late Summer	August	-	-	-	-	-	-	-	-	-	-
Late summer through fall migration and rut	September	0	-	11	0.09	-	-	-	-	-	-
	October	0	-	-	-	-	-	-	-	-	-
Early winter	November	-	-	-	-	73	0.60	-	-	-	-

Note: "-" indicates no survey was conducted

Based on a NU government population survey in 2008, the Qamanirjuaq herd numbers an estimated 348 661, possibly down by about one-third from the previous estimated herd size of 496 000 in 1994 (BQCMB 2011; Campbell et al 2010). This decline is consistent with trends recently observed for other barren-ground caribou herds. Changes in caribou health have been observed by local communities and increases in undernourished and diseased caribou have also been observed (Areva 2011; GN 2005).

Hunters from communities in NU, the NT, northern Manitoba, and Saskatchewan harvest from this herd. The BQCMB has estimated that up to 14 000 caribou may be harvested from the Qamanirjuaq herd on an annual basis. The total net economic value of this harvest is estimated at $15 million (BQCMB 2011). Wildlife harvest statistics for Rankin Inlet indicate that 411 to 1,615 caribou are harvested annually from the area (NWMB 2004) (Table 6.6-6). This does not include non-traditional harvest from resident or sport hunters. Resident hunters may harvest up to 5 caribou per year, between 15 August and 30 April. Caribou are harvested more than any other mammal in the region, followed by Arctic fox and wolf.

Table 6.6-6: Wildlife (Traditional) Harvest Estimates for Rankin Inlet from June 1996 to May 2001

Species	96/97	97/98	98/99	99/00	00/01	5-yr Mean
Caribou	1615	724	982	1128	411	989
Muskox	3	1	6	0	0	2
Polar bear	12	11	13	10	1	9
Wolf	27	17	84	41	0	34
Arctic fox	171	39	33	3	0	49
Wolverine	1	0	5	4	0	2
Arctic hare	11	2	0	0	0	3

Source: NWMB (2004).

The links between demographic variables (e.g., adult and calf survival), environmental factors (e.g., food quality and quantity, insects, hunting, and development), and population growth are not well understood for barren-ground caribou. Although direct losses of habitat (e.g., total mining footprint) are small, and likely have marginal influences on the carrying capacity of the landscape (Johnson et al. 2005), industrial development has the potential to disrupt movements and reduce availability of high-quality habitat (Festa-Bianchet et al. 2011). For example, Johnson et al. (2005) showed that Bathurst caribou avoided areas of industrial development, particularly during post-calving movements. Boulanger et al. (2012) suggested that dust deposition may be the mechanism leading to a 14 km zone of influence (avoidance) detected around mine activities, and there has been some evidence that noise can displace caribou as well (Harrington and Veitch 1991). Other studies have suggested that caribou can adjust their behaviour (e.g., by feeding more in non-disturbed areas) to accommodate some disturbance (e.g., Colman et al. 2001). During the 2013 Pre-Hearing conference in Rankin Inlet, members of the Rankin Inlet community noted that caribou have become desensitized to noise disturbance. IQ

6.6.2.3 Gray Wolf

6.6.2.3.1 Population Status and Distribution

The gray wolf commonly occurs throughout much of NU. In the Kivalliq region, wolves likely migrate with the caribou herds, as do the wolves of the central NT (see Walton et al. 2001). Wolves and caribou have been

observed together west of South Henik Lake (Kendrick and Manseau 2008). Heard and Williams (1992) documented the location of wolf dens in the Kivalliq region, and noted that wolves of the central Canadian barren-grounds generally den near the treeline, where they are able to intercept caribou returning from calving grounds in the fall, and when the nutritional demands of the pups are at their greatest. During the denning season, wolves in the NT and Eastern NU also select esker habitats types where substrate is conducive to denning excavation (Johnson et al. 2005).

In NU, the status of the wolf is secure (CESCC 2001), but the national status is not at-risk (COSEWIC 2012). The density of wolves in the central Canadian Arctic was estimated at approximately 1 per 100 km^2 but can fluctuate to 1 per 200 km^2 depending on the status of the barren-ground caribou population (Mattson et al. 2009). Elders of Whale Cove suggest that wolf populations are increasing (Volume 9, Section 9.3.1.4.2.2); however, wolves are infrequently observed around the LSA, and surveys specific to wolves have not been undertaken in the region. One incidental observation of 3 wolves was made during baseline work in 2008.

In the Kivalliq, the wolf hunting season for resident hunters spans from 1 September to 15 May. The 5-year mean harvest of wolf from Rankin Inlet was 34, ranging from none to 84 between 1996/1997 and 2000/2001 (NWMB 2004; Table 6.6-6). Elders in Rankin Inlet suggest that wolves, wolverines and other carnivores were not displaced by mining in the past, and remained in the region even while mining was taking place (FEIS Volume 9, Section 9.3). However, Johnson et al. (2005) found wolves did avoid major developments. IQ

6.6.2.4 Polar Bear

6.6.2.4.1 Population Status and Distribution

Polar bears are a circumpolar species, but 55 to 65% of the global population is in Canada, distributed among 13 subpopulations, totalling about 15 500 individuals (GN 2011). The polar bear is also an icon of Canada's wildlife heritage and is of important cultural significance to Inuit. The polar bear was last assessed by COSEWIC in 2008, and the status of "Special Concern" was affirmed despite disagreement by the NU government. Polar bear are listed on Schedule 1 under the federal *Species at Risk Act*, and they are considered "Vulnerable" in the Red List of the Species Survival Commission of The World Conservation Union (SARA 2013; Schliebe et al. 2008). Also, polar bear are on Appendix II of Convention on International Trade in Endangered Species, meaning that any international shipment of polar bears or parts requires a permit (COSEWIC 2008).

Rankin Inlet lies within the range of the Western Hudson Bay subpopulation of polar bear. The number of polar bears in Western Hudson Bay has declined from 1194 (95% CI = 1020–1368) to 935 (95% CI = 794, 1076) between 1987 and 2004, a reduction of approximately 22% (Regehr et al. 2007, cited in COSEWIC 2008). Concurrently, but contrary to the scientific re-assessment of abundance, Inuit along the western coast of Hudson Bay reported seeing greater numbers of polar bears, which they interpreted as evidence of an increasing population (COSEWIC 2008; GN 2011). As a result, NU increased its polar bear quota in Western Hudson Bay by 9 bears in 2004 (GN 2012). However, scientific evidence later suggested the subpopulation was declining at a substantial rate (COSEWIC 2008), and so, in 2007, the GN reduced the quota for the western Hudson Bay population from 56 to 38 (GN 2012). The following year, it was reduced to 8. In 2011 the quota was raised once again, up to 21, due to community and Inuit knowledge suggesting the population was not declining (Kotierk 2012). Recent surveys conducted across the entire range, to develop a point estimate of abundance IQ

suggest the population is not declining compared to previous values, though poor reproductive output was noted (Atkinson et al. 2012).

Polar bear hunting in NU is largely managed through quota systems and according to Aboriginal treaty rights. Internationally, the management of polar bears is coordinated under the Agreement on the Conservation of Polar Bears, signed by the federal government on behalf of all Canadian jurisdictions in November 1973. Under this agreement, Aboriginal peoples have the exclusive right to harvest polar bear for subsistence. Quotas are allocated exclusively to Aboriginal peoples who may choose to fill part of their quota by offering a guided hunt. However, guided hunts and all other human-caused polar bear mortalities (including problem bears and illegal kills) are considered to be part of the quota (GN 2011).

Polar bears were recorded in the wildlife log of the Meliadine Lake camp on 2 occasions between 1998 and 1999, and again in 2000. In December 1998, a female and a single cub were seen travelling north along Meliadine Lake. In August 1999, a single polar bear was seen 18 km north and east of WMC's camp (Arc Wildlife Services 2000). Additional sightings in the region have included a lone female in June 2007, a female and young in July 2008, a female and 2 young in July 2012, and a female and young in July 2012 (S. Hartman, Kivalliq Inuit Association, 2012, pers. comm.). Finally, three bears were detected along the coast of Rankin Inlet during recent GN aerial surveys (Figure 6.6-6).

The polar bear is uncommon to the area. From early winter until break-up of annual sea ice in spring, polar bears are dispersed predominantly over sea ice along the coast. They may range >200 km offshore. Maternal denning sites are generally located on land near the coast and are excavated in snowdrifts and in some places frozen ground (COSEWIC 2008). The length and frequency of seasonal movements undertaken by bears within each subpopulation varies with the size of the geographic area occupied, and the annual pattern of freezing and break-up of sea ice (COSEWIC 2008). During colder months of the year, the physical attributes of sea ice are the primary determinants of the quality of polar bear habitat (COSEWIC 2008). Aboriginal people have also noted that polar bear are affected by ice movement and changes to the timing of ice break up (Areva 2011). However, during the ice-free season, the polar bear is a habitat generalist on land (Stirling et al. 2004).

The main limiting factors affecting polar bear distribution and numbers today are availability of food (access to, and abundance of, ice-dependent seals) and human-caused mortality (almost exclusively from hunting). Industrial developments in remote northern landscapes also pose a threat where large carnivores, such as polar bear, can habituate to human activity and develop a dependency on improperly stored food waste and garbage. The attraction to such waste can lead to the removal or euthanization of animals as a measure to avoid human injury and property damage (e.g., Jonkel 1970; CWS 2007; COSEWIC 2008). However, global climate change may pose a more substantial threat to polar bears. There was consensus at the National Roundtable on Polar Bears in 2009 that climate change poses the biggest threat to polar bear persistence. Polar bears rely almost entirely on the marine sea ice environment for their survival, so large-scale changes in the marine sea ice environment will impact the population (Derocher et al. 2004). The polar bear is closely linked to the physical attributes of sea ice (type and distribution) and the density and distribution of ice-dependent seals (mainly ringed seals; *Pusa hispida*). This specialized trait combined with low reproductive rates and naturally occurring low densities precludes the population to declines when there are subtle changes to the environment. Potential impacts from terrestrial Project components to polar bear abundance and distribution are assessed in Section 6.6. Potential impacts from marine components are assessed in FEIS Volume 8, Section 8.2 and 8.3.

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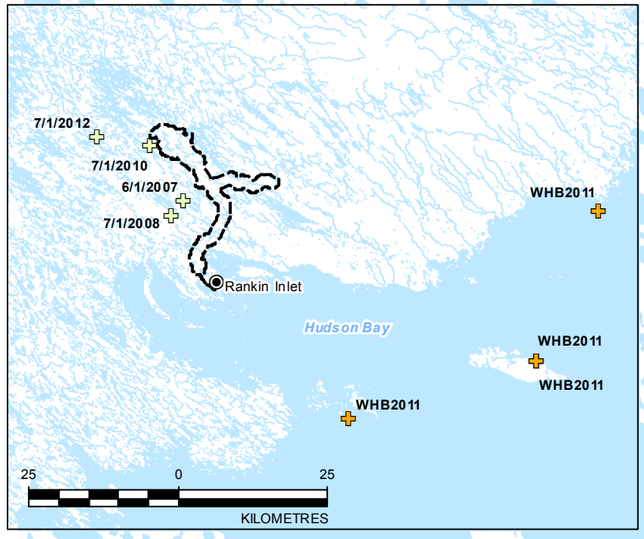
7/1/2012
7/1/2010
6/1/2007
7/1/2008

Tiriganiaq Pit
Wesmeg Pit
Pump Pit
F-Zone Pits
Discovery Pit

Parallel Lake
Meliadine Lake
Little Meliadine Lake (LML)
Meliadine River
Hudson Bay
Rankin Inlet



LEGEND

- Polar Bear Sighting
- Polar Bear Sighting Western Hudson Bay Polar Bear Aerial Survey (Provided by the Government of Nunavut)
- Local Study Area (LSA)
- Municipal Boundary
- Proposed Project Infrastructure
- All-weather Access Road (AWAR)
- Road - New
- Road - Existing
- Watercourse
- Waterbody

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).
Wildlife data obtained from field survey, and the Government of Nunavut through AEM.
Datum: NAD 83 Projection: UTM Zone 15

2.5 0 2.5
KILOMETRES

PROJECT
AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE
POLAR BEAR SIGHTINGS NEAR THE PROPOSED MELIADINE GOLD MINE PROJECT

Golder Associates

PROJECT NO.	10-1373-0076		FILE No.	
DESIGN	KD	02 Oct. 2012	SCALE AS SHOWN	REV. 0
GIS	JW	26 Oct. 2012		
CHECK	KD	18 Dec. 2012		
REVIEW	GRA	18 Dec. 2012		

FIGURE 6.6-6

N:\Bur-Graphics\Projects\2013\1428\13-1428-0007\GIS\Mapping\MXD\IFEIS\Volume_6\Main_Volume\Figure_6.6-6_Polar_Bear_Sightings.mxd

6.6.2.5 Biodiversity and Food Chain Relationships

Wildlife species recorded during summer surveys in the RSA included Arctic fox, Arctic hare (*Lepus arcticus*), barren-ground caribou, gray wolf, muskox, and ermine (*Mustela ermine*), as well as signs of lemmings (*Lemmus* or *Discrostonyx* species) (Table 6.6-7). All incidental data are presented in Appendix B8 in the 2009 Terrestrial Synthesis Report (SD 6-2). Wildlife species in the Project region include herbivores (small mammals, Arctic hare, muskox, and caribou), predators (ermine, wolf, and bears), and scavengers (Arctic fox and wolverine).

Table 6.6-7: Incidental Observations of Wildlife Species, 1998 to 2000, 2008 to 2012

Year	Barren-ground Caribou	Polar Bear	Gray Wolf	Arctic Fox	Muskox	Ermine	Arctic Hare
1998	19	2	0	Present	0	0	Present
1999	~6000	1	0	Present	0	0	Present
2000	~370	1	0	Present	0	1	Present
2008	~2000	0	3	Present	1	0	Present
2009	9	0	0	Present	26	0	Present
2011	89	0	4	present	0	1	uk
2012	~5000	uk	uk	Present	uk	uk	uk

Notes: "~" indicates approximately, and are estimates made by non-biologists; "Present" indicates multiple sightings, common in study area; "uk" indicates unknown

Small mammals primarily feed on vegetation; however Arctic ground squirrels have also been recorded to prey on collared lemmings (Boonstra et al. 1990, Burt and Grossenheider 1980). Lemmings are also a key food source for ermine and Arctic fox, whose populations may cycle in synchrony with lemming populations (Boonstra et al. 1990).

The main diet for barren-ground caribou is lichen; however, they also forage on sedges, willows, and other plant species that are available (Larter and Nagy 1997). Muskox also feed on grasses, sedges, lichen, and leaves; however, their preferred species tend to be in wet lowland habitat types, while caribou prefer more upland sites, reducing likelihood of forage competition (Larter and Nagy 1997).

Wolves are the main predator of caribou and muskoxen, in addition to eating Arctic hare and small mammals (Krizan 2005). Grizzly bear diet is also predominantly caribou, supplemented in the summer by vegetation and berries. Small mammals, such as lemmings, red-backed voles, and Arctic ground squirrels, as well as muskox, ringed seal and young polar bear have also been detected in scats of northern grizzly bears (Gau et al. 2002). While on land, polar bear diet may be similar to grizzly's, predating small mammals, ungulates, birds and their eggs, grasses, mosses and sedges, and human garbage.

Wolverines, and to some extent Arctic foxes, depend on carrion left by larger predators and follow the movements of the caribou herds to scavenge wolf kills (Macpherson 1969, Mulders 2000). Arctic fox may also scavenge carrion left on sea ice from polar bears, whose main prey item is seal (Macpherson 1969).

6.6.3 Pathway Analysis

Pathway analysis identifies and assesses the linkages between Project components or activities, and the correspondent potential residual effects to terrestrial wildlife and wildlife habitat. The first part of the analysis is to produce a list of all potential effects pathways for the Project (FEIS Volume 4, Section 4.3; Table 6.6-8). Each pathway is initially considered to have a linkage to potential effects on terrestrial wildlife and wildlife habitat. This step is followed by the development of environmental design features and mitigation that can be incorporated into the development description to remove a pathway or limit (mitigate) the effects to terrestrial wildlife and wildlife habitat. Environmental design features include Project design elements, environmental best practices, management policies and procedures, and social programs. Environmental design features are developed through an iterative process between the Project's engineering and environmental teams to avoid or mitigate effects.

Pathway analysis is a screening step that is used to determine the existence and magnitude of linkages from the initial list of potential effects pathways for the Project. This screening step is intended to focus the effects analysis on pathways that require a more comprehensive assessment of effects on terrestrial wildlife and wildlife habitat. Pathways are determined to be primary, minor, or as having no linkage using scientific and traditional knowledge, logic, and experience with similar developments and environmental design features. Each potential pathway is assessed and described as follows:

- no linkage – pathway is removed by environmental design features and mitigation so that the Project results in no detectable environmental change and residual effects to terrestrial wildlife and wildlife habitat relative to baseline or guideline values;
- minor – pathway could result in a minor environmental change, but would have a negligible residual effect on terrestrial wildlife and wildlife habitat relative to baseline or guideline values; or
- primary – pathway is likely to result in a measurable environmental change that could contribute to residual effects on terrestrial wildlife and wildlife habitat relative to baseline or guideline values.

Primary pathways require further effects analysis to determine the environmental significance from the Project on terrestrial wildlife and wildlife habitat. Pathways determined to have no linkage to terrestrial wildlife and wildlife habitat, or those that are considered minor, are not predicted to result in environmentally significant effects on terrestrial wildlife and wildlife habitat. No linkage and minor pathways are summarized but not carried through the effects assessment.

Potential pathways through which the Project could affect terrestrial wildlife and wildlife habitat are presented in Table 6.6-8. Environmental design features and mitigation incorporated into the design of the Project to remove a pathway or limit the effects to terrestrial wildlife and wildlife habitat are listed, and pathways are determined to be primary, minor, or as having no linkage. The following section discusses the potential pathways relevant to terrestrial wildlife and wildlife habitat.

Phase 1 of the AWAR was previously assessed under a separate impact assessment (Golder 2011d), and is currently being constructed under a Type B Water License 2BW-MEL1215 issued by the NU Water Board in March 2012 granted under an exception determination by NIRB under Section 12.10.2 (b) of the Nunavut Land Claims Agreement. The Phase 1 AWAR and Project (including Phase 2 AWAR) are considered separate for the pathways analysis and effects assessment; however, the combined AWAR footprint (i.e., Phase 1 and Phase 2) was assessed so as to include the maximum disturbance within the study areas.

Table 6.6-8: Potential Pathways for Effects to the Abundance and Distribution of Terrestrial Wildlife and Wildlife Habitat

Project Activity	Valued Component	Effects Pathways	Environmental Design Features and Mitigation	Pathway Analysis/Section for Further Discussion
Mine infrastructure footprint (e.g., open pit, site roads) Project Access Road Rankin Inlet Infrastructure	Caribou Wolf	Direct loss and fragmentation of wildlife habitat from the Project footprint	Compact plant arrangement is designed to reduce the overall project footprint. Design roads as narrow as possible, while maintaining safe construction and operation practices, and meeting legislated requirements. For example, minimum haul road widths are defined under the *Mine Health and Safety Act, SNWT (Nu)*.	Primary/Section 6.6.4.1 and 6.6.5.1
Mine infrastructure footprint (e.g., open pit, site roads) Project Access Road, Rankin Inlet Infrastructure	Polar Bear	Direct loss and fragmentation of terrestrial wildlife habitat	Compact plant arrangement is designed to reduce the overall project footprint Design roads as narrow as possible, while maintaining safe construction and operation practices, and meeting legislated requirements. For example, minimum haul road widths are defined under the *Mine Health and Safety Act, SNWT (Nu)*.	Minor/Section 6.6.3.2
Water Management (dams, drainage, diversion, intake, discharge and dewatering)	Caribou Wolf Polar Bear	Cross-drainage structures for the mine site roads, AWAR, and Rankin Inlet bypass road may alter stream hydraulics and geomorphology, and can alter wildlife habitat	Cross-drainage structures will be designed and constructed such that structures will not create a hydraulic barrier and will convey peak flows corresponding to 1:25 year 24-hour rainfall event. Use of staggered culvert configuration, and removal of snow at the culvert inlet and outlet prior to the freshet to promote drainage during spring thaw and freshet. Regular inspection of the road to identify any areas where ponding of water along the road represents a risk, and installing additional culverts to alleviate the risk.	No linkage/Section 6.6.3.1
Water Management (dams, drainage, diversion, intake, discharge and dewatering)	Caribou Wolf Polar Bear	Dewatering of waterbodies, Project footprint, and diversion of water, may change downstream flows, water levels, and affect wildlife habitat.	Shoreline areas susceptible to extensive erosion will be addressed by appropriate erosion protection measures to reduce erosion and associated re-suspension of fine sediment. Develop and implement a Site Water Management Plan (SD 2-6) Discharge from dewatering of waterbodies will be sampled regularly to monitor for compliance with discharge criteria, and any water not meeting the criteria will be treated or stored within the controlled Attenuation Ponds until it meets criteria.	Minor/Section 6.6.3.2

Table 6.6-8: Potential Pathways for Effects to the Abundance and Distribution of Terrestrial Wildlife and Wildlife Habitat (continued)

Project Activity	Valued Component	Effects Pathways	Environmental Design Features and Mitigation	Pathway Analysis/Section for Further Discussion
Water Management (dams, drainage, diversion, intake, discharge and dewatering)	Caribou Wolf Polar Bear	Process and potable water requirements for the Project may decrease drainage flows and surface water levels, and affect wildlife habitat	Develop a Site Water Management Plan (SD 2-6). Contact water will be monitored and managed through the Attenuation Ponds Surface runoff and groundwater seeping into the open pits will be collected in in-pit sumps. The collected water will be used for dust control and as process water. Underground water will be re-cycled for re-use underground, where possible. Underground water with high salinity will be treated. Discharge quality will meet MMER at end of pipe and will meet CCME aquatic life standards within a 100 m radius mixing zone of the diffuser in Meliadine Lake. The rotary biological contactor sewage treatment plant for the camp facilities will be designed to meet the Nunavut effluent guidelines for wastewater discharge.	No Linkage/Section 6.6.3.1
General construction and operation of mine and supporting infrastructure	Caribou Wolf Polar Bear	Dust deposition may cover vegetation, change the amount of different quality habitats, and alter movement and avoidance behaviour of wildlife.	Dust will be actively suppressed from roads (water and/or other dust suppressants). Potential use of chemical dust suppressants in accordance with the Environmental Guidance for Dust Suppression published by the Government of Nunavut Department of Environment. Enforcing speed limits will assist in reducing dust. Road surfaces will be maintained through grading and the addition of granular material.	Minor/Section 6.6.3.2
General construction and operation of mine and supporting infrastructure	Caribou Wolf Polar Bear	Air emissions and deposition can cause changes to chemical properties of surface water, soils, vegetation, wetlands, and wildlife habitat	Equipment and vehicles will comply with relevant emission criteria at the time of purchase. Regular maintenance of equipment and vehicles to meet emission standards.	Minor/Section 6.6.3.2

Table 6.6-8: Potential Pathways for Effects to the Abundance and Distribution of Terrestrial Wildlife and Wildlife Habitat (continued)

Project Activity	Valued Component	Effects Pathways	Environmental Design Features and Mitigation	Pathway Analysis/Section for Further Discussion
General construction and operation of mine and supporting infrastructure	Caribou Wolf Polar Bear	Air emissions and deposition can cause changes to the amount of quality habitats through chemical changes to surface water quality, soils, affecting wildlife health	Equipment and vehicles will comply with relevant emission criteria at the time of purchase. Regular maintenance of equipment and vehicles to meet emission standards.	No Linkage/Section 6.6.3.1
General construction and operation of mine and supporting infrastructure	Caribou Wolf Polar Bear	Change in wildlife energetic costs from disturbance or displacement	Project design will use conventional insulation, baffles and noise suppressors on equipment. Stationary equipment will be housed inside buildings. Regular maintenance of equipment to limit noise. All employees will be provided with wildlife environmental awareness training.	Minor/Section 6.6.3.2
General construction and operation of mine and supporting infrastructure	Caribou Wolf	Sensory disturbance can change the amount of different quality habitats, and alter wildlife movement and behaviour (distribution)	All employees will be provided with wildlife environmental awareness training. Project design will use conventional insulation, baffles and noise suppressors on equipment. Stationary equipment will be housed inside buildings. Regular maintenance of equipment to limit noise.	Primary/Sections 6.6.4.2 and 6.6.5.2
General construction and operation of mine and supporting infrastructure	Polar Bear	Sensory disturbance can change the amount of different quality habitats, and alter polar bear movement and behaviour (distribution)	All employees will be provided with wildlife environmental awareness training. Project design will use conventional insulation, baffles and noise suppressors on equipment. Stationary equipment will be housed inside buildings. Regular maintenance of equipment to limit noise.	Minor/Section 6.6.3.2
General construction and operation of mine and supporting infrastructure	Caribou Wolf	Improved access for harvesting wildlife can affect wildlife population sizes	Develop and enforce “no hunting, trapping, harvesting or fishing policy” for employees and contractors. Access to the mine site will be controlled (gated); public vehicles (cars, trucks) allowed only with special authorization. Wildlife will be provided the right-of-way. Vehicle access will be limited when large numbers of caribou are crossing the road; this will occur in consultation with the local HTO.	Primary/Sections 6.6.4.3 and 6.6.5.3

Table 6.6-8: Potential Pathways for Effects to the Abundance and Distribution of Terrestrial Wildlife and Wildlife Habitat (continued)

Project Activity	Valued Component	Effects Pathways	Environmental Design Features and Mitigation	Pathway Analysis/Section for Further Discussion
			Upon consultation with the KIA and HTO, an appropriate 'no shooting zone' will be established along the road and around the mine site. All roads will be decommissioned and scarified during closure	
General construction and operation of mine and supporting infrastructure	Polar Bear	Improved access for harvesting polar bear can affect population sizes	Develop and enforce "no hunting, trapping, harvesting or fishing policy" for employees and contractors. Access to the mine site will be controlled (gated); public vehicles (cars, trucks) allowed only with special authorization. Wildlife will be provided the right-of-way. Vehicle access will be limited when large numbers of caribou are crossing the road; this will occur in consultation with the local HTO. Upon consultation with the KIA and HTO, an appropriate 'no shooting zone' will be established along the road and around the mine site. All roads will be decommissioned and scarified during closure	Minor/Section 6.6.3.2
General construction and operation of mine and supporting infrastructure	Caribou Wolf Polar Bear	Spills on the mine site or along the AWAR can affect surface water quality, soils, vegetation, and wildlife habitat	Equipment will be re-fueled, serviced, and washed away from stream crossings and on impermeable pads wherever possible. There will be a wash bay in the maintenance shop. Emergency response (SD 2-15) and spill contingency plans (SD 2-16) will be developed and implemented.	No Linkage/Section6.6.3.1
General construction and operation of mine and supporting infrastructure	Caribou Wolf Polar Bear	Spills on the mine site or along the AWAR can increase risk of mortality to individual animals, which can affect wildlife population sizes	Ready access to an emergency spill clean-up kit for cleaning up any spills. Hazardous materials and fuel will be stored according to regulatory requirements to protect the environment (i.e., SD 2-13 Hazardous Materials Management Plan). As necessary, individuals working on site and handling hazardous materials will be trained, notably in the Transportation of Dangerous Goods and Hazmat. A biopile will be constructed to treat soils contaminated by light hydrocarbons. Soils contaminated with heavy hydrocarbon oil spills will be excavated, placed into appropriate containers, transported for remediation at a certified hazardous material site, and disposed of appropriately.	No Linkage/Section 6.6.3.1

Table 6.6-8: Potential Pathways for Effects to the Abundance and Distribution of Terrestrial Wildlife and Wildlife Habitat (continued)

Project Activity	Valued Component	Effects Pathways	Environmental Design Features and Mitigation	Pathway Analysis/Section for Further Discussion
			Fuel storage tanks will be situated in a secondary containment area capable of containing 110% of the contents of the largest tank. The storage tanks and fuel-dispensing systems will be constructed in accordance with current regulatory requirements and National Fire Code. Fuel reconciliation will be conducted and structural integrity will be routinely inspected. Construction and mining equipment, machinery, and vehicles will be regularly maintained.	
General construction and operation of mine and supporting infrastructure	Caribou Wolf Polar Bear	Physical hazards on the mine site and collision with vehicles causing injury or mortality to individual animals, which can affect population sizes	Speed limits will be established. Access will be controlled when caribou are present at the mine site. The presence of wildlife will be monitored and communicated to site personnel. Littering and feeding of wildlife will be prohibited. No airstrip on-site. All employees will be provided with wildlife environmental awareness training. Removal of physical hazards will be part of the Mine Closure and Reclamation Plan (SD 2-17).	Minor/Section 6.6.3.2
General construction and operation of mine and supporting infrastructure	Caribou Wolf Polar Bear	Surface water runoff from the core mine facilities area can affect surface water quality, soil, vegetation, and wildlife habitat	Contact water will be managed on-site in accordance with the Site Water Management Plan (SD 2-6). Runoff and seepage from waste rock storage facilities will be collected in sumps located in low topographic points around the perimeter. This water will be monitored for water quality and if necessary transferred to the mine attenuation pond before discharge. Surface runoff and talik water seeping into the open pits will be collected in in-pit sumps. The collected water will be used for dust control and/or pumped to the tailings storage facility for use as process water. Natural construction materials will be tested before they are used to confirm that they are not potential acid draining or potential sources of metal leaching.	No Linkage/Section 6.6.3.1

Table 6.6-8: Potential Pathways for Effects to the Abundance and Distribution of Terrestrial Wildlife and Wildlife Habitat (continued)

Project Activity	Valued Component	Effects Pathways	Environmental Design Features and Mitigation	Pathway Analysis/Section for Further Discussion
General construction and operation of mine and supporting infrastructure	Wolf Polar Bear	Attraction to the Project or AWAR may increase human-carnivore interactions and removal of individual animals (e.g., relocation or mortality), which can affect wildlife population sizes	Most construction of the Project will be based out of Rankin Inlet or the Meliadine camp, eliminating the need for temporary camps along the AWAR route. Littering and feeding of wildlife will be prohibited. Education and reinforcement of proper waste management practices to all workers and visitors to the site. Education on the risk associated with feeding wildlife and careless disposal of food wastes and liquids such as coffee and juices. Ongoing review of the efficiency of the waste management program and improvement through adaptive management. Kitchen garbage and waste from dormitories and offices will be incinerated on a daily basis to limit attractions to wildlife. Skirt all buildings and stairs to the ground to limit opportunities for use as shelter. Development and implementation of a Landfill and Waste Management Plan (SD 2-11). Wastes associated with mechanical maintenance and repairs will be managed of per the Hazardous Materials Management Plan (SD 2-13). A Terrestrial Environment Management and Monitoring Plan (SD 6-4) will be developed and implemented. Wildlife will have the right-of-way.	Minor/Section 6.6.3.2
General construction and operation of mine and supporting infrastructure	Caribou	Attraction to the Project or AWAR may increase predator numbers and predation risk which can affect prey population sizes	All construction personnel for the Project will be based out of Rankin Inlet or the Meliadine camp eliminating the need for temporary camps along the AWAR route. Littering and feeding of wildlife will be prohibited. Education and reinforcement of proper waste management practices to all workers and visitors to the site.	Minor/Section 6.6.3.2

Table 6.6-8: Potential Pathways for Effects to the Abundance and Distribution of Terrestrial Wildlife and Wildlife Habitat (continued)

Project Activity	Valued Component	Effects Pathways	Environmental Design Features and Mitigation	Pathway Analysis/Section for Further Discussion
			Education on the risk associated with feeding wildlife and careless disposal of food wastes and liquids such as coffee and juices. Ongoing review of the efficiency of the waste management program and improvement through adaptive management. Kitchen garbage and waste from dormitories and offices will be incinerated on a daily basis to limit attractions to wildlife. Skirt all buildings and stairs to the ground to limit opportunities for use as shelter. Development and implementation of a Landfill and Waste Management Plan (SD 2-11). Wastes associated with mechanical maintenance and repairs will be disposed of per the Hazardous Materials Management Plan (SD 2-13). A Terrestrial Environment Management and Monitoring Plan (SD 6-4) will be developed and implemented. Wildlife will have the right-of-way.	
Operation of Mine and supporting infrastructure	Caribou	Disruption or alteration of migration routes from the presence of the mine or from mine-related activities	Compact layout of the surface facilities within local watersheds will limit the area that is disturbed by construction and operation. Project design will use conventional insulation, baffles and noise suppressors on equipment. Stationary equipment will be housed inside buildings. Regular maintenance of equipment to limit noise.	Primary/Sections 6.6.4.2 and 6.6.5.2
Operation of Mine and supporting infrastructure	Caribou Wolf Polar Bear	Uptake of metals by wildlife through ingestion of tailings and dust on surface water, soils and vegetation can affect health of individual animals, which can affect wildlife population sizes	Develop a Mine Waste Management Plan (SD 2-8) Any PAG or high metal leaching waste rock will be segregated at source and placed into designated areas within the waste rock storage facilities. If not suitable for construction, overburden will be stored with the waste rock storage facility.	No linkage/Section 6.6.3.1

Table 6.6-8: Potential Pathways for Effects to the Abundance and Distribution of Terrestrial Wildlife and Wildlife Habitat (continued)

Project Activity	Valued Component	Effects Pathways	Environmental Design Features and Mitigation	Pathway Analysis/Section for Further Discussion
			Tailings deposition will be designed to limit dust generation.	
Operation of Mine and supporting infrastructure	Caribou	Leaching of dissolved metals from waste rock may cause changes to groundwater and surface water quality and soils, which may affect vegetation and wildlife habitat	Design waste rock management procedures for potentially problematic waste rock material. Use of non-acid generating and non-metal leaching material at all watercourses. Any PAG or high metal leaching waste rock will be segregated at source and placed into designated areas within the waste rock storage facilities. PAG and high metal leaching waste rock will be encapsulated with non -PAG rock and low metal leaching rock. Over time potential PAG and high metal leaching rock will become permanently frozen beneath an active cover layer of non-PAG rock.	No linkage/Section 6.6.3.1
Operation of Mine and supporting infrastructure	Wolf	Vertical and lateral seepage from facilities may cause changes to groundwater and surface water quality and soils, which may affect vegetation and wildlife habitat	A biopile will be constructed to treat soils and rock contaminated by light hydrocarbons with any leachate captured in sumps. Landfill will not contain any putrescible organic matter so seepage is not expected.	No linkage/Section 6.6.3.1
Post-Closure	Caribou Wolf Polar Bear	Water quality following closure may affect wildlife health	Implement a Mine Closure and Reclamation Plan (SD 2-17) Sewage treatment plant will remain active during the first 2 years of decommissioning. Landfill will be located in a waste rock storage area covered with non- ARD and non-metal leaching waste rock material. PAG and high metal leaching potential waste rock will be stored in designated areas and will be encapsulated with non-PAG and low metal leaching potential waste rock. Hydraulic connections to the natural receiving environment will not be re-established until water quality monitoring demonstrates that the water meets water quality guidelines for direct release without further treatment.	No Linkage/Section 6.6.3.1

Table 6.6-8: Potential Pathways for Effects to the Abundance and Distribution of Terrestrial Wildlife and Wildlife Habitat (continued)

Project Activity	Valued Component	Effects Pathways	Environmental Design Features and Mitigation	Pathway Analysis/Section for Further Discussion
Post-Closure	Caribou Wolf	Permanent changes in wildlife habitat following closure of the mine site	Implement a Mine Closure and Reclamation Plan (SD 2-17) Hydraulic connections to the natural receiving environment will be re-established once water quality monitoring demonstrates that the water meets water quality guidelines for direct release without further treatment. Site infrastructure will be decommissioned and removed from site. All roads will be decommissioned and scarified.	Primary/Sections 6.6.4.1 and 6.6.5.1
Post-Closure	Polar Bear	Permanent changes in wildlife habitat following closure of the mine site	Implement a Mine Closure and Reclamation Plan (SD 2-17) Hydraulic connections to the natural receiving environment will be re-established once water quality monitoring demonstrates that the water meets water quality guidelines for direct release without further treatment. Site infrastructure will be decommissioned and removed from site. All roads will be decommissioned and scarified.	Minor/Section 6.6.3.2

6.6.3.1 Pathways with No Linkage

A pathway may have no linkage if the pathway is removed by environmental design features and mitigation so that the Project results in no detectable environmental change and residual effects to wildlife relative to baseline or guideline values. The pathways described in the following bullets have no linkage to wildlife and will not be carried through the effects assessment.

Changes to Habitat Quality, Movement, and Behaviour

- **Cross-drainage structures for the mine site roads, AWAR, and Rankin Inlet bypass road may alter stream hydraulics and geomorphology, and can alter wildlife habitat**

The installation of cross-drainage structures to prevent roads from impeding water flow can result in the loss and alteration of shoreline habitat. The loss of stream and shoreline habitat may be permanent; however, the amount of habitat altered is expected to be minimal. Cross-drainage structures will be designed to withstand a 1:25 year 24-hour precipitation event without overtopping the roadway, which will result in minor changes in stream velocity, and prevent channel aggradation, degradation, erosion, or changes to bankfull width or depth. The implementation of appropriate cross-drainage structures is expected to result in minor changes to stream flow velocity in the vicinity of the structures relative to baseline conditions and have negligible residual effects on water quantity and geomorphology. Thus, the effects on wildlife habitat from the potential alteration of stream hydraulics and geomorphology are expected to be negligible. Consequently, residual effects to the maintenance of wildlife populations and the continued opportunity for traditional and non-traditional use of wildlife from stream alteration are predicted to be negligible.

- **Process and potable water requirements during Project construction and operations from the Project may decrease drainage flows and surface water levels, and affect wildlife habitat**

The Project will withdraw freshwater from Meliadine Lake for potable water, underground operations and plant operations. Freshwater requirements are estimated at a maximum of approximately 1 130 000 m^3/y during construction and operations. Supply volumes are small in comparison to median monthly and annual outflow volumes at Meliadine Lake (FEIS Volume 7, Section 7.3). Water level changes due to freshwater requirements are expected to be negligible.

Water withdrawal from Meliadine Lake during construction and operations is expected to have minimal effect on wildlife habitat because the water level is not predicted to change and thus there will be negligible residual effects to the abundance and distribution of wildlife populations, and continued opportunity for traditional and non-traditional use of wildlife.

- **Spills on the mine site, mine site roads or along the AWAR can affect surface water quality, soils, vegetation, and wildlife habitat**

A Risk Management and Emergency Response Plan (SD 2-15), Spill Contingency Plan (SD 2-16), and Fuel Management Plan (part of SD 2-13) will be developed and implemented to minimize the likelihood of accidental spills, or if they do occur, to quickly respond and clean up any spills. AEM will not permit the deposit of chemicals, sediment, wastes, or fuels into any waterbody. During construction, equipment will be re-fueled, serviced, and washed away from stream crossings and on impermeable pads wherever possible. There will be a wash bay in the maintenance shop. Hazardous materials and fuel will be stored according to regulatory requirements to protect the environment and workers, and hazardous materials will be stored at the mine site in

a dedicated waste management building and handled according to the Hazardous Materials Management Plan (SD 2-13). As necessary, individuals working on the Project and handling hazardous materials will be trained, notably in the Transportation of Dangerous Goods. Emergency spill kits will be readily available. A biopile will be constructed to treat soils contaminated by light hydrocarbons, and soils contaminated with heavy hydrocarbon oil spills will be excavated, placed into appropriate containers, undergo remediation at a certified hazardous material site and disposed of appropriately. Construction and mining equipment, machinery, and vehicles will be regularly maintained.

Accidental spills (e.g., fuel) have occurred at AEM's Meadowbank Mine, but most of the spill volumes have been small, and clean-up has occurred with only minor effects to the environment (AEM 2011a). Out of 78 spills at Meadowbank since the start of construction, 73 were within the mine site boundary, and 5 were along the all weather access road outside of the mine boundary (AEM 2011b). There were 10 spills greater than 1000 litres (L), one of which was outside the mine boundary. Contaminated material from the larger spill outside the mine boundary was completely recovered (AEM 2011a). All of the spills inside and outside the mine boundary were contained and cleaned-up (AEM 2011b). In NIRB's 2011 annual report (NIRB 2011), it was noted that Meadowbank was kept in an impressively clean state with no apparent spills on location.

The implementation of the Risk Management and Emergency Response Plan (SD 2-15), and environmental design features, including proper equipment maintenance and driver training, are expected to reduce the frequency and severity of spills. It is acknowledged that accidental spills, including vehicular accidents, have the greatest potential to affect soils, vegetation, and wildlife habitat. However, in the event of a spill, contaminated materials will be either collected and treated on-site, or shipped off-site for treatment and disposal.

Consequently, this pathway was determined to have no linkage to effects on the abundance and distribution of wildlife populations, and continued opportunity for traditional and non-traditional use of wildlife.

- **Leaching of dissolved metals from waste rock in waste rock storage facilities may cause changes to groundwater and surface water quality and soils, which may affect vegetation and wildlife habitat**
- **Vertical and lateral seepage from waste rock storage facilities and the tailings storage facility may cause changes to groundwater and surface water quality and soils, which may affect wildlife habitat**

During the life of the Project, there is the potential for leachate, runoff, and seepage (e.g., metals) from the facilities developed for storage of tailings and waste rock. All waste rock is currently categorized as non-PAG type. Separate waste management procedures are proposed for the PAG and non-PAG material should any PAG waste rock be found in continuing studies. All PAG and high metal leaching potential waste rock generated by open pit mining will be segregated at source and placed into designated areas within the waste rock storage facilities. They will then be encapsulated with non-PAG and low metal leaching potential waste rock so that the risk of contaminant release both during the operational and post closure phases of the mine is significantly reduced and/or eliminated to prevent potential contamination of surrounding waterbodies, soils, and vegetation.

Runoff and seepage from the waste rock storage facilities will not be released to the environment during construction or operations. The on-land facilities will have ditch systems to collect seepage and runoff, and all water collected will be monitored and treated, when necessary, prior to release to the environment. Attenuation ponds for the storage of contact water from the Project site have been designed to accommodate the total volume of runoff under the 1-in-100 wet year freshet event, and to limit the potential for seepage. Tailings are expected to have arsenic concentrations that are over MMER and CCME guidelines; therefore, a provision will be made for treating tailings supernatant water to remove arsenic during the life of mine operation prior to discharge to the TSF.

Short-term water leach test results yield concentrations that meet the MMER chemical criteria in all samples of waste rock and ore tested with the exception of arsenic in one Tiriganiaq greywacke/siltstone sample and 3 ore samples from Discovery and Tiriganiaq. However, short-term leach tests are considered a conservative estimate of arsenic leachability. Large column and field cell tests, conducted at low water-to-rock ratios that are more appropriate to site conditions, generate leachate concentrations well below MMER criteria. Scale up studies further support this conclusion, as do on-site surface water quality representing waste rock contact water (operations pad made of Tiriganiaq greywacke run of mine rock).

Permafrost conditions are present under the waste rock storage facilities and over time will penetrate into the facility. The permafrost is anticipated to limit seepage from waste rock storage facilities over the long-term. The aggradation of permafrost into the facility is expected to occur under both current climate and future climate change scenarios.

Currently, there is an open talik beneath Lake B7 that could be a pathway for constituents to enter the deep groundwater flow system. During mining, groundwater modelling suggests that groundwater from the tailings facility would take approximately 8 years to reach the underground mine, where it would be collected and treated if necessary prior to discharge. At closure, when flooding of the open pits and underground has occurred, groundwater originating from the TSF at B7 that has not yet reached the underground will continue in the regional groundwater flow system and groundwater modelling suggests it would take 500 to 1 000 years for this residual groundwater to reach Meliadine Lake. Groundwater modelling also suggests that the rate of discharge to Meliadine Lake of water originating from the tailings facility would be about 3 m^3/day or approximately 0.002 percent of the daily average surface water outflow from Meliadine Lake. Thermal modelling indicates that the once B7 is dewatered it would take 20 to 50 years for the talik to freeze beneath B7. Once the talik beneath B7 is frozen, groundwater will no longer flow from the tailings facility into the regional groundwater system and discharge to Meliadine Lake from this source will be zero (FEIS Volume 7, Section 7.2.3.3).

At closure, the TSF will be dewatered. The tailings storage facility will be covered with non-metal leaching and non-PAG rock. The rock will be tested prior to use on the tailings storage facility. The ditches and sumps and water treatment facilities will be maintained until it is confirmed that the runoff from the waste rock and tailings storage facilities will meet discharge criteria.

The environmental design features and mitigations listed in Table 6.6-8 reduce the potential risk of contact between wildlife and contaminants from waste rock and tailings. Overall, release of runoff and long-term seepage from the tailings and waste rock storage facilities, as well as leachate from waste rock is expected to result in no detectable change to wildlife habitat outside of the Project footprint area relative to baseline conditions. Therefore, these pathways were determined to have no linkage to effects on wildlife habitat, and the

subsequent maintenance of wildlife populations for the continued opportunity for traditional and non-traditional use.

Changes to Survival and Reproduction

- **Spills on the mine site or along the AWAR can increase risk of mortality to individual animals, which can affect wildlife population sizes**

Chemical spills have not been reported as the cause of wildlife mortality at the Ekati Diamond Mine, Diavik Diamond Mine, Jericho Diamond Project, or Snap Lake Mine (Tahera 2008; BHPB 2010; DDMI 2010; De Beers 2010; AEM 2011b; Rio Tinto 2012). At the AEM Meadowbank Mine, accidental spills (e.g., fuel) have occurred, but the volume of spills have primarily been small, and clean-up has occurred with negligible to minor, reversible short-term environmental impact, requiring minor remediation. There has never been a spill at Meadowbank resulting in moderate to serious environmental impact (AEM 2011a).

The implementation of the Risk Management and Emergency Response (SD 2-15) and environmental design features, including proper equipment maintenance and driver training, are expected to reduce the frequency and severity of spills. It is acknowledged that accidental spills, including vehicular accidents, have the greatest potential to affect soils, vegetation, and possibly result in the mortality of individual wildlife. However, construction and mining equipment, machinery, and vehicles will be regularly maintained. Fuel storage tanks will be situated in a secondary containment area capable of containing 110% of the contents of the largest tank. The storage tanks and fuel-dispensing systems will be constructed in accordance with current regulatory requirements and National Fire Code. Fuel reconciliation will be conducted and structural integrity will be routinely inspected. Hazardous materials will also be stored according to regulatory requirements to protect the environment (i.e., SD 2-13 Hazardous Materials Management Plan), and individuals working on-site and handling hazardous materials will be trained. Emergency spill kits will be readily available should a spill occur. Consequently, this pathway was determined to have no linkage to effects on the abundance and distribution of wildlife populations, and continued opportunity for traditional and non-traditional use of wildlife.

- **Surface water runoff from the core mine facilities area can affect surface water quality, soil, vegetation, and wildlife habitat**

Surface water runoff from areas of the mine facilities could potentially affect vegetation and wildlife habitat. However, these facilities incorporate several environmental design features to prevent release of untreated site water into the receiving environment.

During the construction and operations phases, all surface water runoff from the areas of the mine facilities or that has been in contact with any mine facilities or processes will be captured through a series of collection ditches and sumps. Contact water from open pits will be pumped to the TSF, while surface water from the remaining facilities will be pumped to Attenuation Pond 1. Any excess water in the TSF will be treated and discharged to Attenuation Pond 1. Furthermore, water from underground workings will be collected and treated, then directed to Attenuation Pond 1. Water collected at Attenuation Pond 1 will be discharged as an effluent into Meliadine Lake through a diffuser outfall. The diffuser will be configured to promote mixing of the effluent in the lake ambient water, to meet water quality standards established from the CCME guidelines for protection of aquatic life.

During the closure phase, contact water will be directed to Attenuation Pond 1 until it meets the water quality standards, upon which Attenuation Pond 1 and water treatment facilities will be decommissioned. The TSF will be dewatered and covered with a rockfill cover over a graded tailings surface. Runoff will be monitored to ensure it meets the water quality standards before being discharged to the environment or Tiriganiaq pit to assist with pit flooding. Dewatering of the open pits will cease at the end of operations and the open pits will be actively filled with water over a period of approximately 10 years. When flooded, and water quality criteria have been achieved, outflows from the pits will naturally drain toward adjacent waterbodies and eventually reach Meliadine Lake. It is expected that the water quality in the open pits will meet the water quality standards from the CCME guidelines for protection of aquatic life. Contact water ditches and sumps enclosing waste rock facilities will be removed and a layer of non-potentially acid generating rock will be placed over any sediment in the sumps to prevent dusting and erosion.

Implementation of these environmental design features is expected to result in no detectable changes to wildlife habitat from the Project. Therefore, this pathway was determined to have no linkage to effects on wildlife habitat and the maintenance of wildlife populations for the continued opportunity for traditional and non-traditional use.

- **Uptake of metals by wildlife through ingestion of tailings and dust on surface water, soils and vegetation can affect health of individual animals, which can affect wildlife population sizes**

Wildlife within the terrestrial RSA may be directly and indirectly exposed to airborne chemicals through fugitive dust and air emissions from the Project. Airborne chemicals link to metals. Direct exposure to metals includes inhalation of fugitive dust and air emissions, drinking of water, inadvertent ingestion of soil, and ingestion of vegetation. Airborne chemicals may deposit directly onto the surface of plants or may deposit onto soils and be subsequently taken up through plant roots (vascular plants) or tissues (lichen). Accumulation of dust (i.e., TSP deposition) and concentrations of air emissions produced from the Project may result in dust entering local surface waters as runoff. Therefore, wildlife may be indirectly exposed to metals from fugitive dust and air emissions by intentionally or inadvertently consuming vegetation that has accumulated metals through the soil or air, or ingesting water, sediment or invertebrates from waterbodies exposed to chemicals. Airborne chemicals are not expected to extend beyond the terrestrial RSA.

Any PAG or high metal leaching waste rock will be segregated at source and placed into designated areas within the waste rock storage facilities. If not suitable for construction, overburden will be stored with the waste rock storage facility. Tailings deposition will be designed to limit dust generation and airborne chemicals are not expected to extend beyond the terrestrial RSA.

A wildlife health risk assessment was completed to evaluate the potential adverse effect to individual animal health associated with exposure to chemicals from the Project (Section 10.1). For wildlife, there were no contaminants of potential concern (COPC) identified in soil, sediment or surface water for further evaluation in the environmental risk assessment. As such, the environmental risk assessment did not proceed beyond the chemical screening stage of the problem formulation for wildlife. This indicates that adverse health effects to wildlife as a result of the Project are not expected. Consequently, these pathways were determined to have no linkage to effects on the persistence of wildlife populations,

- **Air emissions and deposition can cause changes to amount of quality habitats through chemical changes to surface water quality and soils, affecting wildlife health**

- **Water quality at closure may affect wildlife health**

Accumulation of dust and concentrations of air emissions produced from the Project may result in chemical changes to surface water and soils. Likewise, changes in flows, hydrological processes, and evaporation can change surface water quality. If concentrations of chemicals in soils and surface water exceed CCME or Health Canada guidelines, wildlife health could be negatively affected. Elders also expressed concern that changes to environmental conditions, including surface water, can affect wildlife (Volume 9, Section 9.3.1.4.2.2). A surface water quality model was developed to predicted changes to surface water quality in small waterbodies (i.e., not Meliadine Lake) in the LSA from particulate matter, metals, nitrogen compounds from blasting, and nitrogen dioxide (potential acid input metric) (FEIS Volume 7, Section 7.4.6.2.1).

A wildlife health risk assessment was completed to evaluate the potential adverse effect to individual animal health associated with exposure to chemicals from the Project (Section 10.1). For wildlife, there were no COPC identified in soil, sediment or surface water for further evaluation in the environmental risk assessment. As such, the environmental risk assessment did not proceed beyond the chemical screening stage of the problem formulation for wildlife. This indicates that adverse health effects to wildlife as a result of the Project are not expected. Consequently, these pathways were determined to have no linkage to effects on the persistence of wildlife populations,

6.6.3.2 Minor Pathways

In some cases, both a source and a pathway exist, but the change caused by the Project is anticipated to result in a minor environmental change, and would have a negligible residual effect on terrestrial wildlife and wildlife habitat relative to baseline or guideline values. The following pathways are anticipated to be minor, and will not be carried through the effects assessment.

Changes to Habitat Quantity and Fragmentation

- **Direct loss and fragmentation of terrestrial wildlife habitat can affect the persistence of polar bear population**

- **Permanent changes in terrestrial polar bear habitat following closure of the mine site**

The Western Hudson Bay polar bear population is the only polar bear population expected to potentially interact with the Project. During colder months of the year, the physical attributes of sea ice are the primary determinants of the quality of polar bear habitat (COSEWIC 2008); however, during the ice-free season, the polar bear is a habitat generalist on land (Stirling et al. 2004). Maternal denning sites are generally located on land near the coast, being excavated in snowdrifts and in some places frozen ground (COSEWIC 2008). Polar bears also are highly mobile animals on the landscape. Thus, the total amount of habitat remaining on the study landscape is expected to be more important for survival of these species than the configuration of the remaining habitat (i.e., habitat loss is of greater concern than habitat fragmentation) (Fahrig 1997, 2003; Swift and Hannon 2010).

Baseline studies suggest that the polar bear is not common in the RSA. Polar bears were recorded in the wildlife log of the Meliadine Lake camp on 2 occasions between 1998 and 1999. In December 1998, a female and a single cub were seen travelling north along Meliadine Lake. In August 1999, a single polar bear was seen 18 km north and east of WMC's camp (Arc Wildlife Services 2000). Additional sightings in the region have included a

lone female in June 2007, a female and young in July 2008, a female and 2 young in July 2012, and a female and young in July 2012 (S. Hartman, Kivalliq Inuit Association, 2012, pers. comm.) (Figure 6.6-6). Although inland bears (i.e., those that travel more than 10 km from the coast) are common in southern parts of their distribution (i.e., Manitoba), polar bear generally concentrate near the coast line during the ice-free season (Atkinson et al. 2012). The number of polar bear expected to occur within the inland portions of the RSA is small. Only 6% (41 individuals) of the bears detected in recent GN surveys conducted during the ice-free period were detected in NU, and of these, the highest densities were seen south of Arviat (Atkinson et al 2012). None of the polar bear sightings near Rankin Inlet during those surveys occurred inland or in the RSA (Figure 6.6-6). For this reason, the potential direct loss and fragmentation of polar bear habitat were assessed for inland and coastal portions of the Project footprint.

The Project footprint occurring near the coast consists of the Itivia spud barge, the tank farm, the AWAR and Rankin Inlet bypass road. The Itivia spud barge and the tank farm partially occur within existing disturbance near the community of Rankin Inlet. The majority of direct loss to polar bear habitat due to the Project will occur inland. Construction and operation of the Project (including the AWAR) will result in a maximum disturbance of 2950 ha. Of that footprint, the AWAR will be decommissioned and scarified during closure, waste rock and tailings storage facilities will be reclaimed to a lichen-rock community, water bodies will be reclaimed water bodies, and the mine site roads, plant site and borrow pits will be scarified and left to naturally revegetate, resulting in 669.68 ha of permanent habitat change from this Project, or 0.27% of the RSA area.

In addition to direct loss of habitat, the Project may also result in fragmentation of the existing landscape. Habitat fragmentation is the progressive subdivision of habitat blocks into fragments. Although fragmentation always accompanies habitat loss, it is a different phenomenon (McGarigal and Cushman 2002; Fahrig 2003). Habitat fragmentation effects are lesser in magnitude than direct habitat loss (Andrén 1999; Fahrig 1997, 2003), and species with very specific habitat requirements and low dispersal abilities are more likely to be affected by habitat fragmentation. For example, Elders have expressed concerns that road construction may limit or alter wildlife movement patterns (Volume 9, Section 9.3.1.4.2.2). However, the AWAR will be reclaimed, as will the majority of the Project footprint, and only a small area of permanent habitat change will occur. Thus the effects of fragmentation from the Project are expected to be negligible for polar bear.

Baseline information suggests that the RSA constitutes part of the home range of only a few polar bear. Thus, the Project is predicted to cause a minor change in the amount and configuration of habitat for these individuals relative to baseline conditions. The estimated decrease in habitat for some individuals is expected to have a negligible residual effect on the abundance and distribution of the Western Hudson Bay polar bear population, and continued opportunity for traditional and non-traditional use of wildlife.

Changes to Habitat Quality, Movement and Behaviour

- **Dewatering of waterbodies, Project footprint, and diversion of water, may change downstream flows, water levels, and affect wildlife habitat**

Potential increases in peak annual water levels from the alteration of watershed configuration from the Project footprint, and diversions, will be mitigated by engineered diversion channels (e.g., B5-C-02) and enhanced lake outlet channels. Dewatering rates and schedule will be managed so that peak annual water levels, which typically occur in June, do not increase from baseline conditions. Water levels will be increased during the low flow season (i.e., July to October) but are expected to remain below the baseline peak annual water level. To

attenuate flow changes, pumped discharge from dewatering of waterbodies will be directed to the lake environment, and not directly to outlets. At closure, pumping rates will be managed to minimize potential effects on the water levels of Meliadine Lake during refilling of the pits (FEIS Volume 7, Section 7.3) and effects on the water levels of Meliadine Lake is expected to be negligible.

As a result of the implementation of the above environmental design features the effects on wildlife habitat from the dewatering of waterbodies, Project footprint, and diversion of water, are expected to be minor and have no impact on distribution or abundance of wildlife populations. Consequently, residual effects to the maintenance of wildlife populations and the continued opportunity for traditional and non-traditional use are predicted to be negligible.

- **Dust deposition may cover vegetation, change the amount of different quality habitats, and alter movement and avoidance behaviour of wildlife**
- **Air emissions and deposition can cause changes to chemical properties of surface water, soils, vegetation, wetlands, and wildlife habitat**

Accumulation of dust (i.e., TSP deposition) and concentrations of air emissions produced from the Project may result in a local indirect change on the quality of habitat available within the LSA. Air quality modelling was completed to predict the spatial extent of dust deposition and air emissions from the Project (FEIS Volume 5, Section 5.2). Sources of dust deposition and air emissions modelled include blasting activities, haul roads, the Plant, activities at the open pits and other ancillary facilities, and vehicle traffic along the AWAR. Environmental design features and mitigation have been incorporated into the Project to reduce potential effects from dust deposition (Table 6.6-8). For example, the watering of roads during the non-winter period will facilitate dust suppression. In addition, programs will be implemented to review power and heat use to reduce energy use. Although these environmental design features and mitigation should reduce dust deposition and air emissions, assumptions incorporated into the model are expected to contribute to conservative estimates of emission concentrations and deposition rates.

Dust generation from Project vehicles travelling along the AWAR will occur annually, but will likely be lower during the winter period and will be of lower magnitude during wet and cool conditions. Trucks travelling on the AWAR and site roads also have the potential to directly transfer dust collected on wheels and undercarriage of vehicles at the Project and in Rankin Inlet to other parts of the LSA; however, the relative contribution to the overall dust accumulation in the area along the roads is considered to be negligible (FEIS Volume 5, Section 5.2).

Dust deposition is expected to result in minor and localized changes to vegetation and consequently wildlife habitat along the right-of-ways for the AWAR. For example, Walker and Everett (1987) and Everett (1980) reported that effects were confined to a 50 m buffer on either side of a road. Meininger and Spatt (1988) found that most of effects occurred within 5 to 50 m of a road, with less obvious effects observed between 50 m and 500 m from a road. The amount of dust generated along the road is dependent on the dryness of the road surface, the number of vehicles, weight and speed, and maintenance of the driving surface. Regular grading of the AWAR, combined with the addition of granular material to the driving surface will be needed. This will improve road safety and also reduce the amount of dust. Dust will also be mitigated by maintaining posted speed limits. In areas or times identified by the AEM road supervisor as being prone to high dust levels, or areas where safe road visibility is impaired or where dust deposition is impacting fish habitat and/or water quality, the road supervisor will

arrange mitigation measures as appropriate. This could involve actions such as grading of the road surface, placement of new coarser topping, and/or watering of the road surface. Use of chemical dust suppressants will be used only as a last resort and only in accordance with the Environmental Guidance for Dust Suppression published by the Government of Nunavut Department of Environment (January 2002)[1]. Therefore, dust deposition from vehicles along the AWAR is predicted to result in negligible residual effects to the persistence of wildlife populations.

Air emissions from vehicles along the AWAR were included in the air quality modelling assuming that the AWAR would be open all year round. In general, emissions from the roads are small, and if extended over the whole year, a negligible effect from annual depositions was predicted (FEIS Volume 5, Section 5.2). Annual emissions from vehicles on the roads are anticipated to result in minor and localized changes to soils and vegetation (Section 6.4.2.2 and 6.5.4.3), and are expected to have no detectable effects on wildlife habitat relative to baseline conditions.

The results of the air quality modelling predicted that the maximum annual TSP concentrations resulting from the Project is 29.4 micrograms per cubic metre per year ($\mu g/m^3/y$) within the Project disturbance areas, and 14.6 $\mu g/m^3/y$ outside of the Project disturbance areas (Table 6.6-9). The maximum 24-hour TSP concentration within the Project disturbance areas is 356.5 $\mu g/m^3$, while the maximum 24-hour dust concentration outside of the Project disturbance areas is 212.5 $\mu g/m^3$. Although concentrations are predicted to be above Nunavut Ambient Air Quality guidelines (Department of Environment 2011) during select periods of the Project (Table 6.6-9), the anticipated changes to habitat quality are considered minor and localized. The major sources of dust will be associated with the open pits and haul roads. The strongest effects from dust are generally confined to the immediate area adjacent to the dust source (Walker and Everett 1987).

The air emission modelling results show that predicted maximum concentrations for sulphur dioxide and carbon monoxide for all model cases are below the Nunavut Ambient Air Quality guidelines (Table 6.6-10); however, annual peak concentrations for nitrogen dioxide are predicted to slightly exceed guidelines inside of the Project disturbance areas, reaching levels of 90.1 $\mu g/m^3$. Although some concentrations are predicted to be above criteria concentrations and some are predicted to be above baseline conditions (i.e., PAI), the anticipated changes to vegetation are localized and considered minor (Section 6.5.4.3). Therefore the anticipated changes to habitat quality are considered minor and localized. The concentration predictions are considered to be conservative and the presented concentrations are likely overestimated. Overall, changes in habitat quality (and associated changes to wildlife movement and behaviour) due to dust deposition and air emissions are anticipated to be minor relative to baseline conditions. Consequently, residual effects to the maintenance of wildlife populations and the continued opportunity for traditional and non-traditional use of wildlife from dust deposition and air emissions are predicted to be negligible.

[1] Available online at the following web site: http://env.gov.nu.ca/sites/default/files/Guideline%20Dust%20Suppression.pdf

Table 6.6-9: Summary of Predicted Annual and 24-hour Dust Concentrations from the Project

Substance	Averaging Period	Criteria ($\mu g/m^3$)[a]	Inside the Project Disturbance Areas						Outside the Project Disturbance Areas					
			Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
TSP	24-hour	120	41.6	**220.5**	**346.8**	**356.5**	**155.6**	**300.9**	18.2	62.1	**212.5**	101.8	**134.7**	81.0
	Annual	60	6.0	9.8	24.8	12.5	13.5	29.4	1.7	3.3	14.6	3.8	6.0	3.2
PM_{10}	24-hour	50	41.6	**93.1**	**188.2**	**160.6**	**73.7**	**138.8**	18.1	26.4	**90.7**	48.9	**60.7**	36.6
$PM_{2.5}$	24-hour	30	**41.6**	**42.0**	**42.9**	**41.8**	**41.7**	**42.1**	17.2	18.8	17.2	18.3	17.2	18.0

Notes: bolded values exceed criteria. Refer to FEIS Volume 5, Section 5.2 for a description of the Cases

[a] Criteria are based on the Nunavut Ambient Air Quality guidelines (Department of Environment 2011).

$\mu g/m^2/y$ = micrograms per cubic metre; TSP = total suspended particulate; $PM_{2.5}$ = fine particles of 2.5 micrometres or less in size; PM_{10} = fine particles of 10 micrometres or less in size.

Table 6.6-10: Summary of Predicted Maximum 1-hour, 8-hour, 24-hour, and Annual Air Quality Concentrations from the Project

Substance	Averaging Period	Criteria ($\mu g/m^3$)[a]	Inside the Project Disturbance Areas						Outside the Project Disturbance Areas					
			Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
Nitrogen Dioxide	1-hour	400	285.6	285.6	285.6	285.6	285.6	285.6	270.7	273.1	272.0	273.5	271.0	273.2
	24-hour	200	160.8	160.8	160.8	160.8	160.8	160.8	119.4	120.0	119.8	120.2	119.5	120.2
	Annual	60	**89.6**	**90.1**	**89.9**	**89.9**	**89.7**	**89.9**	25.9	27.7	27.0	27.3	26.2	27.4
Sulphur Dioxide	1-hour	450	4.4	4.4	4.4	4.4	4.4	4.4	2.5	2.6	2.6	2.5	2.5	2.6
	24-hour	150	2.3	2.4	2.4	2.3	2.3	2.4	1.0	1.1	1.0	1.0	1.0	1.0
	Annual	30	0.1	0.2	0.1	0.1	0.1	0.2	0.0	0.0	0.1	0.0	0.0	0.0
Carbon Monoxide	1-hour	35 000	1281.7	1281.7	1416.0	1281.7	1281.7	1281.7	1190.1	1210.7	1203.0	1214.6	1192.2	1214.5
	8-hour	15 600	845.6	845.6	934.2	845.6	845.6	845.6	785.2	798.8	793.7	801.3	786.6	801.3

Notes: bolded values exceed criteria. Refer to FEIS Volume 5, Section 5.2 for a description of the Cases

[a] criteria based on Nunavut Ambient Air Quality guidelines (Department of Environment 2011)

$\mu g/m^3$ = micrograms per cubic metre

- **Sensory disturbance can change the amount of different quality habitats, and alter polar bear movement and behaviour (distribution)**

Carnivores have a keen sense of smell and can be attracted from long distances to a project if food items are frequently present (Eberhardt et al. 1982; Benn and Herrero 2002; Beckman and Berger 2003; Peirce and Van Daele 2006). Mining projects in the Arctic have reported carnivore attraction to landfills (BHBP 2007; DDMI 2008). Carnivores are also attracted to aromatic waste materials such as petroleum based chemicals, grey water, and sewage (CWS 2007). Olfactory disturbance of this type is a concern with polar bear around human developments.

Auditory disturbance is expected to have less of an influence than olfactory disturbance on polar bear movement and behaviour. One of the few studies to investigate the impacts of industrial disturbance on polar bears found that 10 of 12 bears showed substantial tolerance to aircraft and oil field operation disturbances (Amstrup 1993). Noise sources from the Project include mobile and stationary mining equipment, blasting, aircraft, and vehicles. The results of noise modelling indicate that Project-related noise may be distinguishable from the natural environment by wildlife within 5 km from the Project (FEIS Volume 5, Section 5.5). No literature on the effects of in-ground or in-water vibrations (e.g., from blasting activities) to terrestrial wildlife could be found, although marine mammals and fish may be affected by in-water vibrations.

Baseline studies suggest that the polar bear is not common in the RSA, and even fewer would be expected to be within 5 km of the Project footprint where they could encounter sensory disturbance. Polar bears were recorded in the wildlife log of the Meliadine Lake camp on 3 occasions between 1998 and 2000 and there have been 4 additional sightings between 2007 and 2012 (Arc Wildlife Services 2000; S. Hartman, Kivalliq Inuit Association, 2012, pers. comm.). The later sightings have all been more than 5 km from the Project (Figure 6.6-6).

A number of environmental design features (Table 6.6-8) and a wildlife mitigation and monitoring plan (SD 6-4 TEMMP) will be implemented to limit olfactory and auditory disturbance to large carnivores, which should result in minor changes to habitat quality relative to baseline conditions. Therefore, only a small proportion of the Western Hudson Bay polar bear population in the RSA should be affected by sensory disturbance from the Project. Subsequently, this pathway is predicted to have a negligible residual effect on the maintenance of polar bear populations and the continued opportunity for traditional and non-traditional use.

Changes to Survival and Reproduction

- **Improved access for harvesting polar bear can affect population sizes**

Polar bear can be expected to follow the AWAR, due to ease of travel, and will also follow snowmobiles and all-terrain vehicles (ATVs) (Derocher, A., Professor, University of Alberta, 2012, pers. comm.), which are expected to use the road. This can lead to increased human – wildlife conflict, but also it can increase the probability of polar bears being harvested. Polar bear hunting in NU is largely managed through quota systems and according to Aboriginal treaty rights. Internationally, the management of polar bears is coordinated under the Agreement on the Conservation of Polar Bears, signed by the federal government on behalf of all Canadian jurisdictions in November 1973. Under this agreement, Aboriginal peoples have the exclusive right to harvest polar bear for subsistence. Quotas are allocated exclusively to Aboriginal peoples who may choose to fill part of their quota by offering a guided hunt. However, guided hunts and all other human-caused polar bear mortalities (including problem bears and illegal kills) are considered to be part of the quota (GN 2012). Known illegal harvest is low in Rankin Inlet and Western Hudson Bay (Table 6.6-11).

Table 6.6-11: Polar Bear Mortality Due to Illegal Kills

Year	Rankin Inlet	Western Hudson Bay
2010 to 2011	0	1
2009 to 2010	0	0
2008 to 2009	0	1
2007 to 2008	0	1
2006 to 2007	1	1
2005 to 2006	0	0
2004 to 2005	0	0
2003 to 2004	0	0
2002 to 2003	0	0
2001 to 2002	0	0
2000 to 2001	0	0

Source: GN (2012).

All roads will be decommissioned and scarified during closure so the change in access is not expected to persist beyond the operational life of the mine. In addition, environmental design features will be implemented to limit effects of access on harvesting of polar bear. Some environmental design features and mitigation that will be implemented at the Project include the following:

- develop and enforce “no hunting, trapping, harvesting or fishing policy” for employees and contractors;
- access to the mine site will be controlled (gated); public vehicles (cars, trucks) allowed only with special authorization; and
- upon consultation with the Kivalliq Inuit Association (KIA) and the Rankin Inlet HTO, an appropriate ‘no shooting zone’ will be established along the road and around the mine site.

Environmental design features and management plans should limit changes in harvest patterns resulting from increased access. In addition, the Project and AWAR are not expected to increase access to many polar bear since the portion of the subpopulation detected near the Project region tend to remain near the shoreline during the ice-free season (Derocher and Stirling 1990; Towns et al. 2010), and few inland bears (defined as >10 km from the coast) were recorded in recent surveys. Therefore, this pathway is predicted to have a negligible residual effect on the maintenance of the Western Hudson Bay polar bear subpopulation and the continued opportunity for traditional and non-traditional use.

- **Physical hazards on the mine site and collision with vehicles causing injury or mortality to individual animals, which can affect population sizes**

Infrastructure (e.g., buildings, ditches, open pits) and blasting activities associated with the Project may be hazardous to wildlife species. Rankin Inlet community members also expressed concern regarding wildlife, and in particular caribou, encouters with mine infrastructure (Volume 9, Section 9.3.1.4.2.1). Mammals may injure themselves when crossing road berms and ditches, and are vulnerable to injury or mortality if they enter open pits. It is expected that traffic and the presence of humans will deter wildlife from entering the open pits; however, if the open pits are accessed during operations, wildlife will be able to exit via the haul road. During closure, the pits will be flooded to form pit lakes. No wildlife mortalities from animals entering the open pits at

other mines in the NT have been reported (BHPB 2010; DDMI 2010; De Beers 2010). Removal of other project related physical hazards will also be part of the closure and reclamation plan.

During operations, the coarse rockfill dikes and B7 waste rock facility will act as a boulder barrier (similar to a natural boulder field) around the TSF to discourage wildlife species, in particular caribou during migration, from entering. These facilities will remain post-closure.

Vehicles on the AWAR may be hazardous to caribou and other wildlife. Although some research suggests caribou avoid roads, caribou have been observed bedding and travelling on roads. Hunters and elders also suggest caribou seek out roads for insect relief (Golder 2011c). Carnivores may be attracted to road kill (Fahrig and Rytwinski 2009) and carnivore behaviour may be unresponsive to traffic and fail to avoid roads (Dickson and Beier 2002). Also, carnivores and ungulates may use roads more often during the winter because of the ease of travel along cleared roadways (Gunson et al. 2011; Rost and Bailey 1979). In general, few collisions with wildlife have been reported along mine access roads in the NT and NU. For example, from 1996 to 2010, there have been only 3 reported vehicle-related wildlife mortalities along the Tibbitt-to-Contwoyto Winter Road; 5 caribou were killed by a grocery truck in 1999 (EBA 2001), a wolverine was killed by a pick-up truck in 1996 (Banci, pers. comm., in EBA 2001), and a red fox was killed in 2009 (E. Madsen, Director, Communities/External Relations & Winter Road Operations. Diavik Diamond Mines Inc., 2010, pers. comm.). Recent road monitoring of wildlife on the all-weather private road between Baker Lake and the Meadowbank mine show that no more than 2 caribou have been killed during 2009 and 2010 (Gebauer and Associates 2010). There is currently an all-weather road extending from Rankin Inlet to Iqalugaarjuup Nunanga Territorial Park of approximately 10 km; however, the number of wildlife collisions along this road is not monitored.

There will not be an airstrip located on-site, so personnel will be transported from Rankin via the AWAR. Project related traffic in winter months during operations, including personnel transport, is expected to be between 8 and 10 pick-up trucks, 2 cube vans, 2 passenger vans, 2 fuel trucks, and 1 transport truck on week days. The traffic is expected to be reduced to 2 to 4 pick-up trucks, 1 cube van, 1 passenger van, and 1 transport truck on weekends. In summer, traffic will be between 10 and 14 pick-up trucks, 3 cube vans, 2 passenger vans, 2 fuel trucks, 1 transport truck on weekdays and 4 to 8 pick-up trucks, 1 cube van, 1 passenger van, 1 transport truck on weekends. When the barges arrive at Itivia, 6 to 14 transport trucks per day are expected on the road, to move the freight to the Meliadine site. If flights do not get in to Rankin, the number of passenger vans using the AWAR would drop in half. Transport trucks will not travel the road when the weather is bad in any season. Public road usage in winter is expected to include between 1 and 2 pick-up trucks and 5 to 10 snowmobiles on weekdays, and between 2 and 5 pick-up trucks and 10 to 20 snowmobiles on weekend days when the weather is good. In summer, 2 and 5 pick-up trucks and 5 to 10 ATV's are expected on weekdays and between 5 and 10 pickup trucks and 10 to 20 ATV's on weekend days when the weather is good. Between 25 to 50% of these trips are estimated to be incremental to current access via ATVs and snowmobiles.

Traffic speed and volume are the primary factors that contribute to road-related wildlife mortality. These factors directly affect the success of an animal reaching the opposite side of the road. An increase in either factor reduces the probability of an animal crossing safely (Underhill and Angold 2000). The maximum speed on the AWAR will be 50 km/h. Lower speeds allow the motorist and animal to avoid a collision (van Langevelde et al. 2009). To mitigate the increase in injury and mortality risk along the AWAR, several mitigation measures will be implemented when wildlife are detected near the mine site and/or the AWAR (Table 6.6-8). These are detailed in the TEMMP (SD 6-4).

In summary, the implementation of environmental design features and wildlife management practices are expected to result in minor changes in mortality rate from physical hazards, and wildlife-vehicle collisions relative to baseline conditions, and should have a negligible effect on the maintenance of wildlife populations and the continued opportunity for traditional and non-traditional use.

- **Attraction to the Project or AWAR may increase human-carnivore interactions and removal of individual animals (e.g., relocation or mortality), which can affect wildlife population size**
- **Attraction to the Project site or AWAR may increase predator numbers and predation risk, which can affect prey population sizes**

Carnivores can be attracted to mine sites from food smells and other aromatic compounds such as petroleum-based chemicals, grey water, and sewage. In addition, infrastructure may attract carnivores as it can serve as a temporary refuge to escape extreme heat or cold (CWS 2007). Polar bear can also be expected to follow the road, due to ease of travel (Derocher, A., Professor, University of Alberta, 2012, pers. comm.). The attraction of carnivores can lead to accidental mortality of wildlife (e.g., collisions with vehicles) and the need to destroy or relocate problem wildlife posing a risk to human health and property (e.g., polar bear, wolf). The attraction of carnivores can also increase predation pressure on prey species (e.g., caribou) (CWS 2007). This increase in predation has the potential to cause local and regional population declines of these prey species, particularly when caribou migrate through the region in larger groups (CWS 2007).

Wildlife species have been intentionally destroyed at existing mines in the NT and NU, either by government biologists or with government permission. For example, a total of 7 wolverines, 4 grizzly bears, 1 black bear, 16 foxes, and 1 wolf have been intentionally destroyed at the Ekati, Diavik, Jericho, and NICO mine sites from 1996 to 2009 (BHPB 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, and 2010; DDMI 1998, 2003, 2004, 2005, 2006, 2007, 2008, and 2010; Tahera 2000, 2006, 2007a, 2007b, and 2008; Fortune 2011). At the Meadowbank Mine, there were 10 Arctic fox either found dead or killed as a result of mining activity, and 4 problem wolves intentionally destroyed in 2009 (Gebauer et. al. 2012). In 2011 at the Meadowbank Mine, 1 wolverine, 3 wolves, and 2 foxes were intentionally destroyed (Gebauer et al. 2012). Some of these mortalities and relocations have been as a result of wildlife attraction. Further, many Nunavummiut hunters, elders, and community members near the Meadowbank have reported an increase in human-bear conflicts, such as bears getting into cabins, food caches, dump sites, and wandering through communities (GN 2011). Intentional destruction of individuals generally followed habituation of an individual animal to the mine site over an extended period of time, and after multiple deterrent attempts failed with the same individual.

The Western Hudson Bay subpopulation is the most studied subpopulation of polar bears, with a history of conflicting evidence about whether it is stable, increasing, or decreasing (Atkinson et al. 2012). Removal of even a few individuals from populations with low densities or species at risk can impact population persistence. The proportion of the subpopulation likely to have the opportunity to become problems bears at the Project is relatively low. Only 6% of the subpopulation detected during recent GN surveys, conducted during the ice-free period, was detected in NU, and the highest densities were seen south of Arviat (Atkinson et al. 2012). Polar bears tend to remain near the shoreline during the ice-free season (Derocher and Stirling 1990; Towns et al. 2010), and few inland bears (defined as >10 km from the coast) were recorded in NU in recent surveys (Atkinson et al. 2012). None of the bears detected near Rankin Inlet during these surveys were in the RSA (Figure 6.6-6). However, polar bear in this population were detected up to 75 km from the coast in Manitoba (Atkinson et al 2012) and thus, have potential to interact with the mine site. The main Meliadine camp is 20 km

from the coast, and activity at the Discovery site is approximately 10 km from the coast. There have been several polar bear sightings within the region of the main camp site since 1998. Three bears were recorded in the Meliadine Lake camp logbook in 1998, 1999, and 2000. Four additional sightings were recorded within 15 km of the main camp by a member of the KIA in 2007, 2008, 2010, and 2012 (S. Hartman, Kivalliq Inuit Association, 2012, pers. comm.) (Figure 6.6-6).

The numbers of problem polar bear have increased in Rankin Inlet in recent years, and the numbers of polar bear mortalities due to defense kills have increased in Western Hudson Bay in general (Table 6.6-12). A public opinion poll of 106 people from 5 Western Hudson Bay communities, including 35 from Rankin Inlet, also indicated that the polar bear population was above preferred levels, but within their tolerance range. Respondents suggested that there are currently 'the most' polar bears (Kotierk 2012). This trend suggests that bear encounters may occur.

Table 6.6-12: Polar Bear Mortality Due to Defence to Humans or Property

Year	Rankin Inlet	Western Hudson Bay
2010 to 2011	3	14
2009 to 2010	0	12
2008 to 2009	0	6
2007 to 2008	1	1
2006 to 2007	1	3
2005 to 2006	0	0
2004 to 2005	0	0
2003 to 2004	1	1
2002 to 2003	0	3
2001 to 2002	0	4
2000 to 2001	2	3

Source: GN (2012).

Improved waste management practices and staff education decrease the frequency of attractants at mine sites. Since 2004, no carnivores have been accidentally or intentionally destroyed at the Diavik Diamond Mine (DDMI 1998, 2003, 2004, 2005, 2006, 2007, 2008, and 2010). No carnivores have been intentionally destroyed and only one individual has been accidentally killed at the Snap Lake Mine during the 11 years of exploration through current operation (De Beers 2002, 2003, 2004, 2005, 2006, 2007, 2008, and 2010).

A number of environmental design features and management plans will be implemented at the Project to limit the attraction of wildlife and the associated increased risk of mortality from human-wildlife interactions and predation (Table 6.6-8). These mitigation strategies are provided in the TEMMP (SD 6-4) and the Landfill and Waste Management Plan (SD 2-11). These are similar to management practices and policies implemented at other mines in the NT and NU. Some environmental design features and mitigation that will be implemented at the Project include the following:

- kitchen garbage and waste from dormitories and offices will be incinerated on a daily basis;
- littering and feeding of wildlife will be prohibited;
- skirt all buildings and stairs to the ground to limit opportunities for use as shelter;

- ongoing review of the efficiency of the waste management program and improvement through adaptive management;
- education on the risks associated with feeding wildlife; and
- education and reinforcement of proper waste management practices to all workers and visitors to the site.

Environmental design features and management plans should limit attractants to the Project. This should result in a minor increase in wildlife mortality risk from human–wildlife interactions and minor increases in predation on wildlife and/or birds, relative to baseline conditions. Therefore, these pathways are predicted to have a negligible residual effect on the maintenance of wildlife populations and the continued opportunity for traditional and non-traditional use.

- **Change in wildlife energetic costs from disturbance or displacement**

Wildlife survival and reproduction can be negatively affected by sensory disturbance (e.g., increased noise levels during construction and visual disturbances from moving vehicles and humans throughout operation) because animals may avoid (i.e., change movement patterns or flee the area) or move more quickly through areas with human disturbance (Tyler 1991; Fortin and Andruskiw 2003; Bayne et al. 2008). This increase in energy expenditure may reduce individual fitness because energy that could be allocated to survival or reproduction is instead used to cope with disturbance (Bisson et al. 2009).

Species may be more sensitive or vulnerable to disturbance during certain times of the year. Mammals are likely to be more sensitive and vulnerable to disturbance during the breeding season. Adults are more protective of their young and may have lower tolerance to perceived threats (Maier et al. 1998). Females are also investing a lot of energy into milk production, which lowers the amount of energy that is available for fleeing from apparent threats.

Some studies have shown no responses (e.g., no changes in activity levels from baseline conditions; Telesco and VanManen 2006) or transitory responses (e.g., returning to normal hormone, heart rate, or activity levels within a few minutes; Krausman and Hervert 1983; Weisenberger et al. 1996) to human disturbance. Other studies note longer increases in activity, hormone, or heart rate levels with disturbance (e.g., returning to normal levels within a few hours or days; Weimerskirch et al. 2002). These responses may be related to how accustomed species are to disturbance, the time of year (e.g., breeding or non-breeding season), the type of sensory disturbance (olfactory, audio, or visual), as well as the duration and intensity of the disturbance (Fortin and Andruskiw 2003; Bayne et al. 2008; Fahrig and Rytwinksi 2009). No literature on the effects of in-ground or in-water vibrations (e.g., from blasting activities) to terrestrial wildlife could be found, although marine mammals and fish may be affected by in-water vibrations.

During operations, the Project vehicle traffic will vary between weekends and weekdays and by season (summer versus winter), but is not expected to exceed summer weekday volumes of 10 to 14 pick-up trucks, 3 cube vans, 2 passenger vans, 2 fuel trucks, and 1 transport truck per day, in addition to 6 to 14 transport trucks per day when moving freight to the Project site from Itivia Harbour. Public traffic is not expected to exceed 2 to 5 pick-up trucks, and 10 to 20 snowmobiles in winter or 10 to 20 ATV's in summer. Between 25 to 50% of these trips are estimated to be incremental to current access via ATVs and snowmobiles. In addition to

disturbance from traffic, the explosives plant will operate 7-days a week on a 12-h/day basis. Blast frequency will be between 2 and 4 blasts per day.

To minimize risks to wildlife, there is no airstrip planned at the site. There is expected to be an additional 4 charter flights per week to Rankin Inlet from Montreal or Val-d'Or, and 2 additional charter flights from Kivalliq communities. Any emergency air transportation from the mine site will be provided by helicopter. The existing helipad located near the current exploration camp is planned to be used in case of an emergency. During summer exploration, aerial transport, mainly helicopter, will be used. Transport to and from drill sites will also use helicopters. To minimize potential impacts to wildlife, AEM will include mitigation and monitoring strategies in the TEMMP (SD 6-4).

In addition, environmental design features (Table 6.6-8) are expected to reduce disturbance and displacement of wildlife species during Project operations. Some environmental design features and mitigation to reduce disturbance and displacement of wildlife species include the following:

- Project design will use conventional insulation, baffles, and noise suppressors on equipment;
- stationary equipment will be housed inside buildings;
- regular maintenance of equipment to limit noise; and
- all employees will be provided with wildlife environmental awareness training.

The recommended maximum value for the night time noise level for undeveloped areas is 40 dBA (Energy Resources Conservation Board [ERCB] 2007). This is the average night time (23:00 to 07:00) equivalent continuous sound and noise level (L_{eq}) in dBA, that includes both Project related noises and the ambient sound level (existing sound levels without Project-related noises). Noise levels can be higher during the day because of higher levels of human activity and associated tolerance for noise levels. The projected noise levels from the various Project activities are compared with benchmarks in Table 6.6-13. The results show that noise predictions from mine operations and the AWAR will slightly exceed benchmarks, except around Iqalugaarjuup Nunanga Territorial Park. No literature on the effects of in-ground or in-water vibrations (e.g., from blasting activities) to terrestrial wildlife could be found, although marine mammals and fish may be affected by in-water vibrations.

Table 6.6-13: Summary of Noise Levels from the Project

Mine[a] L_{eq} (dBA)		AWAR[b] L_{eq} (dBA)		Rankin Inlet L_{eq} (dBA)		Iqalugaarjuup Nunanga Territorial Park L_{eq} (dBA)	
Benchmark	**Prediction**	**Benchmark**	**Prediction**	**Benchmark**	**Prediction**	**Benchmark**	**Prediction**
40[c]	48	40[c]	57	50[d]	62	40[c]	37

[a] Highest total noise level calculated for all receptors within the Project Site Area

[b] Highest total noise level calculated for all receptors along the length of the All-weather Access Road

[c] ERCB (2007)

[d] WHO (1999)

AWAR = All-weather Access Road; dBA = A-weighted decibel; km = kilometre; L_{eq} = equivalent continuous sound and noise level

A summary of noise levels, not adjusted for human hearing sensitivity (i.e., total amount of noise energy emitted), at certain distances from Project activities are shown in Table 6.6-14. The results indicate that Project-related noises (from the mine, AWAR, and Rankin Inlet infrastructure) will not be distinguishable from the natural environment by wildlife that are 5 km or more from the Project. Noise levels within 1.5 km of the mine, Rankin Inlet infrastructure, and AWAR are predicted to be slightly above baseline values.

Table 6.6-14: Noise Levels at Distances from the Project

Guideline Value (dBL)	1.5 km from Project (dBL)	5 km from Project (dBL)
50 - 60	56.5	46.6

Note: Values are based on results from other projects in remote/undeveloped areas. Baseline noise levels at the Project were between 35 dBA and 50 dBA (Section 5.5). Values in dBL are not available.
dBA = A-weighted decibel; dBL= linear weighted decibel; km = kilometres

As a result a small proportion of wildlife populations (i.e., relatively few individuals) are expected to experience minor changes to energetic costs from disturbance or displacement. Minor changes in energetic costs to individuals are predicted to have a negligible residual effect on the persistence of wildlife populations.

6.6.3.3 Summary of Primary Pathways

The following pathways were assessed to be primary for effects to wildlife (Table 6.6-8) and are analyzed and classified in the effects assessment below:

Changes to Habitat Quantity and Fragmentation

- **Direct loss and fragmentation of wildlife habitat from the Project footprint, including the mine infrastructure, AWAR, and Rankin Inlet infrastructure**
- **Permanent changes in wildlife habitat following closure of the mine site and supporting infrastructure**

Changes to Habitat Quality, Movement and Behaviour

- **Sensory disturbance can change the amount of different quality habitats, and alter movement and behaviour**
- **Disruption or alteration of migration routes from the presence of the mine or from mine-related activities**

Changes to Survival and Reproduction

- **Improved access for harvesting can affect wildlife population sizes**

6.6.3.3.1 General Approach

Based on movements of collared animals and distributions determined from aerial surveys of the region, the Project is anticipated to affect the Qamanirjuaq caribou herd. The Project might also affect the distribution and

abundance of carnivores, such as wolves. However, the Project should have negligible effects on the Lorillard caribou herd. The Lorillard caribou are non-migratory and generally distributed north of Chesterfield Inlet, based on radio-telemetry data collected by the DoE and the location of their historical calving grounds (Figure 6.6-2) (Nagy et al. 2011). The Project may alter the behaviour and movement of a few individuals from regional populations that periodically travel through the RSA; however, the frequency and number of animals affected is expected to result in only negligible changes in the persistence of populations relative to current (baseline) conditions. Thus, the effects analysis for each of the wildlife primary pathways listed above emphasizes the Qamanirjuaq caribou herd (Section 6.6.4) and wolves (Section 6.6.5) and excludes uncommon and less abundant species, such as polar bear and the Lorillard caribou herd. Traditional knowledge and popular science were both used to assess effects to species.

6.6.4 Effects to the Abundance and Distribution of Barren-ground Caribou

The following sections present the effects assessment methodology and results for changes to barren-ground caribou habitat quantity and fragmentation (Section 6.6.4.1); habitat quality, movement and behaviour (Section 6.6.4.2); and survival and reproduction (Section 6.6.4.3).

6.6.4.1 Habitat Quantity and Fragmentation

- **Direct loss and fragmentation of wildlife habitat from the Project footprint, including the mine infrastructure, AWAR, and Rankin Inlet infrastructure**
- **Permanent changes in wildlife habitat following closure of the mine site and supporting infrastructure**

6.6.4.1.1 Methods

Direct effects from the footprint of the Project (including the AWAR) and other previous, existing, and future developments on barren-ground caribou were analyzed by quantifying changes in the area and spatial configuration of habitat types on the landscape (i.e., landscape metrics).

The incremental and cumulative changes in landscape metrics were calculated for each habitat at the RSA scale and included total area, number of patches, mean distance to the nearest patch of the same habitat type, and nearest neighbour index. The incremental and cumulative changes in total area of habitat were also calculated for the CESA based on vegetation data provided by the GN.The nearest neighbour index is the ratio of the observed nearest neighbour distance and the expected distance if patches were randomly distributed on the landscape. Nearest neighbour index values less than 1 indicate the habitat type is clumped across the landscape, while values greater than 1 indicate that patches of the habitat type are dispersed across the landscape. The area and number of patch landscape metrics were determined using the “Summarize” tool in ArcMap. The distance between neighbouring patches was calculated using the “Average Nearest Neighbour” tool in ArcMap. This tool calculates the distance from patch centroids rather than from the patch edge, so values give the relative rather than absolute distance an animal would travel between patches.

Decreases in habitat area can directly influence population size (Fahrig 1997; Festa-Bianchet et al. 2011). Increases in the number of patches and nearest neighbour index, and decreases in the distance between patches indicate increased fragmentation, which can also influence the distribution (and abundance) of caribou by affecting how they travel across the landscape.

Caribou use of habitat in the RSA was ranked based on collar location data from the GN. The GN has operated an on-going caribou collaring program since 1998. Adult, female caribou were targeted for collaring in spring or early winter when they could be located within the distance of fuel cashes for helicopters (Campbell 2005). Collars were set to transmit one location each day. The number and type of active collars has varied over time; however there were no fewer than 7 active collars during any of the last 14 years (Table 6.6-15).

Table 6.6-15: Number and Type of Collars Active between 1998 and 2011

Type	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Satellite (Argos)	12	10	10	12	8	7	8	5	6	5	4	3	0	0
GPS III	0	0	0	0	0	0	9	7	19	19	11	10	0	0
GPS IV	0	0	0	0	0	0	0	0	0	0	20	19	12	34
Total	**12**	**10**	**10**	**12**	**8**	**7**	**17**	**12**	**25**	**24**	**35**	**32**	**12**	**34**

The habitat type for each collar location in the RSA was determined using GIS. The proportional distribution of locations among habitat types was calculated and compared qualitatively to the proportional availability of habitat types in the RSA. Habitat types were ranked according to whether use was more than, equal to, or less than availability. Habitat use rankings were used to assess the impacts of the areal loss of each habitat type.

The quantity of wildlife habitat was classified using a regional ELC map. The map was developed using satellite imagery, remote sensing software, and GIS to determine the abundance of primary land cover classes within the RSA. The RSA ELC was based on cloud-free coverage of LANDSAT 5 satellite spectral imagery with a 30 x 30 m pixel size that was captured on 23 July 2005. A reconnaissance survey completed in July 2008 was used to verify and finalize the regional ELC.

Developments outside the RSA can impact wide ranging species such as caribou and act cumulatively with the Project impacts. To assess cumulative effects, the total area of the Project and other previous, existing, and future developments were calculated for the CESA (Section 6.1.1.3). Habitat information was not available for the CESA so the total area removed by each development case was calculated.

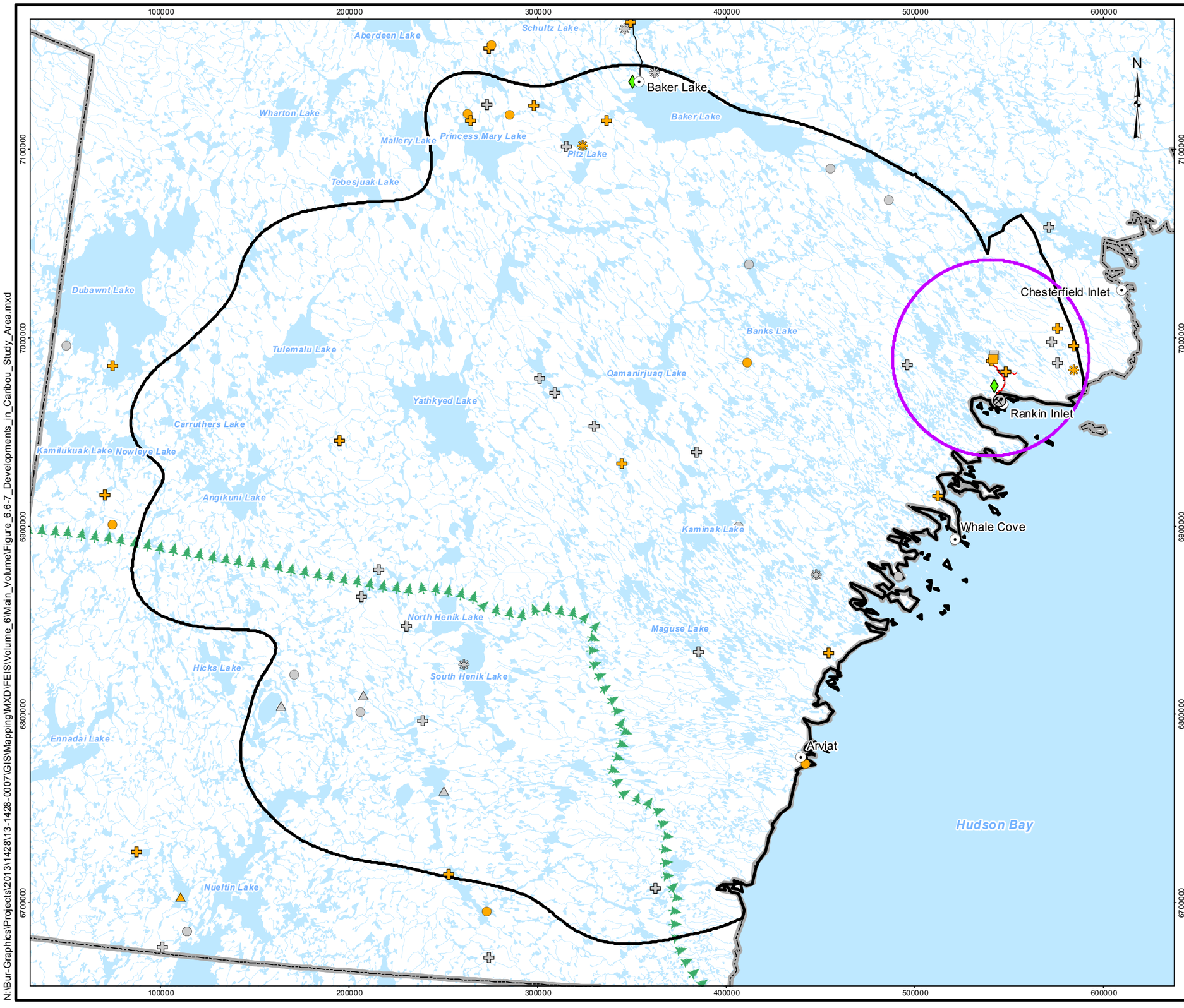
The number and type of previous and existing developments in the RSA and CESA are listed in Table 6.6-16, and illustrated in Figure 6.6-7.

The following proposed projects have been selected as a suite of major developments that may occur in the foreseeable future:

- The Manitoba to Nunavut Road – This major project has received ongoing support from the governments of Nunavut and Manitoba. Although no permit applications have yet been filed, a preferred alignment has been selected, and the project would change the face of development in the Kivalliq region.

- The Churchill Diamonds Project – This project is currently in the exploration phase and applications have not been made to advance to mining, but it was included as a likely project to be induced by the Manitoba to Nunavut Road, and was identified in the Manitoba to Nunavut Road route selection study as such.
- The Ferguson Lake Project – This project is currently in the exploration phase and applications have not been made to advance to mining, but a scoping study has investigated the possibility of advancing to mining. This project was included as a likely project to be induced by the Manitoba to Nunavut Road, and was identified in the Manitoba to Nunavut Road route selection study as such. Although formally outside of the CESA, this project was conservatively included as a future development because it would have impacts to the socio-economics of the region, and may have impacts related to sensory disturbance on the Qamanirjuaq caribou herd.
- The Kiggavik Uranium Project – This project is currently undergoing review to become a uranium mine. Although formally outside of the CESA, this project was conservatively included as a future development because it would have impacts to the socio-economics of the region, and may have impacts related to sensory disturbance on the Qamanirjuaq caribou herd.

The Wolf deposit, located north-west of the Tiriganiaq deposit, is currently known, but still requires some exploration work to be better defined and included in the mine plan. Currently, the Wolf deposit does not have sufficient proven reserves to be economically mined and so was not included as a development, or as part of the Project. An environmental impact assessment (including a cumulative effects analysis) for the Wolf deposit will be completed in the future if the deposit becomes economically feasible to be developed.



LEGEND

- All-weather Access Road (AWAR)
- Regional Study Area (RSA)
- Caribou Effects Study Area (CESA)
- Provincial/Territorial Boundary
- Treeline
- Watercourse
- Waterbody

Previous and Existing Development

- Camp (Active)
- Camp (Inactive)
- Community
- Fuel Storage (Active)
- Fuel Storage (Inactive)
- Mine (Inactive)
- Mineral Exploration (Active)
- Mineral Exploration (Inactive)
- Miscellaneous (Active)
- Miscellaneous (Inactive)
- Quarrying (Active)
- Quarrying (Inactive)
- National or Territorial Park
- All-weather Road
- Winter Road

REFERENCE

Base data obtained from ESRI and Natural Resources Canada.
Datum: NAD 83 Projection: UTM Zone 15

40 0 40
KILOMETRES

PROJECT
AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE
PREVIOUS, EXISTING, AND POSSIBLE FUTURE DEVELOPMENTS IN THE CARIBOU EFFECTS STUDY AREA

Golder Associates

PROJECT NO. 10-1373-0076			FILE No.	
DESIGN	CS	07 Sep. 2011	SCALE AS SHOWN	REV. 0
GIS	JP	12 Sep. 2011		
CHECK	CS	16 Sep. 2011		
REVIEW	GRA	20 Sep. 2011		

FIGURE 6.6-7

N:\Bur-Graphics\Projects\2013\1428\13-1428-0007\GIS\Mapping\MXD\IFEIS\Volume_6\Main_Volume\Figure_6.6-7_Developments_in_Caribou_Study_Area.mxd

Table 6.6-16: Previous and Existing Developments (Points and Polygons) in the Regional Study Area and Caribou Effects Study Area

Activity	Regional Study Area[a]		Caribou Effects Study Area	
	Active[b]	Inactive	Active[b]	Inactive
Camp			7	7
Community	1		4	
Contaminated Site	12			58
Fuel storage				3
Mine		1		1
Mineral exploration camp	2		12	15
Miscellaneous			2	3
Park (Territorial)	1		2	
Quarrying	1	1	1	1
Road				2

[a] There are approximately 58 km of existing (active) winter roads and a 10 km all-weather road from Rankin Inlet to the Iqalugaarjuup Nunaaga Territorial Park in the RSA.

[b] Active developments refer to those with active or unexpired permits as of 2011; active developments are characterized by a footprint and a zone of influence of 5 km.

Data on the location and type of developments in the RSA and CESA were obtained from the following sources:

- NIRB: permitted and licensed activities within NU;
- Aboriginal Affairs and Northern Development Canada (AANDC): permitted and licensed activities within the NT and NU;
- Natural Resources Canada (NRC): GIS file of community locations from NRC's GeoGratis website;
- Treasury Board of Canada: Federal Contaminated Sites Inventory;
- Nunavut Parks: locations of existing and proposed protected areas;
- location of hunting camps from operator websites;
- Nunavut Planning Commission;
- websites of companies holding land use permits; and
- knowledge of the area and Project status.

Some temporal data were available prior to 1996, but most of the known start and end dates of land use permits for developments were from 1996 through 2011. The file was examined for duplication of information (e.g., a water license and a land use permit for the same development). In cases where 2 or more pieces of location information for the same activity were present, the extra information was deleted from the file so that it contained only one point per development. Data associated with the location attributes (e.g., permit status, feature name) also were edited in some instances to update the information for running modelling scenarios efficiently. The information was used to generate a spatially and temporally-explicit development layer within a GIS platform. The developments included in the database are current to 31 December 2011. It is recognized that development is not stagnant and while the number of small developments varies over time, the difference in small development has not changed substantially between December 2011 and December 2013 so as to

change results in any way that would impact the effects assessment. Therefore the CESA database was not updated for smaller developments that may have come into existence or have ceased since December 2011. However the database was reviewed for previous and existing large developments (i.e., mines) and none were identified.

The database contains no information on the size of the physical footprint for developments. For Rankin Inlet, the footprint was digitized from Landsat 7 Imagery from the Government of Canada (NRC 2007). A 500 m radius was used to estimate the area of the footprint for the closed Rankin Inlet Nickel and Copper Mine, as well as for exploration sites (78.5 ha), which likely overestimates the amount of habitat directly disturbed. For example, exploration programs typically contain temporary shelters for accommodations and storage of equipment, and are elevated to limit the amount of disturbance to the soil and vegetation. Drilling is usually carried out with portable drill rigs (5 x 5 m area) at one location at a time. A 200 m radius (12.6 ha) was used to estimate the size of the remaining point development footprints, such as contaminated sites (Table 6.6-17).

Table 6.6-17: Hypothetical Footprints for Previous, Existing, and Future Developments in the Regional Study Area and Caribou Effects Study Area

Development Type	Feature Type[a]	Footprint Extent
Camp	Point	200 m radius
Community	Polygon	actual
Contaminated Sites	point	200 m radius
Fuel Storage	Point	200 m radius
Mine[b]	Point	500 m radius
Mineral exploration camp	Point	500 m radius
Miscellaneous	Point	200 m radius
Territorial campground	Point	200 m radius
Quarrying	Point	200 m radius
Road, all weather	Polygon	Actual

[a] Footprints estimated with the exception of communities, which were delineated and digitized from remote sensing imagery.

[b] The footprint of the inactive Rankin Inlet Nickel and Copper Mine was not easily discernible from remote sensing imagery, and thus, a 500 m radius footprint extent was used to create its footprint polygon in GIS.

m = metre

Landscape metrics were determined for the reference, baseline, Phase 1 AWAR, Project (including the mine footprint, Phase 2 AWAR, and Rankin Inlet infrastructure), and future cases for the RSA. Land cover changes were calculated for each case for the CESA. The reference conditions represent the pristine environment, the baseline case includes all previous, existing, and approved developments up to 2010, and the AWAR phase 1 case includes the winter access road used during exploration for the Project.

The incremental and cumulative changes from the Project and other developments on the loss and fragmentation of habitat were estimated by calculating the relative difference between the baseline case and reference case, between the Phase 1 AWAR and baseline case, between the Project and Phase 1 AWAR case, and between the future and Project case. The following equations were used:

- Existing cumulative effects = (baseline value – reference value) / reference value;
- Phase 1 AWAR incremental effects = (AWAR 1 – baseline value) / baseline value;
- Project and Phase 2 AWAR incremental effects = (Project value – AWAR 1) / AWAR 1;

- Future incremental effects = (future value – Project value) / Project value; and
- Future cumulative effects = (future value – reference value)/ reference value.

The resulting value was multiplied by 100 to give the percent change in a landscape metric for each comparison. The results provide both the direction and magnitude of the effect. For example, a high negative value for habitat area would indicate a substantial loss of that habitat type (and potential reduction in carrying capacity), and a positive value for number of patches would indicate more patches on the landscape, suggesting larger patches have been cut into multiple, smaller patches. Alternately, a negative value for mean distance to nearest neighbour indicates an increase in patch connectivity (and possible increase in travel efficiency for caribou and other wildlife). Increasing index values suggest increasing fragmentation on the landscape.

The quantity of wildlife habitat restored or reclaimed at post-closure was calculated. There is uncertainty in the type of vegetation that may naturally encroach on disturbed areas, so the following general categories were used: reclaimed lichen-rock community, reclaimed water bodies, and scarified natural re-vegetation.

6.6.4.1.2 Results

Based on the collar data obtained from the GN, there are seasonal differences in the percent use of existing habitat types relative to availability (Table 6.6-18). In early and late winter, late summer, and post- calving, the percentage of locations detected in heath tundra was higher than the percentage of heath tundra available on the landscape. Heath boulder was also used more than available during the post-calving season and heath lichen – hair lichen was used more during late summer. Bare ground and water were used more than available during spring migration; which may be due to movement across the landscape. Heath lichen – *cetraria* was used equal to availability in all seasons. Caribou in the NT select lichen veneer, heath tundra, and low shrub habitat (Johnson et al. 2005). The main diet for barren-ground caribou is lichen; thus they are also expected to occur in heath lichen – *cetraria* and heath lichen – hair lichen habitat types in the Project region (Larter and Nagy 1997).

Table 6.6-18: Proportional Use of Habitat Relative to Availability

Habitat Type	Available	Late Winter		Spring Migration		Post Calving		Late Summer		Early Winter		Total	
	% of RSA	% of locations in RSA	Rank[a]	% of locations in RSA	Rank	% of locations in RSA	Rank	% of locations in RSA	Rank	% of locations in RSA	Rank	% of locations in RSA	Rank
Bare Ground	2.1	0	equal	25	more	0	less	0	less	0	less	0.01	equal
Heath Lichen - Hair Lichen	1.8	0	equal	0	equal	0	less	11.1	more	0	less	0.01	equal
Heath Boulder	10.8	3.7	less	0	less	25	more	0	less	15.4	equal	0.09	less
Heath Lichen - *Cetraria*	0.7	0	equal	0	equal	0	equal	0	equal	3.8	equal	0.01	equal
Heath Tundra	44.6	66.7	more	25	less	50	more	66.7	more	69.2	more	0.64	more
Low Shrub	1.4	3.7	equal	0	equal	0	equal	0	equal	3.8	equal	0.03	equal
Tussock-Hummock	10.4	3.7	less	0	less	0	less	11.1	equal	0	less	0.03	less
Water	28.1	22.2	less	50	more	25	equal	11.1	less	7.7	less	0.17	less

[a] If % of RSA and % of locations in RSA were within 5%, they were considered to be used according to availability (equal rank)

RSA = regional study area; % = percent

Water and heath tundra are the dominant habitat classes in the RSA (Table 6.6-18). Heath tundra covers 44.6% of the RSA, and water covers 28.1%. Moderately abundant habitat types in the region included heath boulder (10.8%) and tussock-hummock (10.4%). Heath lichen – hair lichen and heath lichen - *cetraria* habitat types are less abundant (1.8% and 0.7%, respectively), as are bare ground (2.1%), and low shrub (1.4%) communities.

The baseline footprint in the RSA includes the Hamlet of Rankin Inlet (and associated infrastructure), 12 contaminated sites, 1 inactive mine, 2 active exploration camps, 1 territorial park, 1 active quarry, and 1 inactive quarry (Table 6.6-16). Linear developments include an all-season road extending for 10 km between the community and the nearby territorial park, as well as about 58 km of active winter roads between Rankin Inlet and active exploration camps. This total baseline footprint covers approximately 789 ha or 0.3% of the RSA. The Phase 1 AWAR increased the development footprint in the RSA by 27 ha. The Project will increase the development footprint in the RSA by 2526 ha. Cumulative direct effects of development from reference conditions to the expected future scenario will be 3601 ha or 1.5% of the RSA.

In the RSA, direct incremental changes in habitat area from current conditions (including the Phase 1 AWAR) with the application of the Project are expected to be less than 1% for habitat classes other than heath lichen – *cetraria* and heath tundra (Table 6.6-19). Heath lichen - *cetraria* is affected the most by the Project with a predicted decrease in area of 4.67%. The heath lichen-*cetraria* land cover class is found on eskers and the crests and upper slopes of small ridges with poorly developed, rapidly drained soils. The Project development is part of a 6.76% cumulative decline to this habitat class between reference and future conditions. Heath tundra will decrease by 1.47% as a result of Project development. The Project development represents the main source for decrease for this habitat class over the cumulative case (1.80%).

Increasing development on the landscape has resulted in marginal changes to the number of, and distance between similar habitat patches in the RSA. Previous and existing developments have increased the number of patches of all habitat types relative to reference conditions. In particular, the number of heath lichen – *cetraria* and heath tundra patches increased by 2.38 and 2.07%, respectively (Table 6.6-20). The Phase 1 AWAR is expected to further increase the number of patches of all habitat types, and the Project is expected to increase the number of heath tundra, heath boulder, and bare ground patches, while the number of heath lichen – *cetraria*, heath lichen - hair lichen, low shrub, tussock-hummock, and water patches is expected to decrease. A decrease in the number of patches is likely associated with habitat loss.

The distance between neighbouring patches also indicates an increase in fragmentation as a result of the Project; however, the incremental changes from the Project are less than those created by previous and existing developments. Cumulative changes in the distance between neighbouring patches are less than 10% for all habitat types (Table 6.6-20).

Based on nearest neighbour indices, heath lichen – hair lichen, heath boulder, tussock-hummock, and water are distributed randomly across the landscape, while other habitat types occur in more clustered patches (Table 6.6-19). With the exception of heath tundra, the Project (including the Phase 1 AWAR development decreases the nearest neighbour index, changing the landscape structure toward one of more clustered habitat patches.

Table 6.6-19: Direct Change (%) in Area of Habitat Types from Development within the Regional Study Area during Baseline, Project and Future Conditions

Habitat	Reference Area (ha)	Area (ha) Removed from Reference to Baseline	% Change Reference to Baseline	Area (ha) Removed from Baseline to Phase 1 AWAR	% Change Baseline to Phase 1 AWAR	Area (ha) Removed from Phase 1 AWAR to Project	% Change Phase 1 AWAR to Project	Area (ha) Removed from Project to Future	% Change Project to Future	Area (ha) Removed from Reference to Future	% Cumulative Change Reference to Future
Bare ground	5 263.0	246.26	-4.68	0.26	-0.01	32.18	-0.64	0.91	-0.02	279.61	-5.31
Heath Lichen – *Cetraria*	1 733.1	35.18	-2.03	1.90	-0.11	79.13	-4.67	0.95	-0.06	117.16	-6.76
Heath Lichen – Hair Lichen	4 503.5	9.95	-0.22	0.64	-0.01	21.31	-0.47	2.99	-0.07	34.89	-0.77
Heath Boulder	26 499.5	82.24	-0.31	4.88	-0.02	70.59	-0.27	18.84	-0.07	176.55	-0.67
Health Tundra	109 825.9	291.55	-0.27	13.82	-0.01	1608.43	-1.47	60.97	-0.06	1974.76	-1.80
Low Shrub	3 478.3	2.67	-0.08	0.24	-0.01	14.06	-0.40	0.56	-0.02	17.53	-0.50
Tussock Hummock	25 698.7	65.81	-0.26	5.45	-0.02	186.08	-0.73	28.88	-0.11	286.22	-1.11
Water	69 297.8	55.67	-0.08	0.28	<-0.01	514.43	-0.74	35.70	-0.05	606.08	-0.87

AWAR = All-weather Access Road; ha = hectares; % = percent

Table 6.6-20: Direct Change (%) in Number of Patches, Mean Nearest Neighbour Distance, and Nearest Neighbour Index of Habitat Types from Development within the Regional Study Area during Baseline, Project and Future Conditions during Spring to Autumn

Habitat	Number of Patches	% Change Reference to Baseline	% Change Baseline to Phase 1 AWAR	% Change Phase 1 AWAR to Project	% Change Project to Future	% Cumulative Change from Reference	Mean Nearest Neighbour Distance (m)	% Change Reference to Baseline	% Change Baseline to Phase 1 AWAR	% Change Phase 1 AWAR to Project	% Change Project to Future	% Cumulative Change from Reference	Nearest Neighbour Index	% Change Reference to Baseline	% Change Baseline to Phase 1 AWAR	% Change Phase 1 AWAR to Project	% Change Project to Future	% Cumulative Change from Reference
	Reference						Reference						Reference					
Bare ground	989	12.23	0.45	0.27	0.09	13.14	553.4	-9.29	-0.48	0.24	-0.21	-9.70	0.7	-3.90	-0.26	0.37	-0.17	-3.95
Heath Lichen – *Cetraria*	1094	2.38	1.52	-0.97	0.09	3.02	471.8	-2.79	-1.61	-0.18	-0.17	-4.69	0.9	-1.64	-0.87	-0.66	-0.13	-3.26
Heath Lichen – Hair Lichen	2535	0.59	0.24	-1.10	0.24	-0.04	454.4	-0.75	-0.23	0.48	-0.23	-0.73	1.0	-0.46	-0.11	-0.07	-0.11	-0.75
Heath Boulder	2855	2.84	1.29	0.40	0.70	5.32	660.9	-2.64	-1.40	-0.30	-0.56	-4.83	1.0	-1.27	-0.77	-0.10	-0.21	-2.33
Health Tundra	4014	2.07	1.29	0.55	0.81	4.81	323.3	-0.82	-1.19	-0.28	-0.37	-2.63	0.8	0.20	-0.56	<-0.01	0.04	-0.32
Low Shrub	3353	0.06	0.06	-0.74	0.06	-0.57	356.3	-0.15	-0.05	-0.07	-0.09	-0.36	0.8	-0.12	-0.02	-0.44	-0.06	-0.64
Tussock Hummock	5144	1.07	0.60	-0.63	0.54	1.57	361.8	-0.93	-0.61	0.04	-0.36	-1.85	1.0	-0.40	-0.31	-0.28	-0.09	-1.08
Water	4992	0.06	0.06	-0.12	0.34	0.34	371.4	-0.09	-0.07	-0.54	-0.17	-0.87	1.1	-0.06	-0.04	-0.60	<-0.01	-0.70

AWAR = All-weather Access Road; % = percent; m = metre

Direct incremental and cumulative changes in land area developed in the CESA as a result of known and expected future developments, including the Project, are expected to be less than 0.5%. The Project incremental effect is 0.02% (Table 6.6-21). Future developments are expected to have the greatest incremental effect on the amount of land developed in the CESA (Table 6.6-21).

Caribou collar data obtained from the GN suggests that caribou use heath tundra, heath boulder, lichen associated habitats, bare ground and water, low shrub and tussock habitat to varying degrees between seasons. In general, the Project incremental effect to each of these habitat types is less than 0.5%. The greatest Project incremental effect to habitat types that were used more than available by caribou is expected to be lichen tundra (0.14% direct loss). When considered in concert with future developments and historical alterations, the cumulative effect to lichen tundra is estimated at 0.36% within the CESA. The main dietary requirement for barren-ground caribou is lichen. Caribou are expected to use lichen associated habitat within the CESA to some extent year round.

Table 6.6-21: Incremental and Cumulative Change in Land Area in the Caribou Effects Study Area from Direct Effects of Project Development.

Habitat	Reference Area (ha)	Area (ha) Removed from Reference to Baseline	% Change Reference to Baseline	Area (ha) Removed from Baseline to Phase 1 AWAR	% Change Baseline to Phase 1 AWAR	Area (ha) Removed from Phase 1 AWAR to Project	% Change Phase 1 AWAR to Project	Area (ha) Removed from Project to Future	% Change Project to Future	Area (ha) Removed from Reference to Future	% Cumulative Change Reference to Future
Water	3975287.95	929.45	-0.02	0.22	0.00	667.52	-0.02	6085.08	-0.15	7682.27	-0.19
Wet Graminoid	780487.16	103.85	-0.01	3.08	0.00	57.68	-0.01	1597.44	-0.20	1762.06	-0.23
Graminoide tundra	360512.25	46.07	-0.01	0.00	0.00	0.00	0.00	766.55	-0.21	812.63	-0.23
Graminoide/ Heath Tundra	202953.49	60.79	-0.03	0.91	0.00	35.38	-0.02	158.45	-0.08	255.53	-0.13
Graminoide/ Shrub Tundra	205092.42	75.82	-0.04	0.00	0.00	0.00	0.00	161.63	-0.08	237.44	-0.12
Shrub thicket	116493.06	16.46	-0.01	0.00	0.00	0.02	0.00	541.08	-0.46	557.56	-0.48
Shrub tundra	1602334.44	351.01	-0.02	0.00	0.00	0.00	0.00	1357.34	-0.08	1708.35	-0.11
Shrub/ heath tundra	1692220.67	215.33	-0.01	0.18	0.00	24.61	0.00	5316.00	-0.31	5556.11	-0.33
Shrub/ tree complex	12104.70	3.25	-0.03	0.00	0.00	0.00	0.00	0.00	0.00	3.25	-0.03
Tree	112943.34	20.75	-0.02	0.00	0.00	0.00	0.00	21.04	-0.02	41.78	-0.04
Tree/lichen complex	592.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Forbe tundra	92074.26	6.74	-0.01	0.00	0.00	0.00	0.00	782.95	-0.85	789.70	-0.86
Heath tundra	2603738.48	301.63	-0.01	2.96	0.00	174.01	-0.01	6395.51	-0.25	6874.10	-0.26
Heath upland	1034575.64	326.09	-0.03	9.12	0.00	1313.66	-0.13	495.99	-0.05	2144.86	-0.21
Health upland/ rock complex	673282.71	149.81	-0.02	1.85	0.00	25.34	0.00	699.57	-0.10	876.57	-0.13
Lichen tundra	41707.27	66.82	-0.16	2.09	-0.01	57.55	-0.14	25.52	-0.06	151.98	-0.36
Lichen/ rock complex	154577.65	65.55	-0.04	0.56	0.00	30.24	-0.02	37.17	-0.02	133.52	-0.09
Sand	7418.04	8.07	-0.11	0.00	0.00	0.10	0.00	3.32	-0.04	11.49	-0.15
Boulder/gravel	233381.07	11.92	-0.01	0.00	0.00	4.33	0.00	269.20	-0.12	285.45	-0.12
Rock	35624.44	21.79	-0.06	0.00	0.00	0.10	0.00	40.90	-0.11	62.79	-0.18
Disturbance	2714.60	609.79	-22.46	0.34	-0.02	6.94	-0.33	23.47	-1.12	640.54	-23.60
Other	851366.96	588.44	-0.07	1.44	0.00	168.30	-0.02	2055.56	-0.24	2813.74	-0.33

AWAR = All-weather Access Road; ha = hectare; % = percent

A total of 74% of the land disturbed by the Project (including Phase 2 AWAR) and the Phase 1 AWAR will be reclaimed to lichen rock communities, water bodies, or scarified natural re-vegetation (Table 6.6-22). Of the heath tundra disturbed by the Project, 31%, or 496.41 ha will be permanently lost. Likewse, 36%, or 29 ha of the disturbed health lichen – *cetraria* habitat will be permanently lost.

Table 6.6-22: Reclaimed Habitat in the Regional Study Area

Habitat	Area (ha) Removed by Phase 1 AWAR	Area (ha) Removed by Project	Total Area (ha) Disturbed by Phase 1 AWAR and Project	Area (ha) Reclaimed to Lichen Rock Community	Area (ha) Reclaimed to Waterbodies	Area (ha) Reclaimed to Scarified Natural Re-vegetation	Total Area (ha) Reclaimed	Total Area (ha) Permanent Loss	% Project and Phase 1 AWAR not Reclaimed	% Project and Phase 1 AWAR Reclaimed
Bare Ground (Rock Outcrop)	0.26	32.18	32.44	0.19	4.80	24.09	29.08	3.36	10.36	89.64
Heath Boulder	4.88	70.59	75.47	11.14	0.68	58.27	70.09	5.38	7.13	92.87
Heath Lichen - *cetraria*	1.90	79.13	81.03	33.45	4.67	13.74	51.85	29.18	36.01	63.99
Heath Lichen - Hair Lichen	0.64	21.31	21.95	1.97	0.84	21.01	23.82	-1.87*	-8.50	108.50
Heath Tundra	13.82	1 608.43	1 622.25	612.24	230.41	283.19	1 125.84	496.41	30.60	69.40
Low Shrub	0.24	14.06	14.30	2.28	1.28	3.10	6.66	7.64	53.40	46.60
Tussock - Hummock	5.45	186.08	191.53	81.08	36.50	64.72	182.30	9.23	4.82	95.18
Water	0.28	514.43	514.71	173.49	177.68	43.19	394.36	120.35	23.38	76.62
Total	**27.47**	**2 526.21**	**2 553.68**	**915.83**	**456.86**	**511.31**	**1 884.00**	**669.68**	**26.22**	**73.78**

Note: Reclamation of the Phase 1 AWAR and the Project footprint results in a net gain in habitat because some of the area removed by these footprints was removed from existing baseline footprint rather than undisturbed habitat.

ha = hectare; % = percent

6.6.4.2 Habitat Quality, Behaviour and Movement

- **Sensory disturbance can change the amount of different quality habitats, and alter movement and avoidance behaviour**
- **Disruption or alteration of migration routes from the presence of the mine or from mine-related activities**

6.6.4.2.1 Methods

Indirect habitat loss

In addition to direct habitat effects, changes to habitat quality from the Project and other developments have the potential to indirectly affect the population size and distribution of barren-ground caribou. Wildlife distribution can be negatively affected by sensory disturbance (e.g., increased noise levels during construction and visual disturbances from moving vehicles and humans throughout operation) because animals may avoid (i.e., change movement patterns or flee the area) areas with human disturbance (Tyler 1991; Fortin and Andruskiw 2003; Bayne et al. 2008). Dust can also change the quality of forage, potentially leading to caribou avoidance of areas with high amounts of dust deposition. This avoidance may reduce the amount of different quality habitats available for use, and change fitness because energy that could be allocated to survival or reproduction is instead used to cope with disturbance (Bisson et al. 2009).

Some studies have shown no responses (e.g., no changes in activity levels from baseline conditions; Telesco and VanManen 2006) or transitory responses (e.g., returning to normal hormone, heart rate, or activity levels within a few minutes; Krausman and Hervert 1983; Weisenberger et al. 1996) of ungulates and carnivores to human disturbance. Previously completed work in the Canadian Arctic suggests that sensory disturbances from development influence wildlife behaviour, movements, and distributions. For example, long-term monitoring at diamond mines in the NT have suggested that caribou groups with calves spend less time feeding within 5 km of the footprint (BHPB 2004), and that mines cause changes to caribou distribution, leading to lower probability of occurrence within 6 to 14 km (Boulanger et al. 2012). The mechanism causing these effects is not yet understood, but is likely a combination of direct effects (such as physical footprint) and indirect effects (noise, dust, activity, and smells). No literature on the effects of in-ground or in-water vibrations (e.g., from blasting activities) to terrestrial wildlife could be found, although marine mammals and fish may be affected by in-water vibrations.

A conservative approach to estimating the potential incremental and cumulative changes in barren-ground caribou habitat from the Project and other developments was taken for this assessment using maximum published disturbance coefficients (DCs) and ZOIs from empirical studies (Table 6.6-23). Indirect effects from disturbance were determined by applying hypothetical (not modelled) DCs and ZOI to footprints described for the reference development case and combining these with the ELC data for the RSA. Hypothetical disturbance coefficients provided a surrogate to modelled coefficients and were consistent with previously published efforts to estimate effects from development on habitat quality for caribou (Johnson et al. 2005). Disturbance coefficients reduce habitat quality within each defined ZOI. For example, a DC of 0.05 implies that habitat quality was reduced by 95% of the original value. For this analysis, the reduction in habitat quality is represented by a reduction in habitat quantity. The areal amount of habitat available in each ZOI was reduced by the value of the

DC. This assumes that the effect on carrying capacity for a decrease in habitat quality is proportional to a decrease in habitat quantity.

Table 6.6-23: Disturbance Coefficients and Associated Zones of Influence for Development Activities in the Regional Study Area

Disturbance Type	Feature Type	Footprint		ZOI Range 1		ZOI Range 2		ZOI Range 3	
		Extent (m)[a]	DC	Range[b](km)	DC	Range (km)	DC	Range (km)	DC
Campgrounds	point	200	0	n/a	n/a	n/a	n/a	n/a	n/a
Community	polygon	actual	0	0 to 1	0.05	1 to 5	0.5	5 to 15	0.75
Contaminated Sites	point	200	0	n/a	n/a	n/a	n/a	n/a	n/a
Fuel storage	point	200	0	0 to 5	0.75	n/a	n/a	n/a	n/a
Mineral exploration	point	500	0	0 to 5	0.5	n/a	n/a	5 to 14	0.75
Operating mine	polygon	Actual/500	0	0 to 1	0.05	1 to 5	0.5	5 to 14	0.75
Power	point	500	0	0 to 1	0.5	n/a	n/a	n/a	n/a
Quarry	point	200	0	0 to 5	0.75	n/a	n/a	n/a	n/a
Territorial Park	point	200	0	0 to 1	0.90	n/a	n/a	n/a	n/a
Miscellaneous	point	200	0	0 to 5	0.75	n/a	n/a	n/a	n/a
Road	line	actual	0	0 to 1	0.05	1 to 5	0.75	n/a	n/a

Note: DC and ZOI values were guided by published literature (Johnson et al. 2005; Weir et al. 2007; Boulanger et al. 2009).

[a] Footprints estimated with the exception of communities, operating mines, and roads which were delineated and digitized from remote sensing imagery.

[b] From edge of measured or hypothetical footprint.

n/a = not applicable; DC = disturbance coefficient; ZOI = zone of influence; m = metre; km = kilometre.

Several assumptions were made concerning the temporal and spatial extent of effects from the different types of development, particularly with respect to estimating the cumulative effects on caribou. For example, the effects of multiple coefficients at the same location were not multiplied. The coefficient with the strongest effect was applied where ZOIs overlapped, which increased certainty that the predicted effect would not be underestimated. In addition, the development layer database does not contain information on the duration of activities associated with land use permits. For example, although the land use permit for mineral exploration may be active for 5 years, there are no data on the actual frequency and length of time that exploration activities occurred during that period. Subsequently, to estimate the temporal extent of the ZOI from exploration sites, the analysis assumed that approved land use permits were active for 5 years. The assumption likely overestimates the effect from exploration activities, as exploration typically does not occur throughout the year. For all closed mines and inactive land use permits, the physical footprint was carried through the entire effects analysis as it was assumed that direct disturbance to the landscape had not yet been reversed. It is expected that the ZOI surrounding development footprints would account for disturbance from helicopters and aeromagnetic surveys. Projects that do not require a land use permit under the Territorial Land Use Regulations; however, could not be included in this assessment. Mineral exporation activities involving helicopter usage and aeromagnetic surveys do not typically meet the minimum criteria for requiring such a land use permits and thus are not included in the assessment of effects (Territorial Land Use Regulations 2014).

Direct and indirect effects from human disturbance were used to quantify changes in the relative availability of different habitats types, as defined in the ELC, under each development case described above: reference, baseline, Phase 1 AWAR, Project (mine footprint, Rankin Inlet infrastructure, and Phase 2 AWAR) and future

case. Changes within the CESA were also calculated for each case based on GN ELC data (Campbell et al. 2012). Reference conditions represent the initial period of baseline conditions (as far back as data are available). Here, the baseline case includes all previous, existing, and approved developments up to 2012, and includes the winter access road used during exploration for the Project.

The following proposed projects have been selected as a suite of major developments that may occur in the foreseeable future:

- The Manitoba to Nunavut Road – This major project has received ongoing support from the governments of Nunavut and Manitoba. Although no permit applications have yet been filed, a preferred alignment has been selected, and the project would change the face of development in the Kivalliq region.
- The Churchill Diamonds Project – This project is currently in the exploration phase and applications have not been made to advance to mining, but it was included as a likely project to be induced by the Manitoba to Nunavut Road, and was identified in the Manitoba to Nunavut Road route selection study as such. Although formally outside of the CESA, this project was conservatively included as a future development because it would have impacts to the socio-economics of the region, and may have impacts related to sensory disturbance on the Qamanirjuaq caribou herd.
- The Ferguson Lake Project – This project is currently in the exploration phase and applications have not been made to advance to mining, but a scoping study has investigated the possibility of advancing to mining. This project was included as a likely project to be induced by the Manitoba to Nunavut Road, and was identified in the Manitoba to Nunavut Road route selection study as such.
- The Kiggavik Uranium Project – This project is currently undergoing review to become a uranium mine. Although formally outside of the CESA, this project was conservatively included as a future development because it would have impacts to the socio-economics of the region, and may have impacts related to sensory disturbance on the Qamanirjuaq caribou herd.

The Wolf deposit, located north-west of the Tiriganiaq deposit, is currently known, but still requires some exploration work to be better defined and included in the mine plan. Currently, the Wolf deposit does not have sufficient proven reserves to be economically mined and so was not included as a development, or as part of the Project. An environmental impact assessment (including a cumulative effects analysis) for the Wolf deposit will be completed in the future if the deposit becomes economically feasible to be developed.

The following equations were used to estimate the relative change in the amount of each habitat type in the RSA and CESA for each development case:

- Existing cumulative effects = (baseline value – reference value) / reference value;
- Phase 1 AWAR incremental effects = (AWAR 1 – baseline value) / baseline value;
- Project and Phase 2 AWAR incremental effects = (Project value – AWAR 1) / AWAR 1;
- Future incremental effects = (future value – Project value) / Project value; and
- Future cumulative effects = (future value – reference value)/ reference value.

Spatial and Temporal Use

Direct and indirect habitat loss only affects the proportion of the population that would have encountered that habitat. Species may also be more sensitive or vulnerable to disturbance during certain times of the year. Caribou are likely to be more sensitive and vulnerable to disturbance during the breeding season. Adults are more protective of their young and may have lower tolerance to perceived threats (Maier et al. 1998). Females are also investing a lot of energy into milk production, which lowers the amount of energy that is available for fleeing from apparent threats. The magnitude of population level effects depends on what proportion of the population has potential to be affected by the disturbance. Understanding the temporal and spatial overlap between caribou of the Qamanirjuaq herd and the RSA and LSA will help assess the magnitude of impacts of the Project to this caribou herd.

The proportion of collared animals and pooled collar locations were calculated and compared at 3 spatial scales across all caribou seasons: inside and outside the RSA, in the 0 to 14 km ZOI and the 14 to 28 km control zone within the RSA, and inside and outside the LSA. Individuals in the RSA may come into contact with Project related effects, those in the 0 to 14 km buffer will be exposed to sensory disturbance, and those in the LSA will interact directly with the Project footprint. Assessing these spatial and temporal relationships help to quantify the potential impacts to the population. They also provide a before disturbance baseline that can be used to assess whether changes will occur in caribou distribution during the construction and operation of the mine.

Caribou density surfaces (number of locations per square kilometre) were developed using ESRI's Spatial Analyst extension. These identify where and at what relative density caribou detections are expected. Because they are developed for the annual home range, they indicate the relative importance of regions in the RSA to the herd. Each density surface was based on a kernel analysis for the extent of the annual home range, at an output cell size of 100 m. Separate density analyses were generated for each of the 5 seasons when caribou collar locations were recorded in the RSA: late winter, spring migration, post calving, late summer, and early winter. The search radius for each analysis was based on average daily movement statistics determined for each of the 5 seasons (Table 6.6-24).

Table 6.6-24: Search Radii for Density Surface Creation

Season[a]	Search Radius (m)
Late winter	3 220
Spring migration	6 900
Post calving	12 080
Late summer	7 610
Early winter	7 250

[a] No collar locations were present in the RSA for the calving, fall or fall rut seasons.

The density surfaces were grouped into 6 density classes – 5 density classes were determined based on a natural breaks classification, and a 0 density value was added. The classes developed are unique to each season and therefore should be considered as relative density values. The area of each density class within the RSA was summarized in the context of the home range to quantify the amount of each density class as a percentage of the total of that class within the entire range. These statistics help quantify the amount of available habitat within the home range potentially impacted by the proposed development.

Movement

Fragmentation and direct and indirect habitat loss can change movement behaviour and interrupt seasonal movements. Movement was assessed through IQ (Inuit Traditional Knowledge) investigations, and also by mapping subsequent collar locations in the region. Within the RSA, potential movement paths were mapped for each animal by connecting each telemetry location together. Directional arrows were assigned according to date of detection.

6.6.4.2.2 Results

Indirect habitat loss

Direct and indirect incremental decreases in habitat due to the Project, relative to the Phase 1 AWAR, are expected to range between 1.25% and 9.01%, depending on the habitat type (Table 6.6-25). Heath lichen - *cetraria* and heath tundra habitat types will be affected the most by expected Project related sensory disturbance. While heath lichen - *cetraria* is either not used or used in proportion to availability, heath tundra is used more than availability during late and early winter, late summer, and the post calving season, based on collar data (Table 6.6-18). Heath boulder and heath lichen – hair lichen habitat are expected to decrease in area by 3.58 and 4.42% as a result of the direct and indirect effects from the Project (Table 6.6-24). These habitats are used more than available during the post calving and late summer seasons, respectively (Table 6.6-17).

Within the RSA, direct and indirect cumulative changes in habitat area are expected to range between 18.5% and 43.5% (Table 6.6-25). These large effect sizes are mainly the result of ZOI around previous and existing developments (Table 6.6-26). The habitat types expected to undergo the largest decreases in area due to cumulative developments, heath lichen - *cetraria* and bare ground, are used less than or equal to their availability in the RSA during late winter, post calving, late summer, and early winter, according to collar data (Table 6.6-18). During spring migration, when caribou move across the landscape, habitats with little vegetation cover (e.g., bare ground) are used disproportionally compared to overall habitat availability.

Table 6.6-25: Direct and Indirect Effects Measured as Change (percent) in Area of Habitat Types from Development Footprints and Zones of Influence within the Regional Study Area for Wildlife from Reference Conditions to Baseline, Project, and Future Conditions

Habitat	Reference Area (ha)	Area (ha) Removed from Reference to Baseline	% Change Reference to Baseline	Area (ha) Removed from Baseline to Phase 1 AWAR	% Change Baseline to Phase 1 AWAR	Area (ha) Removed from Phase 1 AWAR to Project	% Change Phase 1 AWAR to Project	Area (ha) Removed from Project to Future	% Change Project to Future	Area (ha) Removed from Reference to Future	% Cumulative Change Reference to Future
Bare Ground	5 263.0	1 807.8	-34.35	18.6	-0.54	42.8	-1.25	60.4	-1.78	1 929.7	-36.66
Heath Lichen - Hair Lichen	4 503.5	632.8	-14.05	26.8	-0.69	169.8	-4.42	121.9	-3.32	951.3	-21.12
Heath Boulder	26 499.5	3 185.8	-12.02	231.0	-0.99	826.4	-3.58	712.1	-3.20	4 955.4	-18.70
Heath Lichen - *Cetraria*	1 733.1	578.9	-33.40	39.7	-3.44	100.5	-9.01	34.5	-3.40	753.6	-43.48
Heath Tundra	109 825.9	17 521.7	-15.95	1187.1	-1.29	6877.2	-7.55	2540.8	-3.02	28 126.8	-25.61
Low Shrub	3 478.3	402.0	-11.56	5.4	-0.18	185.9	-6.05	50.0	-1.73	643.2	-18.49
Tussock-Hummock	25 698.7	3 491.9	-13.59	336.7	-1.52	1196.0	-5.47	1021.7	-4.94	6 046.3	-23.53
Water	69 297.8	13 155.4	-18.98	333.9	-0.59	3441.9	-6.17	1579.0	-3.02	18 510.1	-26.71

AWAR = All-weather Access Road; % = percent; ha = hectare

Direct incremental and cumulative changes in area in the CESA as a result of known and expected future developments and their ZOI, including the Project, are expected to be less than 3.0% of the CESA (Table 6.6-26). Baseline developments had a greater incremental effect on the percent change in area due to development in the CESA than expected from the Project or future developments. Direct and indirect effects from the Project are expected to reduce available habitat by 0.10%.

Caribou collar data obtained from GN suggest that caribou use heath tundra, heath boulder, lichen associated habitats, bare ground and water, low shrub and tussock habitat to varying degrees between seasons. In general, the Project incremental direct and indirect (ZOI) effects to each of these habitat types is less than 0.5% with the expection of effects on lichen tundra habitat (1.72% direct and indirect loss). The majority of incremental effects on lichen tundra habitat are attributated to baseline developments (11.68%) with less anticipated direct and indirect loss associated with the Project and future projects (2.13%). Caribou forage on lichen and may occur in lichen associated habitat types year round. Direct and indirect changes to lichen associated habitat reduces the available foraging habitat for caribou in the CESA.

Baseline developments had a greater incremental percent change on the majority of habitat types than the Project or future development with the exception of wet graminoid, graminoid/heath tundra, shrub thicket, shrub tundra, shrub/ heath tundra, tree, tree/ lichen, forbe tundra and heath tundra. Of these, the incremental effect of the Project and future development was similar (less than 1% difference) to that of baseline developments except for shrub thicket and forbe tundra.

Table 6.6-26: Incremental and Cumulative Change in Land Area in the Caribou Effects Study Area from Direct and Indirect Effects of Development

Habitat	Reference Area (ha)	Area (ha) Removed from Reference to Baseline	% Change Reference to Baseline	Area (ha) Removed from Baseline to Phase 1 AWAR	% Change Baseline to Phase 1 AWAR	Area (ha) Removed from Phase 1 AWAR to Project	% Change Phase 1 AWAR to Project	Area (ha) Removed from Project to Future	% Change Project to Future	Area (ha) Removed from Reference to Future	% Cumulative Change Reference to Future
Water	3975287.95	55582.71	-1.40	389.77	-0.01	4468.66	-0.11	48953.36	-1.25	109394.51	-2.75
Wet Graminoid	780487.16	15452.28	-1.98	246.08	-0.03	808.05	-0.11	17902.15	-2.34	34408.56	-4.41
Graminoide tundra	360512.25	16419.94	-4.55	0.00	0.00	1.52	0.00	3057.01	-0.89	19478.47	-5.40
Graminoide/ Heath Tundra	202953.49	3747.38	-1.85	101.44	-0.05	332.46	-0.17	3834.55	-1.93	8015.83	-3.95
Graminoide/ Shrub Tundra	205092.42	11338.15	-5.53	0.00	0.00	0.00	0.00	416.23	-0.21	11754.37	-5.73
Shrub thicket	116493.06	801.18	-0.69	0.00	0.00	2.05	0.00	5546.39	-4.79	6349.62	-5.45
Shrub tundra	1602334.44	8233.36	-0.51	0.00	0.00	0.00	0.00	8656.28	-0.54	16889.64	-1.05
Shrub/ heath tundra	1692220.67	13792.59	-0.82	20.10	0.00	347.92	-0.02	17446.52	-1.04	31607.14	-1.87
Shrub/ tree complex	12104.70	24.57	-0.20	0.00	0.00	0.00	0.00	0.00	0.00	24.57	-0.20
Tree	112943.34	237.49	-0.21	0.00	0.00	0.00	0.00	1049.36	-0.93	1286.85	-1.14
Tree/lichen complex	592.80	9.52	-1.61	0.00	0.00	0.00	0.00	11.05	-1.89	20.57	-3.47
Forbe tundra	92074.26	729.63	-0.79	0.00	0.00	0.00	0.00	2199.09	-2.41	2928.72	-3.18
Heath tundra	2603738.48	23872.64	-0.92	240.63	-0.01	1352.44	-0.05	42228.26	-1.64	67693.97	-2.60
Heath upland	1034575.64	20360.16	-1.97	617.39	-0.06	4126.14	-0.41	10625.58	-1.05	35729.26	-3.45
Health upldand/ rock complex	673282.71	9887.58	-1.47	76.70	-0.01	524.55	-0.08	6709.77	-1.01	17198.60	-2.55

Habitat	Reference Area (ha)	Area (ha) Removed from Reference to Baseline	% Change Reference to Baseline	Area (ha) Removed from Baseline to Phase 1 AWAR	% Change Baseline to Phase 1 AWAR	Area (ha) Removed from Phase 1 AWAR to Project	% Change Phase 1 AWAR to Project	Area (ha) Removed from Project to Future	% Change Project to Future	Area (ha) Removed from Reference to Future	% Cumulative Change Reference to Future
Lichen tundra	41707.27	4870.70	-11.68	68.02	-0.18	630.77	-1.72	770.81	-2.13	6340.29	-15.20
Lichen/ rock complex	154577.65	3773.02	-2.44	59.24	-0.04	97.24	-0.06	972.27	-0.65	4901.77	-3.17
Sand	7418.04	435.14	-5.87	0.00	0.00	0.26	0.00	57.71	-0.83	493.10	-6.65
Boulder/gravel	233381.07	2949.77	-1.26	19.12	-0.01	152.65	-0.07	1378.20	-0.60	4499.74	-1.93
Rock	35624.44	1926.57	-5.41	1.79	-0.01	51.28	-0.15	552.99	-1.64	2532.62	-7.11
Disturbance	2714.60	1690.32	-62.27	0.02	0.00	0.35	-0.03	366.27	-35.77	2056.95	-75.77
Other	851366.96	31640.43	-3.72	255.60	-0.03	1515.84	-0.18	19097.44	-2.33	52509.31	-6.17

Spatial and Temporal Use

In total there were 39 890 caribou locations recorded across the annual Qamairjuaq herd home range during the 14 year collaring program. Less than 1% of seasonal locations were recorded inside the RSA in any season (Table 6.6-27), and no locations were detected in the RSA during the calving, fall, or fall rut seasons. Of the detections inside the RSA, the majority occurred within the 14 km ZOI identified for mine developments; however, very few of these (3 locations over the entire program) occurred within the LSA.

Table 6.6-27: Distribution of Caribou Locations in the Regional Study Area and Local Study Area[a]

Season	Total # Collared Individuals in RSA[b]	% Locations inside RSA	Total # Locations in RSA	% RSA Locations in ZOI (0 to 14 km)	Total # Locations in ZOI	% ZOI Locations in LSA	Total # ZOI Locations in LSA
Late winter	2	0.35	27	70.4	19	5.26	1
Spring migration	2	0.07	4	50	2	0	0
Post calving	3	0.09	4	25	1	0	0
Late summer	3	0.17	9	55.6	5	0	0
Early winter	1	0.45	26	50	13	15.38	2

[a] GN Caribou data were collected and compiled by Government of Nunavut (GN), Department of Environment, Wildlife Division (Mitch Campbell) and represents a collaborative effort between the GN, Gebauer & Associates, Caslys Consulting and Golder Associates Ltd.

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[b] The number of collared animals varied by year and season, thus the total number of collared individuals represent varying proportions of the collared population for each season.

RSA = regional study area; LSA = local study area; ZOI = zone of influence; % = percent

Across the annual home range, density of collar locations ranged from 0 to 5.7 locations/km^2 (Table 6.6-28). Higher density areas may indicate either more collared caribou occurred in that region or individuals remained in that region for a longer period of time, hence accumulating more daily collar fixes. Thus, this is a measure of relative density among regions.

Table 6.6-28: Seasonal Relative Density Classes[a]

Season	Class	Relative Density (locations/km^2)	% in Annual Home Range	% in Regional Study Area
Late winter	Very low	0.001 to 0.045	46.7	0.5
	Low	0.046 to 0.223	44.1	0.4
	Moderate	0.224 to 0.603	7.8	0.4
	High	0.604 to 1.518	1.3	0
	Very high	1.519 to 5.693	0.1	0
Spring migration	Very low	0.001 to 0.025	60.1	0.4
	Low	0.026 to 0.096	29.3	0.1
	Moderate	0.097 to 0.233	8.7	0
	High	0.234 to 0.496	1.7	0
	Very high	0.497 to 1.062	0.2	0
Post calving	Very low	0.001 to 0.010	41.4	2.3
	Low	0.011 to 0.035	27.1	0.3
	Moderate	0.036 to 0.068	17.4	0
	High	0.069 to 0.112	10.0	0
	Very high	0.113 to 0.251	4.1	0
Late summer	Very low	0.001 to 0.016	47.9	1.0
	Low	0.017 to 0.053	38.0	0.2
	Moderate	0.054 to 0.123	12.2	0
	High	0.124 to 0.309	1.9	0
	Very high	0.310 to 0.679	0.1	0
Early winter	Very low	0.001 to 0.015	43.9	1.0
	Low	0.016 to 0.054	40.5	0.7
	Moderate	0.055 to 0.127	13.4	0.3
	High	0.128 to 0.408	2.1	0
	Very high	0.409 to 0.981	0.1	0

[a] GN Caribou data were collected and compiled by Government of Nunavut (GN), Department of Environment, Wildlife Division (Mitch Campbell) and represents a collaborative effort between the GN, Gebauer & Associates, Caslys Consulting, and Golder Associates Ltd.

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The RSA contains very low to moderate relative densities of caribou locations in any season, ranging from 0 to 0.6 locations/km^2, and less than 3% of regions where estimated density is above 0 occur in the RSA (Figures 6.6-8 to 6.6-12; Table 6.6-28).

GN Caribou data were collected and compiled by Government of Nunavut (GN), Department of Environment, Wildlife Division (Mitch Campbell) and represents a collaborative effort between the GN, Gebauer & Associates Ltd., Caslys Consulting Ltd. and Golder Associates Ltd.

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Background:
Official home ranges were provided by the Government of Nunavut and are part of a publication. The ESA citation is as follows:

Nagy, J. A., D. L. Johnson, N. C. Larter, M. W. Campbell, A. E. Derocher, A. Kelly, M. Dumond, D. Allaire, and B. Croft.
Subpopulation structure of caribou (Rangifer tarandus L.) in arctic and subarctic Canada. Ecological Applications doi:10.1890/10-1410.1].

510000 520000 530000 540000 550000 560000 570000

7010000 7000000 6990000 6980000 6970000 6960000

Peter Lake
Meliadine Lake
Parallel Lake
Diana Lake
Meliadine River
Hudson Bay
Tiriganiaq Pit
Wesmeg Pit
Pump Pit
F Zone Pits
Discovery Pit
Rankin Inlet

N

LEGEND

- Late Winter Caribou Location Observation
- Proposed Project Infrastructure
- All-weather Access Road (AWAR)
- Watercourse
- Waterbody
- Local Study Area (LSA)
- Regional Study Area (RSA)

Caribou density (per km²)

- In unshaded areas no caribou were observed.
- Very Low (0.001 - 0.045)
- Low (0.046 - 0.223)
- Moderate (0.224 - 0.603)

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM), National Topographic Database
Caribou Data from Department of Environment (Government of Nunavut).
Datum: NAD 83 Projection: UTM Zone 15

2 0 2
KILOMETRES

PROJECT
AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE
RELATIVE DENSITY OF COLLAR LOCATIONS IN THE RSA - LATE WINTER

PROJECT NO. 10-1373-0076			FILE No.		
DESIGN	KD	18 Jan. 2013	SCALE AS SHOWN	REV.	0
GIS	Caslys	7 Mar. 2014			
CHECK	KD	7 Mar. 2014			
REVIEW	DW	7 Mar. 2014			

Golder Associates

FIGURE 6.6-8

GN Caribou data were collected and compiled by Government of Nunavut (GN), Department of Environment, Wildlife Division (Mitch Campbell) and represents a collaborative effort between the GN, Gebauer & Associates Ltd., Caslys Consulting Ltd. and Golder Associates Ltd.

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Background:
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Nagy, J. A., D. L. Johnson, N. C. Larter, M. W. Campbell, A. E. Derocher, A. Kelly, M. Dumond, D. Allaire, and B. Croft. Subpopulation structure of caribou (Rangifer tarandus L.) in arctic and subarctic Canada. Ecological Applications doi:10.1890/10-1410.1].

LEGEND

- Spring Migration Caribou Location Observation
- Proposed Project Infrastructure
- All-weather Access Road (AWAR)
- Watercourse
- Waterbody
- Local Study Area (LSA)
- Regional Study Area (RSA)

Caribou density (per km²)

- In unshaded areas no caribou were observed.
- Very Low (0.001 - 0.025)
- Low (0.026 - 0.096)

Peter Lake
Meliadine Lake
Parallel Lake
Diana Lake
Meliadine River
Hudson Bay
Tiriganiaq Pit
Wesmeg Pit
Rump Pit
F Zone Pits
Discovery Pit
Rankin Inlet

N

Area of Detail
Qamanirjuaq Herd Annual Home Range
Nunavut

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM), National Topographic Database
Caribou Data from Department of Environment (Government of Nunavut).
Datum: NAD 83 Projection: UTM Zone 15

2 0 2
KILOMETRES

PROJECT
AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE
RELATIVE DENSITY OF COLLAR LOCATIONS IN THE RSA - SPRING MIGRATION

PROJECT NO. 10-1373-0076			FILE No.		
DESIGN	KD	18 Jan. 2013	SCALE AS SHOWN	REV.	0
GIS	Caslys	7 Mar. 2014			
CHECK	KD	7 Mar. 2014			
REVIEW	DW	7 Mar. 2014			

Golder Associates

FIGURE 6.6-9

GN Caribou data were collected and compiled by Government of Nunavut (GN), Department of Environment, Wildlife Division (Mitch Campbell) and represents a collaborative effort between the GN, Gebauer & Associates Ltd., Caslys Consulting Ltd. and Golder Associates Ltd.

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Background:
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Nagy, J. A., D. L. Johnson, N. C. Larter, M. W. Campbell, A. E. Derocher, A. Kelly, M. Dumond, D. Allaire, and B. Croft. Subpopulation structure of caribou (Rangifer tarandus L.) in arctic and subarctic Canada. Ecological Applications doi:10.1890/10-1410.1].

510000 520000 530000 540000 550000 560000 570000

7010000 7000000 6990000 6980000 6970000 6960000

Peter Lake
Meliadine Lake
Parallel Lake
Diana Lake
Meliadine River
Hudson Bay
Rankin Inlet
Tiriganiaq Pit
Wesmeg Pit
Rump Pit
F Zone Pits
Discovery Pit

N

LEGEND

- Post Calving Caribou Location Observation
- Proposed Project Infrastructure
- All-weather Access Road (AWAR)
- Watercourse
- Waterbody
- Local Study Area (LSA)
- Regional Study Area (RSA)

Caribou density (per km²)

- In unshaded areas no caribou were observed.
- Very Low (0.001 - 0.010)
- Low (0.011 - 0.035)
- Moderate (0.036 - 0.068)
- High (0.069 - 0.112)

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM), National Topographic Database
Caribou Data from Department of Environment (Government of Nunavut).
Datum: NAD 83 Projection: UTM Zone 15

2 0 2
KILOMETRES

PROJECT
AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE
RELATIVE DENSITY OF COLLAR LOCATIONS IN THE RSA - POST CALVING

		PROJECT NO. 10-1373-0076		FILE No.	
DESIGN	KD	18 Jan. 2013	SCALE AS SHOWN	REV.	0
GIS	Caslys	7 Mar. 2014			
CHECK	KD	7 Mar. 2014			
REVIEW	DW	7 Mar. 2014			

Golder Associates

FIGURE 6.6-10

GN Caribou data were collected and compiled by Government of Nunavut (GN), Department of Environment, Wildlife Division (Mitch Campbell) and represents a collaborative effort between the GN, Gebauer & Associates Ltd., Caslys Consulting Ltd. and Golder Associates Ltd.

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Background:
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Nagy, J. A., D. L. Johnson, N. C. Larter, M. W. Campbell, A. E. Derocher, A. Kelly, M. Dumond, D. Allaire, and B. Croft.
Subpopulation structure of caribou (Rangifer tarandus L.) in arctic and subarctic Canada. Ecological Applications doi:10.1890/10-1410.1].

510000 520000 530000 540000 550000 560000 570000

7010000 7000000 6990000 6980000 6970000 6960000

Peter Lake
Meliadine Lake
Parallel Lake
Diana Lake
Meliadine River
Hudson Bay
Rankin Inlet
Tiriganiaq Pit
Wesmeg Pit
Pump Pit
F Zone Pits
Discovery Pit

N

LEGEND

- Late Summer Caribou Location Observation
- Proposed Project Infrastructure
- All-weather Access Road (AWAR)
- Watercourse
- Waterbody
- Local Study Area (LSA)
- Regional Study Area (RSA)

Caribou density (per km²)

- In unshaded areas no caribou were observed.
- Very Low (0.001 - 0.016)
- Low (0.017 - 0.053)
- Moderate (0.054 - 0.123)
- High (0.124 - 0.309)

Area of Detail

Qamanirjuaq Herd Annual Home Range

Nunavut

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM), National Topographic Database
Caribou Data from Department of Environment (Government of Nunavut).
Datum: NAD 83 Projection: UTM Zone 15

2 0 2
KILOMETRES

PROJECT
AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE
RELATIVE DENSITY OF COLLAR LOCATIONS IN THE RSA - LATE SUMMER

PROJECT NO. 10-1373-0076			FILE No.		
DESIGN	KD	18 Jan. 2013	SCALE AS SHOWN	REV.	0
GIS	Caslys	7 Mar. 2014			
CHECK	KD	7 Mar. 2014			
REVIEW	DW	7 Mar. 2014			

Golder Associates

FIGURE 6.6-11

GN Caribou data were collected and compiled by Government of Nunavut (GN), Department of Environment, Wildlife Division (Mitch Campbell) and represents a collaborative effort between the GN, Gebauer & Associates Ltd., Caslys Consulting Ltd. and Golder Associates Ltd.

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Background:
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Nagy, J. A., D. L. Johnson, N. C. Larter, M. W. Campbell, A. E. Derocher, A. Kelly, M. Dumond, D. Allaire, and B. Croft.
Subpopulation structure of caribou (Rangifer tarandus L.) in arctic and subarctic Canada. Ecological Applications doi:10.1890/10-1410.1].

510000 520000 530000 540000 550000 560000 570000

7010000 7000000 6990000 6980000 6970000 6960000

Peter Lake
Meliadine Lake
Parallel Lake
Diana Lake
Meliadine River
Hudson Bay
Tiriganiaq Pit
Wesmeg Pit
Pump Pit
F Zone Pits
Discovery Pit
Rankin Inlet

N

LEGEND

- Early Winter Caribou Location Observation
- Proposed Project Infrastructure
- All-weather Access Road (AWAR)
- Watercourse
- Waterbody
- Local Study Area (LSA)
- Regional Study Area (RSA)

Caribou density (per km²)

- In unshaded areas no caribou were observed.
- Very Low (0.001 - 0.015)
- Low (0.016 - 0.054)
- Moderate (0.055 - 0.127)

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM), National Topographic Database
Caribou Data from Department of Environment (Government of Nunavut).
Datum: NAD 83 Projection: UTM Zone 15

2 0 2
KILOMETRES

PROJECT
AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE
RELATIVE DENSITY OF COLLAR LOCATIONS IN THE RSA - EARLY WINTER

PROJECT NO. 10-1373-0076			FILE No.		
DESIGN	KD	18 Jan. 2013	SCALE AS SHOWN	REV.	0
GIS	Caslys	7 Mar. 2014			
CHECK	KD	7 Mar. 2014			
REVIEW	DW	7 Mar. 2014			

Golder Associates

FIGURE 6.6-12

Movement

Caribou move through some portions of the RSA in some years. Southeast of the main mine site, the AWAR follows a ridge and esker system that contains a previously-established ATV trail system. Elders believe that caribou migrate through the area approximately every 6 to 12 years, and that although this is an important hunting area when caribou are present, it is not unique; caribou are hunted throughout the RSA and beyond (FEIS Volume 9, Appendix 9.3-A).

The narrows are a shallow region of Meliadine Lake where the land on either side constricts, east of the main mine site and Meliadine camp. This is a natural crossing area for caribou and an abundance of trails have been recorded funneling into this area in the past. There is also a concentration of archeological sites that suggest this was an important region for subsistence, and may have been an overwintering location, due to abundant caribou catch and fishing opportunities (Linnamae and Clark 1975; FEIS Volume 9, Section 9.3). The narrows is likely the route used by caribou that crossed through the Meliadine mine and camp site in August 2011 and again in July 2012 (Volume 9, Section 9.3.1.5.1.1). Community members of Rankin Inlet have also reported caribou crossing near Peter Lake.

Representatives of the Rankin Inlet HTO expressed concerns during interviews that the mining activities have potential to negatively affect caribou; although some participants expressed the belief that caribou can become accustomed to mining activities. Participants were concerned that the caribou migrations may be adversely affected by motorised vehicles disturbing the caribou, and suggested the road be patrolled while caribou are in the area. While hunting of herds that arrive early in the migration is thought to scare caribou off their route, too many snowmobiles and ATVs can do the same; the caribou change their route and migrate further to the west (FEIS Volume 9, Section 9.3). IQ

Pathways developed from GPS collar data support information gained from IQ. Of the few collared caribou recorded moving through the RSA, individuals moved through the southern part of the RSA in the post-calving and late summer seasons, and through the Narrows region at the main mine and camp site in early and late winter (Figure 6.6-13). Caribou observations were also recorded in the Meliadine Exploration Camp Wildlife Observation Log in August and September 2011, and January 2012. IQ

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510000 520000 530000 540000 550000 560000 570000

7010000 7000000 6990000 6980000 6970000 6960000

Peter Lake
Meliadine Lake
Parallel Lake
Tiriganiaq Pit
Wesmeg Pit
Pump Pit
F Zone Pits
Diana Lake
Discovery Pit
Meliadine River
Rankin Inlet
Hudson Bay

N

LEGEND

Collared Caribou Paths by Season

- Spring
- Post Calving
- Late Summer
- Early Winter
- Late Winter
- Local Study Area (LSA)
- Regional Study Area (RSA)
- Proposed Project Infrastructure
- All-weather Access Road (AWAR)
- Watercourse
- Waterbody

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM), National Topographic Database
Caribou Data from Department of Environment (Government of Nunavut).
Datum: NAD 83 Projection: UTM Zone 15

2 0 2
KILOMETRES

PROJECT
AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE
SEASONAL CARIBOU PATHS WITHIN THE REGIONAL STUDY AREA

PROJECT NO. 10-1373-0076			FILE No.	
DESIGN	KD	18 Jan. 2013	SCALE AS SHOWN	REV. 1
GIS	Caslys	7 Mar. 2014		
CHECK	KD	7 Mar. 2014	**FIGURE 6.6-13**	
REVIEW	DW	7 Mar. 2014		

According to Caribou Protection Measures defined by BQCMB (2004), operations within areas occupied by cows and/or calves should be suspended between May 15 and July 15. Low flying aircraft should avoid caribou at all times, particularly during migration. Operations should not block migration pathways, and blasting and/or construction of camps should not occur within 10 km of a designated water crossing between May 15 and September 1 (Gunn et al. 2007). Given the proportion of the caribou herd predicted to be impacted by the Project, AEM is not committed to following these practices. However, AEM has developed a TEMMP (SD 6-4) that oulines specific caribou mitigation in consultation with Government of Nunauvt, Department of Environment.

The general surveillance monitoring described in the TEMMP (SD 6-4) is designed to determine the frequency and distribution of wildlife interactions with the mine site infrastructure and the AWAR. Staff are also encouraged to report wildlife sightings that will alert staff to the presence of caribou in the vicinity of the Project. The environmental personnel on-site will then manage the situation, alerting security and road users as necessary. The TEMMP (SD 6-4) specifies that during migration of 50 or more caribou, AEM will implement work suspension protocol when the caribou herd is moving in the direction of the activities and crosses the 5 km mark from the site activities. Work suspension will include suspension of helicopter flights, drill operations, and circulation of vehicles.

AEM will work with the KIA and HTO to monitor areas where the road may be impeding caribou migration. Based on experience gained from the Meadowbank Mine all-weather private road, the design of the AWAR is not expected to impede free passage of any caribou migrating across the road; however, AEM is committed to retrofitting areas to create shallower shoulder angles where such monitoring indicates that caribou migration may be impeded (Gebauer et al. 2012).

In the case of aggregations of caribou or other wildlife related problems, the environmental personnel on-site will be in charge of managing the situation, and with the collaboration of the security department, will advise road users by patrolling the road (AWAR and haul roads). Project personnel will be notified by dispatch radio if any wildlife are observed on Project roads.

6.6.4.3 Survival and Reproduction

- **Improved access for harvesting can affect wildlife population sizes**

6.6.4.3.1 Methods

The incremental and cumulative effects of increased access for harvesting on survival and reproduction of caribou were assessed qualitatively using literature review, existing IQ, interviews conducted for the Project and a review of experiences at other mines in NU.

The literature review considered harvest records, IQ, and Traditional Land Use (FEIS Volume 9, Section 9.3) activities inside and outside the RSA. The Inuit Land Use and Occupancy Project (Freeman 1976) described TLU knowledge for northern Canada during three distinct chronological periods. Information from the TLU knowledge for the South and North-East Keewatin Coast during periods II (generally the early-mid 1900s) and

period III (mid 1900s-1974) were considered for this assessment. The NU Atlas (Riewe 1992) describes and maps TLU knowledge collected through interviews in the late 1980s and early 1990s, of which interviews from the communities of Whale Cove, Rankin Inlet, Chesterfield Inlet, and the region surrounding these communities were included in this assessment.

Field studies for the Project were also conducted by Nanuk Enterprises in the late 1990s with participants from Rankin Inlet and Chesterfield Inlet, and in 2010 with participants from Whale Cove, as well as Rankin Inlet and Chesterfield Inlet. Interview participants spoke about their knowledge and use of the Project area and also contributed their views on the impact of mineral exploration and development activities on their lifestyles, the economy of the region, and on the environment (FEIS Volume 9, Appendix 9.3-A). The studies involved the participation of Elders and younger adults, and a mixture of men and women.

6.6.4.3.2 Results

Increased ease of access for traditional and non-traditional harvesting as a result of the AWAR may increase risk of mortality for caribou. The baseline harvest for the region was determined from the NU Wildlife Harvest study (Priest and Usher 2004) which summarizes harvest data from 1996 to 2001. Caribou have been hunted by residents of Rankin Inlet in all months of the year (Priest and Usher 2004). The 5-year mean harvest for Rankin Inlet was 989 caribou, ranging from fewer than 500 to more than 1500 caribou (Table 6.6-6; Priest and Usher 2004). Community feedback on these harvest numbers suggested that an annual harvest near 1128 animals is typical. This is <10% of the traditional harvest for the Qamanirjuaq herd, which can approach 14 000 caribou for all traditional hunting in NU (BQCMB 2011). Travel for hunting occurs by ATV and boat in summer and ATV and snowmobile in winter. Trails are not limiting in winter; however, in summer travel is limited to an existing network of ATV trails. Hunters leave these trails to get closer to caribou if possible, particularly along ridges and eskers where travel is faster (FEIS Volume 9, Section 9.3 and Appendix 9.3-A). The proposed AWAR corridor to the Project is presently used by Inuit to access fishing areas on Meliadine Lake during the winter and spring. Currently there is also a 10 km all-weather road from Rankin Inlet to the Iqalugaarjuup Nunanga Territorial Park. While the mine site and Discovery mine locations will have gated access, the AWAR will be open access. The AWAR will provide easier and faster access along the existing trails. IQ

Changes to hunter land use have been reported at the Meadowbank Mine as a result of an all-weather private road (Gebauer and Associates 2010). The percent of harvests within 5 km of the road have increased and more hunting occurred near the road during the summer season than the winter season. There is evidence that the road is also important in winter, which may be due to ease of access or the security of an established road. The Meadowbank Mine and all-weather private road was completed in 2008. In 2009 the number of caribou harvested within 5 km of the road nearly doubled (110 in 2008, 214 in 2009) as did the total reported harvest for the region (296 in 2008, 587 in 2009) (Gebauer et al. 2012). The total number harvested has continued to increase. In 2011, 283 caribou were harvested within 5 km of the road, which was 42% of the total harvested at Baker Lake (Gebauer et al. 2012). Between 1996 and 2001, prior to development of the road, only 18% of caribou harvests were within 5 km of the road alignment (Gebauer et al. 2012).

Similar shifts in the location of caribou hunts and the abundance harvested near the AWAR may be expected for the Project. However, the harvest rate per hunter is higher in Baker Lake compared to Rankin Inlet, with 187 hunters harvesting 2480 caribou on average per year (approximately 13 caribou per hunter) in Baker Lake, and 166 hunters harvesting 989 caribou on average per year in Rankin Inlet (approximately 6 caribou per hunter) (Priest and Usher 2004). This suggests the number of caribou harvested for each additional hunter given access to the AWAR at the Project would likely be lower than that occurring at Meadowbank. Nevertheless, upon consultation with the KIA and HTO, AEM will establish an appropriate 'no shooting zone' around the mine site. AEM will also develop and enforce a "no hunting, trapping, harvesting or fishing policy" for employees and contractors while on shift and on-site, to help mitigate impacts from increased access for harvesting wildlife.

Interviews conducted with Elders in the communities of Rankin Inlet, Chesterfield Inlet, and Whale Cove indicate concerns that younger generations follow inappropriate hunting practices leading to wastage of meat, and hunt too early, which can scare off larger caribou herds. Overhunting as a result of increasing ease of access to caribou migration routes and calving grounds was also raised as a concern. Members of the Rankin Inlet HTO did not believe that local people would follow policies or constraints relating to caribou and recommended that the AWAR be patrolled to ensure local people follow the policies and constraints regarding land use, particularly when caribou are in the area (FEIS Volume 9, Section 9.3). Vehicle access to the AWAR will be limited when large numbers of caribou are crossing the road; this will occur in consultation with the local HTO.

6.6.5 Effects to the Abundance and Distribution of Northern Gray Wolf

The following sections present the effects assessment methodology and results for changes to wolf habitat quantity and fragmentation (Section 6.6.5.1); habitat quality, movement and behaviour (Section 6.6.5.2); and survival and reproduction (Section 6.6.5.3).

6.6.5.1 Habitat Quantity and Fragmentation

- **Direct loss and fragmentation of wildlife habitat from the Project footprint**
- **Permanent changes in wildlife habitat following closure of the mine site**

6.6.5.1.1 Methods

Direct effects from the footprint of the Project (including the AWAR and Rankin Inlet infrastructure) and other previous, existing, and future developments on wolf habitat quantity and fragmentation were analyzed through changes in the area and spatial configuration of habitat types on the landscape (i.e., landscape metrics). The incremental and cumulative changes in landscape metrics were determined for the RSA; however, it was recognized that developments outside the RSA can impact wide ranging species such as wolves and act cumulatively with Project impacts. To assess the potential impacts of developments outside the RSA on wolf habitat quantity and fragmentation, the total area of the Project and other previous, existing, and future developments were calculated using the CESA (Section 6.1.1.3). Habitat information was not available for the

CESA so the total area removed by each development case was calculated. Methods for the habitat fragmentation analysis completed for caribou (Section 6.6.4.1) are also applicable for wolves, with the exception that collar data were not available for wolves, and habitat types were therefore not ranked.

6.6.5.1.2 Results

During the denning season, wolves select areas with higher esker, heath rock, and heath tundra density (Johnson et al 2005). In spring and autumn, forest density and heath rock density are selected (Johnson et al 2005). Heath boulder habitat comprises 10.8% of the RSA and is not expected to change much as a result of development (Table 6.6-18; 6.6-19). It has decreased by 0.31% due to previous and existing developments, and the application of the Project will decrease the area of heath boulder by a further 0.27% (Table 6.6-19). Over the cumulative case, the area of this habitat type is expected to decrease only 0.67% from the reference condition (Table 6.6-19). During post-closure, 92.9% of heath boulder habitat removed by the Project and Phase 1 AWAR will be reclaimed (Table 6.6-22).

Heath tundra is the dominant habitat class in the RSA, covering 44.6% of the RSA (Table 6.6-17). Heath tundra will decrease by 1.47% as a result of Project development, which represents the main source for decrease for this habitat class over the cumulative case (total = 1.80%) (Table 6.6-18).

Cumulative changes in the number of patches, the distance between neighbouring patches, and the nearest neighbour index are less than 10% for both heath tundra and heath boulder. The number of heath tundra and heath boulder patches has increased by 2.07% and 2.84%, respectively, as a result of previous and existing developments (Table 6.6-20). The Project is expected to increase the number of heath tundra and heath boulder patches a further 0.55% and 0.40%, respectively. The decrease in mean nearest neighbour and nearest neighbour index due to the Project is less than 1% for each habitat type (Table 6.6-20).

Within the CESA, lichen tundra habitat will be most directly (0.14%) and indirectly (1.72%) lost due to the Project development. Wolf denning habitat (boulder/gravel and rock, heath rock and heath tundra) is not expected to be substantially effected by the Project or future developments (2.24%, 1.01% and 1.64%, respectively). Baseline developments resulted in greater loss of these habitat types within the CESA than the Project and future developments.

6.6.5.2 Habitat Quality, Behaviour and Movement

- **Sensory disturbance can change the amount of different quality habitats, and alter movement and behaviour**

6.6.5.2.1 Methods

In addition to direct habitat effects, changes to habitat quality from the Project and other developments have the potential to indirectly affect the population size and distribution of wolves. Wildlife distribution can be negatively affected by sensory disturbance (e.g., increased noise levels during construction and visual disturbances from

moving vehicles and humans throughout operation) because animals may avoid (i.e., change movement patterns or flee the area) areas with human disturbance (Tyler 1991; Fortin and Andruskiw 2003; Bayne et al. 2008). Dust can also change the quality of forage, potentially leading to caribou avoidance of areas with high amounts of dust deposition, which in turn may impact wolf behaviour and movement, resulting in indirect habitat loss for wolves. Johnson et al. (2005) also reported that wolves avoid major developments. The mechanism causing these effects is not yet understood, but is likely a combination of direct effects (such as physical footprint) and indirect effects (noise, dust, activity, and smells). No literature on the effects of in-ground or in-water vibrations (e.g., from blasting activities) to terrestrial wildlife could be found, although marine mammals and fish may be affected by in-water vibrations.

Similar to the approach used for caribou, the potential incremental and cumulative changes in wolf habitat from the Project and other developments was estimated using maximum published DCs and ZOIs from empirical studies (Table 6.6-23).

Indirect effects from disturbance were determined by applying hypothetical (not modelled) disturbance DCs and ZOIs to footprints described for the reference development case and combining these with the ELC data for the RSA (Table 6.6-23). With the exception of denning near treeline, Walton et al. (2001) reported that wolves follow seasonal caribou movements in NT and Western NU. For this reason, the methods for the habitat quality analysis completed for caribou (Section 6.6.4.2) were also followed for wolves. ZOIs reported by Johnson et al (2005) suggested avoidance distances of up to 61 km for wolves. These were not included here because wolves are expected to follow caribou and ZOI for caribou reported by Johnson et al (2005) were reduced in later studies by Boulanger et al. (2012). Wolf habitat selection identified by Johnson et al. (2005), however, was used to assess loss of important wolf habitats.

6.6.5.2.2 Results

During the denning season wolves select areas with higher esker, heath rock, and heath tundra density (Johnson et al. 2005). Heath tundra habitat is expected to incur an incremental decrease of 7.6% from the Project as the result of indirect and direct habitat loss, and overall experience a 25.6% cumulative decrease between reference conditions and future expected developments (Table 6.6-25). The incremental direct and indirect effects of the Project are expected to decrease the amount of heath boulder habitat by 3.6%, while the estimated cumulative effect of all future developments relative to the reference case is a decrease of 18.7% (Table 6.6-25).

6.6.5.3 Survival and Reproduction

- **Improved access for harvesting can affect wildlife population sizes**

6.6.5.3.1 Methods

The incremental and cumulative effects of increased access for harvesting on survival and reproduction of wolves were assessed qualitatively using literature review, existing IQ, interviews conducted for the Project and a review of experiences at other mines in NU.

The literature review considered harvest records, and IQ activities inside and outside the RSA. The Inuit Land Use and Occupancy Project (Freeman 1976) described IQ knowledge for northern Canada during three distinct chronological periods. Information from the IQ knowledge for the South and North-East Keewatin Coast during periods II (generally the early-mid 1900s) and period III (mid 1900s-1974) were considered for this assessment. The NU Atlas (Riewe 1992) describes and maps IQ knowledge collected through interviews in the late 1980s and early 1990s, of which, interviews from the communities of Whale Cove, Rankin Inlet, Chesterfield Inlet, and the region surrounding these communities were also included in this assessment.

Field studies for the Project were also conducted by Nanuk Enterprises in the late 1990s with participants from Rankin Inlet and Chesterfield Inlet, and in 2010 with participants from Whale Cove, as well as Rankin Inlet and Chesterfield Inlet. Interview participants spoke about their knowledge and use of the Project area and also contributed their views on the impact of mineral exploration and development activities on their lifestyles, the economy of the region, and on the environment (FEIS Volume 9 Appendix 9.3-A). The studies involved the participation of Elders and younger adults, and a mixture of men and women.

6.6.5.3.2 Results

Increased ease of access for traditional and non-traditional harvesting as a result of the AWAR may increase risk of mortality for wolves. Wolves are hunted whenever, and wherever seen (FEIS Volume 9, Section 9.3). Increased ease of access will likely increase the frequency and abundance of people along the AWAR route, thus increasing hunting pressure on wolves.

The baseline harvest for the region was determined from the NU Wildlife Harvest study (Priest and Usher 2004), which summarizes harvest data from 1996 to 2001. The 5-year mean harvest of wolves for Rankin Inlet was 34, ranging from 0 to 84 wolves (Priest and Usher 2004) (Table 6.6-6). Consultation with community members suggested these numbers may be low, which is further corroborated by the fact that 62 wolf pelts were purchased from Rankin Inlet hunters in 1999/2000 when only 41 harvests were reported, and 25 in 2000/2001 when no wolf harvests were reported (Priest and Usher 2004). However, wolf populations are typically highly resilient to the effects of harvesting (Hayes and Harestad 2000; Webb et al. 2011), and therefore, the magnitude of cumulative effects from AWAR access on wolf are determined to be detectable but within the range of baseline values.

6.6.6 Effects on Abundance and Distribution of Listed Wildlfie Species

There are 3 SARA listed wildlife species of concern (i.e., grizzly bear, wolverine, and polar bear) and one species listed under COSEWIC as data deficient (i.e., gray wolf) that have the potential to occur in the RSA (COSEWIC 2012, SARA 2013).

The Project is predicted to have a negligible residual effect on the abundance and distribution of grizzly bear and wolverine because the core part of their distributional range does not overlap with the Project (GN 2011). In addition, there have been either no, or very few, observations of these animals in close proximity to the Meliadine camp, and there are few wolverine or grizzly bear harvested by the Rankin Inlet community (Priest and Usher 2004).

Baseline information suggests that the RSA constitutes part of the home range of only a few polar bear, and even fewer would be expected to be within 5 km of the Project footprint, where they could encounter sensory disturbance (Section 6.6.2.4). Thus, the Project is predicted to cause a minor change in the amount and configuration of habitat for these individuals relative to baseline conditions. The estimated decrease in habitat quantity or quality for some individuals is expected to have a negligible residual effect on the abundance and distribution of the Western Hudson Bay polar bear sub-population (Section 6.6.3.2). A number of environmental design features, and a wildlife mitigation and monitoring plan will be implemented to limit olfactory and auditory disturbance to large carnivores (SD 6-4, TEMMP, Section 2.1 and Section 3.0).

The Project is not expected to have any significant adverse effects on the abundance or distribution of gray wolf (Section 6.6.5). Incremental changes to habitat quantity and fragmentation, habitat quality, movement, and behaviour are expected to be of low magnitude. Incremental changes to survival and reproduction is expected to be low to moderate as a result of improved access for harvesting wolves. Impacts will be minimized using environmental design features, such as minimizing the footprint; developing a 'no hunting, trapping, harvesting, or fishing policy' for employees and contractors; and controls on the AWAR (SD 6-4, Section 2.1 and Section 3.1.3). Surveillance monitoring planned as part of the TEMMP will add information on abundance and distribution of gray wolf in this region (SD 6-4, Section 4.0). In addition, a hunter harvest survey will help to determine changes in hunter harvest levels for gray wolf to monitor potential impacts and develop mitigations (SD 6-4, Section 4.6).

Upon approval of the Project, a TEMMP (SD 6-4) will be implemented as a requirement of the Guidelines for the FEIS (NIRB, 2012) in part to limit effects to listed species, determine the effectiveness of mitigation, and test impact predictions. The principal goal of the Program is to provide information required for the Project to adaptively manage potential impacts to species, including listed species. In addition, the TEMMP will be designed to provide a process for regulators, communities, and other people interested in the Project to participate in the development and review of listed species effects mitigation and monitoring.

6.6.7 Cumulative Effects of Climate Change

Section 8.1.11.2 of the Guidelines for the Project (NIRB 2012, p61-62) requires "[t]he Proponent…to present a comprehensive impact analysis for all Project components and activities, including…potential impacts on population size, abundance, distribution and behaviour of wildlife VECs from…[d]irect and indirect impacts from climate change."

Pursuant to NIRB *Guide 7: Guide to the Preparation of Environmental Impact Statements* (NIRB 2006), "[a]n EIS is a documented evaluation of the project proposal, providing detailed information regarding the proposal's environmental and socio-economic impacts (NIRB 2012, p1). As climate change is not part of the project

proposal, the assessment of direct and indirect impacts from climate change on wildlife VECs is outside the scope of this EIS. Therefore, for the purposes of this EIS, the intent of the TOR is interpreted to mean a discussion of the potential cumulative effects of climate change on wildlife impacts associated with the Project.

A review of changing climate was conducted for the climate stations nearest the Project development (FEIS Volume 5, Section 5.4). The review considered past weather records to provide guidance for predicting future conditions. Climate modelling is a complex process that involves the mathematical representation of global land, sea and atmosphere interactions over a long period. The results of global climate models are subject to many uncertainties and interpretations. The climate change assessment used various climate scenarios to partially address this concern. Since the models are susceptible to inter-decadal variability, the analysis used the average of 30 years of data, centred on a decade of interest. Specifically, climate normals during 1981 to 2010 were compared to future projections for the 2041 to 2070 and 2071 to 2100 periods to determine whether climate variables are expected to change.

Rankin Inlet climate trend analysis indicates significant warming in average annual spring and winter temperatures from 1981 to 2010. An increase of 1.1°C per decade has been observed in average spring temperatures, and 1.7°C per decade in average winter temperatures. There has also been a significant increase in winter precipitation of 6.3 mm snow water equivalent per decade over this time. In Baker Lake, the location of a more complete historical climate record, significant changes in climate from 1981 to 2010 included an increase in the winter temperature of 1.1°C per decade, and an increase of 0.6°C per decade in the annual average temperature.

Forecasts for Baker Lake predict a warmer and wetter climate for the period 2041 to 2070 and 2071 to 2100 based on multiple GCMs and climate change scenarios. Increased temperatures are forecast to be 3 to 3.5°C and 4.5 to 5°C higher when averaged over 2041 to 2070 and 2071 to 2100, respectively. The corresponding precipitation increases are expected to be 30 to 50 mm and 35 to 55 mm, respectively. However, the precipitation projections are within the annual recorded range of precipitation values for the last 30 years.

Warming can increase the thickness of the active permafrost layer, and could cause thawing of ice-rich permafrost, potentially resulting in thaw waterbodies and subsidence (shifting downward) of the land surface. Increasing temperatures may also lead to more freezing rain. Freeze thaw cycles may increase, based on increases in winter precipitation and average temperatures, and higher rainfall volume in summer may lead to more frequent heavy rain events (FEIS Volume 5, Section 5.4).

Changes in climate can have direct effects on mammals; however, changes can also affect their resources, predators and competitors, creating a suite of indirect effects (Humphries 2009). Caribou that experience high levels of insect harassment generally have poor body condition (Weladji and Holland 2003) because they spend less time foraging and more time being active (Toupin et al. 1996; Łutsel K'e Dene Elders and Land-Users et al. 2005). Insects can also be vectors of disease, such as brucellosis, which occurs in Nunavut (Mörschel and Klein 1997, NT 2012). Climate warming is expected to increase the duration and intensity of insect harassment on caribou because of earlier insect emergence, greater insect abundance, and increased insect distribution (Weladji and Holland 2003; Vors and Boyce 2009). Climate change is also expected to increase the frequency and intensity of wildfire, and enable plants to expand their ranges northward. As fires increase and plants move

north, moose and wolves may also increase their northern distribution, which may negatively impact caribou populations and distributions (Sharma et al. 2009; Kendrick et al. 2005).

Increased temperatures may lead to earlier plant emergence. As plants are most nutritious soon after emergence, it is important for caribou to access these resources as close to plant emergence as possible; however, caribou migrations are mainly cued by day length. Therefore, as the climate becomes warmer, caribou migrations may become out of sync with plant emergence, which may lead to a decline in reproductive success, as has been shown in Greenland (Post and Forchhammer 2008).

Climate change can also influence the seasonal distribution of caribou by modifying food abundance (primary productivity), snow depth and hardness, predator numbers (and alternative prey), and burns (Sharma et al. 2009; Vors and Boyce 2009).

There is a high level of uncertainly associated with climate change projections from global climate models as they involve relatively simple representations of complex processes. The spatial and temporal scale over which projected changes may occur is also uncertain and may not be relevant to species demography (Ashcroft et. al. 2009). These issues make assessing climate change as a cumulative impact to Project related effects difficult. Climate change impacts on caribou species are evident already (Vors and Boyce, 2009); however, it is likely that the magnitude of the effects of climate change will be higher than those identified for the Project (see Section 6.6.7). An energetic model for caribou, developed for the NICO Project, indicated that sensory disturbance from human developments can influence the demography of the Bathurst caribou herd; however, the effect was estimated to be about 3.5 times smaller than weather-related impacts on demography during the spring migration (Fortune 2011). The types of effects, i.e. insect harassment and phenology changes as the result of climate change, are also different than those associated with the Project, although loss of foraging habitat would act cumulatively to changes in plant phenology (Vors and Boyce 2009).

It is expected that climate change may be a significant impact to caribou, as defined in Section 6.6.10, as climate impacts will likely affect the entire Qamanirjuac herd, whereas the Project will only impact a very small proportion of the Qamanirjuac herd (Section 6.6.4.2). Ultimately, monitoring and adaptive management are recommended by the Intergovernmental Panel on Climate Change for dealing with the uncertainty of climate change effects on ecosystems (Fischlin et al. 2007).

6.6.8 Residual Effects Summary

6.6.8.1 Habitat Quantity and Fragmentation

The total area disturbed by the Project including the mine footprint, Rankin Inlet infrastructure, and the AWAR (Phase 1 and 2) is estimated to be 2554 ha. Although, the Phase 1 AWAR has been previously assessed, the entire AWAR footprint (i.e., Phase 1 and Phase 2) was assessed in this analysis to include the maximum disturbance within the study areas.

Based on collar data obtained from the GN, currently there are seasonal differences in caribou percent use of existing habitat types relative to availability (Table 6.6-18). In early and late winter, late summer, and post-calving, the percentage of locations detected in heath tundra is higher than the percentage of heath tundra

available on the landscape. Heath boulder is also used more than available during the post-calving season and heath lichen – hair lichen is used more during late summer. Bare ground and water is used more than available during spring migration; which may be due to movement across the wet landscape. Heath lichen – *cetraria* is used equal to availability in all seasons.

Direct incremental changes in habitat area with the application of the Project are expected to be less than 1% for habitat classes other than heath lichen – *cetraria* and heath tundra (Table 6.6-19). Heath lichen - *cetraria* is affected the most by the Project with a predicted decrease in area of 79.1 ha, which is 4.7% of that habitat type. The heath lichen-*cetraria* land cover class is found on eskers and the crests and upper slopes of small ridges with poorly developed, rapidly drained soils. The Project development is part of a 6.8% or 117.2 ha cumulative decline to this habitat class between reference and future conditions. During post-closure, 64% of this will be reclaimed (Table 6.6-22). Heath tundra will decrease by 1.5% or 1608.4 ha as a result of Project development. The Project development represents the main source for decrease for this habitat class over the cumulative case (1.80%). During post-closure, 69.4% of this will be reclaimed (Table 6.6-22).

In studies conducted in NT, wolves selected heath rock habitat during spring and autumn (Johnson et al. 2005). Outside of the denning season, wolves in the Kivalliq region likely migrate with the caribou herds (see Walton et al. 2001). Heath boulder habitat comprises 10.8% of the RSA and is not expected to change substantially as result of development (Table 6.6-20). Previous and existing developments have resulted in a 0.31% (82.2 ha) decrease in this habitat type, while the application of the Project will result in a further 0.27% (70.6 ha) decrease (Table 6.6-19).

Cumulative changes in landscape fragmentation metrics are expected to be less than 10% for all habitat types, with the exception of the number of patches of bare ground (Table 6.6-20). Direct incremental and cumulative changes in land area developed in the CESA as a result of known and expected future developments, including the Project, are expected to be less than 0.5%. The incremental effect of the Project is 0.02% (Table 6.6-21). Future developments are expected to have the greatest incremental effect on the amount of land developed in the CESA (Table 6.6-21). Forbe tundra habitat is expected to decrease the most (0.86%) due to cumulative changes.

6.6.8.2 Habitat Quality, Movement, and Behaviour

In addition to direct habitat effects, indirect changes to habitat quality from the Project have the potential to affect the population size and distribution of wildlife through altered movement and behaviour.

Direct and indirect incremental decreases in habitat due to the Project footprint are expected to range between 1.25% and 9.0%, depending on the habitat type (Table 6.6-25). Heath lichen - *cetraria* and heath tundra habitat types will be affected the most by Project related sensory disturbance. While heath lichen - *cetraria* is either not used by caribou or used in proportion to availability, heath tundra is used more than available during late and early winter, late summer, and the post-calving season, according to collar data (Table 6.6-18). Heath boulder and heath lichen – hair lichen are expected to decrease in area by 3.6% and 4.4% as a result of Project development and associated sensory disturbance (Table 6.6-25). These habitats are used more than available

during the post calving and late summer seasons, respectively (Table 6.6-18). Heath boulder is also important to wolves during spring and autumn.

Direct and indirect cumulative changes in habitat area are expected to range between 18.5% and 43.5% (Table 6.6-25). The habitat types expected to undergo the largest decreases in area due to cumulative developments, heath lichen - *cetraria* and bare ground, are used less than or equal to their availability in the RSA during late winter, post calving, late summer, and early winter, according to collar data (Table 6.6-18). During spring migration, when caribou move across the landscape, bare ground is used more than available (Table 6.6-18). Neither heath lichen – *cetraria* nor bare ground are known to be critical habitats for wolves. The cumulative effect of expected future development on areas of heath boulder habitat is a decrease of 18.7% relative to the reference case (Table 6.6-25).

Direct incremental and cumulative changes in development area in the CESA as a result of known and expected future developments and their ZOI, including the Project, are expected to be less than 3.0% of the CESA (Table 6.6-26). Baseline developments had a greater incremental effect on the percent change in area due to development in the CESA than expected from the Project or future developments. Direct and indirect effects from the Project are expected to reduce available habitat by 0.10%. Lichen tundra habitat is expected to decrease the most (15.2%) due to cumulative changes.

In total there were 39 890 caribou locations recorded across the annual Qamairjuaq herd home range during the 14 year collaring program. Less than 1% of seasonal locations were recorded inside the RSA in any season and no locations were detected in the RSA during the calving, fall, or fall rut seasons (Table 6.6-27). Of the detections inside the RSA, the majority occurred within the 14 km ZOI associated with mine developments; however, very few of these (i.e., 3 locations over the entire program) occurred within the LSA.

The RSA contains very low to moderate relative densities of caribou locations in any season, ranging from 0 to 0.603 locations/km^2 (Table 6.6-28). The Government of Nunavut defines seasonal home ranges using the 95 percentile boundary of the resulting density maps (Figures 6.6-8 to 6.6-12). While some density polygons occur in the RSA during other seasons, the 95 percentile boundary of these density polygons only overlaps with the RSA during the post-calving season.

Caribou move through some portions of the RSA in some years. Southeast of the main mine site, the AWAR follows a ridge and esker system that contains a previously-established ATV trail system. Elders believe that caribou migrate through the area approximately every 6 to 12 years, and that although this is an important hunting area when caribou are present, it is not unique; caribou are hunted throughout the RSA and beyond (FEIS Volume 9, Appendix 9.3-A).

Pathways developed from GPS collar data support information gained from IQ. Of the few collared caribou recorded moving through the RSA, individuals moved through the southern part of the RSA in the post-calving and late summer seasons, and through the Narrows region at the main mine and camp site in early and late winter (Figure 6.6-13). Caribou observations were also recorded in the Meliadine Exploration Camp Wildlife Observation Log in August and September 2011, and January 2012.

6.6.8.3 Survival and Reproduction

Increased ease of access for traditional and non-traditional harvesting as a result of the AWAR may increase risk of mortality for caribou and wolves, as the AWAR will provide easier and faster access along the existing trail over which the AWAR will be built. Both species are regularly hunted by residents of Rankin Inlet (NWMB 2004). The 5-year mean caribou harvest for Rankin Inlet was 989 caribou, ranging from fewer than 500 to more than 1500 caribou (NWMB 2004). Community feedback on these harvest numbers suggested that an annual harvest near 1128 animals is typical. This is <10% of the traditional harvest for the Qamanirjuaq herd, which can approach 14 000 caribou for all traditional hunting in Nunavut (BQCMB 2011). At the Meadowbank Mine, caribou harvest within 5 km of the all-weather private road doubled, as did the total reported harvest for the region. Under the most conservative case, if total reported harvest doubled in the Rankin Inlet region as a result of the AWAR, the expected harvest of caribou would range from 1000 to 3000 (Gebauer and Associates 2010). Access near the Meadowbank Mine was much more restricted prior to the building of the road in that region, while ATV access is already well established in the region surrounding Rankin Inlet. Given mitigations for a no shooting zone near the AWAR, hunting with ATV may still be the most efficient option for access to move beyond the AWAR no shooting zone and onto the surrounding trail network. Thus, additional harvest to the Qamanirjuac herd is expected to be a small portion of the traditional harvest of this herd and to be just above baseline levels; and therefore not have an impact at the population level.

The 5-year mean wolf harvest for Rankin Inlet was 34 wolves, ranging from 0 to 84 wolves (NWMB 2004). Consultation with community members suggested these numbers may be low, which is further corroborated by the fact that 62 pelts were purchased in Rankin Inlet in 1999/2000 when only 41 harvests were reported, and 25 in 2000/2001 when no wolf harvests were reported. However, wolf populations are typically highly resilient to the effects of harvesting (Hayes and Harestad 2000; Webb et al. 2011), and therefore, the magnitude of cumulative effects from AWAR access on wolves are determined to be detectable but within the range of baseline values.

In summary, the incremental effect of the proposed AWAR on caribou and wolf survival rates is expected to be detectable but within or slightly exceed the range of baseline values.

6.6.9 Related Effects to People

With increased ease of access along the AWAR, an increase in hunting opportunities is expected during the life of the Project. Any change in availability of wildlife for harvesting from direct and indirect effects of the Project is predicted to be within the range of baseline values. People that hunt in the region should not observe a change in the availability of wildlife relative to current natural cycles in populations during mine life or following post-closure. Effects are expected to last from construction through perpetuity, in some cases, but are not expected to be measureable at the population level.

In Nunavut, wildlife species are managed mostly by controlling the hunting season for resident and non-resident hunters (Department of Environment 2012). The hunting rights of Aboriginal people in Nunavut are based on traditional use and are different from those of other hunters.

Participants in IQ studies from Rankin Inlet believe that local people will not follow AEM polices or contraints relating to caribou and that uncontrolled hunting may excaberate the effects to caribou. Rankin Inlet Elder IQ

interviews done in 2010 suggest that early in the hunting season, caribou can be scared off their migration route by heavy snowmobile traffic and early hunting. Elders explained that the first few herds must be allowed to pass un-hunted to encourage other subsequent herds to follow the same migration routes. Elders added that younger generations hunt too early in the season. With the development of the AWAR, hunters would be able to make more use of vehicles to access areas in the RSA. However, there is currently access in this area through the use of snow machines in the winter months and ATVs in the summer months. Although, the development of the AWAR will ease access into the RSA during the entire year, harvesting of wildlife would occur periodically during traditional and non-traditional hunting seasons.

Access to the region is good and harvesting of caribou and wolves currently occurs from existing trails within the RSA. Furthermore, should harvesting on the AWAR reach a level of concern, the Department of Environment could enact regulations to control harvesting. As such, it is expected that the incremental and cumulative increase in the harvest of wildlife from the increased ease of access afforded by the AWAR will be within the range or approach the upper limits of baseline harvesting values.

6.6.10 Residual Impact Classification

6.6.10.1 Methods

The following criteria suggested in the Guidelines for the Project (NIRB 2012) are used to assess the residual impacts from the Project.

- direction or nature of the impacts;
- magnitude and complexity;
- geographic extent;
- frequency;
- duration;
- reversibility; and
- likelihood or probability of effects.

The term “effect”, as used in the effects analyses and residual effects summary, is regarded as an “impact” in the residual impact classification; therefore, in the residual impact classification, all residual effects are discussed and classified in terms of impacts to wildlife.

For wildlife, the assessment and classification of residual impacts were based on the predicted cumulative changes from reference conditions through application of the Project and into the future case. All sources of information (i.e. existing and collected data, new analyses, existing publications, and IQ) were considered equally in the classification of residual impacts. The spatial boundary of the assessment for Project impacts is at the RSA scale. The incremental effects from the Project relative to 2012 baseline conditions are also classified. Essentially, the only difference in the outcome of impact criteria between cumulative and incremental effects from the Project is in the magnitude and geographic extent of impacts. The magnitude for cumulative impacts involves changes from reference conditions through application of the Project and into the future case, while

incremental impacts are based on changes from the Project relative to 2012 baseline values. Cumulative impacts from the Project and other developments influence the entire annual range of the populations (i.e., CESA scale). In contrast, the geographic extent of incremental impacts from the Project may have a local or regional influence on wildlife populations.

Effects statements are used to focus the analysis of changes to wildlife that are associated with one or more primary pathways. The residual effects summary (Section 6.6.7) presents a numerical assessment for criteria such as magnitude, geographic extent, duration, and frequency. From the summary of residual effects, pathways associated with each effects statement are classified using scales (categorical values such as negligible, low, or high) for each impact criterion (e.g., magnitude).

To provide transparency, the definitions for these scales were ecologically or logically based on wildlife. Although professional judgement is inevitable in some cases, a strong effort was made to classify impacts using scientific principles, supporting evidence, and IQ. The scale for the residual impact criteria for classifying effects from the Project are specifically defined for wildlife, and definitions for each criterion are provided in Table 6.6-29. Additional detail on magnitude, complexity, duration, and geographic extent is provided below.

Table 6.6-29: Definitions of Criteria Used in the Residual Impact Classification of Pathways

Direction	Magnitude and Complexity	Geographic Extent	Duration	Frequency	Reversibility	Likelihood
Negative: less favourable relative to baseline values **Positive:** an improvement over baseline values or conditions	**Negligible:** no predicted detectable change from baseline values **Low:** impact is predicted to be within the range of baseline values **Moderate:** impact is predicted to be at or slightly exceeds the limits of baseline values **High:** impact is predicted to be beyond the upper or lower limit of baseline values so that there is likely a change of state from baseline conditions	**Local:** small-scale direct and indirect impacts from the Project (e.g., footprint, and dust deposition) **Regional:** the predicted maximum spatial extent of combined direct and indirect impacts from the Project that exceed local-scale effects (can include cumulative direct and indirect impacts from the Project and other developments at the regional scale) **Beyond Regional:** cumulative local and regional impacts from the Project and other developments extend beyond the regional scale	**Short-term:** impact is reversible at end of construction **Medium-term:** impact is reversible at end of closure **Long-term:** impact is reversible within a defined length of time beyond closure **Unknown**: Impact may be reversible however the length of time cannot be defined **Permanent**: impact will last into perpetuity	**Isolated:** impact confined to a specific discrete period **Periodic:** impact occurs intermittently but repeatedly over the assessment period **Continuous:** impact will occur continually over the assessment period	**Reversible:** Impact will not result in a permanent change of state of the population compared to “similar” environments not influenced by the Project **Irreversible:** impact is not reversible (i.e., duration of impact is unknown or permanent)	**Unlikely:** the impact is likely to occur less than one in 100 years **Possible:** the impact will have at least one chance of occurring in the next 100 years **Likely:** the impact will have at least one chance of occurring in the next 10 years **Highly Likely:** the impact is very probable (100% chance) within a year

Magnitude and Complexity

Magnitude (i.e., intensity of the impact) for Project-specific (incremental) effects is scaled to the expected change from 2012 baseline conditions from application of the Project. Magnitude for cumulative effects is scaled to the expected quantified and/or qualified change from reference conditions (no development) through application of the Project and reasonably foreseeable developments. Complexity is the degree of intricacy relative to the baseline condition, and is a measure of the number of interconnected or interwoven components. The degree of complexity is incorporated within the assessment of magnitude. The interconnected components were assessed by examining the change relative to baseline for all the interconnected components. Baseline conditions represent the historical and current environmental selection pressures that have shaped the observed patterns in wildlife. Environmental selection pressures include both natural (e.g., weather, predation) and human-related factors (e.g., mineral development), with more than one pressure at any time. Relative to ecological time and space, baseline conditions are in a constant state of change. Thus, baseline conditions can be thought of as a distribution of probability values, and the location of the value (e.g., middle or ends of the distribution) is dependent on which environmental factors are currently playing a key role in the state of the wildlife populations at a particular moment in time.

The approach used to classify the magnitude of changes in measurement endpoints (and related impacts) was based on the degree of complexity attached to the measurement endpoint, scientific literature and professional opinion, and incorporated conservatism. The definition of magnitude provided in Table 6.6-29 is applicable for more qualitative results (e.g., impacts on wildlife movement and behaviour, and related impacts to people). For quantitative analyses and results (e.g., loss and fragmentation of habitat, and changes to habitat suitability), the following definition for magnitude is applied:

- negligible: less than a 1% change from the Project relative to baseline values;
- low: 1 to 10% change from the Project relative to baseline values;
- moderate: greater than 10 to 20% change from the Project relative to baseline values; and
- high: more than 20% change from the Project relative to baseline values.

The proposed scale is consistent with the 20% rule for the severity of effects from chemical exposure on varying spatial scales of ecological effects (i.e., a 20% change in a measurement endpoint constitutes an ecological effect) (Suter et al. 1995; Munkittrick et al. 2009). The scale is also consistent with, and below thresholds identified by empirical and theoretical work on the relationship between loss of suitable habitat and the likelihood of population decline (Andrén 1994, 1999; Fahrig 1997; Mönkkönen and Reunanen 1999; Flather and Bevers 2002). These studies suggested that critical thresholds for changes in rates of population parameters in non-tropical bird and mammal species occur between 10% and 60% of original habitat. In a recent review, Swift and Hannon (2010) found that most empirical studies demonstrated negative effects on insects, plants, birds, and mammals when the amount of habitat lost from the landscape was greater than 70%.

Geographic Extent

Geographic extent is the area or distance influenced by the direct and indirect effects from the Project, and is different from the spatial boundary (i.e., study area) used for the effects analysis and impact assessment. The study area for the effects analysis represents the maximum area used for the assessment and is related to the spatial distribution and movement (i.e., population boundary) of wildlife. Alternatively, the geographic extent of

impacts can occur on a number of scales within the spatial boundary of the assessment. Geographic extent for classifying impacts is based on 3 scales: local, regional, and beyond regional. Local-scale impacts mostly represent incremental (Project-specific) changes to wildlife population size and distribution that are directly related to the Project footprint and activities (e.g., physical disturbance to vegetation [habitat], and mortality of individual animals). Local impacts may also include small-scale indirect effects such as dust deposition on vegetation and sensory disturbance.

Changes at the regional scale are largely associated with the predicted maximum extent of incremental impacts from the Project on wildlife, such as changes to habitat quality that occur beyond the local scale (i.e., more than 1 km from the Project). Changes at the regional scale also can result from the incremental and cumulative impacts from the Project and other developments on wildlife populations. Cumulative impacts from the Project and other developments on traditional and non-traditional use of wildlife also occur at the regional scale. Beyond regional scale effects are associated with cumulative changes to populations that range over very large areas (e.g., barren-ground caribou).

Duration

Duration has 2 components. It is the amount of time between the start and end of a Project activity plus the time required for the impact to be reversible.

By definition, impacts that are short-term, medium-term, or long-term in duration are reversible. Project activities may end at closure, but the impact on wildlife may continue beyond Project closure. Some impacts may be reversible soon after removal of the stressor, such as effects on air quality from equipment operation (a medium-term impact).

For wildlife, the amount of time required for the impact to be reversed (i.e., duration of the effect) is presented in context of the number of life spans that may be influenced. The anticipated duration of effects on wildlife are then used to determine the number of human generations that may be affected by the related changes to traditional and non-traditional land use practices (e.g., harvesting). In this manner, the impact assessment links the duration of Project impacts on wildlife to the amount of time that human use of ecological resources may be influenced.

For impacts that are permanent, the duration of the effect is determined to be irreversible. An example of an irreversible impact includes the localized loss of vegetation and habitat types due to the open pits and the waste rock storage facilities (i.e., the open pits and waste rock storage facilities will create different habitat).

6.6.10.2 Results

Loss and fragmentation of habitat from the Project are predicted to have a negative but low magnitude effect on wildlife populations in the RSA with direct loss from the Project footprint less than 5% for all habitat types (Tables 6.6-19, 6.6-20). Habitat loss from the Project is expected to be a local scale effect but fragmentation is a landscape-scale process and so is expected to have effects on wildlife populations at the regional scale. Although progressive reclamation will be integrated into mitigation and management plans for the Project, Arctic terrestrial ecosystems are slow to recover from disturbance. In addition, not all the areas for the Project will be reclaimed. For example, the waste rock and tailings storage facilities, and open pit lakes will be permanent features on the landscape.

Cumulative habitat loss and fragmentation from previous, existing, and future developments in the RSA are expected to have negative effects on wildlife populations that are low in magnitude. Direct habitat loss is expected to be less than 7% for all habitat types, and fragmentation metrics are expected to change by less than 10% for all habitat types with the exception of the number of patches of bare ground. Direct incremental and cumulative changes in area in the CESA as a result of known and expected future developments and their ZOI, including the Project, are expected to be less than 3.0% of the CESA. Individuals from the caribou population may interact with other developments and activities in the study area. Therefore, the cumulative impacts from direct habitat loss and fragmentation from the Project and other developments on population size and distribution are expected to be beyond regional in geographic extent.

Permanent changes to wildlife habitat from the open pits, and tailings and waste rock storage facilities are expected to have negative and low magnitude effects on wildlife populations in the RSA (Table 6.6-30). Incremental Project effects from permanent habitat loss are expected to be local in geographic extent, while effects from permanent habitat fragmentation are expected to be regional in extent. As the pit lakes and tailings and waste rock storage facilities are expected to be permanent features on the landscape after Project decommissioning and closure, effects to wildlife populations are predicted to be long term but reversible. The amount of habitat that will be changed permanently is not likely to have a permanent effect on wildlife populations due to the amount of habitat available for wildlife populations in the RSA and CESA. Cumulative effects from habitat loss and fragmentation from previous, existing, and future developments are predicted to be low in magnitude and regional in geographic extent.

Table 6.6-30: Summary of Residual Impact Classification on Abundance and Distribution of Wildlife Populations and Related Effects to People

Effects Pathways	Direction	Magnitude		Geographic Extent		Duration	Frequency	Reversibility	Likelihood
		Incremental	Cumulative	Incremental	Cumulative				
Physical footprint decreases habitat quantity and causes fragmentation	negative	low	low	regional	regional to beyond regional	Long term	continuous	reversible	highly likely
Sensory disturbance can change the amount of different quality habitats, and alter wildlife movement and behaviour (distribution)	negative	low	high	regional	regional to beyond regional	medium term	continuous	reversible	highly likely
Improved access for harvesting wildlife can affect wildlife population sizes	negative	low to moderate	low to moderate	local	regional to beyond regional	long term	periodic	reversible	highly likely
Disruption or alteration of caribou migration routes from the presence of the mine or from mine-related activities	negative	low	low	regional	beyond regional	long term	periodic	reversible	likely
Permanent changes in wildlife habitat following closure of the mine site	negative	low	low	regional	regional	long-term	continuous	reversible	highly likely
Effects on population size and distribution changes the availability of animals for traditional and non-traditional use	positive	low to moderate	low to moderate	regional	regional	medium-term	periodic	reversible	highly likely

Sensory disturbance from the Project is predicted to have low to high magnitude effects on wildlife populations in the RSA (Table 6.6-30). Indirect effects from the Project are expected to be regional in geographic extent given zones of influence for caribou. Cumulative indirect effects from previous, existing, and future developments (including the Project and Phase 1 AWAR) are predicted to have high magnitude effects on wildlife populations. Cumulative sensory effects are expected to be regional to beyond regional in extent. Sensory effects from the Project are predicted to be reversible within a few years following closure (long-term). Sensory effects during construction and operation of the Project are expected to be continuous.

Members of the Rankin Inlet HTO believe that the construction and mining operations at the Project could potentially affect caribou. Several Elders in Rankin Inlet noted during IQ studies that the caribou population changed their migratory route in response to previous mining activities and the associated establishment of the Hamlet of Rankin Inlet (Volume 9, Section 9.3.1.3.2.1). Changes in the migration patterns of caribou are expected to be negative but low in magnitude effects for both the incremental and cumulative cases (Table 6.6-30). The extent of the effect will be regional to beyond regional, occurring at the home range scale. Permanent changes at the main mine site will result in long-term disruption or alteration of migratory routes but the effect to wildlife populations is reversible. This effect is likely to occur in the next 10 years, as elders suggest caribou move through the main mine site region every 6 to 10 years. IQ

Improved access for harvesting wildlife from the development of the Project are expected to have low to moderate negative effects on wolf and caribou populations. Incremental effects will be local in geographic extent, however cumulative effects to the population will be regional to beyond regional (Table 6.6-30). Effects may be measurable in other parts of the Qamairjuaq caribou annual home range, and may represent a transboundary effect if outside of Nunavut. The AWAR will be scarified during closure, so effects are expected to be medium and reversible.

Cumulative effects from changes in the availability of wildlife for human use are predicted to be positive and low to moderate in magnitude and regional in geographic extent. The AWAR will be scarified during closure, so effects are expected to be medium and reversible. Effects are expected to occur periodically during traditional and non-traditional hunting seasons.

6.6.11 Environmental Significance

6.6.11.1 Approach and Methods

The evaluation of significance for biophysical VECs considers the entire set of pathways that influence a particular assessment endpoint. The relative contribution of each pathway is then used to determine the significance of the Project on assessment endpoints. For example, a pathway with a high magnitude, large geographic extent, and long-term duration would be given more weight in determining significance relative to pathways with smaller scale effects. The pathways that are predicted to have the greatest influence on changes to assessment endpoints are assumed to contribute the most to the determination of environmental significance.

Maintenance of abundance and distribution of wildlife populations was considered an appropriate and conservative assessment endpoint for determining the significant incremental and cumulative effects from the Project and other developments on caribou and other wildlife VECs in the FEIS. Predicting if the Project is likely to have a significant effect on the maintenance of population abundance and distribution is similar to asking if the

Project will adversely affect self-sustaining and ecologically effective VECs (FEIS Volume 4, Table 4.2-1). Self-sustaining populations are healthy populations capable of withstanding environmental change and accommodating stochastic ecological and demographic processes (e.g., changes in population caused by unpredictable phenomenon such as several dry summers, or an exceptionally cold winter).

Ecologically effective populations are not only self-sustaining, they also sustain other species (e.g., prey for predators) in an ecosystem (Soule et al. 2003). Maintenance of ecologically effective populations over many generations results in the protection of the ecological services to humans, such as the continued opportunity for consumptive and non-consumptive use of wildlife by people that value these resources as part of their culture and livelihood (Hooper et al. 2005).

Resilience and stability are key properties of self-sustaining and ecologically effective populations. Resilience is an inherent trait of a species or a population and represents the ability of a population to adapt to change (e.g., rate and degree of fluctuation in population abundance and distribution after a disturbance). Stability is determined by the trajectory of a population. Stable populations exhibit no long-term change in abundance outside of natural population fluctuations and cycles (e.g., predator-prey cycles). Resilience and stability influence the amount of risk to populations from development (Weaver et al. 1996).

Quantitative and qualitative key factors were considered in the determination of environmental significance as follows:

- results from the residual impact classification of primary pathways;
  - magnitude, geographic extent, and duration (which includes reversibility) of the impact were the principal criteria used, with frequency and likelihood as modifiers; and
  - professional judgment and ecological principles, such as resilience, were used to predict the duration and associated reversibility of impacts.
- ecological or socio-economic context/value;
- historical, cultural, and archaeological significance of the geographic area likely to be affected by the Project; and
- value attached to the individual VEC based on consultation with potentially affected communities and relevant individuals and organizations.

Environmental significance is used to identify predicted impacts that have sufficient magnitude, duration, and geographic extent to cause fundamental changes to wildlife. The following definitions are used for assessing the significance of impacts on the maintenance and resilience of wildlife, and the associated continued opportunity for traditional use of wildlife.

- **Not significant** – impacts are measurable at the individual level, and strong enough to be detectable at the population level, but are not likely to decrease resilience and increase the risk to population maintenance and opportunities for traditional and non-traditional use.

- **Significant** – impacts are measurable at the population level and likely to decrease resilience and increase the risk to population maintenance and impact opportunities for traditional and non-traditional use. A number of high magnitude and irreversible impacts at the population level (regional scale) would likely be significant. For example, empirical and theoretical work on loss of suitable habitat suggests that the likelihood of population decline increases after 20% habitat loss (Andrén 1994, 1999; Fahrig 1997; Mönkkönen and Reunanen 1999; Flather and Bevers 2002). Thus, an example of a significant affect would be a permanent change in wildlife habitat availability and fragmentation affecting 20% or more of caribou habitat.

6.6.11.2 Results

Project pathways influencing wildlife populations were determined to be low to high in magnitude, local to beyond regional in geographic extent, and medium-term to long-term in duration (Table 6.6-30). The range in scales in the residual impact classification reflected the number of pathways and related mechanisms that were predicted to affect wildlife species, particularly caribou. Pathways included direct impacts related to habitat quantity and fragmentation, indirect impacts on the quality of habitat and on caribou migration, and direct impacts from increased harvest on survival. The probability of impacts occurring is predicted to be likely to highly likely for the Project pathways, (while the frequency of most impacts is anticipated to occur continuously throughout construction and operation with the exception for impacts associated with hunting of wildlife and changes in migration routes. The probability and frequency of the impacts do not change the expected magnitude and duration (or environmental significance) of these impacts.

The incremental and cumulative impacts from the Project are predicted to not significantly influence the maintenance of the abundance and distribution of wildlife populations. The scale of impacts from the Project pathways, independently or combined, should not be large enough to cause irreversible changes at the population level and decrease the resilience of the VECs. For example, long-term pathways, such as direct habitat loss, are associated with impacts that have a low magnitude at the regional or regional to beyond regional scale for the incremental and cumulative cases, respectively. Impacts from sensory disturbance which can change habitat quality have a low to high impact at the regional scale but are reversible. Thus, the Project is expected to impact individuals that move through, and use habitats within 14 km of the development footprint. Many people reported that they hunt caribou anywhere that caribou were to be found within ATV reach that access to the region is good, and that harvesting of caribou is current and will likely continue to occur from existing trails within the RSA.

Based on collar data for caribou, incidental observations, and Government of Nunavut delineated seasonal home range densities, this is a very small proportion of the Qamanirjuac herd. Similarly, because wolf densities tend to be low, estimated at 1 per 100 to 200 km^2 in the Canadian Arctic (Mattson et al. 2009), the Project should affect only a small portion of the wolf population.

The incremental changes to the quantity, quality, and spatial distribution of habitats should not have a significant impact on the structure and function of populations and communities in the ecosystem relative to natural factors occurring over the same period of time and space. Subsequently, the Project should not have a significant adverse impact on the continued opportunity for traditional and non-traditional use of wildlife in the region.

6.6.12 Uncertainty

The purpose of the uncertainty section is to identify the key sources of uncertainty in the impact assessment and to discuss how uncertainty has been addressed to increase the level of confidence that impacts are not worse than predicted. Confidence in the assessment of environmental significance is related to the following elements:

- adequacy of baseline data for understanding current conditions and future changes unrelated to the Project (e.g., extent of future developments, climate change, catastrophic events);
- model inputs (e.g., ZOI and disturbance coefficients from developments);
- understanding of Project-related impacts on complex ecosystems that contain interactions across different scales of time and space (e.g., exactly how the Project will influence caribou); and
- knowledge of the effectiveness of the environmental design features and mitigation for reducing or removing impacts (e.g., revegetation of wildlife habitat).

Ecosystems are complex, characterized by interactions across multiple scales, nonlinearity, self organization, and emergent properties (Boyce 1992; Holling 1992; Levin 1998; Wu and Marceau 2002). These characteristics can confound our understanding of ecosystem processes and limit our capacity to make predictions on, for example, population sizes. One of the challenges is to aggregate and simplify available ecological knowledge, retain what is essential and disregard that which is not essential at the particular scale of interest.

Like all scientific results and inferences, residual impact predictions must be tempered with uncertainty associated with the data and the current knowledge of the system. It is anticipated that the baseline data is moderately sufficient for understanding current conditions, and that there is a moderate level of understanding of Project-related impacts on the ecosystem.

A critical component of this assessment was to link spatial patterns of habitat on the landscape to the abundance and distribution of wildlife. The use of fragmentation statistics and conservative estimates of sensory disturbance should limit uncertainty in predictions of no effects on abundance and distribution of VECs due to the Project.

To reduce uncertainty associated with changes in habitat quantity, conservative estimates of previous, existing and future development sizes were applied to calculate the area of habitat directly affected by the Project footprint. For example, a 500 m radius was used to estimate the footprint area for exploration sites (78.5 ha). This likely overestimates direct habitat loss associated with exploration sites as drilling activities are generally completed in the winter to avoid rutting from the rig and on-site vehicles (unless a heli-portable drill rig is used).

To reduce uncertainty associated with changes in habitat quality, conservative estimates of the zones of influence and disturbance coefficients were applied to calculate the area of habitat indirectly affected by the Project footprint. There is uncertainty in exact distance effects of disturbance on wildlife, and there is individual variability in responses to disturbance (Amstrup 1993); however, the ZOI used here were consistent with previously published efforts to estimate effects from development on habitat quality for caribou (e.g., Boulanger et al. 2012; Johnson et al. 2005). During the past 10 to 12 years, monitoring studies at operating diamond mines, and government and university research programs have provided good information on the Bathurst caribou population and development-related effects. Traditional knowledge studies and recommendations from elders about how to mitigate impacts from roads and other mine facilities has also increased during this time. This

information increased the confidence in caribou-development interactions. While these studies focus on the Bathurst caribou herd, they represent the best available information on barren-ground caribou and development interactions in the north.

In addition, zones of influence were applied to all active exploration sites in the RSA and CESA for the entire permit period even though activities typically do not occur throughout the year, and some sites may have been abandoned before permit expiration. Disturbance coefficients (used for reducing habitat quality in the zones of influence) with the greatest effect were applied in cases where zones of influence overlapped, rather than using the average of two or more coefficients. All of these attributes provide confidence that the assessment has not underestimated the environmental significance of the incremental and cumulative impacts from the Project and other developments on wildlife, and the people that value wildlife for their livelihood.

The magnitude of population level effects depends on what proportion of the population has potential to be affected by the disturbance. The use of caribou collar data from the long-term GN collaring program provides useful insight into when caribou of the Qamanirjuac herd may be present in the RSA and LSA, the proportion of the herd that may be present, and for how long. However, the number of collared caribou represents a small portion of the herd, leaving uncertainty surrounding exact spatial and temporal distribution of the herd. There is also a lack of information on wolf distribution and abundance in the CESA, RSA, and LSA, which increases uncertainty about magnitude of effects.

It is understood that development activities will directly and indirectly affect habitat, and wildlife behaviour and movement; however, long-term monitoring studies documenting the resilience of wildlife to development and the time required to reverse impacts are lacking. Direct disturbance from previous, existing, and future development footprints was calculated to be a small proportion of the CESA, and the understanding of the success of mitigation policies and practices for limiting impacts to caribou has increased over the past decade. However, uncertainty remains surrounding the degree to which some effects may occur (e.g., magnitude and duration). A high degree of uncertainty also remains in the effectiveness of revegetation techniques for reversing the impact from direct changes to habitat.

Forecasting a future that may be outside the range of observable baseline environmental conditions is clearly challenging (because of climate change for example; Walther et al. 2002). Quantifying changes to habitat provides a static assessment of a species' environment, ignoring change that may occur over time as a result of ecological succession and natural disturbances such as climatic events. Thus, there is less certainty in long-term predictions of reversibility (e.g., over periods extending beyond 100 years). However, there is a high level of confidence that the regional landscape will be different with or without the Project in future decades.

6.6.13 Monitoring and Follow-Up

Upon approval of the Project, a TEMMP (SD 6-4) will be implemented to limit effects to wildlife and wildlife habitat, determine the effectiveness of mitigation, and test impact predictions. The principal goal of the TEMMP is to provide information required to adaptively manage the Project to protect wildlife and wildlife habitat. In addition, the TEMMP is designed to provide a process for regulators, communities, and other people interested in the Project to participate in the development and review of wildlife effects mitigation and monitoring.

Specific components of the TEMMP include the following:

- continuing to support the GN caribou collaring program;
- surveillance monitoring within the mining area and along the AWAR to search for wildlife;
- systematic road surveys; and
- a hunter harvest survey.

6.7 Birds and Bird Habitat

6.7.1 Introduction

6.7.1.1 Purpose and Scope

The purpose of this section is to describe the baseline conditions for birds and bird habitat and assess the effects of the Project on birds and bird habitat. This assessment includes potential changes resulting from Project-related components and associated activities, including air quality, noise, water quality and quantity, terrain and soils, and vegetation. The effects assessment will evaluate all Project phases, including construction, operation, maintenance, closure (decommissioning and reclamation), and post-closure. Indirect and cumulative effects have been incorporated throughout this section, where applicable. Specific requirements set out in the Guidelines issued by the NIRB in their Guidelines for the Project (NIRB 2012), relating to the baseline and the impact assessment for birds and bird habitat are presented in Volume 1, Appendix 1.0-A.

6.7.1.2 Valued Ecosystem Components

The purpose of this section is to address the Guidelines issued by the NIRB in their Guidelines for the Project (NIRB 2012), specifically relating to the impact of the Project on birds and bird habitat.

Valued ecosystem components and VSECs represent physical, biological, cultural, social, and economic properties of the environment that are either legally, politically, publically, or professionally recognized as important to a particular region, community, or by society as a whole. Valued ecosystem components and VSECS are selected based on their role in the ecosystem, and value placed on them by humans for traditional use and cultural connection, where appropriate.

A range of bird VECs were selected for the Project (Table 6.7-1). Factors considered when selecting bird VECs included the following criteria (Salmo 2006):

- biophysical components identified by NIRB during Project scoping and AEM community and stakeholder consultation;
- represent important ecosystem processes;
- territorial (GN 2000) and federal listed (COSEWIC 2012; *SARA* 2012) species;
- communities or species that reflect the interests of regulatory agencies, traditional use, and communities;
- can be measured or described with measurement endpoints;
- allow cumulative effects to be considered; and

- current experience with environmental assessments and effects monitoring programs in NU and the NT.

Table 6.7-1: Bird Valued Ecosystem Components

Valued Ecosystem Component	Rationale
Upland birds (including migratory birds)	upland birds include upland migratory birds (i.e., songbirds and shorebirds) and non-migratory birds (i.e., ptarmigan). Upland birds have a small territory size so may be affected by habitat loss; migratory birds are susceptible to population declines as a result of changing environmental conditions on breeding and overwintering habitats
Waterbirds	includes waterfowl, loons, and swans; waterbirds may be affected by loss of shoreline habitat for breeding; important staging habitat may also be lost; sensitive to noise disturbance and human activity; some species are important for subsistence; a number of species are listed as sensitive in NU
Raptors	sensitive to noise disturbance and human activity during nesting; include peregrine falcon and short-eared owl (federal species at risk)

Seabirds are also considered a VEC for the Project; however, the impacts to seabirds are assessed in FEIS Volume 8, Section 8.3 Marine Wildlife as part of the marine assessment.

6.7.2 Baseline Environment

6.7.2.1 Methods

Wildlife studies have been undertaken for the Project since the mid-1990s and include baseline studies completed from 1998 to 2000 (Jalkotzy 1999, 2000a, 2000b), 2008 to 2009 (SD 6-2 2009 Terrestrial Synthesis Baseline), and 2011 (Appendix 6.7-A). These studies have used a variety of species-specific methods (Table 6.7-2) to quantify bird populations with a focus on loons and other waterfowl, upland birds, raptors, and on bird species at risk within the RSA (Table 6.7-3). Detailed methods and results are provided in the SD 6-2 2009 Terrestrial Synthesis Baseline for data collected between 1998 and 2009. Detailed methods and results for data collected in 2011 are provided in Appendix 6.7-A.

Table 6.7-2: Summary of Bird Surveys Completed

Surveys	1998	1999	2000	2008	2009	2011
Upland bird – point count surveys				√	√	√
Shorebirds – PRISM surveys				√	√	√
Waterfowl – aerial surveys				√	√	
Loon and Swans – nest surveys	√	√	√		√	
Raptors – nest surveys	√	√	√	√	√	√

Table 6.7-3: Bird Species of Concern in the Regional Study Area

Common Name	Scientific Name	COSEWIC Status[a]	*SARA* Status[b]	Nunavut Status[c]	Record of Presence in the Regional Study Area
Peregrine falcon (tundra)	*Falco peregrinus*	Special Concern	Schedule 1	May be at Risk	Observed within RSA (1998,1999, 2000, 2011); confirmed nesting (2008, 2009, 2011)
Red knot	*Calidris canutus rufa* *Calidris canutus islandica*	Endangered Special Concern	Schedule 1	May be at Risk	Not observed
Short-eared owl	*Asio flammeus*	Special Concern	Schedule 1	Sensitive	Observed within Project RSA (2000, 2008, 2009)
Common eider	*Somateria mollisima*	-	-	Sensitive	Observed within Project RSA (2008, 2009)
King eider	*Somateria spectabilis*	-	-	Sensitive	Observed within Project RSA (2009)
Northern pintail	*Anas acuta*	-	-	Sensitive	Observed within Project RSA (1998, 2008, 2009)
Least sandpiper	*Calidris minutilla*	-	-	Sensitive	Observed within Project RSA (2008, 2009)
Semipalmated sandpiper	*Calidris pusilla*	-	-	Sensitive	Observed within Project RSA (2008, 2009, 2011)
Horned lark	*Eremophila alpestris*	-	-	Sensitive	Observed within Project RSA (1998, 2008, 2009, 2011); confirmed nesting (2011)
American tree sparrow	*Spizella arborea*	-	-	Sensitive	Observed within Project RSA (2008)
Snow bunting	*Plectrophenax nivalis*	-	-	Sensitive	Observed within Project RSA (2008, 2009)
White-crowned sparrow	*Zonotrichia leucophrys*	-	-	Sensitive	Observed within Project RSA (2008)
American pipit	*Anthus rubescens*	-	-	Sensitive	Observed within Project RSA (1998, 2008, 2009)

[a] COSEWIC Status: Committee on the Status of Endangered Wildlife in Canada. http://www.cosewic.gc.ca/eng/sct1/searchform_e.cfm, accessed August 2012

[b] SARA Status: *Species at Risk Act*. http://www.sararegistry.gc.ca/default_e.cfm, accessed August 2012

[c] Nunavut Wild Species – General Status of Wild Species in Nunavut. Government of Nunavut. Department of Sustainable Development. 33 pp.

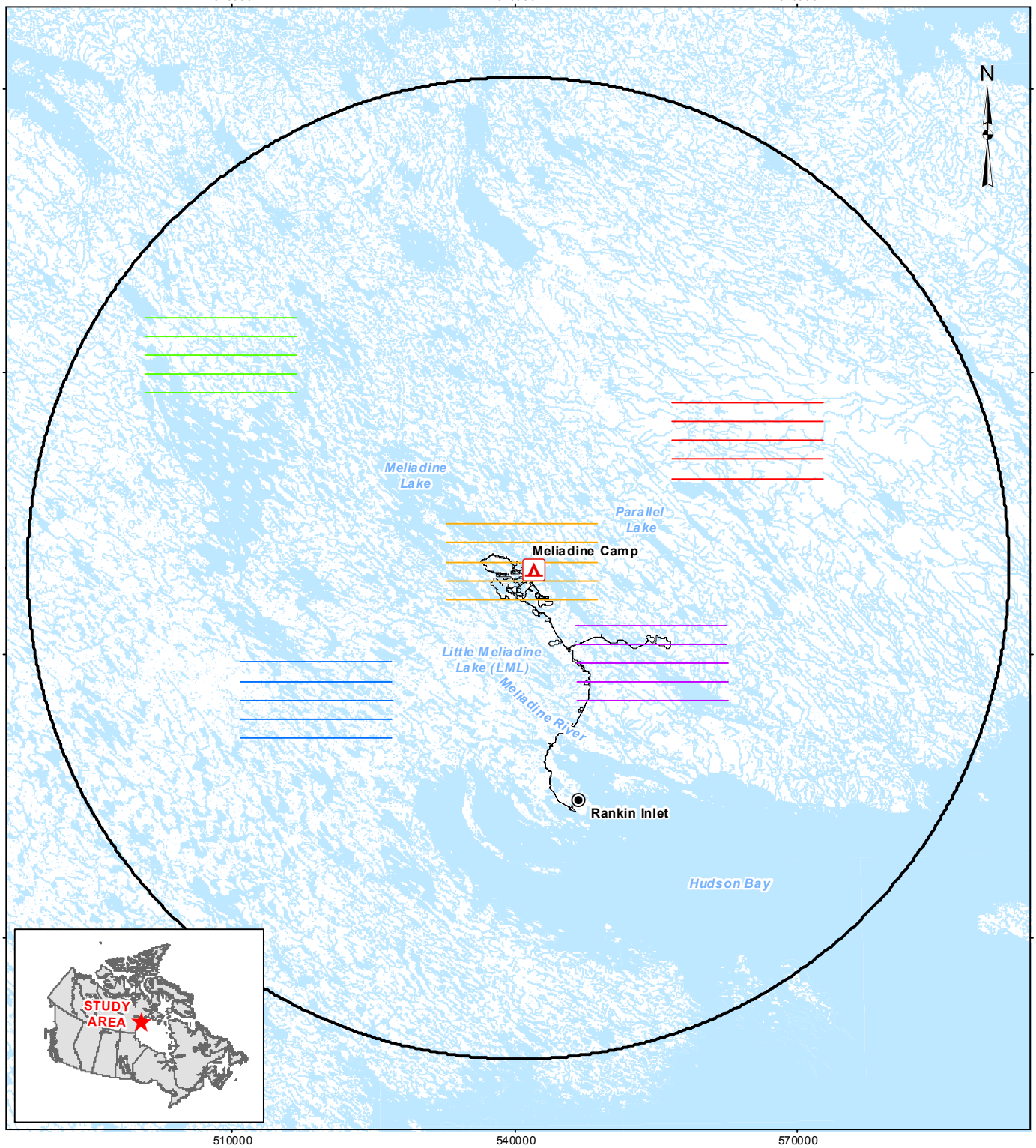
"-" = species is not listed under COSEWIC (2012) or *SARA* (2012)

6.7.2.1.1 Waterbirds

Waterfowl

Aerial surveys to determine waterfowl breeding status and productivity were completed in June (spring/migration) and July (summer/rearing), respectively. Each survey covered 5 separate strata: Mine, North, South, East, and Discovery (Figure 6.7-1). The Mine stratum covered the mine footprint. The North, Mine, and South strata were surveyed in 2008 and 2009, while the East stratum was only surveyed in 2008, and the Discovery stratum in 2009.

Each stratum was comprised of five, 16 km long transects oriented in an east-west direction, spaced 2 km apart. Transects were flown by helicopter at a speed of 80 to 100 kilometres per hour (km/h) at an altitude of 45 m (Jalkotzy 1999, 2000a, 2000b; Hines et al. 2000, 2003). Each stratum took approximately one hour of flying time to complete. Two observers recorded all waterfowl within 200 m on either side of the aircraft (Larned et al. 2003). The number of young in each brood was also recorded during the productivity survey.



LEGEND

- Camp
- Waterfowl Transect
  - East Stratum (2008)
  - Mine Stratum (2008 and 2009)
  - North Stratum (2008 and 2009)
  - South Stratum (2008 and 2009)
  - Discovery Stratum (2009)
- Project Footprint
- Watercourse
- Terrestrial Regional Study Area
- Waterbody

12 0 12
KILOMETRES

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).
Wildlife data obtained from field survey.
Datum: NAD 83 Projection: UTM Zone 15

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

WATERFOWL AERIAL TRANSECTS AND SURVEY STRATA

Golder Associates

PROJECT		10-1373-0076	FILE No.	
DESIGN	LD	26 Nov. 2012	SCALE AS SHOWN	REV. 0
GIS	DSC	27 Nov. 2012		
CHECK	LY	14 Jan. 2013		
REVIEW	CDB	14 Jan. 2013		

FIGURE 6.7-1

N:\Bur-Graphics\Projects\2013\1428\13-1428-0007\GIS\Mapping\MXD\FEIS\Volume_6\Main_Volume\Figure_6.7-1_Waterfowl_Aerial_Transects_Survey_Strata.mxd

Observations of all waterfowl were recorded according to established survey protocols (USFWS and CWS 1987). Observations of lone ducks or swans were recorded as singles or pairs. Two geese or swans in close association were recorded as a pair. A hen (i.e., female duck) and 2 drakes (i.e., male duck) were recorded as a pair and a lone drake, whereas a drake and 2 hens were recorded as one pair and the second hen was not recorded. Groups of 4 or less were separated into singles and pairs if the associations were evident. Groups of 5 or more were recorded as mixed groups. Gulls were recorded so that possible increases in population size following development can be monitored. Sandhill cranes (*Grus canadensis*) were also recorded. Further details are provided in SD 6-2 2009 Terrestrial Synthesis Baseline.

Statistical procedures followed Smith (1995), where duck and goose population indices were based on indicated birds. Indicated bird estimates were calculated from bird observations based on the following formula:

$$T = 2*(S + P) + G$$

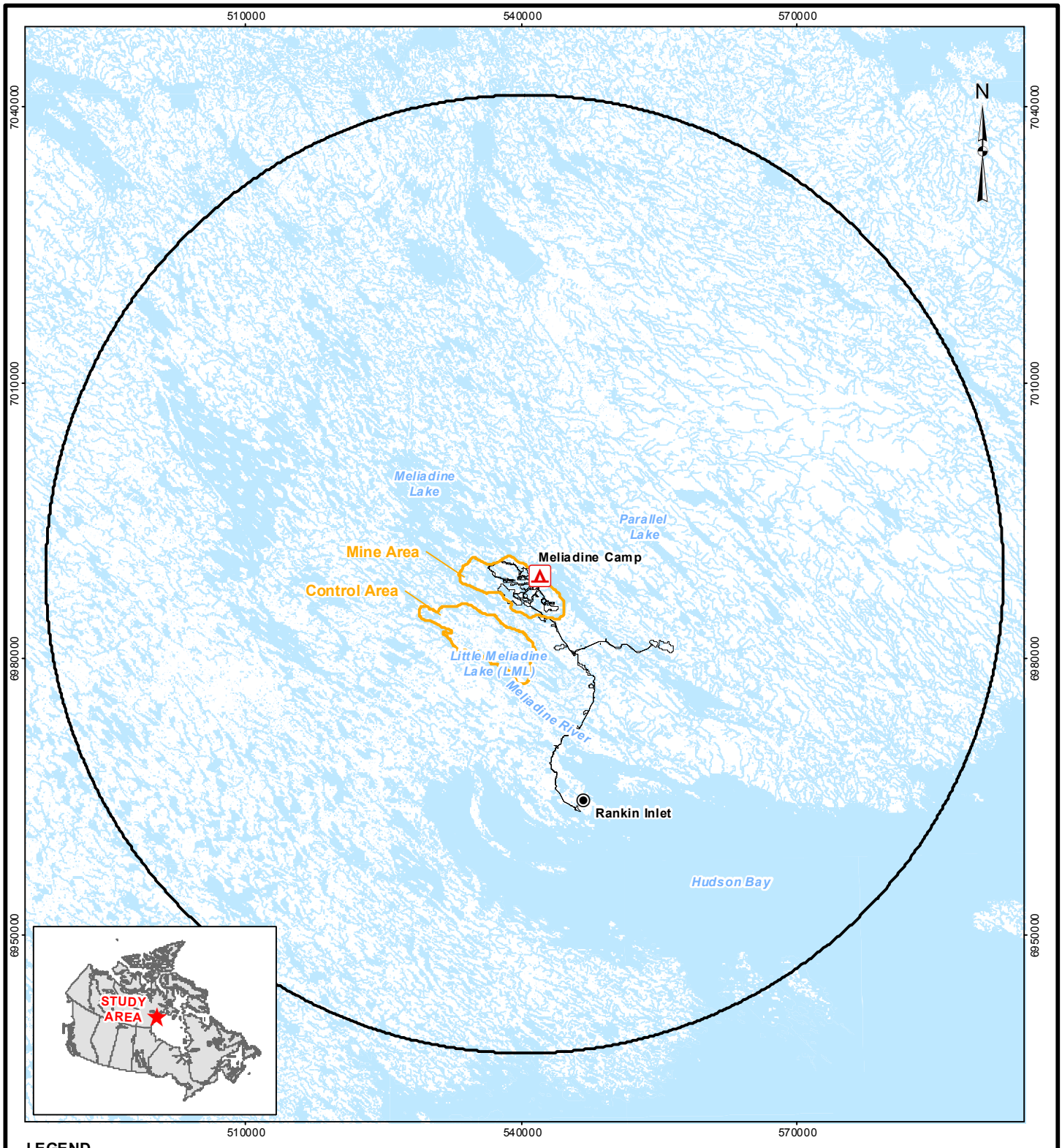
Where T = indicated total birds
S = the number of lone drakes observed
P = the number of pairs observed
G = the number of birds in groups

For this calculation, drakes in groups smaller than 5 were considered as singles (S), except for scaup species, whereas 5 or more grouped drakes, including scaup or any individual scaup, were considered as a group (G). Population indices of the non-duck and non-goose species were based only on the total number of birds observed.

Loon and Swan Nest Surveys

Loon and swan nest surveys were completed in 1998, 1999, 2000, and 2009 to provide breeding status and productivity data on tundra swans (*Cygnus columbianus*) and Pacific loons (*Gavia pacifica*). The objectives were to compare tundra swan and Pacific loon occupancy and productivity between the area potentially affected by mine development (mine study area) and a control area (control study area) (Figure 6.7-2), and to determine if mine-related activities influence nest site selection. Aerial surveys were completed using a helicopter over an area of approximately 9000 ha, which contained 419 waterbodies of various sizes. Each of these 419 waterbodies was surveyed, with special attention paid to shorelines. The number of potential breeding adults was determined by counting the number of adults on nests during surveys in June or early July. Productivity was determined by counting the number of young during surveys in mid- to late July or early August.

Total-coverage ground searches also occurred on all 419 waterbodies between June and August of 1998, 1999, and 2000 to confirm species identification and breeding status. Two observers systematically walked the entire shoreline area of all waterbodies and wetlands and recorded all observations of loons and swans and their nests and young.



LEGEND

- Camp
- Watercourse
- Loon and Swan Survey Area
- Terrestrial Regional Study Area
- Waterbody
- Project Footprint

12 0 12

KILOMETRES

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).
Wildlife data obtained from field survey.
Datum: NAD 83 Projection: UTM Zone 15

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

LOON AND SWAN SURVEY AREAS

Golder Associates

PROJECT		10-1373-0076	FILE No.	
DESIGN	LD	26 Nov. 2012	SCALE AS SHOWN	REV. 0
GIS	DSC	27 Nov. 2012		
CHECK	LY	14 Jan. 2013		
REVIEW	DW	14 Jan. 2013		

FIGURE 6.7-2

N:\Bur-Graphics\Projects\2013\1428\13-1428-0007\GIS\Mapping\MXD\FEIS\Volume_6\Main_Volume\Figure_6.7-2_Loon_Swan_Survey_Areas.mxd

6.7.2.1.2 Upland Birds

Two types of surveys were completed for upland birds (i.e., songbirds [excluding common raven], shorebirds, and ptarmigan): a point-count upland bird survey and a shorebird survey. The upland bird point count survey was used to determine the composition and relative abundance of upland bird species and their habitat associations within the RSA. Upland bird point count surveys estimate population densities and species composition of bird communities (Robbins 1970; Kissling and Garton 2006). They provide habitat-specific density data and can be used to measure the effect of land-use practices on breeding bird populations.

In 2008, 2009, and 2011, 165, 145, and 75 point count surveys (50 m radius) were completed, respectively, within the RSA (Figure 6.7-3; Table 6.7-4). The same point count locations were not surveyed in multiple years. Point counts were located a minimum of 100 m apart on each transect with approximately 100 m between transects to reduce the likelihood of re-counting individuals from adjacent point counts.

Two levels of analysis were performed. A species-level analysis examined how the density of individual species varied across the habitats. A community-level analysis examined the variation in density and richness among habitats of all species in the bird community. In the community-level analysis, observations where birds were recorded as within the plot (i.e., within 50 m of the observer), but could not be identified to species, were included in density estimates, but excluded from the species richness estimates unless it was the only individual recorded in a plot. Species richness and species densities for each habitat type were determined using individuals recorded as within the sampling radius (i.e., 50 m).

Table 6.7-4: Number of Upland Bird Point Count Surveys among Habitat Types Identified by the Ecological Landscape Classification in the Regional Study Area, 2008, 2009, and 2011

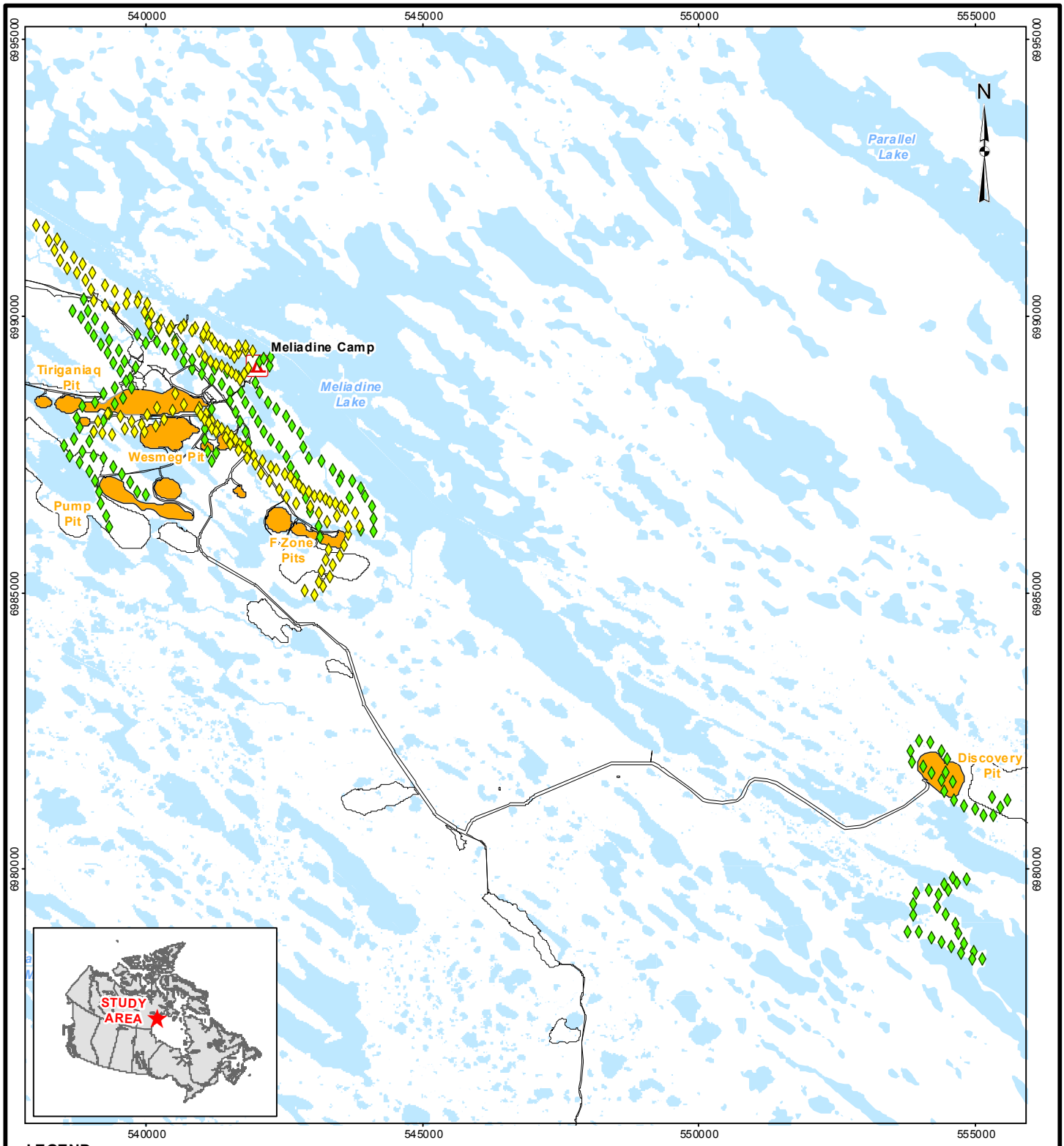
Habitat Type	2008		2009		2011		Total	
	n	%	n	%	n	%	n	%
Heath boulder	5	3	5	4	7	9	17	5
Heath tundra	95	58	73	50	53	71	221	57
Tussock hummock	63	38	46	32	15	20	124	32
Heath Lichen – *Cetraria*	2	1	21	14	0	0	23	6
Total	**165**	**100**	**145**	**100**	**75**	**100**	**385**	**100**

Note: n = number of plots surveyed, % = percent

Shorebird surveys were completed during 2008, 2009, and 2011 following Program for Regional and International Shorebird Monitoring (PRISM) survey methods (CWS 2008). The objectives of PRISM include estimating breeding population size; describing the distribution, abundance, and habitat relationships; and monitoring trends in breeding population size of shorebirds (Bart et al. 2005). The PRISM survey methods are used consistently across North America so data can be compiled and compared across the continent.

Shorebird surveys were completed following rapid survey methods (CWS 2008). Between 2008 and 2011, 29 plots were surveyed in the RSA. Each plot was 300 m by 400 m (12 ha) with plots falling as much as possible into a single habitat type (Figure 6.7-4). Habitat types were classified based on shorebird habitat suitability: good (sedge wetland), fair (tussock/hummock, heath tundra, esker), and poor (heath bedrock, heath boulder) (CWS 2008). Simpson's Diversity Index was used to measure species diversity.

Further details regarding the upland bird survey and shorebird survey methods are described in SD 6-2 2009 Terrestrial Synthesis Baseline.



LEGEND

- Camp
- Bird Plot
  - 2008
  - 2009
- Watercourse
- Open Pit
- Project Footprint
- Waterbody

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).
Wildlife data obtained from field survey.
Datum: NAD 83 Projection: UTM Zone 15

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

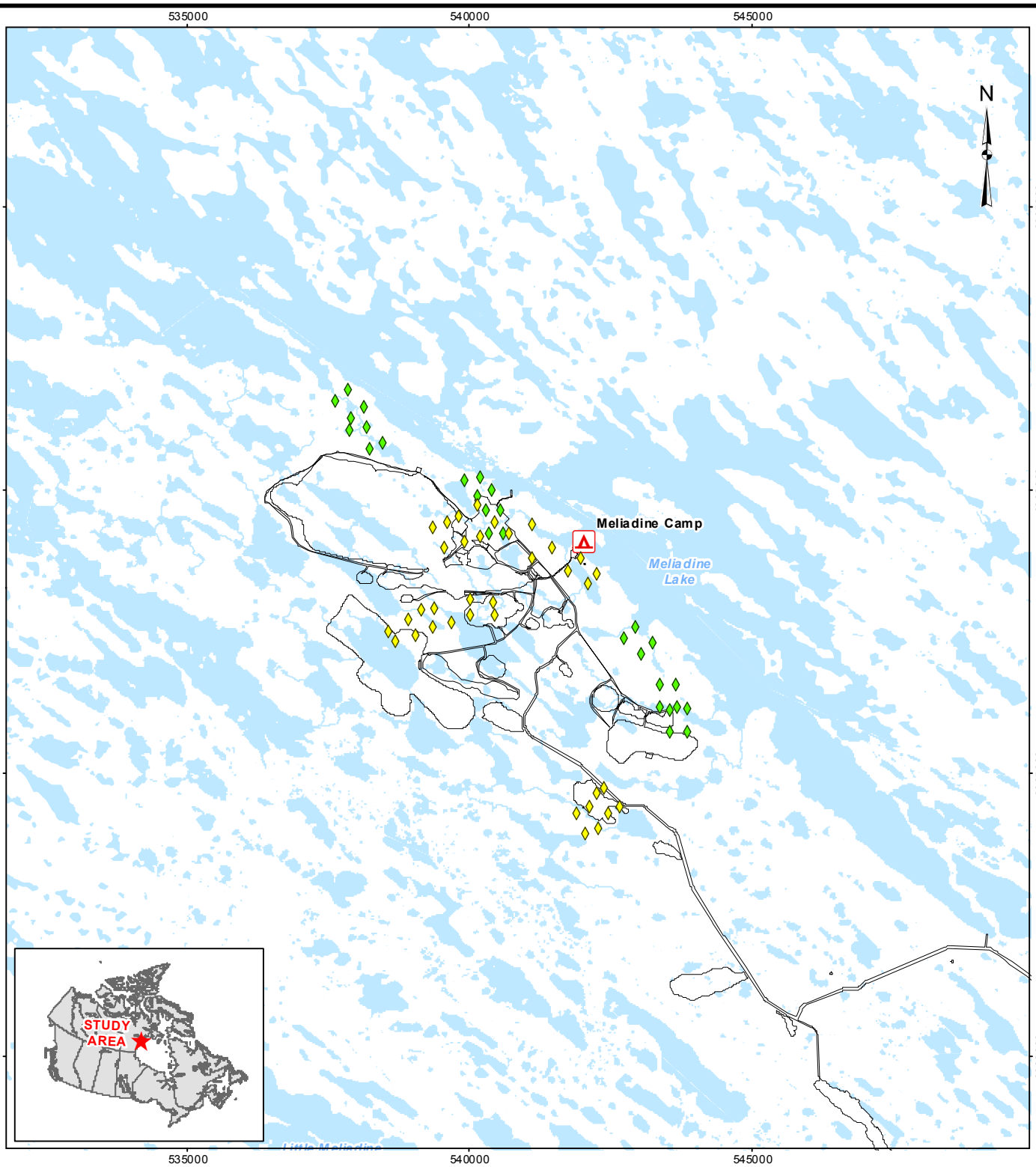
UPLAND BIRD POINT COUNT LOCATIONS

Golder Associates

PROJECT		10-1373-0076	FILE No.	
DESIGN	LD	26 Nov. 2012	SCALE AS SHOWN	REV. 0
GIS	DSC	27 Nov. 2012		
CHECK	LY	14 Jan. 2013		
REVIEW	DW	14 Jan. 2013		

FIGURE 6.7-3

N:\Bur-Graphics\Projects\2013\1428\13-1428-0007\GIS\Mapping\MXD\FEIS\Volume_6\Main_Volume\Figure_6.7-3_Upland_Bird_Point_Count_Location.mxd



LEGEND

- Camp
- Shorebird PRISM Plot Location
  - 2008
  - 2009
- Watercourse
- Waterbody
- Project Footprint

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).
Wildlife data obtained from field survey.
Datum: NAD 83 Projection: UTM Zone 15

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

SHOREBIRD PRISM PLOT LOCATIONS

Golder Associates

PROJECT		10-1373-0076	FILE No.	
DESIGN	LD	26 Nov. 2012	SCALE AS SHOWN	REV. 0
GIS	DSC	27 Nov. 2012		
CHECK	LY	14 Jan. 2013		
REVIEW	DW	14 Jan. 2013		

FIGURE 6.7-4

N:\Bur-Graphics\Projects\2013\1428\13-1428-0007\GIS\Mapping\MXD\FEIS\Volume_6\Main_Volume\Figure_6.7-4_Shorebird_PRISM_Lot_Location.mxd

6.7.2.1.3 Raptor Nest Surveys

Between 1998 and 2000, and in 2008, 2009, and 2011, unstructured ground and aerial surveys were used to search for raptor nesting sites within approximately 10 km of the Project footprint. These surveys were designed to determine occupancy of historical nest sites, identify new nest sites, and monitor for occupancy and productivity.

Special attention was paid to cliffs, rock outcrops, boulders, and eskers. During aerial surveys, the helicopter was flown close to the elevation of the top of each cliff, at 20 to 50 km/h. Observers searched for flushing raptors, as well as whitewash. The locations of all potential nests were recorded and waypoints taken. Project staff also recorded raptor sightings; these sightings were investigated by Golder. Unstructured surveys, targeted to likely nesting sites, are necessary when a study site is unknown, and provide the best opportunity to detect new nests and determine occupancy at known nests (A. Franke, University of Alberta, 2014, pers. comm.).

Occupancy of a nest was determined by observing at least one adult bird at the nest, 2 birds in flight in close proximity to the nest, or finding a nest containing eggs or young. Any new potential nest sites located during raptor surveys and other wildlife surveys were recorded. Unoccupied nests within 200 m of an occupied nest were considered alternate nest sites within the same territory of that nesting pair (Court et al. 1988). Nests were considered successful only if young birds were observed at the site. Productivity was calculated both as the number of young per occupied nest, as well as per successful nest.

The number of potential nest sites that were monitored varied among years. Locations of raptor nests were provided to the GN and were updated with additional nest locations supplied by the GN in 2012 (N. Lecomte, Government of Nunavut, 2012, pers. comm.). Additional information on the status of potential raptor nests located in the RSA by Golder was also obtained in 2012 and 2013 from the Arctic Raptor Project (A. Franke, University of Alberta, 2012, 2014, pers. comm.). This information revealed that some of the sites identified as potential nest sites during baseline studies were not actual nest sites but likely observations of individuals nesting in the vicinity. Because of these changes in the dataset, results from surveys presented SD 6-2 2009 Terrestrial Synthesis Baseline are different than those presented in Section 6.7.3.1.1. See Table 6.7-5 for a summary of these changes.

In 2013, the Arctic Raptor Project continued data collection for raptors in the Project area, providing additional baseline data that are not presented in SD 6-2 2009 Terrestrial Synthesis Baseline. A search area was defined according to methods described by Ratcliff (1980). The outer most sites from 32 years of monitoring data around Rankin Inlet were buffered by the mean nearest neighbour distance for all sites (3.3 km^2 in this case). The search area was then the minimum convex polygon encompassing the buffered sites (A. Franke, University of Alberta, 2014, pers. comm.).

Beginning in May 2013, known nest sites and the intervening habitat were surveyed by snowmobile to determine presence or absence of raptors. After break-up of sea ice, coastal areas were surveyed by boat and inland areas were monitored by all-terrain vehicle, helicopter, or on foot. One helicopter survey was conducted on June 26, 2013 for 2 hours and 26 minutes. Sites were considered occupied if territorial or nest building behaviour was observed. Repeated site visits provide the most complete information at a given nest; however; single visits to different nests throughout the season (pre-laying, egg-laying/incubation, and chick rearing periods) provides a reasonable estimate of site occupancy, clutch size, and productivity across the region.

Table 6.7-5: Nest Sites Located during Baseline Surveys and Changes Suggested by Information Received from the Arctic Raptor Project in 2012

Nest Site[a]	Change Recommended by Arctic Raptor Project[b]	Other Comments
A08-01	No change	-
A08-02	No change	These sightings are close together and A08-05A may be an alternate nest site. Further monitoring is needed to determine nest status[b]. Close to nest site AR-37[d]
A08-05 A	No change	
A08-03	No change	These sightings are close together and A08-04A may be an alternate nest site. Further monitoring is needed to determine nest status[b]. Close to nest site AR-37[d]
A08-04 A	No change	
A98-01	No change	-
A98-02	No change	These sightings are close together and all observations are not likely nest sites. Further monitoring is needed to determine the actual nest site[c]. Close to nest site AR-37[d]
A98-03	No change	
A98-04	No change	-
A98-05	No change	-
B08-01	No change	-
B08-02	No change	-
B08-05	No change	-
B09-01	No change	-
C00-01	Replace with AR number	Same nest site as AR-34
C00-02	Replace with AR number	Same nest site as AR-34
C08-01	No change	-
C09-01	No change	-
D08-01	Replace with AR number	These sightings are close together and D08-02 may be an alternate nest site. Further monitoring is needed to determine nest status[b]. Same nest site as AR-95
D08-02	Replace with AR number	
E08-01	No change	Poor quality nest site[d]
F08-01	Replace with AR number	Same nest site as AR-67[d]
F08-02	Replace with AR number	Same nest site as AR-67[c.d]
F08-03	Replace with AR number	Same nest site as AR-67[c.d]
F08-04	Replace with AR number	Same nest site as AR-67[c.d]
G08-01	No change	-
G08-02	Remove from dataset	Close to AR13-63 [c.d] ;not a nesting site [c]
G98-01	Remove from dataset	Close to AR13-63 [c.d] ;not a nesting site [c]
G98-02	Remove from dataset	Not a nesting site [c]
G98-03	No change	-
H98-01	Replace with AR number	Same nest site as AR-89[d]
H98-02	Replace with AR number	Same nest site as AR-96[d]
J00-01	No change	-
J98-01	No change	Close to AR-109[d]; might be alternate of AR-84[c]
J98-02	No change	-

[a] Locations of nests in the original (unaltered) dataset are available in Figure 6.7-12. See Figure 6.7-13 for locations of nests after recommended changes were made (A. Franke, University of Alberta, 2012, 2014, pers. comm.).

[b] Comments are observations from field personnel.

[c] Comments are from the Arctic Raptor Project (A. Franke, University of Alberta, 2012, pers. comm.).

[d] Comments are from the Arctic Raptor Project (A. Franke, University of Alberta, 2014, pers. comm.).

' - ' = no comment

6.7.3 Results

6.7.3.1 Waterbirds

6.7.3.1.1 Population Status and Distribution

Waterfowl

The RSA contains numerous lakes, ponds, and wetlands. These waterbodies provide habitat for migratory waterfowl, and breeding habitat for geese, swans, ducks, and herring gulls (*Larus argentatus*). Aerial surveys can be used to index the abundance of waterfowl in extensive, inaccessible arctic breeding areas (McLaren and Alliston 1985; Conant et al. 2006; Conant et al. 2007).

Waterfowl aerial surveys in June and July of 2008 and 2009 recorded 3 to 12 species within the 5 different aerial survey strata (Tables 6.7-6 and 6.7-7). The population indices were higher for June than July; and higher in 2009 than 2008. In June 2008 and 2009, and July 2008, the South stratum had the highest density of birds (Figures 6.7-5 and 6.7-6). In July 2009, the Mine stratum had the highest density. Densities were similar within each stratum between years. Overall, waterbird density in June was higher in 2009 than in 2008. Conversely, waterfowl density in July was higher in 2008 than in 2009.

Waterfowl have been identified as an important resource through traditional knowledge studies (FEIS Volume 9, Appendix 9.3-A). Ducks, snow geese (*Chen caerulescens*), and Canada geese (*Branta canadensis*) are hunted in the spring and fall by local Inuit people, from Rankin Inlet to Mirage Island and along the flow edge in spring (Freeman 1976). Eggs are collected in the springbetween Rankin Inlet and Mistake Bay (Riewe 1992). Eggs are also collected on islands near Rankin inlet, along the coast and on lakes and ponds (Freeman 1976).

The breeding season is critically important to the population dynamics of waterfowl. The breeding season is the time when population increases as well as high rates of mortality occur all within a small portion of the total year (Johnson et al. 1992).

Table 6.7-6: Waterfowl Population Index and Species Richness among Survey Strata, June 2008 and 2009

Common Name	Scientific Name	Mine Stratum		North Stratum		South Stratum		East Stratum	Discovery Stratum	Total	
		2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
Red-throated loon	*Gavia stellata*	0	21	0	0	0	0	0	0	0	21
Pacific loon	*Gavia pacifica*	42	42	42	0	21	0	0	0	105	42
Common loon	*Gavia immer*	0	21	0	0	0	0	0	0	0	21
Red-breasted merganser	*Mergus serrator*	53	107	0	0	0	0	0	0	53	107
Tundra swan	*Cygnus columbianus*	231	567	0	0	0	0	21	609	252	1 176
Canada goose	*Branta canadensis*	588	1239	441	1134	1218	1008	42	987	2 289	4 368
Snow goose	*Chen caerulescens*	0	147	0	1995	0	2709	0	1239	0	6 090
Northern pintail	*Anas acuta*	256	1025	0	128	128	128	0	641	384	1 922
Scaup species	*Aythya marila* or *A. affinis*	81	324	0	0	0	162	0	324	81	810
Long-tailed duck	*Clangula hyemalis*	628	471	432	314	1100	1100	0	1924	2 160	3 809
Sandhill crane	*Grus canadensis*	147	189	84	84	483	504	0	189	714	966
Herring gull	*Larus argentatus*	168	105	63	168	273	567	21	882	525	1 722
Common eider	*Somateria mollissima*	0	0	0	0	0	0	0	105	0	105
Unidentified duck species	-	42	0	0	0	0	0	0	42	42	42
Total		**2236**	**4258**	**1062**	**3823**	**3223**	**6178**	**84**	**6942**	**6 605**	**21 201**
Species Richness[a]		**9**	**12**	**5**	**6**	**6**	**7**	**3**	**9**	**9**	**13**
Density (individuals/km^2)-		**16.6**	**31.5**	**7.9**	**28.3**	**23.9**	**45.8**	**0.6**	**51.4**	**-**	**-**

[a] Does not include unidentified duck species

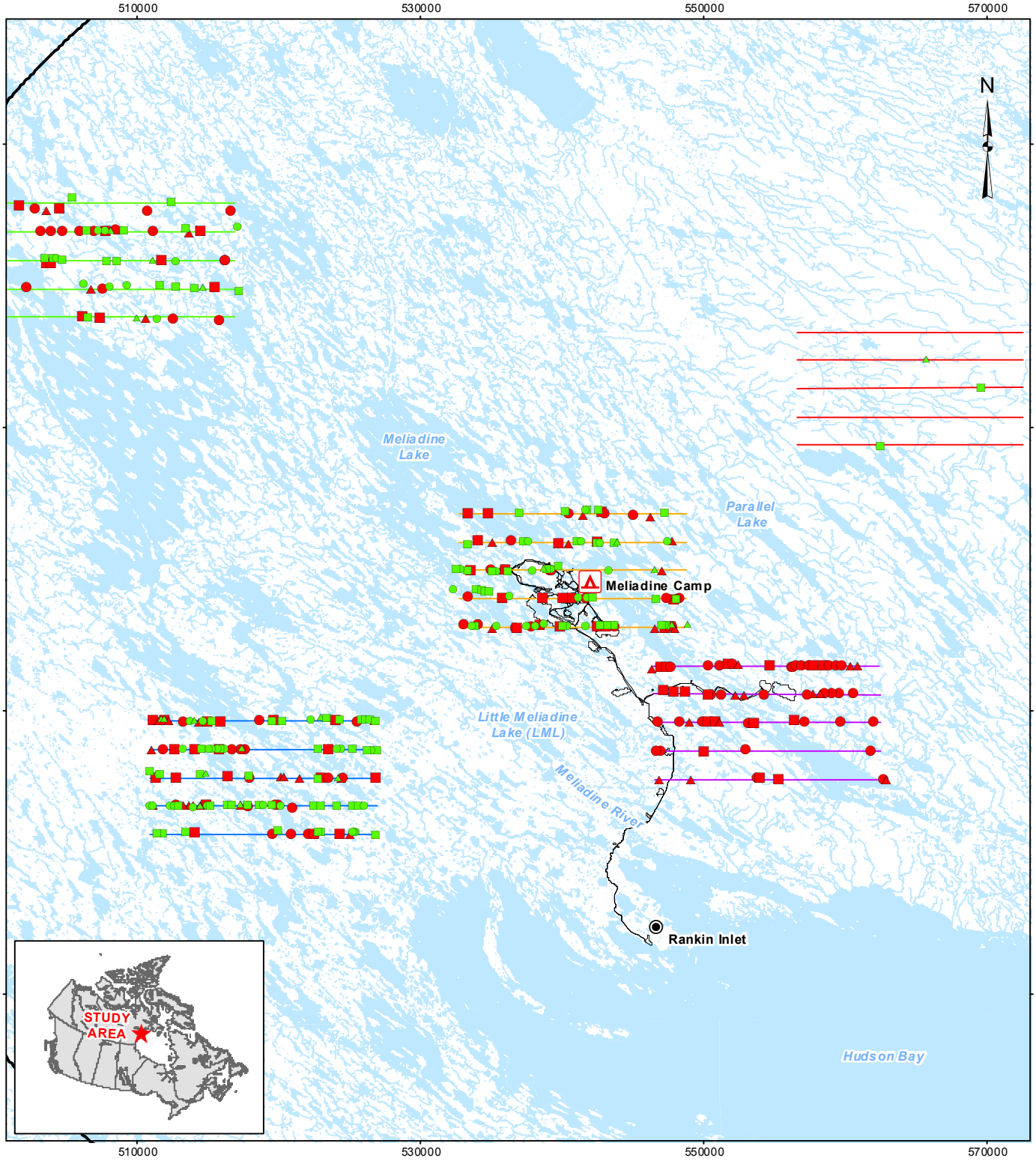
'-' = not applicable; km^2 = square kilometre

Table 6.7-7: Waterfowl Population Index and Species Richness among Survey Strata, July 2008 and 2009

Common Name	Scientific Name	Mine Stratum		North Stratum		South Stratum		East Stratum	Discovery Stratum	Total	
		2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
Red-throated loon	*Gavia stellata*	0	0	21	21	63	0	0	0	84	21
Pacific loon	*Gavia pacifica*	0	147	84	42	0	0	0	189	84	378
Common loon	*Gavia immer*	42	0	42	0	0	0	0	0	84	0
Red-breasted merganser	*Mergus serrator*	0	0	160	107	0	0	0	0	160	107
Tundra swan	*Cygnus columbianus*	483	882	0	42	0	0	0	504	483	1428
Canada goose	*Branta canadensis*	546	945	2583	2016	2100	882	1995	210	7224	4053
Snow goose	*Chen caerulescens*	0	21	21	0	0	42	315	0	336	63
Long-tailed duck	*Clangula hyemalis*	79	353	0	157	236	314	0	393	315	1217
Sandhill crane	*Grus canadensis*	63	441	105	168	336	567	21	189	525	1365
Herring gull	*Larus argentatus*	63	126	105	84	252	294	0	315	420	819
Greater white-fronted goose	*Anser albifrons*	0	105	0	0	0	0	0	0	0	105
Unidentified duck species	-	42	105	42	0	84	42	0	210	168	357
Total		**1318**	**3125**	**3163**	**2637**	**3071**	**2141**	**2331**	**2010**	**9883**	**9913**
Species Richness[a]		**6**	**8**	**9**	**8**	**6**	**5**	**3**	**6**	**10**	**10**
Density (individuals/km^2)		**9.2**	**23.2**	**24.1**	**19.6**	**22.7**	**15.9**	**17.3**	**14.9**	**-**	**-**

[a] Does not include unidentified duck species.

'-' = not applicable; km^2 = square kilometres



LEGEND

- Camp
- Waterfowl Observation (June 2008)
  - Group
  - Pair
  - Single
- Waterfowl Observation (June 2009)
  - Group
  - Pair
  - Single
- Watercourse
- Waterfowl Transect
  - East Stratum (2008)
  - Mine Stratum (2008 and 2009)
  - North Stratum (2008 and 2009)
  - South Stratum (2008 and 2009)
  - Discovery Stratum (2009)
- Terrestrial Regional Study Area
- Project Footprint
- Waterbody

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).
Wildlife data obtained from field survey.
Datum: NAD 83 Projection: UTM Zone 15

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

JUNE WATERFOWL OBSERVATIONS

Golder Associates

PROJECT		10-1373-0076	FILE No.	
DESIGN	LD	26 Nov. 2012	SCALE AS SHOWN	REV. 0
GIS	DSC	27 Nov. 2012		
CHECK	LY	14 Jan. 2013		
REVIEW	CDB	14 Jan. 2013		

FIGURE 6.7-5

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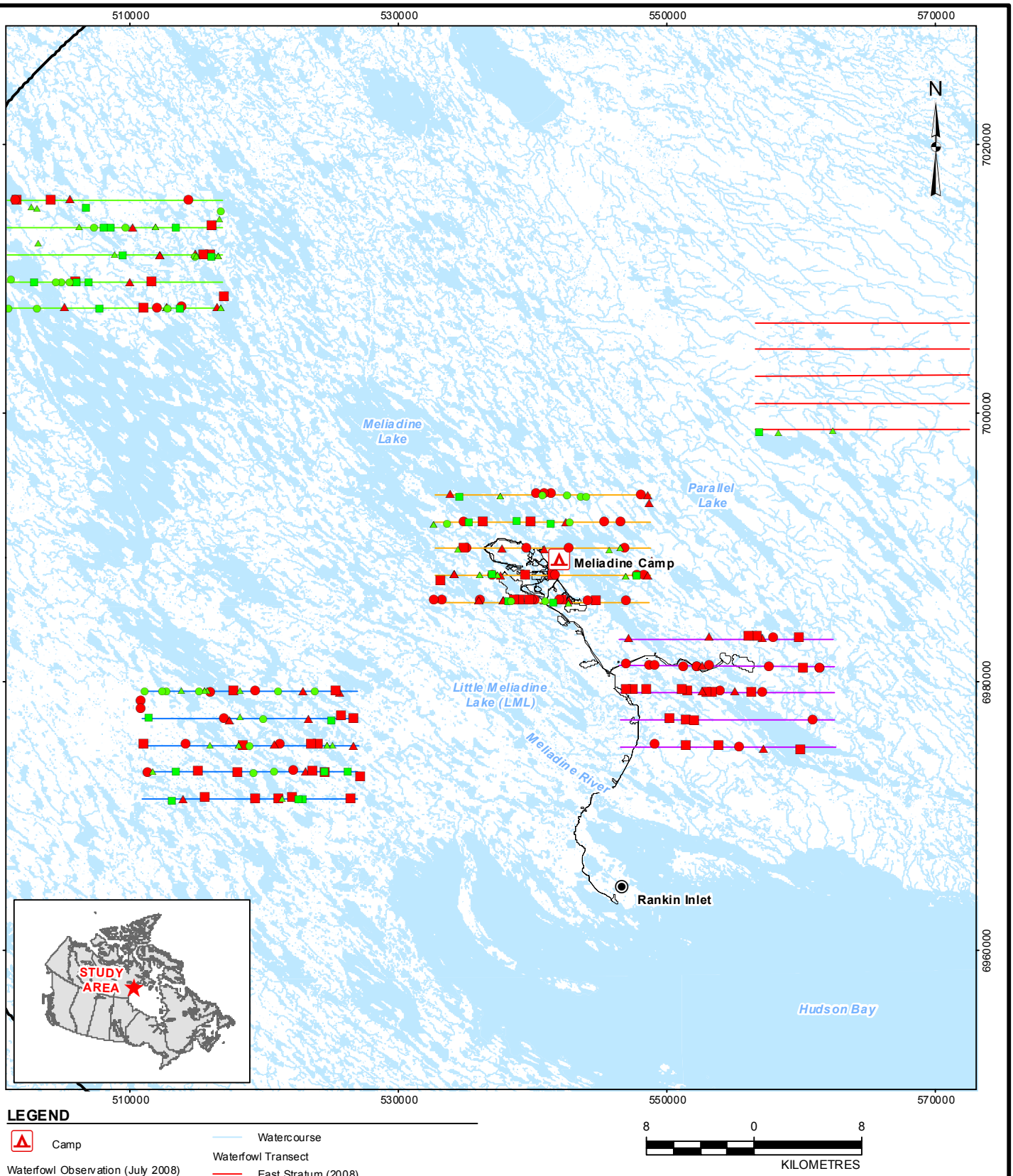


LEGEND

- Camp
- Waterfowl Observation (July 2008)
  - Group
  - Pair
  - Single
- Waterfowl Observation (July 2009)
  - Group
  - Pair
  - Single
- Watercourse
- Waterfowl Transect
  - East Stratum (2008)
  - Mine Stratum (2008 and 2009)
  - North Stratum (2008 and 2009)
  - South Stratum (2008 and 2009)
  - Discovery Stratum (2009)
- Terrestrial Regional Study Area
- Project Footprint
- Waterbody

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).
Wildlife data obtained from field survey.
Datum: NAD 83 Projection: UTM Zone 15

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

JULY WATERFOWL OBSERVATIONS

Golder Associates

PROJECT		10-1373-0076	FILE No.	
DESIGN	LD	26 Nov. 2012	SCALE AS SHOWN	REV. 0
GIS	DSC	27 Nov. 2012		
CHECK	LY	14 Jan. 2013		
REVIEW	DW	14 Jan. 2013		

FIGURE 6.7-6

N:\Bur-Graphics\Projects\2013\1428\13-1428-0007\GIS\Mapping\MXD\FEIS\Volume_6\Main_Volume\Figure_6.7-6_July_Waterfowl_Observation.mxd

Canada geese, snow geese, tundra swans, and long-tailed ducks (*Clangula hyemalis*) were the most common waterfowl observed during waterfowl surveys in 2008 and 2009 (Tables 6.7-6 and 6.7-7). Common eiders (*Somateria mollissima*) were only recorded during the June 2009 survey in the Discovery stratum, and greater white-fronted geese (*Anser albifrons*) were only recorded in the Mine stratum in July 2009. Greater scaup (*Aythya marila*) and lesser scaup (*Aythya affinis*) were not differentiated due to the similarities in appearance.

In both years, only tundra swans and Canada geese were observed with broods during waterfowl aerial surveys. More broods were recorded in 2008 (14 broods) than in 2009 (7 broods) (Table 6.7-8). This could be due to the late ice break-up that occurred in 2009. During June 2009 surveys, most small ponds and wetlands were frozen whereas at the same time in 2008, ice break-up was further advanced and there was more open water. This could affect the brood production in July because when spring is late, waterfowl may not attempt to nest (Marshall 1952; Ryder 1970). Overall, Canada geese had more broods and a higher number of young than tundra swans.

Table 6.7-8: Waterfowl Productivity (Number of Broods and Young Observed) within Survey Strata, July 2008 and 2009

Common Name	Scientific Name	Mine Stratum		North Stratum		South Stratum		East Stratum	Discovery Stratum
		2008	2009	2008	2009	2008	2009	2008	2009
Tundra Swan	*Cygnus columbianus*	4 (12)	2 (3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)
Canada Goose	*Branta canadensis*	3 (11)	2 (7)	4 (15)	1 (3)	3 (15)	0 (0)	0 (0)	1 (1)
Total		**7 (23)**	**4 (10)**	**4 (15)**	**1 (3)**	**3 (15)**	**0 (0)**	**0 (0)**	**2 (2)**
Mean		**5.5 (16.5)**		**2.5 (9.0)**		**1.5 (7.5)**			

Note: number outside of parentheses is total number of broods observed.
number in parentheses is total number of young observed.

Loons

Pacific loons, red-throated loons (*Gavia stellata*), and common loons (*Gavia immer*) are summer residents in the RSA. In all baseline survey years, Pacific loons were the most-frequently observed loon species and red-throated and common loons were uncommon. In 1998, based on the intensive ground survey in June and follow-up ground checks on selected waterbodies in June and July, there were 11 breeding pairs of Pacific loons (Table 6.7-9). One pair of common loons and 2 pairs of red-throated loons were also observed in 1998. Pacific loons nest on small, quiet, fish-bearing waterbodies with sloping shorelines (Ruggles 1994). Nesting Pacific loons were not randomly distributed within the RSA. In all survey years, breeding pairs were concentrated in the northwest and southeast ends of the aerial survey areas (Figure 6.7-7). Nest locations in the same immediate areas were used in consecutive years based on repeated observations of nests and waterbody use by adults with fledglings (Figures 6.7-7 and 6.7-8).

Occupancy and productivity of Pacific loons varied, with the number of adult nesting pairs ranging from 7 to 16 in the mine study area, and from 7 to 14 in the control study area. Observations were similar in 1998 to 2000 but the number of breeding pairs in both survey areas was lower in 2009 (Table 6.7-9). This is due to reduced survey effort in 2009 because no ground searches or follow up surveys occurred. Productivity can also vary between years due to predation. Kertell (1996) found that the principal cause of reproductive failure in Pacific loons appeared to be predation by Arctic fox (*Alopex lagopus*) during incubation.

Table 6.7-9: Pacific Loon Occupancy and Productivity, 1998 to 2000, and 2009

Year	Mine Study Area		Control Study Area	
	# Adult Nesting Pairs	# Broods (Mean # of Fledglings per brood)	# Adult Nesting Pairs	# Broods (Mean # of Fledglings per brood)
1998	11	Unknown	-	-
1999	16	4 (1.3)	14	3 (1.5)
2000	14	8 (1.5)	14	4 (1.0)
2009	7	3 (>1.3)	7	3 (>0.7)
Mean[a]	12.0	5 (1.4)	11.7	3.3 (>0.9)

[a] Mean based on total number of fledglings.

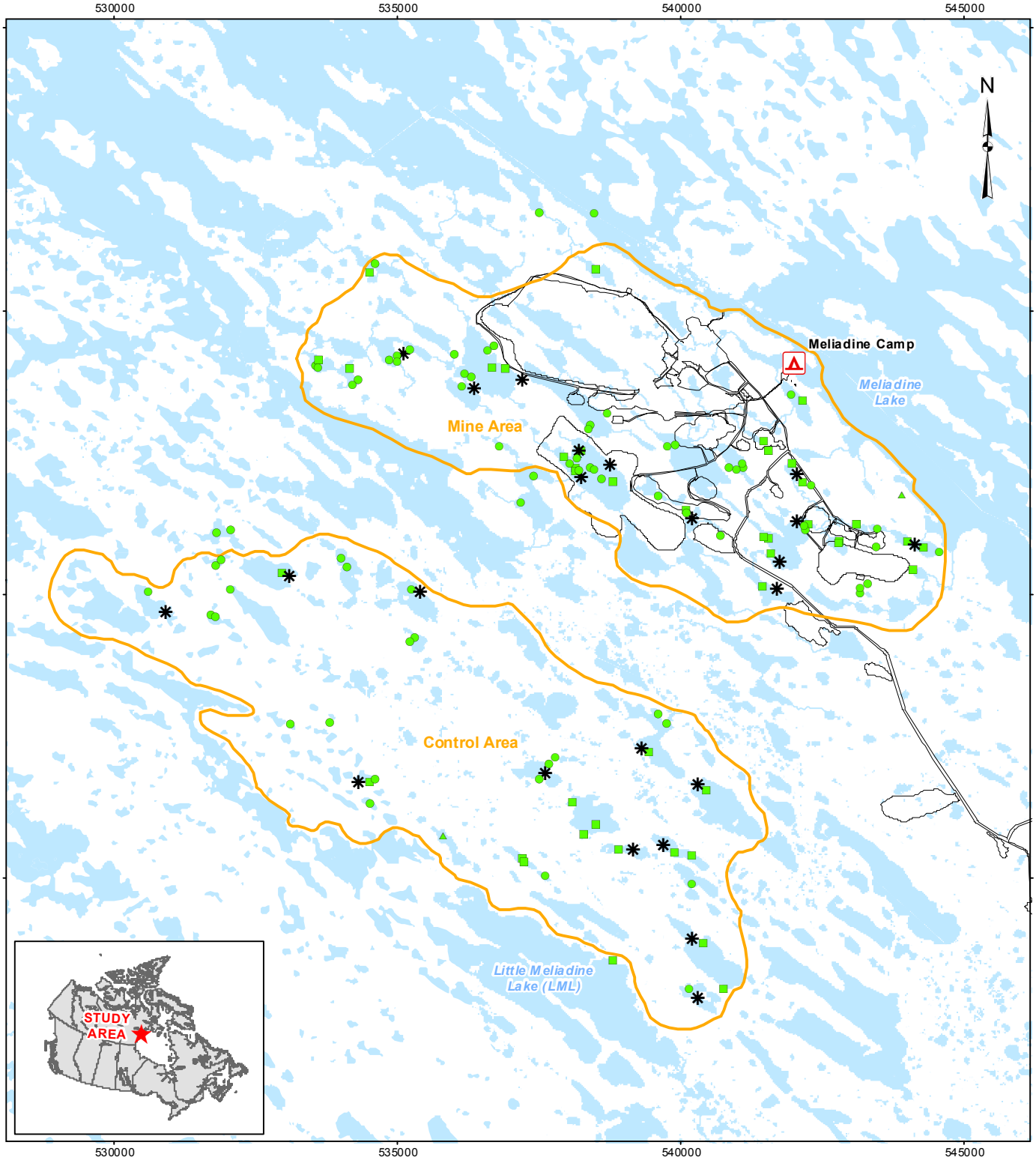
Note: "#" = number;" -" = area not surveyed;" >" = nests were still being incubated during July survey, accurate brood count not possible

Density for breeding pairs of Pacific loons was higher for all years in the mine study area than the control study area (Table 6.7-10). This may be due to habitat suitability, as there is more variability in the size of waterbodies in the mine study area. Predation upon eggs and young is often high, and loons avoid predation by breeding at low densities, nesting on islands, and using nesting ponds to escape from predators. Adults may also actively defend eggs and chicks against small predators (Petersen 1979; Davis 1972). Again, reduced density observed in 2009 compared to previous years is likely directly related to reduced survey effort.

Table 6.7-10: Pacific Loon Breeding Density, 1998 to 2000 and 2009

Year	Breeding Density (Breeding Pairs per hectare)	
	Mine Study Area	Control Study Area
1998	0.0028	-
1999	0.0041	0.0027
2000	0.0036	0.0027
2009	0.0018	0.0014
Mean density	0.0029	0.0023

Note: "-" = area not surveyed



LEGEND

- Camp
- Pacific Loon Observation
  - Pacific Loon - Group
  - Pacific Loon - Pair
  - Pacific Loon - Single
  - Pacific Loon - Nest
- Watercourse
- Loon and Swan Survey Area (1998-2000, 2009)
- Project Footprint
- Waterbody

2 0 2
KILOMETRES

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).
Wildlife data obtained from field survey.
Datum: NAD 83 Projection: UTM Zone 15

PROJECT
AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

PACIFIC LOON OCCUPANCY JUNE/JULY

Golder Associates

PROJECT		10-1373-0076	FILE No.	
DESIGN	LD	26 Nov. 2012	SCALE AS SHOWN	REV. 0
GIS	DSC	27 Nov. 2012		
CHECK	LY	14 Jan. 2013		
REVIEW	DW	14 Jan. 2013		

FIGURE 6.7-7

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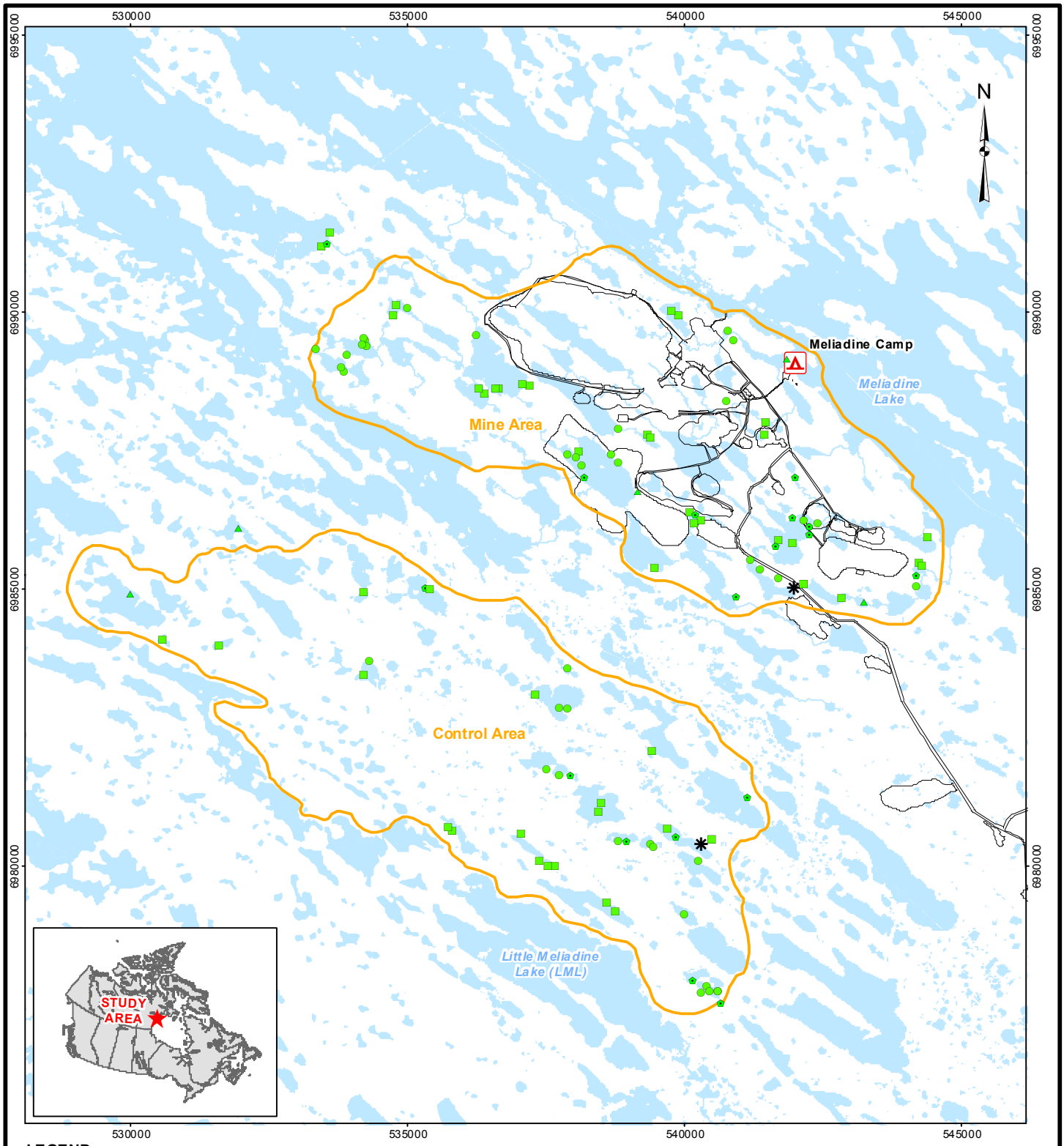

LEGEND

- Camp
- Pacific Loon Observation
  - Pacific Loon - Group
  - Pacific Loon - Brood
  - Pacific Loon - Pair
  - Pacific Loon - Single
  - Pacific Loon - Nest
- Watercourse
- Loon and Swan Survey Area (1998-2000, 2009)
- Project Footprint
- Waterbody

2 0 2
KILOMETRES

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).
Wildlife data obtained from field survey.
Datum: NAD 83 Projection: UTM Zone 15

PROJECT
AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

PACIFIC LOON PRODUCTIVITY JULY/AUGUST

Golder Associates

PROJECT		10-1373-0076	FILE No.	
DESIGN	LD	26 Nov. 2012	SCALE AS SHOWN	REV. 0
GIS	DSC	27 Nov. 2012		
CHECK	LY	14 Jan. 2013		
REVIEW	DW	14 Jan. 2013		

FIGURE 6.7-8

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During all survey years, waterbodies occupied by Pacific loons ranged in area from 0.80 to 95.1 ha (Table 6.7-11). Petersen (1979) found ponds with nests to be on average 1.8 ha in size, with less than 1% of occupied ponds being greater than 9.6 ha, and only 24% of occupied ponds being less than 0.3 ha. Ruggles (1994) found that Pacific loons used waterbodies as small as 4 ha.

Table 6.7-11: Comparison of Size Range in Hectares of Occupied Waterbodies by Pacific Loons in Project Area and Control Area, 1998 to 2000 and 2009

1998	1999		2000		2009	
Mine Study Area	Mine Study Area	Control Study Area	Mine Study Area	Control Study Area	Mine Study Area	Control Study Area
0.80 to 12.5	1.0 to 87.1	1.0 to 44.9	1.0 to 85	1.0 to 65	21.1 to 49.9	16.2 to 95.1

Tundra Swans

Tundra swans were regularly documented as breeding in the RSA, and were easily observed due to their large size and white colour. Tundra swan breeding territories are comprised of a lake, used for refuge and foraging, and adjacent terrestrial habitats and ponds near the lake's perimeter used for foraging and nesting (Earnst and Rothe 2004). The lake provides important refuge for cygnets (juvenile swans) during brood-rearing (Limpert and Earnst 1994).

Nesting tundra swans were not randomly distributed within the RSA. In all survey years, breeding pairs were concentrated in the northwest and southeast ends of the aerial survey areas (Figure 6.7-9). Nest locations in the same immediate areas were used in consecutive years based on repeated observations of nests and waterbody use by adults with fledglings (Figures 6.7-9 and 6.7-10).

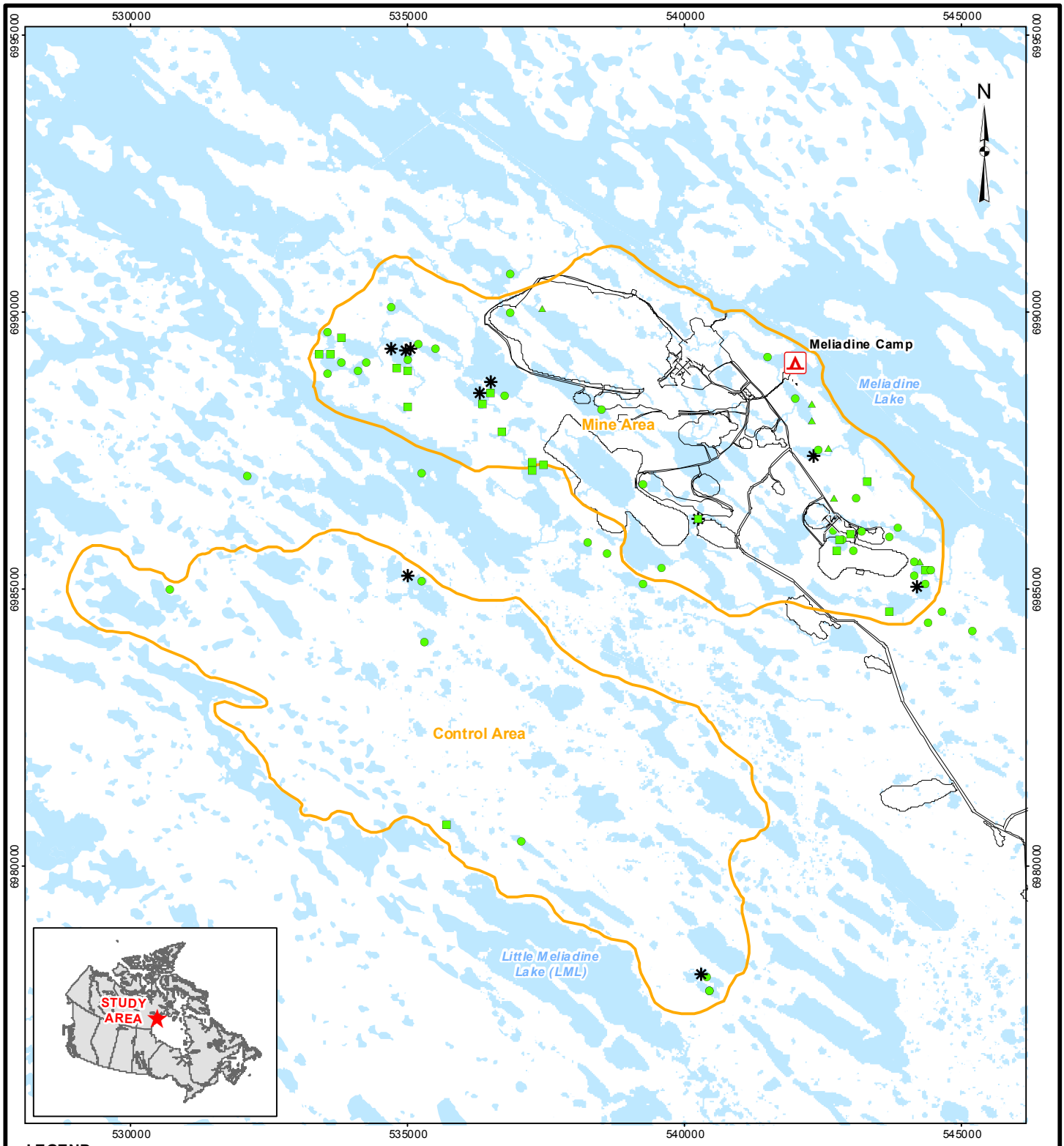
Tundra swan breeding and productivity was variable during the 4 surveys completed between 1998 and 2009. The number of adult nesting pairs ranged from 5 to 8 in the mine study area and from one to 5 in the control study area (Table 6.7-12). In all survey years, the number of broods ranged from 0 to 7, and the mine study area was consistently more successful with more broods and fledglings, and a greater breeding density than the control study area (Table 6.7-13).

Table 6.7-12: Tundra Swan Occupancy and Productivity, 1998 to 2000 and 2009

Year	Mine Study Area		Control Study Area	
	# Adult Nesting Pairs	# Broods (Mean # of Fledglings)	# Adult Nesting Pairs	# Broods (Mean # of Fledglings)
1998	8	3 (unknown)	-	-
1999	5 to 7	6 (1.7)	1	0 (0)
2000	7	3 (3)	5	2 (3)
2009	7	7 (2)	1	1(3)
Mean[a]	6.8 to 7.3	4.8 (2.1)[a]	2.3	1.0 (2.3)[a]

[a] Mean based on total number of fledglings

Note: "#" = number; "-" = area not surveyed



LEGEND

- Camp
- **Tundra Swan Observation**
  - Tundra Swan - Group
  - Tundra Swan - Pair
  - Tundra Swan - Single
  - Tundra Swan - Nest
- Watercourse
- Loon and Swan Survey Area (1998-2000, 2009)
- Project Footprint
- Waterbody

2 0 2
KILOMETRES

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).
Wildlife data obtained from field survey.
Datum: NAD 83 Projection: UTM Zone 15

PROJECT
AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

TUNDRA SWAN OCCUPANCY JUNE/JULY

Golder Associates

PROJECT		10-1373-0076	FILE No.	
DESIGN	LD	26 Nov. 2012	SCALE AS SHOWN	REV. 0
GIS	DSC	27 Nov. 2012		
CHECK	LY	14 Jan. 2013		
REVIEW	DW	14 Jan. 2013		

FIGURE 6.7-9

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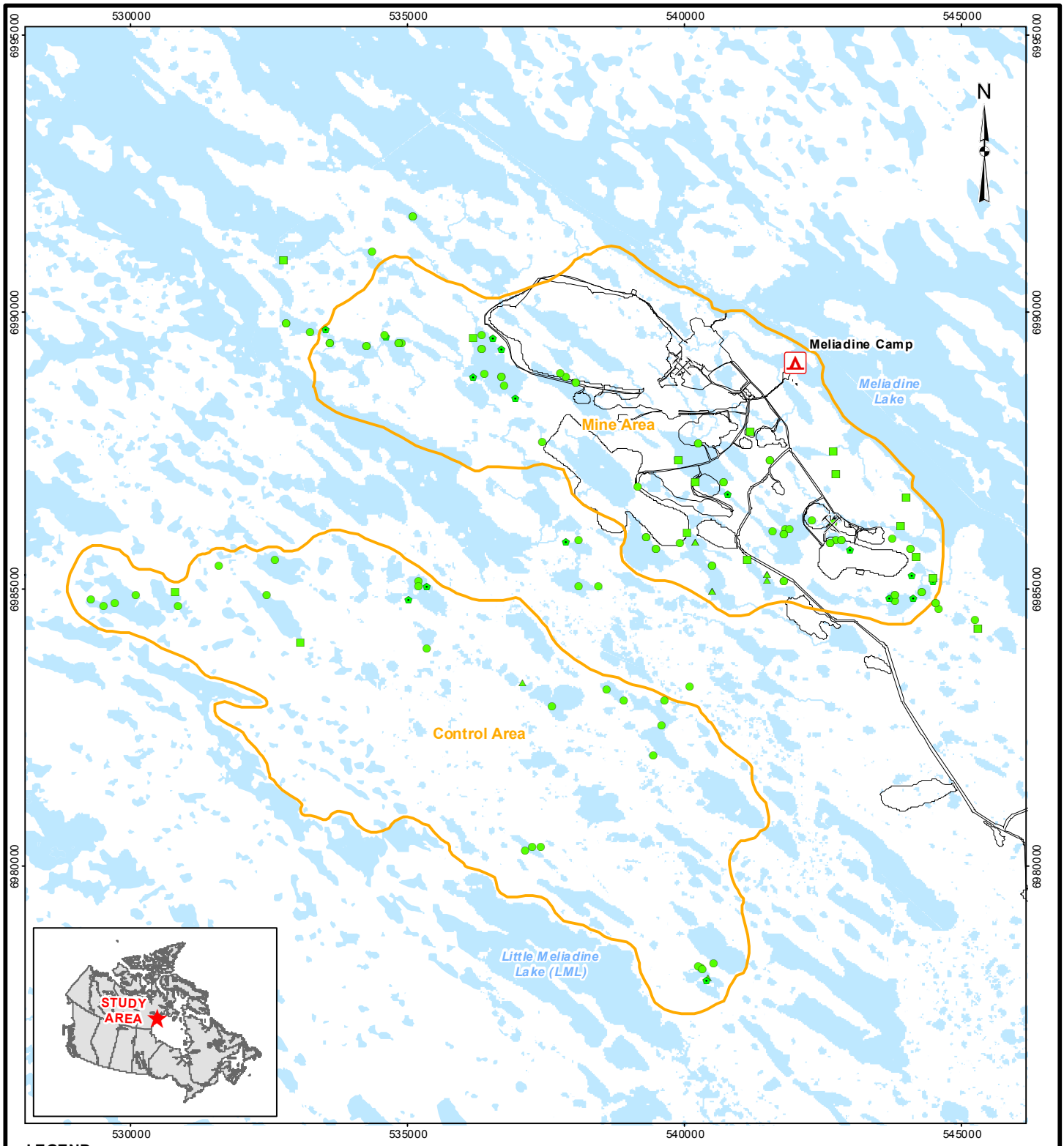


LEGEND

- Camp
- Tundra Swan Observation
  - Tundra Swan - Group
  - Tundra Swan - Brood
  - Tundra Swan - Pair
  - Tundra Swan - Single
- Watercourse
- Loon and Swan Survey Area (1998-2000, 2009)
- Project Footprint
- Waterbody

2 0 2
KILOMETRES

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).
Wildlife data obtained from field survey.
Datum: NAD 83 Projection: UTM Zone 15

PROJECT
AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

TUNDRA SWAN PRODUCTIVITY JULY/AUGUST

Golder Associates

PROJECT		10-1373-0076	FILE No.	
DESIGN	LD	26 Nov. 2012	SCALE AS SHOWN	REV. 0
GIS	DSC	27 Nov. 2012		
CHECK	LY	14 Jan. 2013		
REVIEW	DW	14 Jan. 2013		

FIGURE 6.7-10

N:\Bur-Graphics\Projects\2013\1428\13-1428-0007\GIS\Mapping\MXD\FEIS\Volume_6\Main_Volume\Figure_6.7-10_Swan_Productivity_July_August.mxd

Table 6.7-13: Tundra Swan Breeding Density, 1998 to 2000 and 2009

Year	Breeding Density (individuals/ha)	
	Mine Study Area	Control Study Area
1998	0.0015	-
1999	0.0013 to 0.0018	0.0002
2000	0.0018	0.0013
2009	0.0018	0.0002
Mean density	0.0017	0.0006

Note: "-" = area not surveyed; ha = hectare

The waterbodies in the mine study area used for nesting were larger than in the control study area. Earnst and Rothe (2004) found that larger waterbodies likely provide better refuge for cygnets and may have more foraging and nesting sites on the lake proper and adjacent habitats.

6.7.3.2 Upland Birds

6.7.3.2.1 Population Status and Distribution

Upland birds are commonly studied in baseline and monitoring programs because they are well-studied indicators of habitat quality and habitat change. Some birds are also an important resource for Aboriginals in the NT and NU as they are used for food and provide other materials, such as feathers, which are used to make blankets and pillows (LKDFN et al. 2001). Local community members have observed that bird species composition has changed, possibly due to changing climate conditions, with some native populations in decline and the introduction of new species not historically observed in the region (GN 2005).

The spring migration of birds to NU begins in early May and peaks around mid- to late May (P. Smith, Environment Canada, 2012, pers. comm.). The breeding season for small perching birds (passerines) typically starts during the first week of June and continues for approximately 3 weeks. Fall migration begins in mid-August for some species, such as sandpipers, and continues through to mid-September for late migrants, such as horned larks.

A total of 11 upland bird species were identified in 4 habitat types during upland bird surveys from 2008 to 2011, including incidental observations (i.e., heard outside of 50 m, or fly-overs). Nine upland bird species were identified within upland bird survey plots (i.e., within 50 m).

In 2008, 9 identified species and 1 unidentified species of upland songbirds and shorebirds were recorded within the plots. Six identified species were recorded within the plots in 2009, and 3 identified species were recorded in 2011 (Table 6.7-14). Eight songbird and 2 shorebird species were recorded within the plots in 2008, whereas 5 species of songbird and 1 shorebird species were recorded in 2009, and 3 species of songbird and no shorebird species were recorded in 2011. Lapland longspurs (*Calcarius lapponicus*), horned larks (*Eremophila alpestris*), and savannah sparrows (*Passerculus sandwichensis*), were the most common birds observed in all years.

Table 6.7-14: Total Number of Individuals Observed and Species Richness Inside Point Counts, 2008, 2009, and 2011

Common Name	Scientific Name	2008	2009	2011	Total
Lapland longspur	*Calcarius lapponicus*	50	34	10	94
Horned lark	*Eremophila alpestris*	48	36	11	95
Savannah sparrow	*Passerculus sandwichensis*	39	26	22	87
American pipit	*Anthus rubscens*	6	13	0	19
Redpoll species	*Carduelis hornemanni* or *C. flammea*	1	0	0	1
Snow bunting	*Plectrophenax nivalis*	3	1	0	4
White-crowned sparrow	*Zonotrichia leucophrys*	1	0	0	1
Semipalmated plover	*Charadruis semipalmatus*	2	0	0	2
Least sandpiper	*Calidris minutilla*	4	1	0	4
Unidentified songbird	-	3	0	0	3
Total Species Richness[a]		**9**	**6**	**3**	**9**

[a] Does not include unidentified songbird
Notes - = not applicable

All species had low mean densities (<0.70/ha) (Table 6.7-15). Some individual plot locations had higher densities including up to 7.64/ha for savannah sparrow and 6.37/ha for horned lark. The other species had relatively low densities and a small range of densities over all locations.

Table 6.7-15: Mean Density (± 1 SE) (Individuals per Hectare) of Upland Bird Species among Habitat Types in the Regional Study Area, Combined 2008, 2009, and 2011

Common Name	Scientific Name	Heath Boulder	Heath Lichen – *Cetraria*	Heath Tundra	Tussock-Hummock
Semipalmated plover	*Charadruis semipalmatus*	0.07[a]	0	0.01[a]	0
Least sandpiper	*Calidris minutilla*	0	0	0	0.05 ± 0.03
Horned lark	*Eremophila alpestris*	0.52 ± 0.22	0.66 ± 0.21	0.32 ± 0.05	0.22 ± 0.06
American pipit	*Anthus rubscens*	0.15 ± 0.10	0.11 ± 0.11	0.05 ± 0.02	0.07 ± 0.04
Savannah sparrow	*Passerculus sandwichensis*	0.07[a]	0	0.17 ± 0.04	0.59 ± 0.10
White-crowned sparrow	*Zonotrichia leucophrys*	0	0	0.01[a]	0
Lapland longspur	*Calcarius lapponicus*	0.30 ± 0.17	0.06[a]	0.32 ± 0.05	0.35 ± 0.07
Snow bunting	*Plectrophenax nivalis*	0.30 ± 0.23	0	0	0
Redpoll species	*Carduelis hornemanni or C. flammea*	0	0	0	0.01[a]
Unknown songbird species		0	0	0.01[a]	0.02 ± 0.01

[a] Only the mean is reported as the species was only recorded once within the habitat type
Note: < = less than; SE = standard error of the mean

Upland bird density ranged from 0.00 to 8.92 individuals/ha, with the maximum density recorded in heath tundra (Table 6.7-16). This may be due to effort; heath tundra was the most frequently surveyed habitat type in both years. The highest mean density was recorded in heath boulder habitat. Upland bird density in tussock hummock habitat was significantly higher than density in heath tundra habitat (Figure 6.7-11). Variation in species richness among habitat types was low. Species richness ranged from 0 to 3 across the 4 different habitat types.

Table 6.7-16: Density (Individuals per Hectare) and Species Richness of Observed Upland Birds per Habitat Type in the Regional Study Area over 2008, 2009, and 2011 Combined

Habitat	Number of Plots	Species Richness		Density	
		Mean ± SE	Min-Max[a]	Mean ± SE	Min-Max[a]
Heath Tundra	222	0.52 ± 0.04	0 - 3	0.87 ± 0.09	0.00 - 8.92
Heath Boulder	17	0.82 ± 0.21	0 - 2	1.42 ± 0.44	0.00 - 6.37
Tussock Hummock	123	0.72 ± 0.07	0 - 3	1.32 ± 0.15	0.00 - 7.64
Heath Lichen – *Cetraria*	23	0.48 ± 0.12	0 - 2	0.83 ± 0.25	0.00 - 3.82
Total	**385**	**0.59 ± 0.04**	**0 - 9**	**1.04 ± 0.07**	**0.00 - 8.92**

[a] minimum to maximum values

Note: ± = plus or minus; SE = standard error of the mean

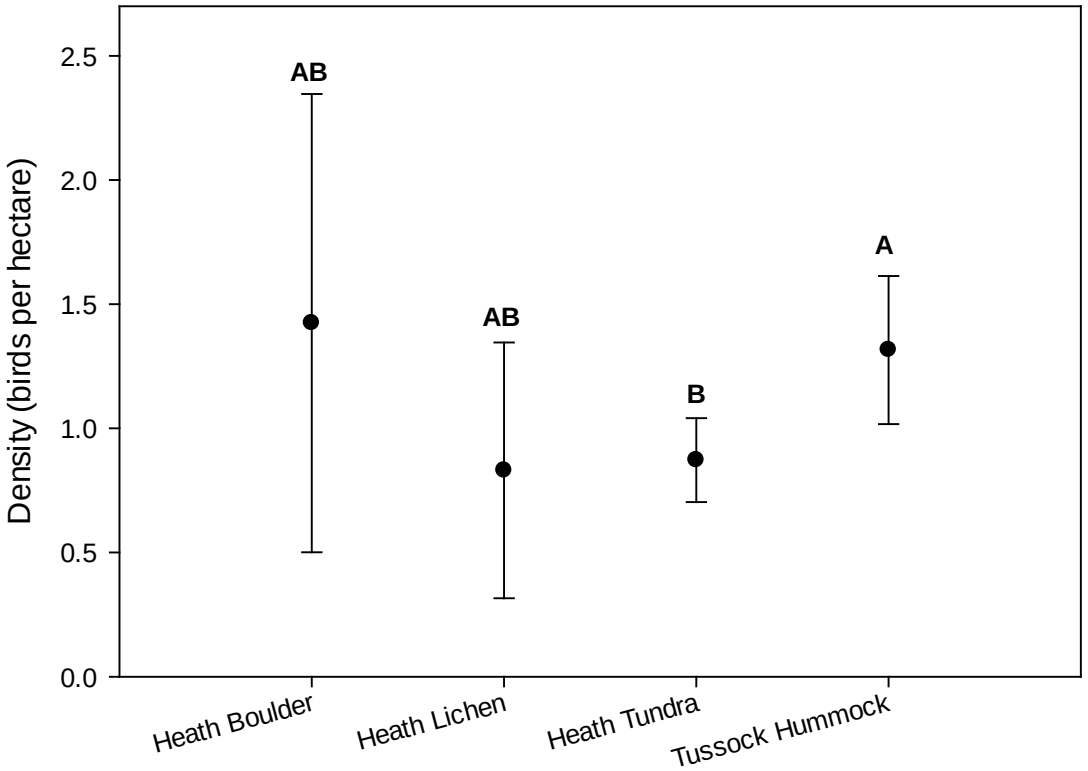


Figure 6.7-11: Mean (± 1SE) Density (birds per hectare) of Upland Birds by Habitat Type

Note: Habitats not connected by the same letter are significantly different from each other (i.e. Health Tundra and Tussock Hummock)

Note: Heath Lichen = Heath Lichen - *Cetraria*

Shorebirds

Prism plot surveys were completed in 2008 and 2009 to target shorebirds. In 2008, 4 shorebird species were recorded in the RSA: least sandpiper (*Calidris minutilla*), semipalmated sandpiper (*Calidris pusilla*), American golden plover (*Pluvialis dominica*), and semipalmated plover (*Charadrius semipalmatus*). However, only semipalmated plovers were recorded during PRISM surveys (Table 6.7-17). In 2009, least sandpiper and semipalmated sandpiper, and semipalmated plover were again observed along with one additional species

observed, dunlin (*Calidris alpina*). All 4 species were recorded during PRISM surveys in 2009. One shorebird species was observed in 2011. The highest number of individuals counted in one plot during all surveys was 2.

Table 6.7-17: PRISM Survey Observations, 2008, 2009, and 2011

Year	Habitat Type	Habitat Quality	Common Name	Scientific Name	Number	Sex
2008	Tussock/hummock	Fair	Semipalmated plover	*Charadrius semipalmatus*	2	Pair
2009	Heath tundra	Fair	Semipalmated plover	*Charadrius semipalmatus*	1	Unknown
2009	Sedge wetland	Good	Least sandpiper	*Calidris minutilla*	2	Pair
2009	Sedge wetland	Good	Dunlin	*Calidris alpina*	1	Unknown
2009	Heath tundra	Fair	Semipalmated sandpiper	*Charadrius semipalmatus*	1	Unknown
2011	Not Collected	Not Collected	Semipalmated sandpiper	*Charadrius semipalmatus*	2	Pair

Density of shorebirds ranged from 0 to 0.05 individuals/ha. The mean Simpson's Diversity Index was similar among years (Table 6.7-18). The Index has a value between 1.0 and 5.0, with higher values indicating greater diversity. Therefore, the maximum Simpson's Diversity Index value of 1.6 in 2009 indicates that shorebird diversity in the RSA is low.

Table 6.7-18: Species Richness, Total Abundance, Density, and Diversity within PRISM plots, 2008, 2009, and 2011

Year	Species Richness		Total Abundance			Density (individuals/ha)		Diversity[(a)]	
	Total	Min - Max	Total	Mean ± 1SE	Min - Max	Mean ± 1SE	Min - Max	Mean ± 1SE	Min - Max
2008	1	0 - 1	2	0.3 ± 0.3	0 - 2	0.02 ± 0.02	0.0 - 0.2	1.0 ± 0.0	1.0
2009	4	0 - 2	5	0.6 ± 0.3	0 - 3	0.05 ± 0.03	0.0 - 0.3	1.6 ± 0.2	1.0 - 1.6
2011	1	0 - 1	2	0.3 ± 0.3	0 - 2	0.02 ± 0.02	0.0 - 0.2	1.0 ± 0.0	1.0

[a] Simpson's Diversity Index

Note: ha= hectare; PRISM=Program for Regional and International Shorebird Monitoring; ± = plus or minus; SE = standard error of the mean; min = minimum; max = maximum

No shorebird species were confirmed as breeding because shorebird nests were not observed during PRISM surveys or during other surveys. The small number of observations and lack of breeding confirmation of any shorebird species may be related to the relative lack of good shorebird nesting habitat in the area, as well as the small number of plots surveyed.

6.7.3.3 Raptors

6.7.3.3.1 Population Status and Distribution

Some raptor species have been identified as potential indicators of environmental change when assessing the impact of human activities (Bildstein 2001). Population declines have been reported for nesting raptors because of disturbance from human activity and development (Newton 1979; Craighead and Mindell 1981). The effects of human disturbance may become evident through reduced frequency of nest site occupancy (Fyfe and

Oldendorff 1976) and through changes in breeding site selection – a sensitive time in raptor reproduction (White and Thurow 1985). As such, documenting changes in nest site reuse frequencies and breeding potential are important components of a monitoring program.

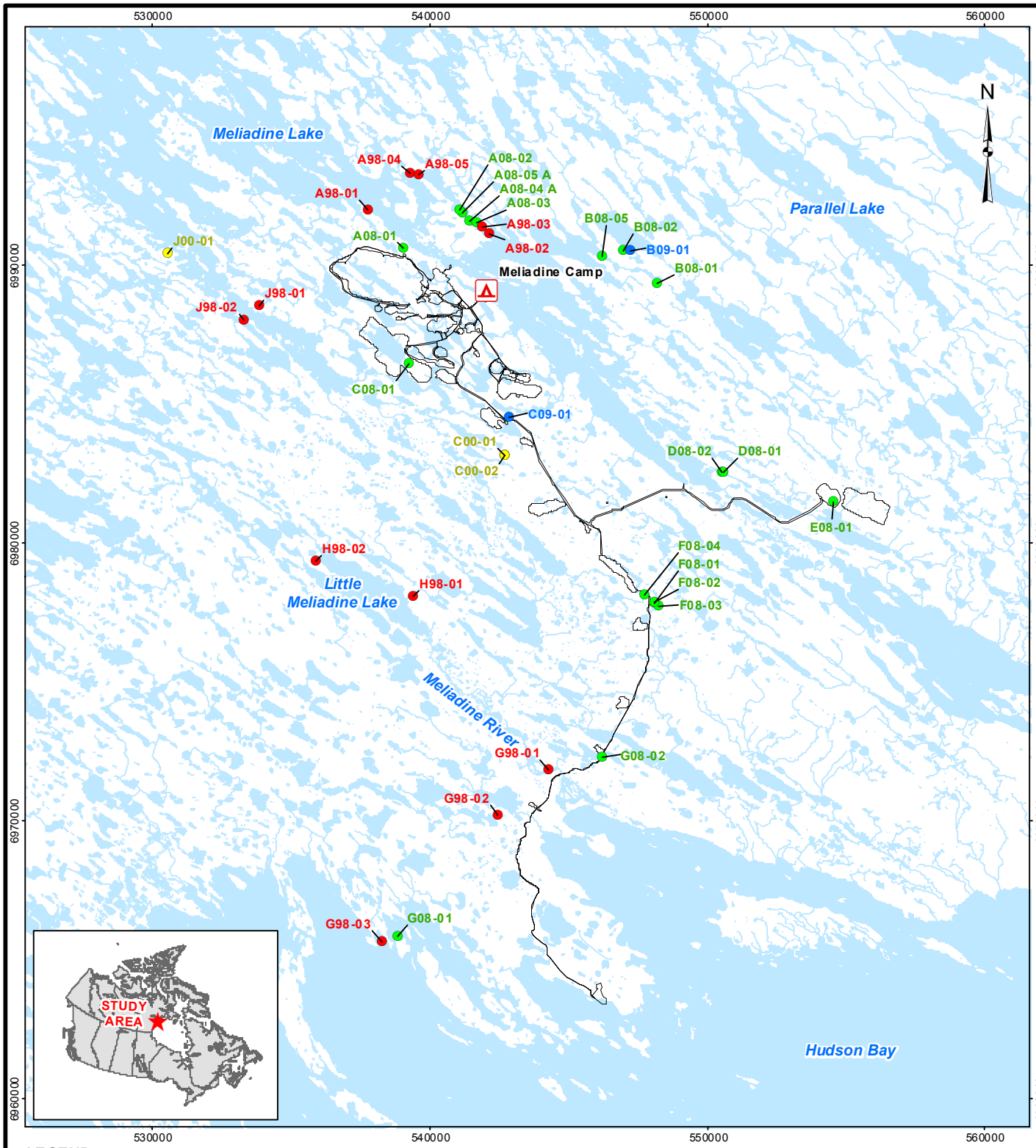
Following a precipitous dichlorodiphenyltrichloroethane (DDT)-induced population decline (Ritchie and Shook 2011), peregrine falcon (*Falco peregrinus*) populations have increased in many parts of the Arctic (Cade 2011; Ritchie and Shook 2011). The Rankin Inlet area supports the highest density of breeding peregrine falcons in the Arctic region (Franke et al. 2011) where nesting occurs on cliffs, rock outcrops, and frost heaves (A. Franke, University of Alberta, 2012, pers. comm.). This population of peregrine falcons has been the subject of long-term and intensive studies (Johnstone 1998; Court et al. 1988; Franke et al. 2011).

Human activities in the RSA can negatively affect raptor nest site occupancy and productivity (White and Thurow 1985). These potential effects are important to consider for all species, especially those identified as species at risk, such as the short-eared owl (*Asio flammeus*) (COSEWIC 2012) and peregrine falcon (GN 2000; COSEWIC 2012; *SARA* 2012).

Between 1998 and 2000, and in 2008, 2009 and 2011, 35 potential nest sites were observed in the RSA during baseline surveys for the Project (Figure 6.7-12). Upon review from the Arctic Raptor Program, 27 of these nest sites were retained for this assessment, including 5 that were renamed. An additional 26 new nest sites were also added in the region (Table 6.7-5). All nest sites are within 10 km of the Project and belonged to one of the following 4 raptor species: (Figure 6.7-13).

- Rough-legged hawk (*Buteo lagopus*);
- Gyrfalcon (*Falco rusticolus*);
- Peregrine falcon; and
- Short-eared owl.

Between 1998 and 2000, peregrine falcons and rough-legged hawks, and their eyries and nests, were recorded within a 10 km radius of the Project location (Table 6.7-19. Figure 6.7-12). Individual peregrine falcons and rough-legged hawks and their occupied nests were observed in all 3 years. Occupancy rate was 44% in 1998 and 2000, and 100% in 1999. Snowy owls (*Bubo scandiacus*) were recorded twice in the wildlife log by Project staff. Gyrfalcons were observed during the 1998 and 1999 field programs, but not during the 2000 field program.



LEGEND

- Camp
- Raptor Nest (1998)
- Raptor Nest (2000)
- Raptor Nest (2008)
- Raptor Nest (2009)
- Watercourse
- Waterbody
- Project Footprint

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).
Wildlife data obtained from field survey.
Datum: NAD 83 Projection: UTM Zone 15

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

OBSERVED RAPTOR NEST SITE LOCATIONS AS DETERMINED FROM FIELD SURVEYS COMPLETED FOR THE PROJECT

Golder Associates

PROJECT	13-1428-0007		PHASE 7000/7300	
DESIGN	KD	20 Feb. 2014	SCALE AS SHOWN	REV. 0
GIS	SGR	20 Feb. 2014		
CHECK				
REVIEW				

FIGURE 6.7-12

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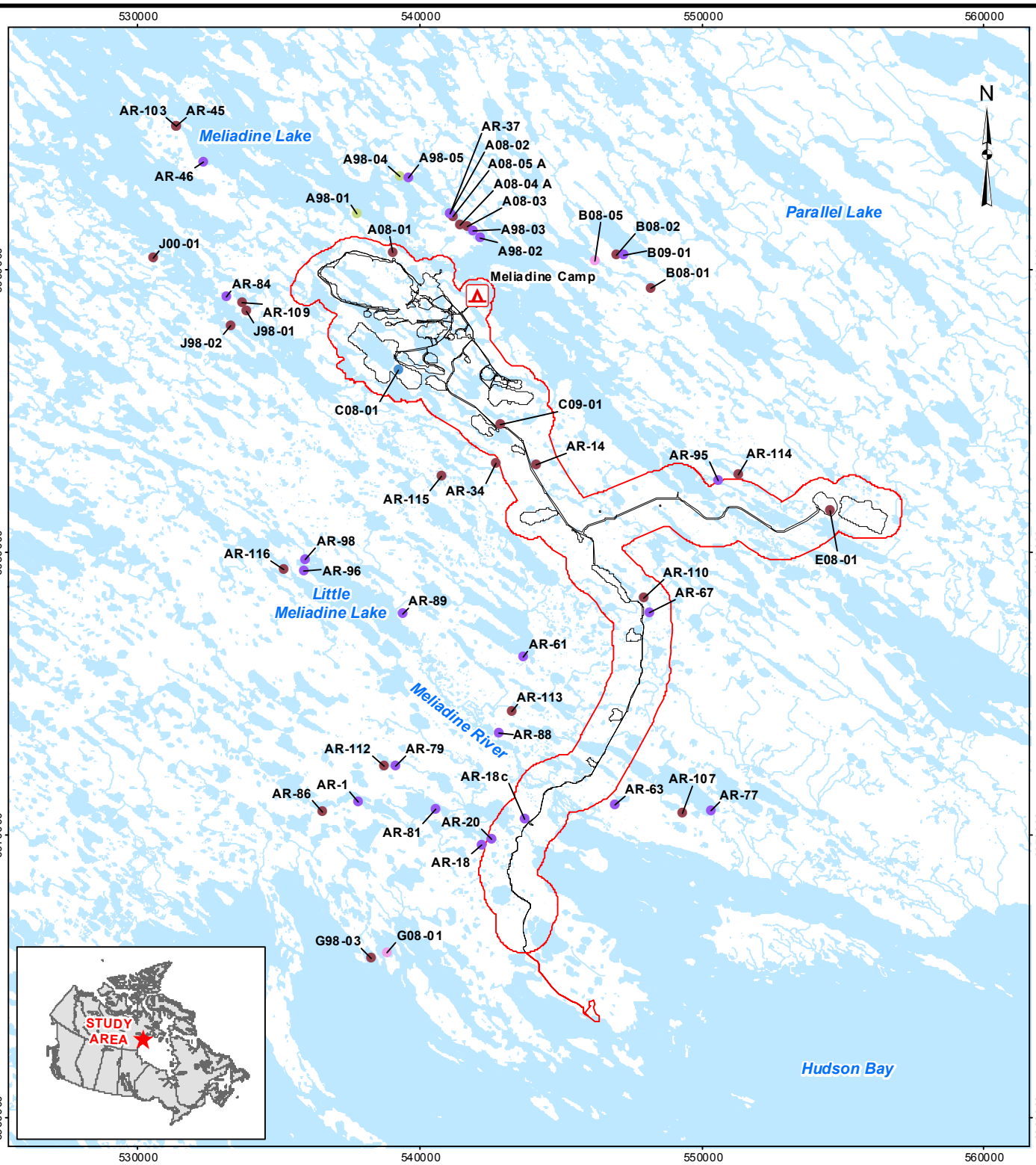


LEGEND

- Camp
- Project Footprint
- Terrestrial Local Study Area
- Waterbody
- Watercourse

SPECIES:

- GYRFALCON
- PEREGRINE FALCON
- ROUGH-LEGGED HAWK
- SHORT-EARED OWL
- UNKNOWN

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).
Wildlife data obtained from field survey.
A. Franke, University of Alberta, 2012, 2014, pers. comm.
Datum: NAD 83 Projection: UTM Zone 15

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

OBSERVED RAPTOR NEST SITE LOCATIONS UPDATED AND AMENDED BY THE ARCTIC RAPTOR PROJECT

Golder Associates

PROJECT		13-1428-0007	PHASE 7000/7300	
DESIGN	KD	20 Feb. 2014	SCALE AS SHOWN	REV. 0
GIS	SGR	20 Feb. 2014		
CHECK			FIGURE 6.7-13	
REVIEW				

N:\Bur-Graphics\Projects\2013\1428\13-1428-0007\GIS\Mapping\MXD\FEIS\Volume_6\Main_Volume\Figure_6.7-13_Observed_Raptor_Nest_Locations_Amended.mxd

Table 6.7-19: Raptor Nest Sites Surveyed and Occupancy, 1998 to 2000, 2008, 2009, 2011, and 2013

Common Name	Scientific Name	1998		1999		2000		2008		2009		2011		2013[a]		Average Occupancy Rate per Species (%)
		# Nests Surveyed	# Nests Occupied	# Nests Surveyed	# Nests Occupied	# Nests Surveyed	# Nests Occupied	# Nests Surveyed	# Nests Occupied	# Nests Surveyed	# Nests Occupied	# Nests Surveyed	# Nests Occupied	# Nests Surveyed	# Nests Occupied	
Peregrine falcon	*Falco peregrinus*	5	2	3	3	3	1	3	3	1	1	3	1	23	19	67
Rough-legged hawk	*Buteo regalis*	3	2	2	2	5	3	8	5	5	3	4	0	13	13	56
Gyrfalcon	*Falco rusticolus*	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Short-eared owl	*Asio flammeus*	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Unidentified raptor	-	0	0	0	0	0	0	6	0	0	0	1	0	0	0	0
Total		**9**	**4**	**5**	**5**	**9**	**4**	**18**	**8**	**6**	**4**	**8**	**1**	**36**	**32**	**84**
Occupancy Rate (%)		44		100		44		44		67		12.5		89		-

[a] Data collected by the Arctic Raptor Program.

Note: # = number; % = percent; "-" = not applicable

In 2008, 3 raptor species (short-eared owl, rough-legged hawk, and peregrine falcon) nests were identified in the RSA. Eight occupied nests were located within the RSA based on the presence of at least one adult at the nest, 2 adults in close proximity to the nest, or presence of eggs or young. Most nests were found during the July survey and were located on cliffs along Meliadine Lake, to the north and east of the Project. Ten unoccupied nests were recorded within the RSA. Two unoccupied nests had signs of species presence and were classified as occupied based on feathers and scat present in the area (nests E08-01 and C08-01). Four unoccupied nests were found within 200 m of occupied nests and were considered alternate nest sites within an occupied territory (Court et al. 1988) (nests A08-04A, A08-05A, D08-02, and F08-03 [Table 6.7-5]). All occupied raptor nests belonged to peregrine falcons (3) or rough-legged hawks (5). Gyrfalcons and snowy owls were not observed in the RSA during the 2008 field program.

In 2009, 6 nest sites were surveyed during a brief aerial survey. The raptor eyries on the cliffs north and northeast of the Project on Meliadine Lake were surveyed, as well as the raptor stick nest on a large boulder northwest of the Project. Of the 6 nests located, 3 rough-legged hawk nests were occupied (A08-04A, A08-05A, and C09-01), one peregrine falcon nest was occupied (B09-01), and 2 rough-legged hawk nests were unoccupied (B08-02, A08-01). Gyrfalcons, snowy owls, and short-eared owls were not observed during the 2009 field program. Few nests were observed in June 2009 due to a combination of cold weather conditions and a late spring resulting in reduced survey effort.

In 2011, 5 potential nest sites were located, with one peregrine falcon nest occupied (F08-01) and 4 rough-legged Hawk nests unoccupied (C00-02, C09-01, J98-01, J98-02). Gyrfalcons, snowy owls, and short-eared owls were not observed in 2011. An additional 8 nest sites were supplied to AEM by the GN in 2012 (N. Lecomte, Government of Nunavut, 2012, pers. comm.) (Figure 6.7-12). In 2012, a raptor nest was destroyed at quarry R19 prior to the breeding season (J. Witteman, AEM, 2012, pers. comm.). AEM had no knowledge of the existence of the nest as it was not detected during baseline surveys. There were no raptors using the nest at the time.

In 2013, 58 eggs were laid at 19 peregrine falcon nests sites in the Project RSA, with a hatching rate of 71% (Franke 2013; Table 6.7-20). There were 13 nest sites occupied by rough-legged hawk, containing 34 eggs, of which 44% hatched. Gyrfalcons and snowy owls were not detected breeding in the Project RSA or in other areas surveyed near Rankin Inlet.

Table 6.7-20: Raptor Nest Sites Surveyed, and Occupancy and Reproductive Success, 2013

Common Name	Scientific Name	# Nests Surveyed	# Nests Occupied	# Eggs	# Eggs Hatched	Eggs/Site	Hatch/Site
Peregrine falcon	*Falco peregrinus*	23	19	58	41	3.05	2.16
Rough-legged hawk	*Buteo regalis*	13	13	34	15	2.62	1.15
Total		**36**	**32**	**92**	**56**	**2.88**	**1.75**

Source Franke (2013)
Note: # = number

Overall, rough-legged hawks and peregrine falcons were confirmed to be breeding in the RSA. However, nest productivity and success varied considerably between years. Late springs and cold, wet weather can affect nesting success (Poole and Bromley 1988; Bradley et al. 1997; Steenhof et al. 1997). Variability is likely

compounded by natural population fluctuations, which are thought to occur at regular intervals in rough-legged hawk and gyrfalcon populations (Hagen 1969; White and Cade 1977; Swartz et al. 1974; Mindell 1983; Cade 2011). However, variability in survey effort was likely the main factor affecting observations of nesting peregrine falcons, as breeding populations in the area surrounding Rankin Inlet have been found to be consistent among years (Court et al. 1988; Johnstone 1998).

Snowy owls, short-eared owls, and gyrfalcons, although observed in the RSA, were not confirmed breeding in the area. Snowy owl nests, typically scrapes on bare ground with no insulating lining of vegetation or feathers (Parmelee 1992), are difficult to detect and were not observed. Short-eared owls also nest in scrapes on the ground, and although they are lined with grasses and feathers (Wiggins et al. 2006), they may not be conspicuous during aerial surveys. The one potential short-eared owl nest that was located in the RSA in 2008 could not be confirmed as occupied. Gyrfalcon nests were observed in 1998 and 2000 but these nests could be confirmed as occupied.

6.7.4 Pathway Analysis

A pathway analysis was completed to identify and assess the linkages between Project components or activities, and the correspondent potential residual effects to birds and bird habitat. The first part of the analysis produced a list of all potential effects pathways for the Project (FEIS Volume 4, Section 4.3; Table 6.7-20). Each pathway was initially considered to have a linkage to potential effects on birds and bird habitat. This step was followed by the development of environmental design features and mitigation that can be incorporated into the development description to remove a pathway or limit (mitigate) the effects to birds and bird habitat. Environmental design features include Project design elements, environmental best practices, management policies and procedures, and social programs. Environmental design features are developed through an iterative process between the Project's engineering and environmental teams to avoid or mitigate effects.

Pathway analysis is a screening step that is used to determine the existence and magnitude of linkages from the initial list of potential effects pathways for the Project. This screening step is intended to focus the effects analysis on pathways that require a more comprehensive assessment of effects on birds and bird habitat. Pathways are determined to be primary, minor, or as having no linkage using scientific and traditional knowledge, logic, and experience with similar developments and environmental design features. Each potential pathway is assessed and described as follows:

- no linkage – pathway is removed by environmental design features and mitigation so that the Project results in no detectable environmental change and residual effects to birds relative to baseline or guideline values;
- minor – pathway could result in a minor environmental change, but would have a negligible residual effect on birds relative to baseline or guideline values; or
- primary – pathway is likely to result in a measurable environmental change that could contribute to residual effects on birds relative to baseline or guideline values.

Primary pathways require further effects analysis to determine the environmental significance from the Project on birds. Pathways determined to have no linkage to birds or those that are considered minor are not predicted to result in environmentally significant effects on birds. No linkage and minor pathways are summarized but not carried through the effects assessment.

Potential pathways through which the Project could affect birds are presented in Table 6.7-20. Environmental design features and mitigation incorporated into the design of the Project to remove a pathway or limit the effects to birds are listed, and pathways are determined to be primary, minor, or as having no linkage. The following section discusses the potential pathways relevant to birds.

Phase 1 of the AWAR was previously assessed under a separate impact assessment (Golder 2011d), and is currently being constructed under a Type B Water License 2BW-MEL1215 issued by the Nunavut Water Board in March 2012 granted under an exception determination by NIRB under Section 12.10.2 (b) of the Nunavut Land Claims Agreement. The Phase 1 AWAR and Project (including Phase 2 AWAR) are considered separate for the pathways analysis and effects assessment; however, the combined AWAR footprint (i.e., Phase 1 and Phase 2) was assessed so as to include the maximum disturbance within the study areas.

Table 6.7-21: Potential Pathways for Effects to the Abundance and Distribution of Birds

Project Component/Activity	Valued Components	Effect Pathways	Environmental Design Features and Mitigation	Pathway Assessment/ Section for Further Discussion
Mine infrastructure footprint (e.g., open pits, site roads) Project Access Road Rankin Inlet Infrastructure	waterbirds upland birds; migratory birds raptors (including short-eared owl and peregrine falcons)	Direct loss and fragmentation of bird habitat from the Project footprint	Compact plant arrangement is designed to reduce the overall project footprint Design roads as narrow as possible, while maintaining safe construction and operation practices, and meeting legislated requirements. For example, minimum haul road widths are defined under the Nunavut *Mine Health and Safety Act*. Use previous monitoring data and ongoing research from the Arctic Raptor Group to determine the location of raptor nests in the RSA.	Primary/Section 6.7.4.3
Water Management (dams, drainage, diversion, intake, discharge and dewatering)	waterbirds	Destruction of waterbird nests from increased flows or water levels can increase risk of mortality to individual birds, which can affect waterbird population sizes	Dewatering rates and schedule will be managed such that peak annual water levels will not greatly increase from baseline conditions Shoreline areas susceptible to extensive erosion will be addressed by appropriate erosion protection measures to reduce erosion and associated re-suspension of fine sediment. Where practical, natural drainage patterns will be used to reduce the use of ditches or diversion berms.	No Linkage/Section 6.7.4.1
	waterbirds	Cross-drainage structures for the mine site roads, AWAR, and Rankin Inlet bypass road may alter stream hydraulics and geomorphology, and can alter bird habitat	Cross-drainage structures will be designed for a 1:25 year precipitation event without overtopping the roadway Use of staggered culvert configuration, and removal of snow at the culvert inlet and outlet prior to the freshet to promote drainage during spring thaw and freshet. Regular inspection of the road to identify any areas where ponding of water along the road represents a risk, and installing additional culverts to alleviate the risk.	No Linkage/Section 6.7.4.1

Table 6.7-21: Potential Pathways for Effects to the Abundance and Distribution of Birds (continued)

Project Component/Activity	Valued Components	Effect Pathways	Environmental Design Features and Mitigation	Pathway Assessment/ Section for Further Discussion
	waterbirds upland birds; migratory birds raptors (including short-eared owl and peregrine falcons)	Process and potable water requirements for the Project may decrease drainage flows and surface water levels, and affect bird habitat	Develop a Site Water Management Plan (SD 2-6). Contact water will be monitored and managed through the Attenuation Ponds Surface runoff and groundwater seeping into the open pits will be collected in in-pit sumps. The collected water will be used for dust control and as process water. Underground water will be re-cycled for re-use underground, where possible. Excess underground water with high salinity will be treated Discharge quality will meet MMER at end of pipe from AP01 and will meet CCME aquatic life standards within a 100 m wide mixing zone of the diffuser in Meliadine Lake. The rotary biological contactor sewage treatment plant for the camp facilities will be designed to meet discharge criteria.	No Linkage/Section 6.7.4.1

Table 6.7-21: Potential Pathways for Effects to the Abundance and Distribution of Birds (continued)

Project Component/Activity	Valued Components	Effect Pathways	Environmental Design Features and Mitigation	Pathway Assessment/ Section for Further Discussion
	waterbirds	Release of treated mine wastewater and sewage may cause changes to surface water quality and sediment quality affecting aquatic habitat and waterbirds in Meliadine Lake	Develop a Site Water Management Plan (SD 2-6) Contact water will be monitored and managed through the Attenuation Ponds Surface runoff and groundwater seeping into the open pits will be collected in in-pit sumps. The collected water will be used for dust control and as process water. Underground water will be re-cycled for re-use underground, where possible. Excess underground water with high salinity will be treated Discharge quality will meet MMER at end of pipe and will meet CCME aquatic life standards within a 100 m wide mixing zone of the diffuser in Meliadine Lake. The rotary biological contactor sewage treatment plant for the camp facilities will be designed to meet discharge criteria.	No Linkage/Section 6.7.4.1

Table 6.7-21: Potential Pathways for Effects to the Abundance and Distribution of Birds (continued)

Project Component/Activity	Valued Components	Effect Pathways	Environmental Design Features and Mitigation	Pathway Assessment/ Section for Further Discussion
General construction and operation of mine and supporting infrastructure	waterbirds upland birds; migratory birds raptors (including short-eared owl and peregrine falcons)	Dust deposition may cover vegetation, change the amount of different quality habitats, and alter movement and behaviour	Dust will be actively suppressed from roads (water and/or other dust suppressants). Potential use of chemical dust suppressants in accordance with the Environmental Guidance for Dust Suppression published by the Government of Nunavut Department of Environment Watering of roads will suppress dust production. Enforcing speed limits will assist in reducing dust. Road surfaces will be maintained through grading and the addition of granular material Equipment and vehicles will comply with relevant non-road emission criteria at the time of purchase Regular maintenance of equipment and vehicles to meet emission standards	Minor/Section 6.7.4.2
	waterbirds upland birds; migratory birds raptors (including short-eared owl and peregrine falcons)	Air emissions and deposition can cause changes to chemical properties of surface water, soils, vegetation, and wetlands, affecting habitat quality	Equipment and vehicles will comply with relevant emission criteria at the time of purchase. Regular maintenance of equipment and vehicles to meet emission standards.	Minor/Section 6.7.4.2
	waterbirds upland birds; migratory birds raptors (including short-eared owl and peregrine falcons)	Air emissions and deposition can cause changes to the amount of quality habitats through chemical changes to surface water quality, soils, affecting bird health	Equipment and vehicles will comply with relevant emission criteria at the time of purchase. Regular maintenance of equipment and vehicles to meet emission standards.	No Linkage/Section 6.7.4.1

Table 6.7-21: Potential Pathways for Effects to the Abundance and Distribution of Birds (continued)

Project Component/Activity	Valued Components	Effect Pathways	Environmental Design Features and Mitigation	Pathway Assessment/ Section for Further Discussion
	waterbirds upland birds; migratory birds raptors (including short-eared owl and peregrine falcons)	Change in energetic costs from disturbance or displacement	Project design will use conventional insulation, baffles and noise suppressors on equipment. Stationary equipment will be housed inside buildings. Regular maintenance of equipment to limit noise. All employees will be provided with wildlife environmental awareness training.	Minor/Section 6.7.4.2
General construction and operation of mine and supporting infrastructure (continued)	waterbirds upland birds; migratory birds raptors (including short-eared owl and peregrine falcons)	Destruction of nests from Project infrastructure can affect individual mortality, resulting in changes to abundance and distribution of bird populations.	Where possible, clearing of vegetation would take place outside the migratory bird breeding season. Where active raptor nests are identified, a nest-specific management plan will be developed to minimize disturbance to nesting activities.	No Linkage/Section 6.7.4.1

Table 6.7-21: Potential Pathways for Effects to the Abundance and Distribution of Birds (continued)

Project Component/Activity	Valued Components	Effect Pathways	Environmental Design Features and Mitigation	Pathway Assessment/ Section for Further Discussion
	Waterbirds upland birds; migratory birds raptors (including short-eared owl and peregrine falcons)	Dewatering of waterbodies, Project footprint, and diversion of water, may change downstream flows, water levels, and affect bird habitat quality	Develop and implement a Site Water Management Plan (SD 2-6) Pumped discharge to receiving waterbody will only occur while water quality discharge criteria are met. Pumped discharge will be directed to the lake environment, and not directly to outlets, to attenuate flow changes. Shoreline areas susceptible to extensive erosion will be addressed using appropriate erosion protection measures, mitigation measures based on adaptive management, or a combination of both, to reduce erosion and associated re-suspension of fine sediment Where practical, natural drainage patterns will be used to reduce the use of ditches or diversion berms. Discharge from dewatering of waterbodies will be sampled regularly to monitor for compliance with discharge criteria, and any water not meeting the criteria will be treated or stored within the controlled Attenuation Ponds until it meets criteria	Minor/Section 6.7.4.2

Table 6.7-21: Potential Pathways for Effects to the Abundance and Distribution of Birds (continued)

Project Component/Activity	Valued Components	Effect Pathways	Environmental Design Features and Mitigation	Pathway Assessment/ Section for Further Discussion
	waterbirds upland birds; migratory birds raptors (including short-eared owl and peregrine falcons)	Sensory disturbance can change the amount of different quality habitats, and alter bird movement and behaviour (distribution)	All employees will be provided with wildlife environmental awareness training. Project design will use conventional insulation, baffles and noise suppressors on equipment. Stationary equipment will be housed inside buildings. Regular maintenance of equipment to limit noise. Use previous monitoring data and ongoing research from the Arctic Raptor Group to determine the location of raptor nests in the RSA.	Primary/Section 6.7.4.3
	waterbirds (ducks, geese, swans and cranes) upland birds (ptarmigan)	Improved access for harvesting can affect upland bird and waterbird population sizes	Develop and enforce “no hunting, trapping, harvesting or fishing policy” for employees and contractors, while on work rotations. Upon consultation with the Kivalliq Inuit Association and Hunters and Trappers Organizations, an appropriate “no shooting zone” will be established along the road Develop and implement a Roads Management Plan (SD 2-9).	Minor/Section 6.7.4.2
	raptors (including short-eared owl and peregrine falcons)	Improved access for harvesting can affect raptor population size		No Linkage/Section 6.7.4.1
General construction and operation of mine and supporting infrastructure (continued)	waterbirds upland birds; migratory birds raptors (including short-eared owl and peregrine falcons)	Spills on the mine site, mine site roads or along the AWAR can affect bird habitat	Equipment will be re-fueled, serviced, and washed away from stream crossings. Emergency response (SD 2-15) and spill contingency plans (SD 2-16) will be developed and implemented	No Linkage/Section 6.7.4.1

Table 6.7-21: Potential Pathways for Effects to the Abundance and Distribution of Birds (continued)

Project Component/Activity	Valued Components	Effect Pathways	Environmental Design Features and Mitigation	Pathway Assessment/ Section for Further Discussion
		Spills on the mine site, mine site roads or along the AWAR can increase risk of mortality to individual birds, which can affect bird population sizes	Ready access to an emergency spill clean-up kit for cleaning up any spills. Vehicles properly loaded and loads appropriately covered where necessary Hazardous materials and fuel will be stored according to regulatory requirements to protect the environment and workers (i.e., SD2-13 Hazardous Materials Management Plan). Individuals working on site and handling hazardous materials will be trained in the Transportation of Dangerous Goods and Hazmat Response. A biopile will be constructed to treat soils and rock contaminated by light hydrocarbons. The biopile will have a low permeability liner. Soils from petroleum spill areas will be excavated, placed into appropriate containers and shipped for remediation. Soils contaminated with heavy hydrocarbon oil spills will be excavated, placed into appropriate containers, transported for remediation at a certified hazardous materials treatment site, and disposed of appropriately Fuel storage tanks will be situated in a lined and bermed containment area and the storage tanks and fuel-dispensing systems will be constructed in accordance with current regulatory requirements and fire regulations. Fuel will be transported year-round by double-walled tanker trucks to the Meliadine tank farm. Construction and mining equipment, machinery, and vehicles will be regularly maintained.	No Linkage/Section 6.7.4.1

Table 6.7-21: Potential Pathways for Effects to the Abundance and Distribution of Birds (continued)

Project Component/Activity	Valued Components	Effect Pathways	Environmental Design Features and Mitigation	Pathway Assessment/ Section for Further Discussion
General construction and operation of mine and supporting infrastructure (continued)	waterbirds upland birds; migratory birds raptors (including short-eared owl and peregrine falcons)	Physical hazards on the mine site and collision with vehicles or aircraft causing injury or mortality to individual birds, which can affect population sizes	Speed limits will be established. Develop a Roads Management Plan (SD 2-9) The presence of wildlife will be monitored and communicated to site personnel. Littering and feeding of wildlife will be prohibited No airstrip on-site All employees will be provided with environmental awareness training. Visibility markers will be used on tall structures and overhead and guy wires. Removal of physical hazards will be part of the Mine Closure and Reclamation Plan (SD 2-17). Wildlife will be given the right-of-way	Minor/Section 6.7.4.2

Table 6.7-21: Potential Pathways for Effects to the Abundance and Distribution of Birds (continued)

Project Component/Activity	Valued Components	Effect Pathways	Environmental Design Features and Mitigation	Pathway Assessment/ Section for Further Discussion
	waterbirds upland birds; migratory birds raptors (including short-eared owl and peregrine falcons)	Surface water runoff from the core mine facilities area can affect surface water quality, soil, vegetation, and bird habitat	Contact water will be managed on-site in accordance with the Site Water Management Plan (SD 2-6). Runoff and seepage from waste rock storage facilities will be collected in sumps located in low topographic points around the perimeter. This water will be monitored for water quality and if necessary transferred to the mine attenuation pond before discharge. Surface runoff and talik water seeping into the open pits will be collected in in-pit sumps. The collected water will be used for dust control and/or pumped to the tailings storage facility for use as process water Sumps will be sized to hold water running off the waste rock storage facilities and the ore stockpiles and open pits. Construction materials will be clean and contaminant free. Sewage will be treated in packaged multi-stage rotary biological contactor sewage treatment plant	No Linkage/Section 6.7.4.1

Table 6.7-21: Potential Pathways for Effects to the Abundance and Distribution of Birds (continued)

Project Component/Activity	Valued Components	Effect Pathways	Environmental Design Features and Mitigation	Pathway Assessment/ Section for Further Discussion
	waterbirds upland birds; migratory birds raptors (including short-eared owl and peregrine falcons)	Attraction to the Project (e.g., food waste, oil products) may increase human-wildlife interactions and removal of individual animals (e.g., relocation or mortality), which can affect bird population sizes	Most construction of the Project will be based out of Rankin Inlet or the Meliadine camp, eliminating the need for temporary camps along the AWAR route. Littering and feeding of wildlife will be prohibited. Education and reinforcement of proper waste management practices to all workers and visitors to the site will be provided. Education on the risk associated with feeding wildlife and careless disposal of food wastes and liquids such as coffee and juices will be provided. Ongoing review of the efficiency of the waste management program and improvement through adaptive management. Kitchen garbage and waste from dormitories and offices will be incinerated on a daily basis to limit attractions to wildlife. A Landfill and Waste Management Plan (SD 2-11) will be developed and implemented. Wastes associated with mechanical maintenance and repairs will be managed of per the Hazardous Materials Management Plan (SD 2-13). A Terrestrial Environment Management and Monitoring Plan (SD 6-4) will be developed and implemented.	Minor/Section 6.7.4.2

Table 6.7-21: Potential Pathways for Effects to the Abundance and Distribution of Birds (continued)

Project Component/Activity	Valued Components	Effect Pathways	Environmental Design Features and Mitigation	Pathway Assessment/ Section for Further Discussion
General construction and operation of mine and supporting infrastructure (continued)	waterbirds upland birds; migratory birds raptors (including short-eared owl and peregrine falcons)	Attraction to the Project may increase predator numbers and predation risk, which can affect prey populations	Most construction of the Project will be based out of Rankin Inlet or the exploration camp eliminating the need for temporary camps along the AWAR route. Littering and feeding of wildlife will be prohibited. Education and reinforcement of proper waste management practices to all workers and visitors to the site. Education on the risk associated with feeding wildlife and careless disposal of food garbage. Ongoing review of the efficiency of the waste management program and improvement through adaptive management Kitchen garbage and waste from dormitories and offices will be routinely incinerated to limit attractions to wildlife. Skirt all buildings and stairs to the ground to limit opportunities for use as shelter. Development and implementation of a Landfill and Waste Management Plan (SD 2-11) Wastes associated with mechanical maintenance and repairs will be managed of per the Hazardous Materials Management Plan (SD 2-13). A Terrestrial Environment Mitigation and Monitoring Program (SD 6-4) will be developed and implemented. Active bird nests on infrastructure will be quarantined from activity, monitored and reported to regulators	Minor/Section 6.7.4.2
General construction and operation of mine and supporting infrastructure (continued)	upland birds; migratory birds raptors (including short-eared owl and peregrine falcons)	Attraction of birds to Project facilities and infrastructure for roosting and nesting sites can affect mortality and productivity		Minor/Section 6.7.4.2

Table 6.7-21: Potential Pathways for Effects to the Abundance and Distribution of Birds (continued)

Project Component/Activity	Valued Components	Effect Pathways	Environmental Design Features and Mitigation	Pathway Assessment/ Section for Further Discussion
	waterbirds	Landing or use of Attenuation Ponds may increase bird mortality through exposure to contaminants and impact waterbird health	Attenuation Ponds will be monitored for use by birds as part of the Terrestrial Environment Mitigation and Monitoring Program (SD 6-4) Hydrocarbon contaminated snow will be treated at a biopile Attenuation Ponds will be monitored for water quality	Minor/Section 6.7.4.2
	waterbirds upland birds; migratory birds raptors (including short-eared owl and peregrine falcons)	Disruption or alteration of migration routes from the presence of the mine or from mine-related activities	Compact layout of the surface facilities within local watersheds will limit the area that is disturbed by construction and operation. Project design will use conventional insulation, baffles and noise suppressors on equipment. Stationary equipment will be housed inside buildings. Regular maintenance of equipment to limit noise.	No Linkage/Section 6.7.4.1
Operation of mine and supporting infrastructure	waterbirds upland birds; migratory birds raptors (including short-eared owl and peregrine falcons)	Uptake of metals by wildlife through ingestion of tailings and dust on surface water, soils and vegetation can affect bird health	Develop a Mine Waste Management Plan (SD 2-8) Any PAG or high metal leaching waste rock will be segregated at source and placed into designated areas within the waste rock storage facilities. If not suitable for construction, overburden will be stored with the waste rock storage facilities. Tailings deposition will be designed to limit dust generation.	No Linkage/Section 6.7.4.1

Table 6.7-21: Potential Pathways for Effects to the Abundance and Distribution of Birds (continued)

Project Component/Activity	Valued Components	Effect Pathways	Environmental Design Features and Mitigation	Pathway Assessment/ Section for Further Discussion
	waterbirds upland birds; migratory birds raptors (including short-eared owl and peregrine falcons)	Leaching of dissolved metals from waste rock in the waste rock storage facilities may cause changes to groundwater and surface water quality and soils, which may affect bird habitat	Design waste rock management procedures for potentially problematic waste rock material. Use of non-acid generating and non-metal leaching material at all watercourses. Any PAG or high metal leaching waste rock will be segregated at source and placed into designated areas within the waste rock storage facilities. PAG and high metal leaching waste rock will be encapsulated with non -PAG rock and low metal leaching rock. Over time potential PAG and high metal leaching rock will become permanently frozen with an active cover layer of non-PAG rock.	No Linkage/Section 6.7.4.1
	waterbirds upland birds; migratory birds raptors (including short-eared owl and peregrine falcons)	Vertical and lateral seepage from facilities may cause changes to groundwater and surface water quality and soils, which may affect bird habitat	A biopile will be constructed to treat soils and rock contaminated by light hydrocarbons with any leachate captured in sumps. Landfill will not contain any putrescible organic matter so seepage is not expected.	No Linkage/Section 6.7.4.1

Table 6.7-21: Potential Pathways for Effects to the Abundance and Distribution of Birds (continued)

Project Component/Activity	Valued Components	Effect Pathways	Environmental Design Features and Mitigation	Pathway Assessment/ Section for Further Discussion
Post-closure	waterbirds upland birds; migratory birds raptors (including short-eared owl and peregrine falcons)	Water quality following closure may affect bird health	Sewage treatment plant will remain active during the first 2 years of decommissioning. Landfill will be located in a waste rock storage area covered with non- ARD and non-metal leaching waste rock material. PAG and high metal leaching potential waste rock will be stored in designated areas and will be encapsulated with non-PAG and low metal leaching potential waste rock Implement a Closure and Reclamation Plan (SD 2-17).	No Linkage/Section 6.7.4.1
	waterbirds upland birds; migratory birds raptors (including short-eared owl and peregrine falcons)	Permanent changes in bird habitat following closure of the mine site and supporting infrastructure	Hydraulic connections to the natural receiving environment will be re-established once water quality monitoring demonstrates the water meets water quality guidelines for direct release without further treatment. Site infrastructure will be decommissioned and removed from site. All roads will be decommissioned and scarified. Implement a Mine Closure and Reclamation Plan (SD 2-17).	Primary/Section 6.7.4.3

6.7.4.1 Pathways with No Linkage

A pathway has no linkage if the pathway is removed by environmental design features and mitigation so that the Project results in no detectable environmental change and residual effects to birds relative to baseline or guideline values. The pathways described in the following bullets have no linkage to birds and will not be carried through the effects assessment.

Changes to Habitat Quality, Movement and Behaviour

- **Cross-drainage structures for the mine site roads, AWAR, and Rankin Inlet bypass road may alter stream hydraulics and geomorphology, and can alter bird habitat**

The installation of cross-drainage structures to prevent roads from impeding water flow can result in the loss and alteration of shoreline habitat. The loss of stream and shoreline habitat may be permanent, however the amount of habitat altered is expected to be minimal. Cross-drainage structures will be designed to withstand a 1:25 year 24-hour precipitation event without overtopping the roadway, which will result in minor changes in stream velocity, and prevent channel aggradation, degradation, erosion, or changes to bankfull width or depth. The implementation of appropriate cross-drainage structures is expected to result in minor changes to stream flow velocity and levels in the vicinity of the structures relative to baseline conditions and have negligible residual effects on water quantity and geomorphology. Thus, the effects on bird habitat from the potential alteration of stream hydraulics and geomorphology are expected to be negligible. Consequently, residual effects to the maintenance of bird populations and the continued opportunity for traditional and non-traditional use of birds from stream alteration are predicted to be negligible.

- **Process and potable water requirements during Project construction and operations may decrease drainage flows and surface water levels, and affect bird habitat**

The Project will withdraw freshwater from Meliadine Lake for potable water, underground operations and plant operations. Freshwater requirements are estimated at a maximum of approximately 1 130 000 m^3/y during construction and operations. Supply volumes are small in comparison to median monthly and annual outflow volumes at Meliadine Lake (FEIS Volume 7, Section 7.3). Water level changes due to fresh water requirements are expected to be negligible.

Water withdrawal from Meliadine Lake during construction and operations is expected to have minimal effect on bird habitat because the water level is not predicted to change and thus there will be negligible residual effects to the abundance and distribution of bird populations, and continued opportunity for traditional and non-traditional use of birds.

- **Release of treated mine wastewater and sewage may cause changes to surface water quality and sediment quality affecting aquatic habitat and waterbird habitat in Meliadine Lake**

Release of mine effluent may cause a change in surface water quality of Meliadine Lake, thereby potentially affecting waterbird habitat.

During operations and closure, all contact water will be intercepted and diverted to the TSF or contact water attenuation pond (AP-01). There will be one discharge point of contact water for the mine which will be from AP-01 into the east basin of Meliadine Lake via a diffuser. Since water in the attenuation pond will have been directly affected by mine operations, it will be tested and treated, if required, to meet discharge objectives prior to

release to Meliadine Lake. Therefore, this pathway is predicted to have no detectable change to bird habitat, and the persistence of bird populations and the continued opportunity for traditional and non-traditional use of birds from baseline values.

Additional information regarding predicted effluent treatment requirements are presented in FEIS Volume 7, Section 7.4.

- **Air emissions and deposition can cause changes to the amount of quality habitats through chemical changes to surface water quality and soils, affecting bird health**
- **Water quality following closure may affect bird health**

Accumulation of dust and concentrations of air emissions produced from the Project may result in chemical changes to surface water and soils. Likewise, changes in flows, hydrological processes, and evaporation can change surface water quality. If concentrations of chemicals in soils and surface water exceed CCME or Health Canada guidelines, bird health could be negatively affected. A surface water quality model was developed to predict changes to surface water quality in small waterbodies (i.e., not Meliadine Lake) in the LSA from particulate matter, metals, nitrogen compounds from blasting, and nitrogen dioxide (potential acid input metric) (FEIS Volume 7, Section 7.4.6.2.1).

A wildlife health risk assessment was completed to evaluate the potential adverse effect to individual animal health associated with exposure to chemicals from the Project (Section 10.1). For birds, there were no COPCs identified in soil, sediment, or surface water for further evaluation in the environmental risk assessment. This indicates that adverse health effects to birds as a result of the Project are not expected. Therefore, changes to surface water and soil quality from air emissions, dust deposition, and post-closure water quality are predicted to have no effect on the persistence of bird populations and the continued opportunity for traditional and non-traditional land use of birds.

- **Spills on the mine site, mine site roads, or along the AWAR can affect bird habitat**

A Risk Management and Emergency Response Plan (SD 2-15), Spill Contingency Plan (SD 2-16), and Fuel Management Plan (part of SD 2-13) will be developed and implemented to minimize the likelihood of accidental spills, or if they do occur, to quickly respond and clean up any spills. AEM will not permit the deposit of chemicals, sediment, wastes, or fuels into any waterbody. During construction, equipment will be re-fueled, serviced, and washed away from stream crossings and on impermeable pads wherever possible. There will be a wash bay in the maintenance shop. Hazardous materials and fuel will be stored according to regulatory requirements to protect the environment and workers, and hazardous materials will be stored at the mine site in a dedicated waste management building and handled according to the Hazardous Materials Management Plan (SD 2-13). As necessary, individuals working on the Project and handling hazardous materials will be trained, notably in the Transportation of Dangerous Goods. Emergency spill kits will be readily available. A biopile will be constructed to treat soils contaminated by light hydrocarbons, and soils contaminated with heavy hydrocarbon oil spills will be excavated, placed into appropriate containers, undergo remediation at a certified hazardous material site and disposed of appropriately. Construction and mining equipment, machinery, and vehicles will be regularly maintained.

Accidental spills (e.g., fuel) have occurred at AEM's Meadowbank Mine, but most of the spill volumes have been small, and clean-up has occurred with only minor effects to the environment (AEM 2011a). Out of 78 spills at Meadowbank since the start of construction, 73 were within the mine site boundary, and 5 were along the all-weather private road outside the mine boundary (AEM 2011b). There were 10 spills greater than 1000 L, one of which was outside the mine boundary. Contaminated material from the larger spill outside the mine boundary was completely recovered (AEM 2011a). All of the spills inside and outside the mine boundary were contained and cleaned-up (AEM 2011b). In NIRB's annual report (NIRB 2011), it was noted that Meadowbank Mine was kept in an impressively clean state with no apparent spills on location.

The implementation of the Risk Management and Emergency Response Plan (SD 2-15), and environmental design features, including proper equipment maintenance and driver training, are expected to reduce the frequency and severity of spills. It is acknowledged that accidental spills, including vehicular accidents, have the greatest potential to affect soils, vegetation, and bird habitat. However, in the event of a spill, contaminated materials will be either collected and treated on-site, or shipped off-site for treatment and disposal.

Consequently, this pathway was determined to have no linkage to effects on the abundance and distribution of bird populations, and continued opportunity for traditional and non-traditional use of birds.

- **Surface water runoff from the core mine facilities area can affect surface water quality, soil, vegetation, and bird habitat**

Surface water runoff from areas of the mine facilities could potentially affect vegetation and bird habitat. However, these facilities incorporate several environmental design features to prevent release of untreated site water to the receiving environment.

During the construction and operations phases, all surface water runoff from the areas of the mine facilities or that has been in contact with any mine facilities or processes (contact water) will be captured through a series of collection ditches and sumps. Contact water from open pits will be pumped to the TSF, while surface water from the remaining facilities will be directed to Attenuation Pond 1. Any excess water in the TSF will be treated and discharged to Attenuation Pond 1. Furthermore, excess water from underground workings will be collected and treated, then directed to Attenuation Pond 1. Water collected at Attenuation Pond 1 will be discharged as an effluent into Meliadine Lake through a diffuser outfall after it meets water quality guidelines. The diffuser will be configured to promote mixing of the effluent in the lake ambient water, in order to meet water quality standards established based on CCME guidelines for protection of aquatic life.

During the closure phase, contact water will continue to be directed to Attenuation Pond 1 until it meets the water quality standards, upon which Attenuation Pond 1 and water treatment facilities will be decommissioned. The TSF will be dewatered and covered with a rockfill cover over a graded tailings surface. Runoff will be monitored to ensure it meets the water quality standards before being discharged to the environment or Tiriganiaq pit to assist with pit flooding. Dewatering of the open pits will cease at the end of operations and the open pits will be actively filled with water over a period of approximately 10 years. When flooded, and water quality criteria have been achieved, outflows from the pits will naturally drain toward adjacent waterbodies and eventually reach Meliadine Lake. It is expected that the water quality in the open pits will meet the water quality standards from the CCME guidelines for protection of aquatic life. Contact water ditches and sumps enclosing the waste rock storage facilities will be removed and a layer of non-PAG rock will be placed in the sumps to prevent dusting and erosion. Implementation of these environmental design features is expected to result in no

detectable changes to vegetation and bird habitat from the Project. Therefore, this pathway is determined to have no linkage to effects on the persistence of bird populations and the continued opportunity for traditional and non-traditional use of birds.

- **Uptake of metals by birds through ingestion of tailings and dust on surface water, soils and vegetation can affect bird health**

Birds within the terrestrial RSA may be directly and indirectly exposed to airborne chemicals through fugitive dust and air emissions from the Project. Airborne chemicals link to metals. Direct exposure to metals includes inhalation of fugitive dust and air emissions, drinking of water, inadvertent ingestion of soil, and ingestion of vegetation. Airborne chemicals may deposit directly onto the surface of plants or may deposit onto soils and be subsequently taken up through plant roots (vascular plants) or tissues (lichen). Accumulation of dust (i.e., TSP deposition) and concentrations of air emissions produced from the Project may result in dust entering local surface waters as runoff. Therefore, birds may be indirectly exposed to metals from fugitive dust and air emissions by intentionally or inadvertently consuming vegetation that has accumulated metals through the soil or air, or ingesting water, sediment, or invertebrates from waterbodies exposed to chemicals. Egg shell thinning is primarily a result of ingestion of organochlorine chemicals; ingestion of mercury and other heavy metals have not been found to be associated with effects to shell thickness (Cooke 1973). Tailings and dust from the Project are not expected to contain organochlorine chemicals and so should not result in changes to egg shell thickness and chick development. Tailings deposition will be designed to limit dust generation and airborne chemicals are not expected to extend beyond the terrestrial RSA.

A wildlife health risk assessment was completed to evaluate the potential adverse effect to individual animal health associated with exposure to chemicals from the Project (Section 10.1). For birds, there were no COPCs identified in soil, sediment or surface water for further evaluation in the environmental risk assessment. As such, the environmental risk assessment did not proceed beyond the chemical screening stage of the problem formulation for birds. This indicates that adverse health effects to birds as a result of the Project are not expected. Consequently, these pathways were determined to have no linkage to effects on the persistence of bird populations,

- **Leaching of dissolved metals from waste rock in waste rock storage facilities may cause changes to groundwater and surface water quality and soils, which may affect bird habitat**
- **Vertical and lateral seepage from waste rock storage facilities and the tailings storage facility may cause changes to groundwater and surface water quality and soils, which may affect bird habitat**

During the life of the Project, there is the potential for leachate, runoff, and seepage (e.g. metals) from the facilities developed for storage of tailings and waste rock. All waste rock is currently categorized as non-PAG type (SD 6-3 Geochemistry Baseline Report). Separate waste management procedures are proposed for the PAG and non-PAG material should any PAG waste rock be found in continuing studies (SD 2-8 Mine Waste Management Plan). All PAG and high metal leaching potential waste rock generated by open pit mining will be segregated at source and placed into designated areas within the waste rock storage facilities. They will then be encapsulated with non-PAG and low metal leaching potential waste rock so that the risk of contaminant release both during the operational and post-closure phases of the mine is significantly reduced and/or eliminated to prevent potential contamination of surrounding waterbodies, soils, and vegetation.

Runoff and seepage from the waste rock storage facilities will not be released to the environment during construction or operations. The on-land facilities will have ditch systems to collect seepage and runoff, and all water collected will be monitored and treated, when necessary, prior to release to the environment (SD 2-6 Site Water Management Plan). Attenuation ponds for the storage of contact water from the Project site have been designed to accommodate the total volume of runoff under the 1-in-100 wet year freshet event, and to limit the potential for seepage. Tailings are expected to have arsenic concentrations that are over MMER and CCME guidelines; therefore, a provision will be made for treating tailings supernatant water to remove arsenic during the life of mine operation prior to discharge to the TSF.

Short-term water leach test results yield concentrations that meet the MMER chemical criteria in all samples of waste rock and ore tested with the exception of arsenic in one Tiriganiaq greywacke/siltstone sample and 3 ore samples from Discovery and Tiriganiaq (SD 6-3 Geochemistry Baseline Report). However, short term leach tests are considered a conservative estimate of arsenic leachability. Large column and field cell tests, conducted at low water-to-rock ratios that are more appropriate to site conditions, generate leachate concentrations well below MMER criteria. Scale up studies further support the conservativeness of the short-term leach tests, as do on-site surface water quality representing waste rock contact water (operations pad made of Tiriganiaq greywacke run of mine rock).

Permafrost conditions are present under the waste rock storage facilities and over time will penetrate into the facility. The permafrost is anticipated to limit seepage from waste rock storage facilities over the long-term. The aggradation of permafrost into the facility is expected to occur under both current climate and future climate change scenarios (Section 6.3).

Currently, there is an open talik beneath Lake B7 that could be a pathway for constituents to enter the deep groundwater flow system. Thermal modelling indicates that once B7 is dewatered it would take 20 to 50 years for the talik to freeze beneath B7. During mining, groundwater modelling suggests that groundwater from the TSF would take approximately 8 years to reach the underground mine, where it would be collected and treated if necessary prior to discharge. At closure, when flooding of the open pits and underground has occurred, any residual groundwater originating from the TSF at B7 that has not yet reached the underground will continue in the regional groundwater flow system and groundwater modelling suggests it would take 500 to 1000 years for the residual groundwater under the TSF to reach Meliadine Lake (FEIS Volume 7, Section 7.2.3.3).

At closure, the Reclaim Pond will be dewatered and the tailings will be covered with non-metal leaching and non-PAG rock. The rock will be tested prior to placement. The ditches and sumps and water treatment facilities will be maintained until it is confirmed that the runoff from the waste rock and tailings storage facilities meet Project discharge criteria.

The environmental design features and mitigations listed in Table 6.7-21 reduce the potential risk of contact between birds and contaminants from waste rock and tailings. Overall, release of runoff and long-term seepage from the tailings and waste rock storage facilities, as well as leachate from waste rock is expected to result in no detectable change to bird habitat outside of the Project footprint area relative to baseline conditions. Therefore, these pathways were determined to have no linkage to effects to bird habitat, and the subsequent maintenance of bird populations for the continued opportunity for traditional and non-traditional use of birds.

Changes to Survival and Reproduction

- **Destruction of waterbird nests from changes to flows or water levels can increase risk of mortality to individual birds, which can affect waterbird population sizes**

The *Migratory Birds Convention Act* (*MBCA* 1994) prohibits the destruction of migratory bird nests (passerine, waterfowl, and raptor) during the breeding season. In the northern Arctic region of NU, the migratory bird breeding season extends from approximately 31 May to 28 August (P. Smith, Environment Canada, 2012, pers. comm.). Potential increases in peak annual water levels from the alteration of watershed configuration from the Project footprint and diversions, will be mitigated by engineered diversion channels (e.g., B5-C-02) and enhanced lake outlet channels (SD 2-6 Site Water Management Plan). Dewatering rates and schedule will also be managed so that peak annual water levels, which typically occur in June, do not increase outside of the range of baseline conditions. Water levels will be increased during the low flow season (i.e., July to October) but are expected to remain below the baseline peak annual water level. At closure, pumping rates will be managed to minimize potential effects on the water levels of Meliadine Lake during refilling of the pits (FEIS Volume 7, Section 7.3) and effect on the water levels of Meliadine Lake is expected to be negligible.

The implementation of the above environmental design features are expected to maintain flows and water levels within the range of baseline conditions and so destruction of waterbird nests from Project activities are not likely to occur. Thus, this pathway was determined to have no effects on the persistence of waterbird populations and the continued opportunity for traditional and non-traditional use of waterbirds.

- **Destruction of nests by Project infrastructure can affect individual mortality, resulting in changes to abundance and distribution of bird populations.**

The *Migratory Birds Convention Act* (*MBCA* 1994) prohibits the destruction of migratory bird nests (passerine, waterfowl, and raptor) during the breeding season. In the northern Arctic region of NU, the migratory bird breeding season extends from approximately 31 May to 28 August (P. Smith, Environment Canada, 2012, pers. comm.). Vegetation removal is expected to occur at the processing plant and open pit areas. As much as possible, vegetation clearing would take place outside of the migratory bird season, resulting in little chance of destruction of migratory bird nests. If construction activities must be completed during the migratory bird breeding season, then vegetation and top soil will be removed from potentially affected upland areas, prior to the nesting season or nest searches will be completed prior to the clearing of vegetation.

To mitigate against the destruction of raptor nests in the future, AEM has committed to provide support to the Arctic Raptor Project. AEM would use the research to identify all known nests in the RSA and take action to avoid existing nests in consultation with the GN. Where active raptor nests are identified, a nest-specific management plan will be developed to minimize disturbance to nesting activities (SD 6-4). Nest-specific mitigations have been implemented by AEM at the Meadowbank mine (Nunavut Environmental Consulting Ltd. 2012).

These mitigation practices are anticipated to prevent change to the nest success of birds from the Project relative to baseline conditions. Therefore, this pathway was determined to have no linkage to the persistence of bird populations and the continued opportunity for traditional and non-traditional use of birds.

- **Improved access for harvesting can affect raptor population size**

The Wildlife Research Section of the Department of Environment recommends a total allowable harvest of zero for all raptors, except gyrfalcons (Wildlife Research Section 2007). The Hunting Regulations for 2012 and 2013 in NU do not have a bag limit for any raptors for residents and non-residents in NU (Department of the Environment 2012). Traditional Knowledge suggests that birds of prey are not hunted (FEIS Volume 9, Section 9.3 Traditional Activity and Knowledge).

Considering that most residents of Rankin Inlet have few harvesting restrictions and the good access to hunting that currently exists in the RSA (e.g., 15 km all-weather road from Rankin Inlet to the Iqalugaarjuup Nunanga Territorial Park), the addition of the AWAR is not anticipated to cause significant changes to harvesting levels.

In summary, given that the AWAR should not open new areas for hunting and raptors are not hunted for traditional use, there should be no change to raptor survival rates from increased harvesting. Consequently, there is no linkage to effects on the persistence of raptor populations and the traditional and non-traditional use of raptors.

- **Spills on the mine site or along the AWAR can increase risk of mortality to individual birds, which can affect bird population size**

Chemical spills have not been reported as the cause of bird mortality at the Ekati Diamond Mine, Diavik Diamond Mine, Jericho Diamond Project, Snap Lake Mine, or Fortune NICO Project (Tahera 2008; BHPB 2010; De Beers 2010, AEM 2011b, Fortune 2011; Rio Tinto 2012). At the AEM Meadowbank Mine, accidental spills (e.g., fuel) have occurred, but the volume of spills have primarily been small, and clean-up has occurred with negligible to minor, reversible short-term environmental impact, requiring minor remediation. There has never been a spill at Meadowbank resulting in moderate to serious environmental impact (AEM 2011a).

The implementation of the Risk Management and Emergency Response Plan (SD 2-15), and environmental design features, including proper equipment maintenance and driver training, are expected to reduce the frequency and severity of spills. It is acknowledged that accidental spills, including vehicular accidents, have the greatest potential to affect soils, vegetation, and possibly result in the mortality of individual birds. However, construction and mining equipment, machinery, and vehicles will be regularly maintained. Fuel storage tanks will be situated in a secondary containment area and the storage tanks and fuel-dispensing systems will be constructed in accordance with current regulatory requirements and National Fire Code. Fuel reconciliation will be conducted and structural integrity will be routinely inspected. Hazardous materials will also be stored according to regulatory requirements to protect the environment (SD 2-13 Hazardous Materials Management Plan), and individuals working on site and handling hazardous materials will be trained. Emergency spill kits will be readily available should a spill occur. Consequently, this pathway was determined to have no linkage to effects on the abundance and distribution of bird populations, and continued opportunity for traditional and non-traditional use of birds.

- **Disruption or alteration of migration routes from the presence of the mine or from mine-related activities can affect bird populations**

Impacts to bird migrations could be related to increased air traffic from the Project. To minimize risks to birds, there is no airstrip planned at the site. Air traffic at Rankin Inlet is expected to increase by 6 additional flights per week with the development of the Project.

In the United States, songbirds account for 14% of collisions with aircraft, while waterfowl and raptors each account for 4% of collisions (Dolbeer and Wright 2008). Bird strikes are more common at night during migration periods. From 2000 to 2009, three bird collisions have been reported at the Rankin Inlet airport (Transport Canada 2012). During 2006 to 2010 total annual aircraft movements at the airport ranged from 12 400 to 14 000 (Statistics Canada 2010), so the rate of bird collisions at the Rankin Inlet airport has been low. An additional 6 flights per week is not expected to increase the rate of bird collisions during migration. Therefore, the potential changes from the Project on migration routes for upland birds, waterbirds, and raptors are expected to be negligible. Consequently, this pathway was determined to have no linkage to effects on the persistence of bird populations, and traditional and non-traditional use of birds from changes to migration routes from air traffic. Effects to migration routes from shipping activities are assessed in Marine Wildlife (FEIS Volume 8, Section 8.3).

6.7.4.2 Minor Pathways

In some cases, both a source and a pathway exist, but the change caused by the Project is anticipated to result in a minor environmental change, and would have a negligible residual effect on birds relative to baseline or guideline values. The following pathways are anticipated to be minor, and will not be carried through the effects assessment.

Changes to habitat quality, movement and behaviour

- **Dewatering of waterbodies, Project footprint, and diversion of water, may change downstream flows, water levels, and affect bird habitat quality.**

Potential increases in peak annual water levels from the alteration of watershed configuration due to the Project footprint and diversions, will be mitigated by engineered diversion channels and enhanced lake outlet channels (SD 2-6 Site Water Management Plan). Dewatering rates and schedule will be managed so that peak annual water levels, which typically occur in June, do not increase from baseline conditions. The Project will result in residual effects to the hydrology of downstream locations in the LSA including watersheds B, C, D, E, I, J, CH, and P (FEIS Volume 7, Section 7.3.4). The effects are projected to occur during the Preproduction Phase, Mining Phase 1 to Mining Phase 5, and Closure, with effects that will continue after Closure for the long-term. Effects will be a result of a combination of Project-related activities, including the dewatering of waterbodies, infrastructure development, and the diversion of waterbodies. Water levels will be increased during the low flow season but are expected to remain below the baseline peak annual water level. To attenuate flow changes, pumped discharge from dewatering of waterbodies will be directed to the lake environment, and not directly to outlets. At closure, pumping rates will be managed to minimize potential effects on the water levels of Meliadine Lake during refilling of the pits (FEIS Volume 7, Section 7.3) and effects on the water levels of Meliadine Lake are expected to be negligible. The magnitude and direction of these effects depend on the type and timing of upstream Project activities and thus vary across sub-basins and over time.

Diversion of relatively large volumes of water into a single discharge flow path could increase erosion causing an increase of particulate material transported to Meliadine Lake. To minimize impacts to habitat quality, best management practices will be used. In some cases, dewatering flows will be pumped through pipelines to the lake environment, and not directly to outlets, to attenuate flow changes. In other cases water will be diverted with constructed channels designed to prevent erosion and to maintain stability in permafrost. Where practical, natural drainage patterns will be used to reduce the use of ditches or diversion berms. However, discharge to

receiving waterbodies will only occur while water quality discharge criteria are met. Water will be managed to prevent the release of water to the natural receiving environment if total suspended solid (TSS) concentrations exceed specific water quality criteria.

It is expected that raised waterbodies and streams could be subject to erosion as new shorelines are established, particularly for the flow path from Lake B45 to the Lake P2 outlet where increases in annual water volumes will be highest (see FEIS Volume 7, Section 7.3.3). Shoreline areas susceptible to extensive erosion will be addressed by appropriate erosion protection measures to reduce erosion and associated re-suspension of fine sediment. Natural armouring of morainal soils, where present, is expected to limit erosion in these areas and persistent TSS is expected to be limited as coarse materials settle out on the lakebed. Low slopes in new shoreline areas with organic (peat) soils are expected to minimize erosion and generation of TSS.

Changes to shoreline structure or erosion of shorelines will be localized and over a relatively short duration during spring freshets or high rain events in the early years of construction and operation. Thus, effects to the abundance and distribution of waterfowl in the LSA will be negligible in magnitude, in part because potential changes in habitat quality will be limited by use of best management practices during construction and operation phases. The practices will not only reduce erosion and sedimentation potential, but also potential increases in the bioavailability of contaminants of potential concern. Erosion and sediment monitoring under an adaptive management framework will be incorporated into planning for all receiving sub-basins (SD 7-3 Aquatic Effects Monitoring Plan).

As a result of the implementation of the above environmental design features, the effects on bird habitat quality from the dewatering of waterbodies, Project footprint, and diversion of water are expected to be minor and have no detectable impact on distribution or abundance of bird populations. Consequently, residual effects to the maintenance of bird populations and the continued opportunity for traditional and non-traditional use of birds are predicted to be negligible.

- **Dust deposition may cover vegetation, change the amount of different quality bird habitats, and alter bird movement and behaviour**
- **Air emissions and deposition can cause changes to chemical properties of surface water, soils, vegetation, and wetlands, affecting habitat quality.**

Accumulation of dust (i.e., TSP deposition) and concentrations of air emissions produced from the Project may result in a local indirect change on the quality of habitat available within the LSA) Air quality modelling was completed to predict the spatial extent of dust deposition and air emissions from the Project (FEIS Volume 5, Section 5.2). Sources of dust deposition and air emissions modelled include blasting activities, haul roads, the processing plant, activities at the open pits and other ancillary facilities, and vehicle traffic along the AWAR. Environmental design features and mitigation have been incorporated into the Project to reduce potential effects from dust deposition (Table 6.7-21). For example, the watering of roads during the non-winter period will facilitate dust suppression. In addition, as a member of the Mining Association of Canada, AEM will periodically review power and heat use and consider opportunities to optimize energy use (SD 2-5 Environmental Management Protection Plan). Although these environmental design features and mitigation should reduce dust deposition and air emissions, assumptions incorporated into the model are expected to contribute to conservative estimates of emission concentrations and deposition rates.

Dust generation from Project vehicles travelling along the AWAR will occur annually, but will likely be lower during the winter period and will be of lower magnitude during wet and cool conditions. Trucks travelling on the AWAR and site roads also have the potential to directly transfer dust collected on wheels and undercarriage of vehicles at the Project and in Rankin Inlet to other parts of the LSA; however, the relative contribution from this source to the overall dust accumulation in the area along the roads is considered to be negligible (FEIS Volume 5, Section 5.2).

Dust deposition is expected to result in minor and localized changes to vegetation and consequently bird habitat along the right-of-ways for the AWAR. For example, Walker and Everett (1987) and Everett (1980) reported that effects were confined to a 50 m buffer on either side of a road. Moreover, Meininger and Spatt (1988) found that most of effects occurred within 5 to 50 m of a road, with less obvious effects observed between 50 m and 500 m from a road. The amount of dust generated along the road is dependent on the dryness of the road surface, the number of vehicles, weight and speed, and maintenance of the driving surface. Regular grading of the AWAR combined with the addition of granular material to the driving surface will be needed (SD 2-9 Roads Management Plan). This will improve road safety and also reduce the amount of dust. Dust will also be mitigated by maintaining posted speed limits. In areas or times identified by the AEM road supervisor as being prone to high dust levels or areas where safe road visibility is impaired, the road supervisor will arrange mitigation measures as appropriate. This could involve actions such as grading of the road surface, placement of new coarser topping, and/or watering of the road surface. Use of chemical dust suppressants will be used only as a last resort and only in accordance with the Environmental Guidance for Dust Suppression published by the Government of Nunavut Department of Environment (January 2002)[2]. Therefore, dust deposition from vehicles along the AWAR is predicted to result in negligible residual effects to the persistence of bird populations.

Air emissions from vehicles along the AWAR were included in the air quality modelling assuming that the AWAR would be open all year round. In general, emissions from the roads are small, and if extended over the whole year, a negligible effect from annual depositions is predicted (FEIS Volume 5, Section 5.2). Annual emissions from vehicles on the roads are anticipated to result in minor and localized changes to soils and vegetation (Section 6.4.2.2 and 6.5.4.3), and are expected to have no residual effect on bird habitat relative to baseline conditions.

The results of the air quality modelling predict that the maximum annual TSP concentrations resulting from the Project is 29.4 $\mu g/m^3/y$ within the Project disturbance areas, and 14.6 $\mu g/m^3/y$ outside of the Project disturbance areas (Table 6.7-22). The maximum 24-hour TSP concentration within the Project disturbance areas is 356.5 $\mu g/m^3$, and is 212.5 $\mu g/m^3$outside of the Project disturbance areas. Although concentrations are predicted to be above Nunavut Ambient Air Quality guidelines (Department of Environment 2011) during select periods of the Project (Table 6.7-22), the anticipated changes to habitat quality are considered minor and localized. The major sources of dust will be associated with the open pits and haul roads. The strongest effects from dust are generally confined to the immediate area adjacent to the dust source, such as roads (Walker and Everett 1987). Everett (1980) reported that effects were confined to a 50 m buffer on either side of a road.

The air emission modelling results show that predicted maximum concentrations for sulphur dioxide and carbon monoxide during all model cases are below the Nunavut Ambient Air Quality guidelines (Table 6.7-23); however,

[2] Available online at the following web site: http://env.gov.nu.ca/sites/default/files/Guideline%20Dust%20Suppression.pdf

annual peak concentrations for nitrogen dioxide are predicted to slightly exceed guidelines inside the Project disturbance areas, reaching levels of 90.1 µg/m^3. Although some concentrations are predicted to be above criteria concentrations, and some are predicted to be above baseline conditions (i.e., PAI), the anticipated changes to vegetation are localized and considered minor (Section 6.5.4.3). The concentration predictions are considered to be conservative and the presented concentrations are likely overestimated (FEIS Volume 5, Section 5). Therefore the anticipated changes to habitat quality are considered minor and localized.

Overall, changes in habitat quality (and associated changes to bird movement and behaviour) due to dust deposition and air emissions are anticipated to be minor relative to baseline conditions. Consequently, residual effects to the persistence of bird populations and the continued opportunity for traditional and non-traditional use of birds from dust deposition and air emissions are predicted to be negligible.

Table 6.7-22: Summary of Predicted Annual and 24-hour Dust Concentrations from the Project

Substance	Averaging Period	Criteria ($\mu g/m^3$)[a]	Inside the Project Disturbance Areas						Outside the Project Disturbance Areas					
			Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
TSP	24-hour	120	41.6	**220.5**	**346.8**	**356.5**	**155.6**	**300.9**	18.2	62.1	**212.5**	101.8	**134.7**	81.0
	Annual	60	6.0	9.8	24.8	12.5	13.5	29.4	1.7	3.3	14.6	3.8	6.0	3.2
PM_{10}	24-hour	50	41.6	**93.1**	**188.2**	**160.6**	**73.7**	**138.8**	18.1	26.4	**90.7**	48.9	**60.7**	36.6
$PM_{2.5}$	24-hour	30	**41.6**	**42.0**	**42.9**	**41.8**	**41.7**	**42.1**	17.2	18.8	17.2	18.3	17.2	18.0

Note: bolded values exceed criteria. Refer to FEIS Volume 5, Section 5.2 for a description of the Cases

[a] Criteria are based on the Nunavut Ambient Air Quality guidelines (Department of Environment 2011)

$\mu g/m^2/y$ = micrograms per cubic metre; TSP = total suspended particulate; $PM_{2.5}$ = fine particles of 2.5 micrometres or less in size; PM_{10} = fine particles of 10 micrometres or less in size

Table 6.7-23: Summary of Predicted Maximum 1-hour, 8-hour, 24-hour, and Annual Air Quality Concentrations from the Project

Substance	Averaging Period	Criteria ($\mu g/m^3$)[a]	Inside the Project Disturbance Areas						Outside the Project Disturbance Areas					
			Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
Nitrogen Dioxide	1-hour	400	285.6	285.6	285.6	285.6	285.6	285.6	270.7	273.1	272.0	273.5	271.0	273.2
	24-hour	200	160.8	160.8	160.8	160.8	160.8	160.8	119.4	120.0	119.8	120.2	119.5	120.2
	Annual	60	**89.6**	**90.1**	**89.9**	**89.9**	**89.7**	**89.9**	25.9	27.7	27.0	27.3	26.2	27.4
Sulphur Dioxide	1-hour	450	4.4	4.4	4.4	4.4	4.4	4.4	2.5	2.6	2.6	2.5	2.5	2.6
	24-hour	150	2.3	2.4	2.4	2.3	2.3	2.4	1.0	1.1	1.0	1.0	1.0	1.0
	Annual	30	0.1	0.2	0.1	0.1	0.1	0.2	0.0	0.0	0.1	0.0	0.0	0.0
Carbon Monoxide	1-hour	35 000	1281.7	1281.7	1416.0	1281.7	1281.7	1281.7	1190.1	1210.7	1203.0	1214.6	1192.2	1214.5
	8-hour	15 600	845.6	845.6	934.2	845.6	845.6	845.6	785.2	798.8	793.7	801.3	786.6	801.3

Note: bolded values exceed criteria. Refer to FEIS Volume 5, Section 5.2 for a description of the Cases

[a] Criteria based on Nunavut Ambient Air Quality guidelines (Department of Environment 2011)

$\mu g/m^3$ = micrograms per cubic metre

Changes to Survival and Reproduction

- **Improved access for harvesting can affect waterbird and upland bird population sizes**

The incremental and cumulative effects of increased access for harvesting on survival and reproduction of waterbirds and upland birds (i.e., ptarmigan [*Lagopus lagopus* and *L. muta*]) were assessed qualitatively using literature review, existing Traditional Knowledge or IQ, interviews completed for the Project and a review of experiences at other mines in NU. The literature reviewed included harvest records, IQ, and TLU activities inside and outside the RSA. Traditional Knowledge was collected for the Project by Nanuk Enterprises in the late 1990s, with participants from Rankin Inlet and Chesterfield Inlet, and in 2010, with participants from Whale Cove, Rankin Inlet, and Chesterfield Inlet. Interviews were conducted in Inuktitut and audio-taped. Additional details are provided in FEIS Volume 9, Section 9.3 Traditional Activity and Knowledge.

Increased access from the AWAR for traditional and non-traditional harvesting may increase risk of mortality for waterbirds and ptarmigan, as well as alter movements and behaviour in response to perceived risk. However, there is an existing network of ATV trails in the RSA that can be used for hunting. Through Traditional Knowledge studies (FEIS Volume 9, Appendix 9.3-A) waterfowl have been identified as an important resource for hunting in the RSA. In times when caribou are unavailable, birds and bird eggs provide sources of food and other materials to the Inuit. The development of the AWAR may increase access for hunters, which may affect ptarmigan populations, especially if hunters take more than 15% of the ptarmigan population (Sandercock et al. 2011).

The response of willow ptarmigan that live in open areas (e.g., tundra) to hunting pressure has not been studied but may depend on the level of hunting pressure and the availability of topographical areas or vegetation types that provide escape areas (Brøseth and Pedersen 2010), such as willow thickets (Ehrich et al. 2012). Ptarmigan are regularly hunted in the LSA. They are highly prized as a local delicacy, and hunted wherever they are encountered (FEIS Volume 9, Appendix 9.3-A).

The area around Meliadine Lake and the lower Meliadine valley and southeast of the Meliadine River bridge crossing have been identified as goose and waterfowl hunting areas (FEIS Volume 9, Appendix 9.3-A). In the lower Meliadine valley, participants in Traditional Knowledge studies have indicated that thousands of snow geese, Canada geese, and white-fronted geese stop in the lower Meliadine area to rest and feed during both spring and fall migrations. People hunted there in the past and continue to do so now (FEIS Volume 9, Appendix 9.3-A). Northeast of the Meliadine River bridge crossing, snow geese, Canada geese, occasionally white-fronted geese, tundra swans, and sandhill cranes forage throughout Section 2 of the AWAR in spring and fall. Tundra swans, sandhill cranes, and geese also nest in the area. Geese are hunted in the spring and fall. Sandhill cranes and swans are also hunted, although these do not form a major part of the diet today. Southeast of the Meliadine River bridge crossing, waterfowl are hunted along the AWAR alignment. In the fall, large flocks of snow geese and smaller flocks of Canada geese pass through the area and feed on berries on hill slopes. These are hunted where present throughout the area (FEIS Volume 9, Appendix 9.3-A). The estimated annual catch for birds in Rankin Inlet is 300 individuals (FEIS Volume 9, Section 9.3, Table 9.3-15).

Changes to land use have been reported at the Meadowbank Mine as a result of a 106 km road (Gebauer and Associates 2010). A study on the Tibbitt-to-Contwoyto Winter Road reported that hunting was the most common land use along the road, followed by fishing, sightseeing, and camping (Ziemann 2007). Considering that most residents of Rankin Inlet have few harvesting restrictions, that good access to hunting and fishing areas currently

exists in the RSA, and that harvesting currently occurs from existing trails within the RSA, the addition of the AWAR to Meliadine Lake is not anticipated to cause significant changes to current land use. Currently there is a 10 km all-weather road from Rankin Inlet to the Iqalugaarjuup Nunanga Territorial Park.

Hunting by residents and non-residents of Canada is not expected to change due to the AWAR because there are existing hunting regulations for migratory birds (i.e., geese, American coots, Wilson's snipe and ducks) (Environment Canada 2012). There are restrictions on daily bag limits, possession limits, open season, and open hunting seasons for over-abundant species (i.e., snow geese). The bag limit for ptarmigan is 10 per day and possession of 40 for residents, and bag limit of 5 with the possession 10 for non-residents (Department of Environment 2012). These restrictions are not expected to change.

It is anticipated that the use of AWAR by harvesters should result in minor changes to overall annual harvest rate relative to baseline conditions until the mine closes and the AWAR is decommissioned. The AWAR will provide faster access to Meliadine Lake rather than new access. The AWAR will not open areas previously inaccessible to harvesters as the RSA is currently accessible by ATV and snowmobile. Access will be improved (travel on maintained road versus using trails), thus, the number of harvesters accessing the RSA may increase. Public access to the mine site will be restricted during operations. Access along the AWAR outside the mine lease boundary will be controlled by an unmanned gate located at its south end, which will be open in most instances to allow public use of the road. The gate and road will be closed only if there is a risk to public safety.

In summary, given that the AWAR is not expected to open new areas for hunting, and that the AWAR will be decommissioned after closure, the incremental effect of the proposed AWAR on waterbird and upland survival rates is expected to be negligible. Therefore, this pathway was determined to have negligible residual effects to the persistence of bird populations and the continued opportunity for traditional and non-traditional use.

- **Physical hazards on the mine site and collision with vehicles or aircraft causing injury or mortality to individual birds, which can affect population sizes**

Infrastructure (e.g., buildings, ditches, open pits) and blasting activities associated with the Project may be hazardous to bird species. Birds are vulnerable to collisions with man-made structures, such as buildings (reviewed in Erickson et al. 2005 and Drewitt and Langston 2008). The likelihood of bird collisions with buildings depends on the location of the building, seasonal activity levels of birds, the presence of windows, and the use of lighting within and around buildings (Klem 1990). Buildings that are located close to wetlands or bird congregation areas (e.g., nesting or roosting areas, migration flyways) increase the likelihood of bird-building collisions. Collisions may be expected to increase during spring and fall migration periods due to the lack of familiarity of migrant birds with the location of buildings, flocking behaviour of migrating birds (i.e., a higher concentration of birds), and the increased number of young and inexperienced birds (during the fall migration) (Drewitt and Langston 2008). Birds with poor manoeuvrability and high flight speeds (e.g., waterfowl) are more vulnerable to infrastructure collisions than other bird species (Bevanger 1998).

Vehicles on the AWAR may be hazardous to raptors, waterbirds, and upland birds, which can collide with vehicles, particularly during the breeding season if they are not accustomed to vehicular traffic (Mumme et al. 2000; Clevenger et al. 2003). Juvenile birds are also susceptible to vehicular collisions during their natal dispersal because they are inexperienced with vehicular traffic. Raptors may be attracted to road kill (Fahrig and Rytwinski 2009).

In general, few collisions with birds have been reported along mine access roads in the NT and NU. For example, between 1997 and 2009, 11 willow ptarmigan, 1 rock ptarmigan, 8 other ptarmigan (species not recorded), 1 green-winged teal (*Anas crecca*), 1 unidentified bird, and 1 rough-legged hawk have been killed by vehicle collisions on the Ekati mine site (BHBP 2008, 2009, 2010). One unidentified duck and approximately 6 rock ptarmigan have been killed by vehicle collisions on the Diavik mine site from 2000 to 2009 (DDMI 2007, 2008, 2009, 2010). No birds have been killed by vehicle collisions on the Snap Lake mine site from 1999 to 2009 (De Beers 2010). Road monitoring of birds on the all-weather private road between Baker Lake and the Meadowbank mine have recorded 2 willow ptarmigan, 2 rock ptarmigan, 18 ptarmigan species (could not be identified to species), and 3 Lapland longspur mortalities between 2008 and 2011 (Nunavut Environmental Consulting Ltd. 2012).

There will not be an airstrip located on-site, so personnel will be transported to site from Rankin via the AWAR. Project related traffic in winter months during operations, including personnel transport, is expected to be between 8 and 10 pick-up trucks, 2 cube vans, 2 passenger vans, 2 fuel trucks, and 1 transport truck on week days. The traffic is expected to be reduced to 2 to 4 pick-up trucks, 1 cube van, 1 passenger van, and 1 transport truck on weekends. In summer, traffic will be between 10 and 14 pick-up trucks, 3 cube vans, 2 passenger vans, 2 fuel trucks, 1 transport truck on weekdays and 4 to 8 pick-up trucks, 1 cube van, 1 passenger van, 1 transport truck on weekends. When the barges arrive at Itivia, 6 to 14 transport trucks per day are expected on the road to move the freight to the Meliadine site. If air craft are not able to land in Rankin Inlet, the number of passenger vans using the AWAR would drop in half. Transport trucks will not travel the road when the weather is bad in any season. Public road usage in winter is expected to include between 1 and 2 pick-up trucks and 5 to 10 snowmobiles on weekdays, and between 2 and 5 pick-up trucks and 10 to 20 snowmobiles on weekend days when the weather is good. In summer, 2 and 5 pick-up trucks and 5 to 10 ATV's are expected on weekdays and between 5 and 10 pickup trucks and 10 to 20 ATV's on weekend days when the weather is good. Between 25 to 50% of these trips are estimated to be incremental to current access via ATVs and snowmobiles.

Traffic speed and volume are the primary factors that contribute to road-related bird mortality. These factors directly affect the success of an animal reaching the opposite side of the road. An increase in either factor reduces the probability of an animal crossing safely (Underhill and Angold 2000). Several mitigation measures will be implemented to mitigate the increase in injury and mortality risk along the AWAR and other Project roads. Passenger vans will transport workers from Rankin Inlet to site during construction and operation to reduce traffic volume. Road safety training will be provided to site personnel and partnerships built to educate the public on road safety. Speed limits will be posted and enforced on the AWAR. The maximum speed will be 50 km/h. Lower speeds better allow the motorist and animal to avoid a collision (van Langevelde et al. 2009). The presence of birds will be monitored and communicated to site personnel, and birds on the AWAR will be given the right-of-way (vehicles must stop until animals are off the road).

There are expected to be 4 charter flights per week to Rankin Inlet from Montreal or Val-d'Or, and 2 additional charter flights from Kivalliq communities. In the United States, bird collisions with aircraft are most common between 0 and 150 m above ground level (Dolbeer and Wright 2008). Passerines (i.e., songbirds) account for 14% of these collisions, while waterfowl and raptors each account for 4% of these collisions. Bird strikes are more common at night during migration and are more common during the day during the breeding season. From 2000 to 2009, 3 bird collisions have been reported at the Rankin Inlet airport (Transport Canada 2012). During 2006 to 2010, total annual aircraft movements ranged from 12 400 to 14 000 (Statistics Canada 2010) so the

rate bird collisions at the Rankin Inlet airport has been low. An additional 6 flights per week is not expected to increase the rate of bird collisions during migration. There will be no airstrip at the Project site.

Mine infrastructure and collisions with aircrafts and road vehicles is expected to result in minor changes to mortality rates from bird-vehicle collisions and interactions with infrastructure that would still be in the range of baseline conditions. Consequently these pathways would have a detectable effect on individual birds but the effect to the persistence of bird populations and the continued opportunity for traditional and non-traditional use of birds is expected to be minor.

- **Changes in energetic costs from disturbance or displacement**

Bird survival and reproduction can be negatively affected by sensory disturbance (e.g., increased noise levels during construction, visual disturbances from moving vehicles and humans throughout operation) because animals may avoid (i.e., change movement patterns or flee the area) or move more quickly through areas with human disturbance (Fortin and Andruskiw 2003; Bayne et al. 2008). This increase in energy expenditure may reduce individual fitness because energy that could be allocated to survival or reproduction is instead used to cope with disturbance (Bisson et al. 2009).

Birds may be more sensitive to disturbance early in the nesting season because the amount of energy invested in brood-rearing is not outweighed by nest abandonment (Bisson et al. 2009). Birds may also be more vulnerable to disturbance during the molting season as they will have less energy to use towards stress responses (e.g., fleeing) (Cyr et al. 2008).

Some studies have shown no responses (e.g., no changes in activity levels from baseline conditions; Telesco and VanManen 2006) or transitory responses (e.g., returning to normal hormone, heart rate, or activity levels within a few minutes; Krausman and Hervert 1983; Weisenberger et al. 1996) to human disturbance. Other studies note longer increases in activity, hormone, or heart rate levels with disturbance (e.g., returning to normal levels within a few hours or days; Weimerskirch et al. 2002). These responses may be related to how accustomed species are to disturbance, the time of year (e.g. breeding or non-breeding season), the type of sensory disturbance (olfactory or visual), as well as the duration and intensity of the disturbance (Fortin and Andruskiw 2003; Bayne et al. 2008; Fahrig and Rytwinksi 2009). No literature on the effects of in-ground or in-water vibrations (e.g., from blasting activities) to upland breeding birds and raptors could be found. Lacroix et al. (2003) found no effect on vibrations from seismic activity on movements and diving behaviour of long-tailed ducks (*Clangula hyemalis*).

Raptors can also habituate to human disturbance. Peregrine falcons commonly nest in urban environments (White et al. 2002). There have been several attempts by peregrine falcons, gyrfalcons, and rough-legged hawks to nest within both active and abandoned open pits at the Ekati and Diavik diamond mines in NT. Peregrine falcons made nesting attempts in open pits at Diavik diamond mine in 2005 and 2006 (DDMI 2007). Since 2004, there have been 8 such occurrences among 5 open pits at the Ekati diamond mine, and all 5 Ekati pits had nesting birds in 2006 (BHPB 2007). In some cases, young have been detected in these nests (BHPB 2003, 2007). Nesting on pit walls has become so common at the Ekati diamond mine that a monitoring program has been implemented. At the Meadowbank Mine, peregrine falcons have moved in to new cliff-like habitat created at quarries along the all-weather private road, successfully rearing young in 2009 (Nunavut Environmental Consulting Ltd. 2012).

The type of sensory disturbance may also influence behavioural responses in raptors. Rough-legged hawks were found to flush more readily when approached by humans on foot than by vehicles. Hawks flushed when humans on foot were, on average, 177 m (range 55 to 900 m) from the nest versus flushing when vehicles were, on average, 71 m (range 9 to 170 m) from the nest (Holmes et al. 1993).

Project vehicle traffic will vary between weekends and week days, and by season (summer versus winter), but is not expected to exceed summer weekday volumes of 10 to 14 pick-up trucks, 3 cube vans, 2 passenger vans, 2 fuel trucks, and 1 transport truck per day, in addition to 6 to 14 transport trucks per day when moving freight to the Project site from Itivia Harbour. Public traffic is not expected to exceed 2 to 5 pick-up trucks and 10 to 20 snowmobiles in winter or 10 to 20 ATV's in summer. Between 25 to 50% of these trips are estimated to be incremental to current access via ATVs and snowmobiles.

The explosives plant will operate 7-days a week on a 12-h/day basis. Blast frequency will be between 2 and 4 blasts per day.

To minimize risks to birds, there is no airstrip planned at the site. There is expected to be an additional 4 charter flights per week to Rankin Inlet from Montréal or Val-d'Or and 2 additional charter flights from Kivalliq communities. Any emergency air transportation from the mine site will be provided by helicopter. The existing helipad located near the current exploration camp is planned to be used in case of an emergency. During summer exploration, aerial transport, mainly helicopter, will be used. Transport to and from drill sites will also use helicopters.

Mitigation measures that will be implemented to minimize potential impacts to birds are presented in SD 6-4 TEMMP. The environmental design features (Table 6.7-21) are expected to reduce disturbance and displacement of bird species during Project operations. Some environmental design features and mitigation to reduce disturbance and displacement of bird species include the following:

- Project design will use conventional insulation, baffles and noise suppressors on equipment;
- stationary equipment will be housed inside buildings;
- regular maintenance of equipment to limit noise; and
- all employees will be provided with wildlife environmental awareness training.

The recommended maximum value for the night time noise level for undeveloped areas is 40 dBA (ERCB 2007). This is the average night time (23:00 to 07:00) equivalent continuous sound and noise level (L_{eq}) in dBA, that includes both Project related noises and the ambient sound level (existing sound levels without Project-related noises). The typical night time ambient sound level in rural Alberta is 35 dBA L_{eq} with higher winds, precipitation, and thunder being the principal sources of increases above this value (ERCB 2007). During the night time, few people in urban environments are seriously or moderately annoyed by activities with Leq levels below 50 dBA (WHO 1999). Noise levels can be higher during the day because of higher levels of human activity and associated tolerance for noise levels. The projected noise levels from the various Project activities are compared with benchmarks in Table 6.7-24. The results show that noise predictions from mine operations and the AWAR will slightly exceed benchmarks, except around Iqalugaarjuup Nunanga Territorial Park.

A summary of noise levels, not adjusted for human hearing sensitivity (i.e., total amount of noise energy emitted), at certain distances from Project activities are shown in Table 6.7-25. The results indicate that Project-related noises (from the mine, AWAR, and Rankin Inlet infrastructure) will not be distinguishable from the natural environment by birds that are 5 km or more from the Project. Noise levels within 1.5 km of the mine, Rankin Inlet infrastructure, and AWAR are predicted to be slightly above baseline values.

Table 6.7-24: Summary of Noise Levels from the Project

Mine[a] L_{eq} (dBA)		AWAR[b] L_{eq} (dBA)		Rankin Inlet L_{eq} (dBA)		Iqalugaarjuup Nunanga Territorial Park L_{eq} (dBA)	
Benchmark	**Prediction**	**Benchmark**	**Prediction**	**Benchmark**	**Prediction**	**Benchmark**	**Prediction**
40[c]	48	40[c]	57	50[d]	62	40[c]	37

[a] Highest total noise level calculated for all receptors within the Project Site Area

[b] Highest total noise level calculated for all receptors along the length of the All-weather Access Road

[c] ERCB (2007)

[d] WHO (1999)

AWAR = All-weather Access Road; dBA = A-weighted decibel; km = kilometre; L_{eq} = equivalent continuous sound and noise level

Table 6.7-25: Noise Levels at Distances from the Project

Baseline Levels (dBL)[a]	1.5 km from Project (dBL)	5 km from Project (dBL)
50	56.5	46.6

[a] Values are based on results from other projects in remote/undeveloped areas. Baseline noise levels at the Project were between 35 dBA and 50 dBA (FEIS Volume 5, Section 5.5). Values in dBL are not available

dBA = A-weighted decibel; dB L= linear weighted decibel; km = kilometres

Studies of prairie falcon responses to blasting activities found that falcons showed behavioural reactions to blasting in 54% of blasts (Holthuijzen et al. 1990). Incubating or brooding falcons flushed from their eyries in 22% of the blasts, but returned to their nests within an average of 3.4 minutes. The authors suggested that blasting associated with limited human activity does not need to be restricted at distances greater than 125 m from occupied prairie falcon nests, provided that peak noise levels do not exceed 140 dBL at the eyrie and no more than 3 blasts occur on a given day, or 90 blasts during the nesting season. Peak air vibration levels predicted along the Phase 1 AWAR at 125 m offset is estimated to be 136 dBL (AEM 2011c), which is below the 140 dBL threshold value noted in the literature for falcon nests. This vibration level is likely to be the same for the Project. Studies of flushing distances of wintering bald eagles in a boreal environment by Stalmaster and Kaiser (1998) suggested that activity be restricted within 400 m to protect wintering grounds.

A small proportion of bird populations (i.e., relatively few individuals) are expected to experience minor changes to energetic costs from disturbance or displacement. A small proportion of the different upland bird populations in the RSA are also expected to experience changes in energetic costs from disturbance. Raptors that nest in close proximity to the Project footprint may experience changes in energetic costs that are associated with sensory disturbance. However, raptors have been shown to flush more readily when approached by humans on foot than by vehicles. For example, rough-legged hawks were found to flush when humans on foot were, on average, 177 m (range 55 to 900 m) from the nest versus flushing when vehicles were, on average, 71 m (range 9 to 170 m) from the nest (Holmes et al. 1993). Studies at the Ekati mine in the NT have found no change in reproductive success (Male and Nol 2005) or density (Smith et al. 2005) of upland birds adjacent to roads and

the mine site. A study near 2 diamond mines in the barren-ground tundra of the NT determined that peregrine falcons, rough-legged hawks, and gyrfalcons had higher nest occupancy closer to mine sites, and there were no negative effects of human activity on nest productivity (Coulton et al. 2013).

Based on the above, minor changes in energetic costs to individuals are predicted to have a negligible residual effect on the persistence of bird populations and continued opportunity for traditional and non-traditional land use.

- **Attraction to the Project (e.g., food waste, oil products) may increase human-wildlife interactions and removal of individual animals (e.g., relocation or mortality), which can affect bird population sizes**
- **Attraction to the Project may increase predator numbers and predation risk, which can affect prey populations**

Corvids and raptors may be attracted to infrastructure and anthropogenic food sources (Restani et al. 2001; Marzluff and Netherland 2006; CWS 2007; Kristan and Boarman 2007; Baxter and Allan 2008). Attraction of birds to the Project also increases the risk for accidental mortality of birds (e.g., collisions with vehicles and Project infrastructure). The attraction of raptors, corvids, and gulls can increase predation pressure on prey species (e.g., passerines and waterfowl) (CWS 2007; Liebezeit et al. 2009). This increase in predation has the potential to cause local and regional population declines of these prey species (Monda et al. 1994; CWS 2007; Liebezeit et al. 2009).

A number of environmental design features and management plans will be implemented at the Project to limit the attraction of corvids, raptors, and gulls, and the associated increased risk of mortality from human-bird interactions and predation (Table 6.7-21). These mitigation strategies are provided in the SD 6-4 TEMMP, SD 2-11 Landfill and Waste Management Plan, and SD 2-12 Incineration Management Plan, and are similar to management practices and policies implemented at other mines in the NT and NU. Some environmental design features and mitigation that will be implemented at the Project include the following:

- food wastes will be collected in suitable receptacles that limit attraction or impact to birds;
- littering and feeding of birds will be prohibited;
- recyclables and waste hazardous materials will be stored on-site in appropriate containers to prevent exposure until shipped off-site to an approved facility; and
- education and reinforcement of proper waste management practices to all workers and visitors to the site.

Environmental design features and management plans should limit attractants to the Project and result in a minor increase in bird mortality risk from predation relative to baseline conditions. Therefore, these pathways are predicted to have a minor residual effect on the persistence of bird populations and the continued opportunity for traditional and non-traditional use of birds.

- **Attraction of birds to Project facilities and infrastructure for roosting and nesting sites may change survival or productivity**

Raptors and ravens can habituate to disturbance and have been reported to nest on development infrastructure, such as towers, tanks, and open pit walls. Raptor use of development infrastructure for nests may result in an increased risk of development-related mortality and/or lower nest productivity. However, a study near 2 diamond mines in the barren-ground tundra of the NT determined that peregrine falcons, rough-legged hawks, and gyrfalcons had higher nest occupancies closer to mine sites, and there were no negative effects of human activity on nest productivity (Coulton et al. 2013).

At the Meadowbank Mine, peregrine falcons have moved in to new cliff-like habitat created at quarries along the all-weather private road, successfully rearing young in 2009 (Gebauer and Associates 2010). There have been several attempts by peregrine falcons, gyrfalcons, rough-legged hawks, and common ravens to nest within both active and abandoned open pits at the Ekati and Diavik diamond mines. Peregrine falcons made nesting attempts in open pits at Diavik Diamond Mine in 2005 and 2006 (DDMI 2007). Since 2004, there have been 8 such occurrences among 5 open pits at the Ekati Diamond Mine, and all 5 Ekati pits had nesting birds in 2006 (BHPB 2007). In some cases, young have been detected in these nests (BHPB 2003, 2007). Nesting on pit walls has become so common at Ekati that a monitoring program has been implemented.

Monitoring of infrastructure and Project facilities for raptor nests and the implementation of deterrents or limiting activities around nests that are deemed to be in a safe location are likely to limit effects on bird survival or productivity. Therefore, this pathway was determined to have minor effects on the persistence of bird populations and the continued opportunity for traditional and non-traditional use of raptors.

- **Landing or use of attenuation ponds, drainage ditches, and tailings storage facility may increase bird mortality through exposure to contaminants and impact waterbird health**

Members of the Whale Cove community have expressed concern that birds may become caught in tailings storage ponds (Volume 9, Section 9.3.1.4.2.2).Experience from existing mines in NT and NU (such as at the Meadowbank, Snap Lake, Diavik, Giant, and Con mines) indicates that waterbirds do not often use water management ponds, TSF, and ditches; likely because these waterbodies are typically small, are located in areas of high activity, and have little forage and nesting cover (De Beers 2010; Gebauer et al. 2012; DDMI 2012).

Approximately 28% of the RSA is covered by waterbodies, including many large waterbodies like Meliadine Lake. This reduces the risk of waterbirds selecting attenuation ponds, the TSF, or other water management areas by providing an abundance of alternative suitable nesting and feeding areas. An exception to this could be the preferred use of Attenuation Ponds, the TSF, or other water management areas by waterbirds if they are the first to thaw in spring.

The untreated water quality of the attenuation ponds and TSF will likely not meet CCME guidelines for the protection of aquatic life (CCME 2012b) for all constituents. Constituents of concern in the TSF are chloride, fluoride, cyanide, arsenic, cadmium, chromium, copper, lead, molybdenum, and selenium, which are expected to have concentrations over MMER and CCME protection of aquatic life guidelines. However, in the unlikely event waterbirds did land on the attenuation ponds or TSF, the lack of foraging opportunities would force them to leave.

At closure, the TSF will be capped with layer of non-PAG and low metal leaching potential rock and attenuation ponds and other water management ponds will be reclaimed and all hydrological connections will be restored. Consequently the risks to bird health from landing on water facilities at the Project are considered negligible and

will have a minor effect on the persistence of waterbird populations or on the continued opportunity for traditional and non-traditional land use of waterbirds.

6.7.4.3 Primary Pathways

The following pathways were assessed to be primary for effects to birds and bird habitat and are analyzed and classified separately for waterbirds, upland birds, and raptors in the effects assessment below:

Changes to Habitat Quantity and Fragmentation

- **Direct loss and fragmentation of bird habitat from the Project footprint, including the mine infrastructure, AWAR and Rankin Inlet infrastructure**
- **Permanent changes in bird habitat following closure of the mine site and supporting infrastructure**

Changes to Habitat Quality, Movement and Behaviour

- **Sensory disturbance can change the amount of different quality habitats, and alter bird movement and behaviour (distribution)**

6.7.5 General Approach to Primary Pathways

The effects analysis considers all primary pathways that result in expected changes to the abundance and distribution of bird VECs, after implementing environmental design features and mitigation. Thus, the analysis is based on the residual effects from the Project. Residual effects to bird populations are analyzed using measurement endpoints (FEIS Volume 4, Section 4, Table 4.2-1) and are expressed as effects statements, including the following:

- effects from changes in habitat quantity and fragmentation; and
- effects from changes in habitat quality, movement, and behaviour.

The magnitude, spatial extent, and duration of changes in measurement endpoints (e.g., habitat quantity and quality) from the Project and other developments are expected to be similar to or greater than the actual effects to the abundance and distribution of populations. Effects statements may have more than one primary pathway that link a Project activity with a change in bird populations. For example, the pathways for effects on habitat quality, movement, and behaviour include changes due to sensory disturbance (e.g., noise and the presence of vehicles, people, and mine infrastructure), which ultimately affect bird population abundance and distribution.

The analyses of residual effects from the Project on birds were quantitative, where possible, and included data from field studies, scientific literature, monitoring programs at existing mines, government publications, and personal communications. Traditional knowledge and community information were incorporated where available. Due to the amount and type of data available, some analyses were qualitative and included professional judgement or experienced opinion.

6.7.6 Effects on Abundance and Distribution of Waterbirds

The following sections present the effects assessment methodology and results for changes to waterbirds habitat quantity and fragmentation (Section 6.7.6.1) and habitat quality, movement and behaviour (Section 6.7.6.2).

6.7.6.1 Habitat Quantity and Fragmentation

- **Direct loss and fragmentation of bird habitat from the Project footprint, including the mine infrastructure, AWAR and Rankin Inlet infrastructure**
- **Permanent changes in bird habitat following closure of the mine site and supporting infrastructure**

6.7.6.1.1 Methods

Direct effects from the Project (i.e., the mine, the Phase 2 AWAR, and the Rankin Inlet infrastructure) footprint and footprints of other previous, existing, and future developments on waterbirds were analyzed through changes in the area and spatial configuration of habitat types on the landscape (i.e., landscape metrics). All Project activities were included in the Project footprint for this analysis.

The incremental and cumulative changes in landscape metrics were calculated for each habitat at the RSA scale and included total area, number of patches, mean distance to the nearest patch of the same habitat type, and nearest neighbour index. The nearest neighbour index is the ratio of the observed nearest neighbour distance and the expected distance if patches were randomly distributed on the landscape. Nearest neighbour index values less than 1 indicate the habitat type is clumped across the landscape, while values greater than 1 indicate that patches of the habitat type are dispersed across the landscape. The area and number of patch landscape metrics were determined using the “Summarize” tool in ArcMap. The distance between neighbouring patches was calculated using the “Average Nearest Neighbour” tool in ArcMap. This tool calculates the distance from patch centroids rather than from the patch edge, so values give the relative rather than absolute distance an animal would travel between patches.

Decreases in habitat area and number of similar quality habitat patches can directly influence population size by reducing the carrying capacity of the environment. Changes in the number of patches and distance between similar habitat patches can influence the distribution (and abundance) of waterbirds by affecting the ability of individuals to access habitat patches. Fragmentation can also influence several ecological processes including movement between nesting and foraging areas, nest predation and parasitism along habitat edges, encounter rate between potential breeders, and dispersal between local populations.

The quantity of waterbird habitat was classified using the ELC map for the RSA. The map was developed using satellite imagery, remote sensing software, and GIS to determine the abundance of primary land cover classes within the RSA. The RSA ELC was based on cloud-free coverage of LANDSAT 5 satellite spectral imagery with a 30 x 30 m pixel size that was captured on the 23 July 2005. A reconnaissance survey completed in July 2008 was used to verify and finalize the RSA ELC classification.

The type and number of previous, existing, and reasonably foreseeable developments in the RSA, not including the Project, are listed in Tables 6.7-26 and 6.7-27, and are illustrated in Figure 6.7-14. Data on the location and type of developments were obtained from the following sources:

- NIRB: permitted and licensed activities within NU;
- AANDC: permitted and licensed activities within the NT and NU;
- NRC: GIS file of community locations from NRC's GeoGratis website;
- Treasury Board of Canada: Federal Contaminated Sites Inventory;
- Nunavut Parks: locations of existing and proposed protected areas;
- location of hunting camps from operator websites;
- Nunavut Planning Commission;
- websites of companies holding land use permits; and
- knowledge of the area and Project status.

Table 6.7-26: Hypothetical Footprints for Previous, Existing, and Future Developments in the Regional Study Area

Development Type	Feature Type[a]	Footprint Extent
Camp	Point	200 m radius
Community	Polygon	actual
Contaminated Sites	point	200 m radius
Fuel Storage	Point	200 m radius
Mine[b]	Point	500 m radius
Mineral exploration camp	Point	500 m radius
Miscellaneous	Point	200 m radius
Territorial campground	Point	200 m radius
Quarrying	Point	200 m radius
Road, all weather	Polygon	Actual

[a] Footprints estimated with the exception of communities, which were delineated and digitized from remote sensing imagery.

[b] The footprint of the inactive Rankin Inlet Nickel and Copper Mine was not easily discernible from remote sensing imagery, and thus, a 500 m radius footprint extent was used to create its footprint polygon in GIS.

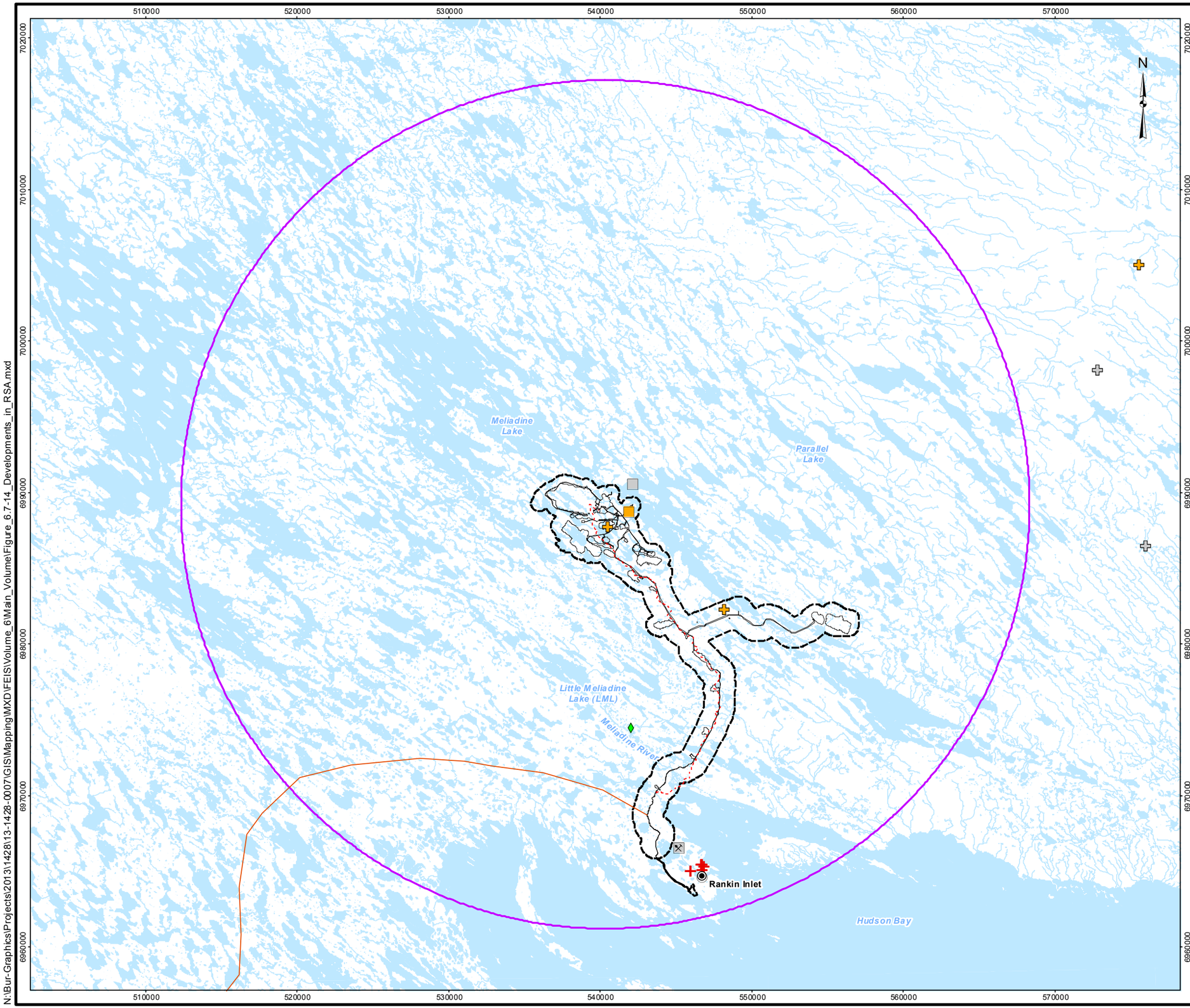
m = metre

Table 6.7-27: Previous and Existing Developments (Points and Polygons) in the Regional Study Area

Activity	Regional Study Area[a]	
	Active[b]	Inactive
Community	1	
Contaminated Site	12	
Mine		1
Mineral exploration camp	2	
Park (Territorial)	1	
Quarrying	1	1

[a] There are approximately 58 km of existing (active) winter roads and a 10 km all weather road from Rankin Inlet to a territorial campground in the RSA.

[b] Active developments refer to those with active or unexpired permits as of 2011; active developments are characterized by a footprint and a zone of influence of 200 m for waterbirds and 1 km for upland birds.



LEGEND

- Regional Study Area (RSA)
- Local Study Area (LSA)
- Project Footprint
- Watercourse
- Waterbody

Previous, Existing and Possible Future Development

- Community
- Contaminated Site
- Mine (Inactive)
- Mineral Exploration (Active)
- Mineral Exploration (Inactive)
- Quarry (Active)
- Quarry (Inactive)
- National or Territorial Park
- Proposed All-weather Road (Future)
- Winter Road

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM), E.S.R.I and Natural Resources Canada.
Datum: NAD 83 Projection: UTM Zone 15

5 0 5
KILOMETRES

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

PREVIOUS, EXISTING, AND POSSIBLE FUTURE DEVELOPMENTS IN THE REGIONAL STUDY AREA

Golder Associates

PROJECT NO.	10-1373-0076		FILE No.	
DESIGN	LD	26 Nov. 2012	SCALE AS SHOWN	REV. 0
GIS	DSC	27 Nov. 2012		
CHECK	LY	14 Jan. 2013		
REVIEW	DW	14 Jan. 2013		

FIGURE 6.7-14

N:\Bur-Graphics\Projects\2013\1428\13-1428-0007\GIS\Mapping\MXD\FEIS\Volume_6\Main_Volume\Figure_6.7-14_Developments_in_RSA.mxd

Some temporal data were available prior to 1996, but most of the known start and end dates of land use permits for developments were from 1996 through 2011. The file was examined for duplication of information (e.g., a water license and a land use permit for the same development). In cases where 2 or more pieces of location information for the same activity were present, the extra information was deleted from the file so that it contained only one point per development. Data associated with the location attributes (e.g., permit status, feature name) also were edited in some instances to update the information for running modelling scenarios efficiently. The information was used to generate a spatially and temporally-explicit development layer within a GIS platform.

The database contains no information on the size of the physical footprint for developments. For Rankin Inlet, the footprint was digitized from Landsat 7 Imagery from the Government of Canada (NRC 2007). A 500 m radius was used to estimate the footprint area for the closed Rankin Inlet Nickel and Copper Mine, as well as for exploration sites (78.5 ha), which likely overestimates the amount of habitat directly disturbed. For example, exploration programs typically contain temporary shelters for accommodations and storage of equipment, and are elevated to limit the amount of disturbance to the soil and vegetation. Drilling is usually carried out with portable drill rigs (5 x 5 m area) at one location at a time. A 200 m radius (12.6 ha) was used to estimate the size of the remaining point development footprints, such as historical remediated and non-remediated sites, and a 30 m corridor was used for linear features (Table 6.7-26).

The following proposed projects have been selected as a suite of major developments that may occur in the foreseeable future:

- The Manitoba to Nunavut Road – This major project has received ongoing support from the governments of Nunavut and Manitoba. Although no permit applications have yet been filed, a preferred alignment has been selected, and the project would change the face of development in the Kivalliq region.
- The Churchill Diamonds Project – This project is currently in the exploration phase and applications have not been made to advance to mining, but it was included as a likely project to be induced by the Manitoba to Nunavut Road, and was identified in the Manitoba to Nunavut Road route selection study as such. Although formally outside of the CESA, this project was conservatively included as a future development because it would have impacts to the socio-economics of the region, and may have impacts related to sensory disturbance on the Qamanirjuaq caribou herd.
- The Ferguson Lake Project – This project is currently in the exploration phase and applications have not been made to advance to mining, but a scoping study has investigated the possibility of advancing to mining. This project was included as a likely project to be induced by the Manitoba to Nunavut Road, and was identified in the Manitoba to Nunavut Road route selection study as such.
- The Kiggavik Uranium Project – This project is currently undergoing review to become a uranium mine. Although formally outside of the CESA, this project was conservatively included as a future development because it would have impacts to the socio-economics of the region, and may have impacts related to sensory disturbance on the Qamanirjuaq caribou herd.

The Wolf deposit, located north-west of the Tiriganiaq deposit, is currently known, but still requires some exploration work to be better defined and included in the mine plan. Currently, the Wolf deposit does not have sufficient proven reserves to be economically mined and so was not included as a development or as part of the Project. An environmental impact assessment (including a cumulative effects analysis) for the Wolf deposit will be completed in the future if the deposit becomes economically feasible to be developed. Local aboriginal communities are concerned that gravel removal from islands within Meliadine Lake will affect nesting birds (Volume 9, section 9.3.1.5.4.2); however, sourcing aggregate materials from islands is not being considered for the proposed Project.

Landscape metrics were determined for a reference case (no development), baseline case (previous and existing developments), Phase 1 AWAR case, Project case (the mine, Phase 2 AWAR, and Rankin Inlet infrastructure), and future case (reasonably foreseeable developments). The following equations were used to estimate the percent relative change in the value of landscape metrics (habitat) in the RSA for different development scenarios on the landscape

- Existing cumulative effects = (baseline value – reference value) / reference value;
- Phase 1 AWAR incremental effects = (Phase 1 AWAR value – baseline value) / baseline value;
- Project incremental effects = (Project value – Phase 1 AWAR value) / Phase 1 AWAR value;
- Future incremental effects = (future value – Project value) / Project value; and
- Future cumulative effects = (future value – reference value)/ reference value.

The resulting value was multiplied by 100 to give the percent change in a landscape metric for each comparison. The result provides both the direction and magnitude of the effect. For example, a high negative value for habitat area would indicate a substantial loss of habitat type. Alternatively, a negative value for mean distance to nearest neighbour indicates an increase in patch connectivity.

Direct effects from previous, existing, and future developments (including the Project) on waterbird populations were also estimated using relative abundance (density) data from baseline studies. Aerial surveys were used to determine waterbird densities in the RSA based on the total area surveyed (i.e., including terrestrial habitat) (Tables 6.7-6 and 6.7-7). However, waterbird species are tied to water, which they use as nesting or foraging habitat. Therefore, waterbird densities were adjusted based on the area of open water habitat surveyed only. Low shrub and tussock hummock habitats were not included because of difficulty in identifying species in these habitats while during aerial surveys. The area of open water habitat that was surveyed during the aerial surveys in 2008 and 2009 was determined in a GIS platform. The maximum density of waterbirds observed over the surveyed strata when adjusted for area of water only (0.69 birds/ha; Table 6.7-28) was used in the analysis.

For the reference case, the regional waterbird abundance estimate was calculated by multiplying the maximum waterbird density estimate, based on area of water only per stratum, (0.69 birds/ha; Table 6.7-28) by the area of the open water, low shrub, and tussock hummock habitat in the RSA. For all development scenarios, the quality of open water, low shrub, and tussock hummock habitats within footprints of previous, existing, and future developments (including the Project) was reduced to zero. A coefficient of variation of 30% was applied to the resulting effect size values to approximate the uncertainty in density estimates.

Table 6.7-28: Waterbird Density (individuals per hectare) in Water Habitat among Survey Strata, 2008 and 2009

Survey Date	Mine Stratum	North Stratum	South Stratum	East Stratum	Discovery Stratum
June 2008	0.10	0.05	0.18	0.04	NS
July 2008	0.05	0.13	0.14	0.69	NS
June 2009	0.13	0.12	0.28	NS	0.30
July 2009	0.12	0.10	0.10	NS	0.09

Note: Density estimates are different than those reported in Section 6.7.3.1.1 because estimates in this table are based on the amount of open water habitat surveyed only (i.e., terrestrial habitats were excluded). Density estimates in Section 6.7.3.1.1 are based on the total area of terrestrial and water habitats surveyed.

NS = not surveyed

Bird abundance was determined for a reference case (no development), baseline case (previous and existing developments), Phase 1 AWAR case, Project case (the mine, Phase 2 AWAR, and Rankin Inlet infrastructure), and future case (reasonably foreseeable developments). The following equations were used to estimate the percent relative change in bird abundance in the RSA for different development scenarios on the landscape:

- Existing cumulative effects = (baseline value – reference value) / reference value;
- Phase 1 AWAR incremental effects = (Phase 1 AWAR value – baseline value) / baseline value;
- Project incremental effects = (Project value – baseline value) / baseline value;
- Future incremental effects = (future value – Project value) / Project value; and
- Future cumulative effects = (future value – reference value)/ reference value.

The resulting value was multiplied by 100 to give the percent change in bird abundance for each comparison.

6.7.6.1.2 Results

Key waterbird habitats in the RSA include open water (e.g., lakes and ponds) and wetlands (i.e., low shrub and tussock hummock habitats). Previous and existing developments have removed 0.08% of both water and low shrub habitats in the RSA, relative to reference conditions, and 0.26% of tussock hummock (Table 6.7-29). The Phase 1 AWAR is predicted to remove less than or equal to 0.02% of low shrub, tussock hummock, and water habitats in the RSA, relative to baseline conditions. The total area of the Project footprint is estimated to be 2 950 ha. The Project and Phase 1 AWAR are predicted to remove 0.75% and 0.74% of tussock hummock and water habitat, respectively, relative to the baseline case, and 0.41% of low shrub habitat. Cumulatively, previous, existing, and future developments are predicted to remove 0.50%, 0.87%, and 1.11% of low shrub, water, and tussock hummock habitat types, respectively, relative to reference conditions.

Subarctic ecosystems are slow to recover from disturbance and the open pits, TSF, attenuation ponds, other ponds, ditches, and the waste rock storage facilities will be permanent features on the landscape, covering approximately 670 ha. Therefore, permanent habitat loss is predicted to be 0.27% of the RSA. Approximately 1 884 ha (74%) of the land disturbed by the Project and Phase 1 AWAR will be reclaimed to lichen rock communities, water bodies, or scarified natural re-vegetation (Table 6.7-30). The Project is predicted to permanently affect 7.64 ha (53.4%), 9.23 ha (4.8%), and 120.35 ha (23.4%) of low shrub, tussock hummock, and water habitats, respectively.

Table 6.7-29: Direct Change (%) in Area of Habitat Types from Development within the Regional Study Area during Baseline, Project and Future Conditions during Spring to Autumn

Habitat	Reference Area (ha)	Area (ha) Removed from Reference to Baseline	% Change Reference to Baseline	Area (ha) Removed from Baseline to Phase 1 AWAR	% Change Baseline to Phase 1 AWAR	Area (ha) Removed from Phase 1 AWAR to Project	% Change Phase 1 AWAR to Project	Area (ha) Removed from Baseline to Project	% Change Baseline to Project	Area (ha) Removed from Project to Future	% Change Project to Future	Area (ha) Removed from Reference to Future	% Cumulative Change Reference to Future
Bare ground	5 263.0	246.26	-4.68	0.26	-0.01	32.18	-0.64	32.44	-0.65	0.91	-0.02	279.61	-5.31
Heath Lichen – *Cetraria*	1 733.1	35.18	-2.03	1.90	-0.11	79.13	-4.67	81.03	-4.77	0.95	-0.06	117.16	-6.76
Heath Lichen – Hair Lichen	4 503.5	9.95	-0.22	0.64	-0.01	21.31	-0.47	21.95	-0.49	2.99	-0.07	34.89	-0.77
Heath Boulder	26 499.5	82.24	-0.31	4.88	-0.02	70.59	-0.27	75.47	-0.29	18.84	-0.07	176.55	-0.67
Health Tundra	109 825.9	291.55	-0.27	13.82	-0.01	1 608.43	-1.47	1 622.25	-1.48	60.97	-0.06	1 974.76	-1.80
Low Shrub	3 478.3	2.67	-0.08	0.24	-0.01	14.06	-0.40	14.30	-0.41	0.56	-0.02	17.53	-0.50
Tussock Hummock	25 698.7	65.81	-0.26	5.45	-0.02	186.08	-0.73	191.53	-0.75	28.88	-0.11	286.22	-1.11
Water	69 297.8	55.67	-0.08	0.28	<-0.01	514.43	-0.74	514.71	-0.74	35.70	-0.05	606.08	-0.87
Total	246 299.7	789.33	-0.32	27.47	-0.01	2 526.20	-1.03	2 553.67	-1.04	149.80	-0.06	3 492.80	-1.42

AWAR = All-weather Access Road; ha = hectare; % = percent

Table 6.7-30: Reclaimed Habitat in the Regional Study Area

Habitat	Area (ha) Removed by Phase 1 AWAR	Area (ha) Removed by Project	Total Area (ha) Disturbed by Phase 1 AWAR and Project	Area (ha) Reclaimed to Lichen Rock Community	Area (ha) Reclaimed to Waterbodies	Area (ha) Reclaimed to Scarified Natural Re-vegetation	Total Area (ha) Reclaimed	Total Area (ha) Permanent Loss	% Project and Phase 1 AWAR not Reclaimed	% Project and Phase 1 AWAR Reclaimed
Bare Ground	0.26	32.18	32.44	0.19	4.80	24.09	29.08	3.36	10.36	89.64
Heath Lichen - *Cetraria*	1.90	79.13	81.03	33.45	4.67	13.74	51.85	29.18	36.01	63.99
Heath Lichen - Hair Lichen	0.64	21.31	21.95	1.97	0.84	21.01	23.82	-1.87	-8.50	108.50
Heath Boulder	4.88	70.59	75.47	11.14	0.68	58.27	70.09	5.38	7.13	92.87
Heath Tundra	13.82	1 608.43	1 622.25	612.24	230.41	283.19	1 125.84	496.41	30.60	69.40
Low Shrub	0.24	14.06	14.30	2.28	1.28	3.10	6.66	7.64	53.40	46.60
Tussock Hummock	5.45	186.08	191.53	81.08	36.50	64.72	182.30	9.23	4.82	95.18
Water	0.28	514.43	514.71	173.49	177.68	43.19	394.36	120.35	23.38	76.62
Total	27.47	2 526.21	2 553.68	915.83	456.86	511.31	1884.00	669.68	26.22	73.78

RSA = regional study area; ha = hectare; % = percent

There has been a 0.06% increase in the number of patches of low shrub and open water habitats in the RSA from previous and existing developments, relative to the reference case, and a 1.07% increase in the number tussock hummock patches (Table 6.7-31). The Phase 1 AWAR is predicted to increase the number of both low shrub and water habitat patches by 0.06%, relative to baseline conditions and increase the number of tussock hummock habitat patches by 0.60%. The Project and Phase 1 AWAR are predicted to decrease the number of low shrub, tussock hummock, and open water habitat patches by 0.69%, 0.04%, and 0.06%, respectively, relative to the baseline case. Cumulatively, previous, existing, and future developments are predicted to decrease the number of low shrub habitat patches by 0.57%, relative to reference conditions, and increase the number of tussock hummock and water habitat patches by 1.57% and 0.34%, respectively.

Previous and existing developments have decreased the mean nearest neighbour distance of low shrub, tussock hummock, and open water habitats by 0.15%, 0.93%, and 0.09%, respectively, relative to reference conditions (Table 6.7-31). The development of the Phase 1 AWAR is predicted to decrease mean nearest neighbour distance of low shrub, tussock hummock, and open water habitats by 0.05%, 0.61%, and 0.07%, respectively, relative to the baseline case. The Project and Phase 1 AWAR are predicted to decrease the mean nearest neighbour distance of low shrub, tussock hummock, and open water habitats by 0.12%, 0.57%, and 0.61%, respectively, relative to the baseline case. Cumulatively, previous, existing, and future developments in the RSA are predicted to decrease the mean nearest neighbour distance of low shrub, tussock hummock, and water habitats by 0.36%, 1.85%, and 0.87%, respectively, relative to reference conditions. Previous, existing, and reasonably foreseeable future developments are predicted to increase clustering of low shrub, tussock hummock, and open water habitats in the RSA (i.e., these habitat types show a decrease in the nearest neighbour index for all scenarios).

Direct loss of habitat from reference to baseline conditions is predicted to have decreased total waterbird abundance in the RSA by 0.13% (Table 6.7-32). The development of the Phase 1 AWAR is predicted to decrease total waterbird abundance by 0.01%, relative to baseline conditions. The Project and Phase 1 AWAR are expected to decrease overall waterbird abundance in the RSA by 0.77%, relative to the baseline case. Cumulative loss of habitat from reference conditions to the future case is expected to decrease total waterbird abundance in the RSA by 0.96%, relative to the reference case.

Direct habitat loss from previous and existing developments decreased habitat-specific waterbird abundance by 0.08%, 0.26%, and 0.08% for low shrub, tussock hummock, and open water habitats, respectively, relative to reference conditions (Table 6.7-32). The Phase 1 AWAR is predicted to decrease habitat-specific waterbird abundances by less than or equal to 0.02%, relative to baseline conditions. With the development of the Project and Phase 1 AWAR, habitat-specific decreases in waterbird abundance are predicted to be 0.44%, 0.76%, and 0.79% for low shrub, tussock hummock, and water habitats, respectively, relative to the baseline case. Cumulative loss of specific habitats from reference conditions to the future case is expected to decrease habitat-specific waterbird abundance in the RSA by between 0.53% and 1.12%, relative to the reference case.

Waterbirds are likely to be affected by transboundary effects from human disturbances during migration and over the winter. However, the cumulative effect from the Project when considered with transboundary developments and activities is expected to be negligible because the changes from the Project are predicted to be small.

Table 6.7-31: Direct Change (%) in Number of Patches, Mean Nearest Neighbour Distance, and Nearest Neighbour Index of Habitat Types from Development within the Regional Study Area during Baseline, Project, and Future Conditions during Spring to Autumn

Habitat	Reference	% Change Reference to Baseline	% Change Baseline to Phase 1 AWAR	% Change Phase 1 AWAR to Project	% Change Baseline to Project	% Change Project to Future	% Cumulative Change from Reference
Number of Patches							
Bare ground	989	12.23	0.45	0.27	0.72	0.09	13.14
Heath Lichen – *Cetraria*	1094	2.38	1.52	-0.97	0.54	0.09	3.02
Heath Lichen – Hair Lichen	2535	0.59	0.24	-1.10	-0.86	0.24	-0.04
Heath Boulder	2855	2.84	1.29	0.40	1.70	0.70	5.32
Health Tundra	4014	2.07	1.29	0.55	1.86	0.81	4.81
Low Shrub	3353	0.06	0.06	-0.74	-0.69	0.06	-0.57
Tussock Hummock	5144	1.07	0.60	-0.63	-0.04	0.54	1.57
Water	4992	0.06	0.06	-0.12	-0.06	0.34	0.34
Mean Nearest Neighbour Distance (m)							
Bare ground	553.4	-9.29	-0.48	0.24	-0.25	-0.21	-9.70
Heath Lichen – *Cetraria*	471.8	-2.79	-1.61	-0.18	-1.79	-0.17	-4.69
Heath Lichen – Hair Lichen	454.4	-0.75	-0.23	0.48	0.25	-0.23	-0.73
Heath Boulder	660.9	-2.64	-1.40	-0.30	-1.70	-0.56	-4.83
Health Tundra	323.3	-0.82	-1.19	-0.28	-1.47	-0.37	-2.63
Low Shrub	356.3	-0.15	-0.05	-0.07	-0.12	-0.09	-0.36
Tussock Hummock	361.8	-0.93	-0.61	0.04	-0.57	-0.36	-1.85
Water	371.4	-0.09	-0.07	-0.54	-0.61	-0.17	-0.87
Nearest Neighbour Index							
Bare ground	0.7	-3.90	-0.26	0.37	0.11	-0.17	-3.95
Heath Lichen – *Cetraria*	0.9	-1.64	-0.87	-0.66	-1.52	-0.13	-3.26
Heath Lichen – Hair Lichen	1.0	-0.46	-0.11	-0.07	-0.18	-0.11	-0.75
Heath Boulder	1.0	-1.27	-0.77	-0.10	-0.86	-0.21	-2.33
Health Tundra	0.8	0.20	-0.56	<-0.01	-0.56	0.04	-0.32
Low Shrub	0.8	-0.12	-0.02	-0.44	-0.46	-0.06	-0.64
Tussock Hummock	1.0	-0.40	-0.31	-0.28	-0.59	-0.09	-1.08
Water	1.1	-0.06	-0.04	-0.60	-0.64	<-0.01	-0.70

AWAR = All-weather Access Road; % = percent; m = metre

Table 6.7-32: Relative Changes in the Abundance of Waterbirds in the Regional Study Area from Direct Effects from Reference to Reasonably Foreseeable Projects

Habitat Type	Area (ha)	Bird Abundance under Reference Conditions	% Change Reference to Baseline (30% CV)	% Change Baseline to Phase 1 AWAR (30% CV)	% Change Phase 1 AWAR to Project (30% CV)	% Change Project to Baseline (30% CV)	% Change Project to Future (30% CV)	% Cumulative Change from Reference (30% CV)
Low Shrub	3 478.3	2 400	-0.08 (-0.02)	-0.01 (<-0.01)	-0.43 (-0.13)	-0.44 (-0.13)	-0.02 (<-0.01)	-0.53 (-0.16)
Tussock Hummock	25 698.7	17 732	-0.26 (-0.08)	-0.02 (-0.01)	-0.73 (-0.22)	-0.76 (-0.23)	-0.11 (-0.03)	-1.12 (-0.34)
Water	69 297.8	47 815	-0.08 (-0.02)	<-0.01 (<-0.01)	-0.79 (-0.24)	-0.79 (-0.24)	-0.05 (-0.02)	-0.92 (-0.28)
Total	**98 474.8**	**67 947**	**-0.13 (-0.04)**	**-0.01 (<-0.01)**	**-0.77 (-0.23)**	**-0.77 (-0.23)**	**-0.07 (-0.02)**	**-0.96 (-0.29)**

Notes: < = change is close to zero.

ha = hectares; AWAR = All-weather Access Road; % = percent; CV = coefficient of variation; < = less than

6.7.6.2 Habitat Quality, Behaviour and Movement

- **Sensory disturbance can change the amount of different quality habitats, and alter bird movement and behaviour (distribution)**

6.7.6.2.1 Methods

Indirect (or sensory) effects from previous, existing, and future developments (including the Project) on waterbird populations were estimated using relative abundance (density) data from baseline studies. Aerial surveys were used to determine waterbird densities in the RSA based on the total area surveyed (i.e., including terrestrial habitat) (Tables 6.7-6 and 6.7-7). However, waterbird species are tied to water, which they use as nesting or foraging habitat. Therefore, waterbird densities were adjusted based on the area of open water habitat surveyed only. Low shrub and tussock hummock habitats were not included because of difficulty in identifying species in these habitats while during aerial surveys. The area of open water habitat that was surveyed during the aerial surveys in 2008 and 2009 was determined in a GIS platform. The maximum density of waterbirds observed over the surveyed strata (0.69 birds/ha in the East Stratum in July 2008; Table 6.7-28) was used in the analysis.

For the reference case, the regional waterbird abundance estimate was calculated by multiplying the maximum waterbird density estimate (0.69 birds/ha; Table 6.7-28) by the area of the open water, low shrub, and tussock hummock habitat in the RSA. For all development scenarios, the quality of open water, low shrub, and tussock hummock habitats within 200 m of footprints for previous, existing, and future developments (including the Project) was reduced to zero.

More birds flush, and at greater distances, when approached by humans on foot rather than by vehicles (Pease et al. 2005). Laursen et al. (2005) showed that the waterfowl species took flight when human observers on foot approached within an average of 197 to 319 m (range 55 to 1000 m) from birds. In Japan, when flocks of waterbirds were approached by observers in a boat, average flight distances were between 64.5 and 160 m (Mori et al. 2001). There are not expected to be a large number of human observers on foot along the AWAR; most traffic is expected to be vehicular. Therefore, the assumption that all waterbirds in wetland and water habitats within 200 m of human developments will be completely removed from the population is considered to provide a conservative estimate of the number of waterbirds that may be lost from human developments in the RSA. The use of the maximum density of waterbirds observed also provides a conservative estimate of the number of birds that are expected to be lost from human developments in the RSA.

Bird abundance was determined for a reference case (no development), baseline case (previous and existing developments), Phase 1 AWAR case, Project case (the mine, Phase 2 AWAR, and Rankin Inlet infrastructure), and future case (reasonably foreseeable developments). The following equations were used to estimate the percent relative change in bird abundance in the RSA for different development scenarios on the landscape.

- Existing cumulative effects = (baseline value – reference value) / reference value;
- Phase 1 AWAR incremental effects = (Phase 1 AWAR value – baseline value) / baseline value;
- Project incremental effects = (Project value – baseline value) / baseline value;
- Future incremental effects = (future value – Project value) / Project value; and
- Future cumulative effects = (future value – reference value) / reference value.

The resulting value was multiplied by 100 to give the percent change in bird abundance for each comparison.

The following proposed projects have been selected as a suite of major developments that may occur in the foreseeable future:

- The Manitoba to Nunavut Road – This major project has received ongoing support from the governments of Nunavut and Manitoba. Although no permit applications have yet been filed, a preferred alignment has been selected, and the project would change the face of development in the Kivalliq region.
- The Churchill Diamonds Project – This project is currently in the exploration phase and applications have not been made to advance to mining, but it was included as a likely project to be induced by the Manitoba to Nunavut Road, and was identified in the Manitoba to Nunavut Road route selection study as such. Although formally outside of the CESA, this project was conservatively included as a future development because it would have impacts to the socio-economics of the region, and may have impacts related to sensory disturbance on the Qamanirjuaq caribou herd.
- The Ferguson Lake Project – This project is currently in the exploration phase and applications have not been made to advance to mining, but a scoping study has investigated the possibility of advancing to mining. This project was included as a likely project to be induced by the Manitoba to Nunavut Road, and was identified in the Manitoba to Nunavut Road route selection study as such.
- The Kiggavik Uranium Project – This project is currently undergoing review to become a uranium mine. Although formally outside of the CESA, this project was conservatively included as a future development because it would have impacts to the socio-economics of the region, and may have impacts related to sensory disturbance on the Qamanirjuaq caribou herd.

The Wolf deposit, located north-west of the Tiriganiaq deposit, is currently known, but still requires some exploration work to be better defined and included in the mine plan. Currently, the Wolf deposit does not have sufficient proven reserves to be economically mined and so was not included as a development or as part of the Project. An environmental impact assessment (including a cumulative effects analysis) for the Wolf deposit will be completed in the future if the deposit becomes economically feasible to be developed in the future.

6.7.6.2.2 Results

Indirect (or sensory) effects (e.g., noise, presence of humans, and vehicles) from previous and existing developments are predicted to have reduced waterbird abundance in the RSA by a total of 1.15%, relative to reference conditions (Table 6.7-33). Sensory effects from the development of the Phase 1 AWAR are predicted to reduce waterbird abundance in the RSA by 0.27%, relative to the baseline case, while indirect effects from the Phase 1 AWAR and Project are expected to decrease total waterbird abundance by 1.69%. Cumulative sensory disturbance from previous, existing, and future developments in the RSA are expected to reduce total waterbird abundance by 2.63% from reference conditions to the future case.

Indirect effects from previous and existing developments are predicted to have reduced habitat-specific waterbird abundance by less than or equal to 1.72%, relative to reference conditions, for all habitat types (Table 6.7-33). Indirect effects from the Phase 1 AWAR are predicted to reduce habitat-specific waterbird abundance in the RSA

by less than 0.80%, relative to baseline conditions. Sensory disturbance from the Phase 1 AWAR and Project is expected to decrease habitat-specific waterbird abundance between 0.93% and 2.61%, relative to the baseline case. The cumulative effects of sensory disturbance from previous, existing, and future developments are expected to decrease habitat-specific waterbird abundance between 1.60% and 3.48%, relative to reference conditions.

Little research has been completed to determine the avoidance response of waterbirds to sensory disturbance from human developments; most studies have focused on the effects of recreational activity (e.g., walking, boating) on waterbirds. Heimberger et al. (1983) observed that the probability of common loon (*Gavia immer*) chicks hatching decreased with an increase in the amount of cottages and human recreational activity. However, chick survival after hatching was not influenced by the amount of human activity because parents usually move to an area with a lower amount of disturbance. Conversely, Badzinksi et al. (2006) did not find a correlation between the amount of recreational activity disturbance and shoreline development on loon productivity during the pre-fledgling stage. Laursen et al. (2005) showed that the waterfowl species took flight when human observers approached within an average of 197 to 319 m (range 55 to 1 000 m) from birds. Gulls took flight when observers were an average of 118 m (range 50 to 450 m) from birds. Pease et al. (2005) found that waterfowl exhibited stronger responses to humans walking or riding a bicycle than they did to vehicles driving past; more birds flew when a human walked or biked past a wetland than when a vehicle passed by. Therefore, observations of responses of waterfowl to recreational activities are considered to be a conservative estimate of responses that are likely to occur because of Project activities. Waterbirds continue to use nests within 200 m of the all-weather private road connecting Baker Lake to the Meadowbank Mine (Nunavut Environmental Consulting Ltd. 2012).

Projected noise level results from mine operations and the AWAR will slightly exceed benchmarks, except around Iqalugaarjuup Nunanga Territorial Park (Table 6.7-24 A summary of noise levels, not adjusted for human hearing sensitivity (i.e., total amount of noise energy emitted), at certain distances from Project activities are shown in Table 6.7-25. The results indicate that Project-related noises (from the mine, AWAR, and Rankin Inlet infrastructure) will not be distinguishable from the natural environment by birds that are 5 km or more from the Project. Noise levels within 1.5 km of the mine, Rankin Inlet infrastructure, and AWAR are predicted to be slightly above baseline values. Vibrations from seismic activity were not found to have an effect on long-tailed duck site fidelity, movement, and behaviour in the Beaufort Sea, Alaska (Lacroix et al. 2003).

Waterbirds are likely to be affected by transboundary effects from human disturbances during migration and over the winter. However, the cumulative effect from the Project when considered with transboundary developments and activities is expected to be negligible because the changes from the Project are predicted to be small.

Table 6.7-33: Relative Changes in the Abundance of Waterbirds in the Regional Study Area from Indirect Effects from Reference to Reasonably Foreseeable Projects

Habitat Type	Area (ha)	Bird Abundance under Reference Conditions	% Change Reference to Baseline (30% CV)	% Change Baseline to Phase 1 AWAR (30% CV)	% Change Phase 1 AWAR to Project (30% CV)	% Change Baseline to Project (30% CV)	% Change Project to Future (30% CV)	% Cumulative Change from Reference (30% CV)
Low Shrub	3 478.3	2 400	-0.62 (-0.19)	-0.13 (-0.04)	-0.80 (-0.24)	-0.93 (-0.28)	-0.36 (-0.11)	-1.60 (-0.48)
Tussock Hummock	25 698.7	17 732	-1.72 (-0.52)	-0.71 (-0.21)	-1.91 (-0.57)	-2.61 (-0.78)	-0.80 (-0.24)	-3.48 (-1.04)
Water	69 297.8	47 815	-0.96 (-0.29)	-0.12 (-0.04)	-1.28 (-0.38)	-1.39 (-0.42)	-0.40 (-0.12)	-2.37 (-0.71)
Total	**98 474.8**	**67 947**	**-1.15 (-0.34)**	**-0.27 (-0.08)**	**-1.42 (-0.43)**	**-1.69 (-0.51)**	**-0.50 (-0.15)**	**-2.63 (-0.79)**

ha = hectares; AWAR = All-weather Access Road; % = percent; CV = coefficient of variation; < = less than

6.7.7 Effects on Abundance and Distribution of Upland Birds

6.7.7.1 Habitat Quantity and Fragmentation

- **Direct loss and fragmentation of bird habitat from the Project footprint, including the mine infrastructure, AWAR and Rankin Inlet infrastructure**
- **Permanent changes in bird habitat following closure of the mine site and supporting infrastructure**

6.7.7.1.1 Methods

The incremental and cumulative direct habitat effects from the Project footprint and footprints of other previous, existing, and future developments in the RSA were analyzed through changes in the area and spatial configuration of habitat types on the landscape (i.e., landscape metrics). All Project activities are included as part of the Project footprint in this analysis. The change in landscape metrics from the development of the Project was determined for the spring through autumn period. Decreases in habitat area and number of similar quality habitat patches can directly influence population size by reducing the carrying capacity of the environment. Changes in the number of patches and distance between similar habitat patches can influence the distribution (and abundance) of upland birds by affecting the ability of individuals to access habitat patches. Fragmentation can also influence several ecological processes including movement between nesting and foraging areas, nest predation and parasitism along habitat edges, encounter rate between potential breeders, and dispersal between local populations. Detailed methods for the habitat fragmentation analysis completed for waterbirds are also applicable for upland birds and are found in Section 6.7.6.1.1.

Direct effects from previous, existing, and future developments (including the Project) on upland bird populations were also estimated using relative abundance (density) data from baseline studies (Table 6.7-16). All calculations were completed using raster file types within a GIS platform. Each 30 x 30 m (0.09 ha) raster cell in the RSA that represented a habitat type was assigned a density value equal to the mean density estimate for the habitat type adjusted for the size of the raster cell (i.e., individuals per 0.09 ha; Table 6.7-34). For the reference case, regional abundance estimates for upland birds were calculated by multiplying mean density estimates for each habitat type by the area of the habitat type within the RSA (Table 6.7-29). For all development scenarios, the quality of habitats (i.e., raster cell bird density values) associated with habitat types within the Project footprint and footprints for previous, existing and future developments (e.g., existing and future roads) were reduced to zero. A coefficient of variation of 30% was applied to the resulting effect size values to approximate the uncertainty in density estimates.

As no upland bird surveys were completed in the heath lichen – hair lichen, low shrub, and bare ground habitat types, density estimates were assigned based on similarity of habitat structure to other habitats in the RSA and a literature review. The heath lichen – hair lichen habitat class has a similar structure to the heath lichen – *Cetraria* habitat class and so was assigned the same density value (Table 6.7-34). Horned lark and American pipit were two of the most common upland bird species recorded in the RSA (Table 6.7-14). These species nest in habitats with little to no ground cover (Verbeek and Hendricks 1994; Beason 1995) and had highest densities in heath boulder and heath lichen – *Cetraria* habitat types (Table 6.7-15). The density estimate for the bare ground (rock outcrop) habitat class was calculated as the average of the heath boulder and heath lichen – *Cetraria* densities because of the similarity in bird use among the heath boulder, heath lichen – *Cetraria*, and bare ground (rock outcrop) habitat classes. Low shrub habitat was assigned the same density value as tussock hummock habitat because of the similarity in bird use between these two habitat types (Hussell and Montgomerie 2002;

Wheelwright and Rising 2008). Water habitat was not included in the analysis because upland birds do not nest in this habitat type.

Table 6.7-34: Density (Individuals per 0.090 ha) of Observed Upland Birds per Habitat Type

Habitat Type	Bird Density (Individuals/0.09 ha)
Bare Ground (rock outcrop)	0.11
Heath Boulder	0.13
Heath Lichen – *Cetraria*	0.08
Heath Lichen – Hair Lichen	0.08
Heath Tundra	0.08
Low Shrub	0.12
Tussock Hummock	0.12
Water	0.00

ha = hectares

Bird abundance was determined for a reference case (no development), baseline case (previous and existing developments), Phase 1 AWAR case, Project case (the mine, Phase 2 AWAR, and Rankin Inlet infrastructure), and future case (reasonably foreseeable developments). The following equations were used to estimate the percent relative change in bird abundance in the RSA for different development scenarios on the landscape.

- Existing cumulative effects = (baseline value – reference value) / reference value
- Phase 1 AWAR incremental effects = (Phase 1 AWAR value – baseline value) / baseline value
- Project incremental effects = (Project value – baseline value) / baseline value
- Future incremental effects = (future value – Project value) / Project value
- Future cumulative effects = (future value – reference value) / reference value

The resulting value was multiplied by 100 to give the percent change in bird abundance for each comparison.

The Wolf deposit, located north-west of the Tiriganiaq deposit, is currently known, but still requires some exploration work to be better defined and included in the mine plan. Currently, the Wolf deposit does not have sufficient proven reserves to be economically mined and so was not included as a development or as part of the Project. An environmental impact assessment (including a cumulative effects analysis) for the Wolf deposit will be completed in the future if the deposit becomes economically feasible to be developed in the future. It is also worth noting that local aboriginal communities are concerned that gravel removal from islands within Meliadine Lake will affect nesting birds (Volume 9, section 9.3.1.5.4.2); however, sourcing aggregate materials from islands is not being considered for the proposed Project.

6.7.7.1.2 Results

Upland bird density recorded during baseline surveys was the highest in heath boulder and tussock hummock habitats, while the maximum density of upland birds was highest in heath tundra habitat (Table 6.7-16). Based on the results of baseline data, these three habitat types were considered to be key upland bird habitats.

Previous and existing developments have removed 0.31%, 0.27%, and 0.26% of heath boulder, heath tundra, and tussock hummock habitats, respectively, in the RSA, relative to reference conditions (Table 6.7-29). The Phase 1 AWAR is predicted to remove less than or equal to 0.02% of each heath boulder, heath tundra, and tussock hummock habitats in the RSA, relative to the baseline case. The total area of the Project footprint is estimated to be 2 950 ha. The Project and Phase 1 AWAR are predicted to remove 0.29%, 1.48%, and 0.75% of heath boulder, heath tundra, and tussock hummock habitat in the RSA, respectively, relative to the baseline case. Cumulatively, previous and existing developments, the Project, and reasonably foreseeable future developments are predicted to remove 0.67%, 1.80%, and 1.11% of heath boulder, heath tundra, and tussock-hummock habitat in the RSA, respectively, relative to reference conditions.

Subarctic ecosystems are slow to recover from disturbance and the open pits, TSF, attenuation ponds, other ponds, ditches, and the waste rock storage facilities will be permanent features on the landscape, covering approximately 670 ha. Therefore, permanent habitat loss is predicted to be 0.27% of the RSA. Approximately 1 884 ha (74%) of the land disturbed by the Project and Phase 1 AWAR will be reclaimed to lichen rock communities, waterbodies, or scarified natural re-vegetation (Table 6.7-30). The Project is predicted to permanently affect 9.23 ha (4.82%), 5.38 ha (7.13%), and 496.41 ha (30.60%) of tussock hummock, health boulder, and heath tundra habitats, respectively.

Direct loss of habitat from reference to baseline conditions is predicted to have decreased the amount of total bird abundance in the RSA by 0.43% (Table 6.7-35). The development of the Phase 1 AWAR is predicted to decrease upland bird abundance by 0.02%, relative to baseline conditions. The Phase 1 AWAR and Project are expected to decrease abundance by 1.09%, relative to the baseline case. Cumulative loss of habitat from reference conditions to the future case is expected to decrease total upland bird abundance in the RSA by 1.58%, relative to the reference case.

Direct habitat loss from previous and existing developments decreased habitat-specific upland bird abundance by less than 5.0% for all habitat types (Table 6.7-35), relative to reference conditions. The Phase 1 AWAR is predicted to decrease habitat-specific bird abundances by less than or equal to 0.11%, relative to baseline conditions. With the development of the Project and Phase 1 AWAR, habitat-specific decreases in bird abundance are predicted to be less than or equal to 1.54% for all habitat types, except for heath lichen – *Cetraria* habitat, which is expected to have an abundance decrease of 5.06%, relative to the baseline case. Cumulative loss of specific habitats from reference conditions to the future case is expected to decrease total upland and breeding bird abundance in the RSA by between 0.53% and 7.02%, relative to the reference case.

Upland birds are likely to be affected by transboundary effects from human disturbances during migration and over the winter. However, the cumulative effect from the Project when considered with transboundary developments and activities is expected to be negligible because the changes from the Project are predicted to be small.

Table 6.7-35: Relative Changes in the Abundance of Upland Birds in the Regional Study Area from Direct Effects from Reference to Reasonably Foreseeable Projects

Habitat Type	Area (ha)	Bird Abundance under Reference Conditions	% Change Reference to Baseline (30% CV)	% Change Baseline to Phase 1 AWAR (30% CV)	% Change Phase 1 AWAR to Project (30% CV)	% Change Baseline to Project (30% CV)	% Change Project to Future (30% CV)	% Cumulative Change from Reference (30% CV)
Bare Ground (Rock Outcrop)	5 263.0	6 430	-4.69 (-1.41)	-0.01 (<-0.01)	-0.64 (-0.19)	-0.64 (-0.19)	-0.02 (-0.01)	-5.32 (-1.60)
Heath Boulder	26 499.5	38 301	-0.31 (-0.09)	-0.02 (-0.01)	-0.27 (-0.08)	-0.29 (-0.09)	-0.07 (-0.02)	-0.67 (-0.20)
Heath Lichen - *Cetraria*	1 733.1	4 005	-2.01 (-0.60)	-0.11 (-0.03)	-4.96 (-1.49)	-0.49 (-0.15)	-0.06 (-0.02)	-7.02 (-2.11)
Heath Lichen – Hair Lichen	4 503.5	1 541	-0.23 (-0.07)	-0.01 (<-0.01)	-0.48 (-0.14)	-5.06 (-1.52)	-0.06 (-0.02)	-0.78 (-0.23)
Heath Tundra	109 825.9	97 634	-0.26 (-0.08)	-0.01 (<-0.01)	-1.53 (-0.46)	-1.54 (-0.46)	-0.06 (-0.02)	-1.86 (-0.56)
Low Shrub	3 478.3	4 638	-0.08 (-0.02)	-0.01 (<-0.01)	-0.43 (-0.13)	-0.44 (-0.13)	-0.02 (<-0.01)	-0.53 (-0.16)
Tussock Hummock	25 698.7	34 273	-0.26 (-0.08)	-0.02 (-0.01)	-0.73 (-0.22)	-0.75 (-0.23)	-0.12 (-0.03)	-1.12 (-0.34)
Total	**177 002**	**186 821**	**-0.43 (-0.13)**	**-0.02 (<-0.01)**	**-1.07 (-0.32)**	**-1.09 (-0.33)**	**-0.07 (-0.02)**	**-1.58 (-0.48)**

Notes: ha = hectares; AWAR = All-weather Access Road; % = percent; CV = coefficient of variation; < = less than

In addition to direct loss of habitat, the application of the Project will also result in fragmentation (or perforation of habitats from a point source of disturbance such as mine sites) of the existing landscape. Fragmentation (or breaking apart of the landscape) can influence several ecological processes including movement between nesting and foraging areas, nest predation and parasitism along habitat edges, encounter rate between potential breeders, and dispersal between local populations. Although fragmentation can influence individual, population, and community processes, fragmentation effects have less influence than habitat loss when there is a large proportion of natural habitat on the landscape (Fahrig 1997, 2003; Andrén 1999; Flather and Bevers 2002; Swift and Hannon 2010). Studies using simulation models found that the effect of habitat fragmentation on a species depends on its habitat requirements, amount of habitat remaining, and movement ability (With and Crist 1995; Flather and Bevers 2002; Swift and Hannon 2010).

For example, a species with very specific habitat requirements and low ability to move is more likely to be negatively affected by habitat fragmentation. Species that can move effectively (such as most birds) may consider habitat patches to be connected even when covering only 35 to 40% of the landscape (With and Crist 1995). In other studies, effects from habitat fragmentation on populations are small until habitat amounts decrease below a threshold level (70 to 90% habitat loss) related to population persistence (Flather and Bevers 2002; Swift and Hannon 2010). Willow ptarmigan (*Lagopus lagopus*) showed a positive response to willow (*Salix* spp.) thicket cover and a negative relationship to the amount of willow thicket fragmentation in an area with low willow cover at the landscape level (Ehrich et al. 2012).

Habitat fragmentation can also increase edge habitat, which can increase nest predation and parasitism (Robinson and Wilcove 1994). Brood parasitism from species such as grown-headed cowbirds (*Molothrus ater*) is not likely to occur in the RSA (i.e., cowbirds were not observed during baseline studies and are not expected to occur in the RSA). Although some studies have detected increased predation rate on nests near edges in forested and non-forested landscapes, other studies have shown no effect of distance from disturbed edge on nest success (Johnson and Temple 1990; Hanski 1996; Donovan et al. 1997; Winter et al. 2000; Chalfoun et al. 2002). Støen et al. (2010) noted a higher predation rate on artificial willow ptarmigan nests that were located closer to cabins in a forested mountain area in Norway. Conversely, at the Ekati Diamond Mine, Male and Nol (2005) found that nest success of Lapland longspurs was independent of distance to roads, suggesting no changes in the abundance of nest predators near human activity.

Increasing development on the landscape has also resulted in marginal changes to the number of habitat patches in the RSA. Previous and existing developments have increased the number of heath boulder, heath tundra, and tussock hummock patches by 2.84%, 2.07%, and 1.07%, respectively, relative to reference conditions (Table 6.7-31). The development of the Phase 1 AWAR is predicted to increase the number of both heath boulder and heath tundra patches by 1.29%, relative to baseline conditions, and the number of tussock-hummock habitat patches by 0.60%. The Project and Phase 1 AWAR are predicted to remove 0.04% of tussock-hummock habitat patches, relative to the baseline, and increase the number of heath boulder and heath tundra habitat patches by 1.70% and 1.86%, respectively. Cumulatively, previous, existing, and future developments are predicted to increase the number of patches of heath boulder, heath tundra, and tussock hummock habitats by 5.32%, 4.81%, and 1.57%, respectively, relative to reference conditions.

Previous and existing developments have decreased the mean nearest neighbour distance of heath boulder, heath tundra, and tussock hummock habitats by 2.64%, 0.82%, and 0.93%, respectively, relative to the reference case (Table 6.7-31). The mean nearest neighbour distance of heath boulder, heath tundra, and

tussock hummock habitats is predicted to decrease by 1.40%, 1.19%, and 0.61%, respectively, relative to baseline conditions, with the development of the Phase 1 AWAR. The mean nearest neighbour distance of heath boulder, heath tundra, and tussock hummock habitat is predicted to decrease by 1.70%, 1.47%, and 0.57%, respectively, with the development of the Project and Phase 1 AWAR case, relative to the baseline case. Cumulatively, the Project and previous, existing, and future developments are predicted to decrease the mean nearest neighbour distance of heath boulder, heath tundra, and tussock hummock habitat by 4.83%, 2.63%, and 1.85%, respectively, relative to the reference case. Generally, previous, existing, and reasonably foreseeable future developments are predicted to increase clustering of habitat types in the RSA (i.e., most habitat types show a decrease in the nearest neighbour indices for all scenarios).

6.7.7.2 Habitat Quality, Behaviour, and Movement

- **Sensory disturbance can change the amount of different quality habitats, and alter bird movement and behaviour (distribution)**

6.7.7.2.1 Methods

In addition to direct habitat effects, changes to habitat quality from the Project have the potential to indirectly affect the population size and distribution of upland birds through altered movement and avoidance behaviour of individuals. Upland birds are a diverse array of species with a range of habitat requirements. Therefore, indirect (or sensory) effects from the Project and other developments in the RSA on upland birds were estimated using relative abundance (density) data from baseline studies (Table 6.7-16). All calculations were completed using raster file types within a GIS platform. Each 30 x 30 m (0.09 ha) raster cell in the RSA that represented a habitat type (other than water) was assigned a density value equal to the mean density estimate for the habitat type adjusted for the size of the raster cell (i.e., individuals per 0.09 ha; Table 6.7-34). For the reference case, regional abundance estimates for upland birds were calculated by multiplying mean density estimates for each habitat type by the area of the habitat type within the RSA (Table 6.7-29). See Section 6.7.7.1.1 for rationale on determining densities in habitat types that were not surveyed.

For all development scenarios, the quality of upland bird habitats (i.e., raster cell bird density values) was reduced according to a curvilinear one-asymptote relationship that plateaus at 1 km from disturbance (ZOI) (Figure 6.7-15). This is similar to the Type II functional response that is well documented in empirical studies of predator-prey dynamics (Begon et al. 2006). For example, at 100 m from an active development (e.g., Project footprint), the baseline value for bird density was multiplied by a disturbance modifier equal to about 0.2, which reduced the density of birds by 80%. At a distance of approximately 800 m from a development, there is a correspondent 5% decrease in density. The disturbance modifier is equal to 1.0 (no effect) at and beyond 1 km. A 1 km ZOI was chosen for determining effects from sensory disturbance on upland bird populations based on studies that have documented avoidance effects and reduced bird densities within 1 km of human infrastructure (Reijnen et al. 1997; Benitez-Lopez et al. 2010). Other studies (Canaday and Rivadeneyra 2001; Habib et al. 2007; Bayne et al. 2008) have reported effects from noise to birds within 200 to 700 m from disturbance, so the 1 km ZOI is considered to be conservative.

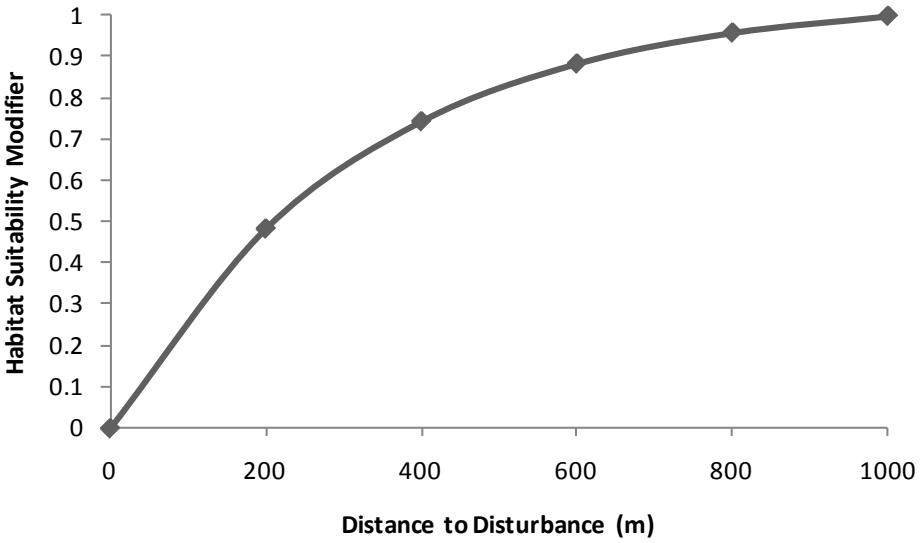


Figure 6.7-15: Relationship between Distance from Human Disturbance and Habitat Suitability Modifier for Upland Birds

Next, the adjusted densities were multiplied by the habitat area within the 1 km ZOI. Abundances were then summed by habitat type across the ZOI to estimate the reduction in bird abundance caused by indirect effects from the Project and other developments. Effects were expressed as relative differences in upland bird abundance between the baseline and reference case, between the Project and baseline case, and between the future and Project case. A coefficient of variation of 30% was applied to the resulting effect size values to approximate the uncertainty in modelled density estimates.

Bird abundance was determined for a reference case (no development), baseline case (previous and existing developments), Phase 1 AWAR case, Project case (the mine, Phase 2 AWAR, and Rankin Inlet infrastructure), and future case (reasonably foreseeable developments). The following equations were used to estimate the percent relative change in bird abundance in the RSA for different development scenarios on the landscape.

- Existing cumulative effects = (baseline value – reference value) / reference value
- Phase 1 AWAR incremental effects = (Phase 1 AWAR value – baseline value) / baseline value
- Project incremental effects = (Project value – baseline value) / baseline value
- Future incremental effects = (future value – Project value) / Project value
- Future cumulative effects = (future value – reference value) / reference value

The resulting value was multiplied by 100 to give the percent change in bird abundance for each comparison.

6.7.7.2.2 Results

Indirect (or sensory) effects (e.g., noise, presence of humans, and vehicles) from previous and existing developments are predicted to have reduced upland bird abundance in the RSA by a total of 2.23%, relative to reference conditions (Table 6.7-36). Sensory effects from the development of the Phase 1 AWAR are predicted to reduce upland bird abundance in the RSA by 0.17%, relative to the baseline case, while indirect effects from the Phase 1 AWAR and Project combined are expected to decrease total upland bird abundance by 1.64%. Cumulative sensory disturbance from previous, existing, and future developments in the RSA are expected to reduce total upland bird abundance by 4.48% from reference conditions to the future case.

Indirect effects from previous and existing developments are predicted to have reduced habitat-specific upland bird abundance by less than or equal to 2.18%, relative to reference conditions, for all habitat types except bare ground and heath lichen – *Cetraria* habitat types, which are predicted to have decreased bird abundance of 11.19% and 8.78%, respectively, relative to reference conditions (Table 6.7-36). Indirect effects from the Phase 1 AWAR are predicted to reduce habitat-specific upland bird abundance in the RSA by less than 1.80%, relative to baseline conditions. Sensory disturbance from the Phase 1 AWAR and Project combined is expected to decrease habitat-specific bird abundance between 0.62% and 2.27%, except for heath lichen – *Cetraria* habitat (decrease of 7.83%), relative to the baseline case. The cumulative effects of sensory disturbance from previous, existing, and future developments are expected to decrease habitat-specific bird abundance between 1.75% and 4.53%, relative to reference conditions, for all habitat types except bare ground (decrease of 12.10%) and heath lichen – *Cetraria* (decrease of 16.56%).

Few studies have focused on the effects of noise and disturbance to upland bird avoidance behaviour and movement. Avoidance behaviours are most likely to affect nest site selection, territory selection, mate attraction, and foraging. Noise may also inhibit predator detection and interfere with mate/chick communication (Habib et al. 2007; Parris and Schneider 2009). Habib et al. (2007) found that pairing success of Ovenbirds (*Seiurus aurocapilla*) was significantly lower within 200 to 400 m of compressor stations. Studies by Canaday and Rivadeneyra (2001) and Bayne et al. (2008) found noise to be a disturbance to birds over distances of 300 to 700 m. A study of Lapland longspurs by Male and Nol (2005) showed no difference in nest success between sites with high and low levels of human noise at the Ekati Diamond Mine. Similarly, no decrease in species richness or abundance from mine activity has been observed at the Meadowbank Mine (Nunavut Environmental Consulting Ltd. 2012). Conversely, Reijnen et al. (1997) reported that noise can affect birds up to 1 km from the noise source. No literature on the effects of in-ground or in-water vibrations (e.g., from blasting activities) to upland breeding birds could be found.

According to Jalkotzy et al. (1997), many studies have found a relationship between traffic volume and bird densities adjacent to roads. For example, a 12 to 15% reduction in bird densities was observed within 500 m of roads with more than 50 cars per day (Reijnen et al. 1997). Other studies have not found a significant effect of traffic intensity on mean bird species abundance (Benitez-Lopez et al. 2010). Overall, it appears as though some bird species may benefit from human disturbance while others do not (Spellerberg and Morrison 1998).

Table 6.7-36: Relative Changes in the Abundance of Upland Birds in the Regional Study Area from Indirect Effects from Reference to Reasonably Foreseeable Projects

Habitat Type	Area (ha)	Bird Abundance under Reference Conditions	% Change Reference to Baseline (30% CV)	% Change Baseline to Phase 1 AWAR (30% CV)	% Change Phase 1 AWAR to Project (30% CV)	% Change Baseline to Project (30% CV)	% Change Project to Future (30% CV)	% Cumulative Change from Reference (30% CV)
Bare Ground (Rock Outcrop)	5 263.0	6 430	-11.19 (-3.36)	-0.22 (-0.07)	-0.57 (-0.17)	-0.79 (-0.24)	-0.23 (-0.07)	-12.10 (-3.63)
Heath Boulder	26 499.5	38 301	-2.18 (-0.65)	-0.24 (-0.07)	-0.38 (-0.11)	-0.62 (-0.18)	-0.67 (-0.20)	-3.44 (-1.03)
Heath Lichen – *Cetraria*	1 733.1	4 005	-8.78 (-2.64)	-1.76 (-0.53)	-6.18 (-1.85)	-1.09 (-0.33)	-0.74 (-0.22)	-16.56 (-4.97)
Heath Lichen – Hair Lichen	4 503.5	1 541	-1.28 (-0.38)	-0.30 (-0.09)	-0.79 (-0.24)	-7.83 (-2.35)	-0.48 (-0.14)	-2.82 (-0.85)
Heath Tundra	109 825.9	97 634	-1.71 (-0.51)	-0.11 (-0.03)	-2.16 (-0.65)	-2.27 (-0.68)	-0.61 (-0.18)	-4.53 (-1.36)
Low Shrub	3 478.3	4 638	-0.67 (-0.20)	-0.01 (0.00)	-0.67 (-0.20)	-0.68 (-0.20)	-0.41 (-0.12)	-1.75 (-0.52)
Tussock Hummock	25 698.7	34 273	-2.13 (-0.64)	-0.17 (-0.05)	-0.91 (-0.27)	-1.07 (-0.32)	-0.95 (-0.28)	-4.10 (-1.23)
Total	**177 002**	**186 821**	**-2.23 (-0.67)**	**-0.17 (-0.05)**	**-1.48 (-0.44)**	**-1.64 (-0.49)**	**-0.67 (-0.20)**	**-4.48 (-1.34)**

Notes: AWAR = All-weather access road; % = percent; CV = coefficient of variation; < = less than

Projected noise level results from mine operations and the AWAR will slightly exceed benchmarks, except around Iqalugaarjuup Nunanga Territorial Park (Table 6.7-24). A summary of noise levels, not adjusted for human hearing sensitivity (i.e., total amount of noise energy emitted), at certain distances from Project activities are shown in Table 6.7-25. The results indicate that Project-related noises (from the mine, AWAR, and Rankin Inlet infrastructure) will not be distinguishable from the natural environment by birds that are 5 km or more from the Project. Noise levels within 1.5 km of the mine, Rankin Inlet infrastructure, and AWAR are predicted to be slightly above baseline values.

Upland birds are likely to be affected by transboundary effects from human disturbances during migration and over the winter. However, the cumulative effect from the Project when considered with transboundary developments and activities is expected to be negligible because the changes from the Project are predicted to be small.

6.7.8 Effects on Abundance and Distribution of Raptors

6.7.8.1 Habitat Quantity and Fragmentation

- **Direct loss and fragmentation of bird habitat from the Project footprint, including the mine infrastructure, AWAR and Rankin Inlet infrastructure**
- **Permanent changes in bird habitat following closure of the mine site and supporting infrastructure**

6.7.8.1.1 Methods

Incremental direct habitat effects from the Project footprint (i.e., AWAR Phase 2, mine infrastructure, and Rankin Inlet infrastructure) and the AWAR Phase 1 were analyzed through changes in the area of potential raptor nesting habitat in the LSA. Peregrine falcons, rough-legged hawks, and other raptor species prefer to nest on steep cliffs and large boulders in barren-ground tundra environments (Bechard and Swem 2002; White et al. 2002; Booms et al. 2008) as terrestrial predators have difficulty accessing these areas. Fine-scale habitat features, such as large boulders and cliff areas, could not be identified from the ELC. Instead, slope grades in the LSA were determined from digital elevation model data by calculating slopes between 1 m Comaplex or 5 m Photosat pixels using a GIS platform (Figure 6.7-16). Slope grades could not be calculated for the RSA because the digital elevation model data were not available. Slopes of 33 degrees or more were assumed to indicate rock outcrops and were considered to be steep cliff habitat, and, therefore, potential raptor nesting habitat. The use of 33 degree slopes is considered to be a conservative estimate of potential areas that could be used by raptors for nesting and was used because of limitations with the 5 m Photosat data.

The total area of steep cliff habitat in the LSA under baseline conditions and the total area of steep cliff habitat that is predicted to be removed by the Project and Phase 1 AWAR were calculated in GIS. The total area, not the spatial configuration of steep cliff habitat, was used in the analysis; therefore, the number of nests that may be in the LSA could not be predicted. Raptors are territorial and the average distance between peregrine falcon nests near Rankin Inlet has been found to be 3.3 km (range 0.7 to 9.9 km) (Court et al. 1988). The average distance between rough-legged hawks nests in central NT has been found to range between 3.6 km and 11.8 km and is influenced by prey abundance (Poole and Bromley 1988). Therefore, factors other than the total area of steep cliff habitat need to be considered before the potential number of raptor nests in the LSA can be

determined. Therefore, the number of raptor nests identified in the RSA that will be removed by the Project footprint was also determined using a GIS platform. Specifically, nests were considered to be removed if they overlapped the Project footprint.

The Wolf deposit, located north-west of the Tiriganiaq deposit, is currently known, but still requires some exploration work to be better defined and included in the mine plan. Currently, the Wolf deposit does not have sufficient proven reserves to be economically mined and so was not included as a development or as part of the Project. An environmental impact assessment (including a cumulative effects analysis) for the Wolf deposit will be completed in the future if the deposit becomes economically feasible to be developed in the future.

530000
540000
550000
560000
6990000
6980000
6970000

Parallel Lake
Meliadine Lake
Little Meliadine Lake (LML)
Meliadine River
Hudson Bay
Rankin Inlet
Tiriganiaq Pit
Wesmeg Pit
Pump Pit
F Zone Pits
Discovery Pit

N

LEGEND

- Terrestrial Disturbance
- Local Study Area (LSA)
- Photosat 1 meter
- Comaplex 5 meter
- No Data
- Proposed Project Infrastructure
- All-weather Access Road (AWAR)
- Road - New
- Road - Existing
- Watercourse
- Waterbody

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).
Datum: NAD 83 Projection: UTM Zone 15

2.5 0 2.5
KILOMETRES

PROJECT
AGNICO EAGLE
AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE
DIGITAL ELEVATION MODEL DATA BOUNDARIES IN THE LOCAL STUDY AREA

Golder Associates

PROJECT NO.	10-1373-0076	FILE No.		
DESIGN	LD	26 Nov. 2012	SCALE AS SHOWN	REV. 0
GIS	JW	27 Nov. 2012		
CHECK	LY	14 Jan. 2013		
REVIEW	DW	14 Jan. 2013		

FIGURE 6.7-16

N:\Bur-Graphics\Projects\2013\1428\13-1428-0007\GIS\Mapping\MXD\IFEIS\Volume_6\Main_Volume\Figure_6.7-16_DEM_Data_Boundaries_LSA.mxd

6.7.8.1.2 Results

There are 2.33 ha of steep cliff habitat in the LSA under baseline conditions. It is predicted that the Project and Phase 1 AWAR will remove 18.79% of steep cliff habitat, relative to baseline conditions; however, it is not likely that the total amount of steep cliff habitat that is predicted to be removed by the Project will be entirely used by raptors for nesting because territoriality and other factors influence where raptors nest (Court et al. 1988; Poole and Bromley 1988).

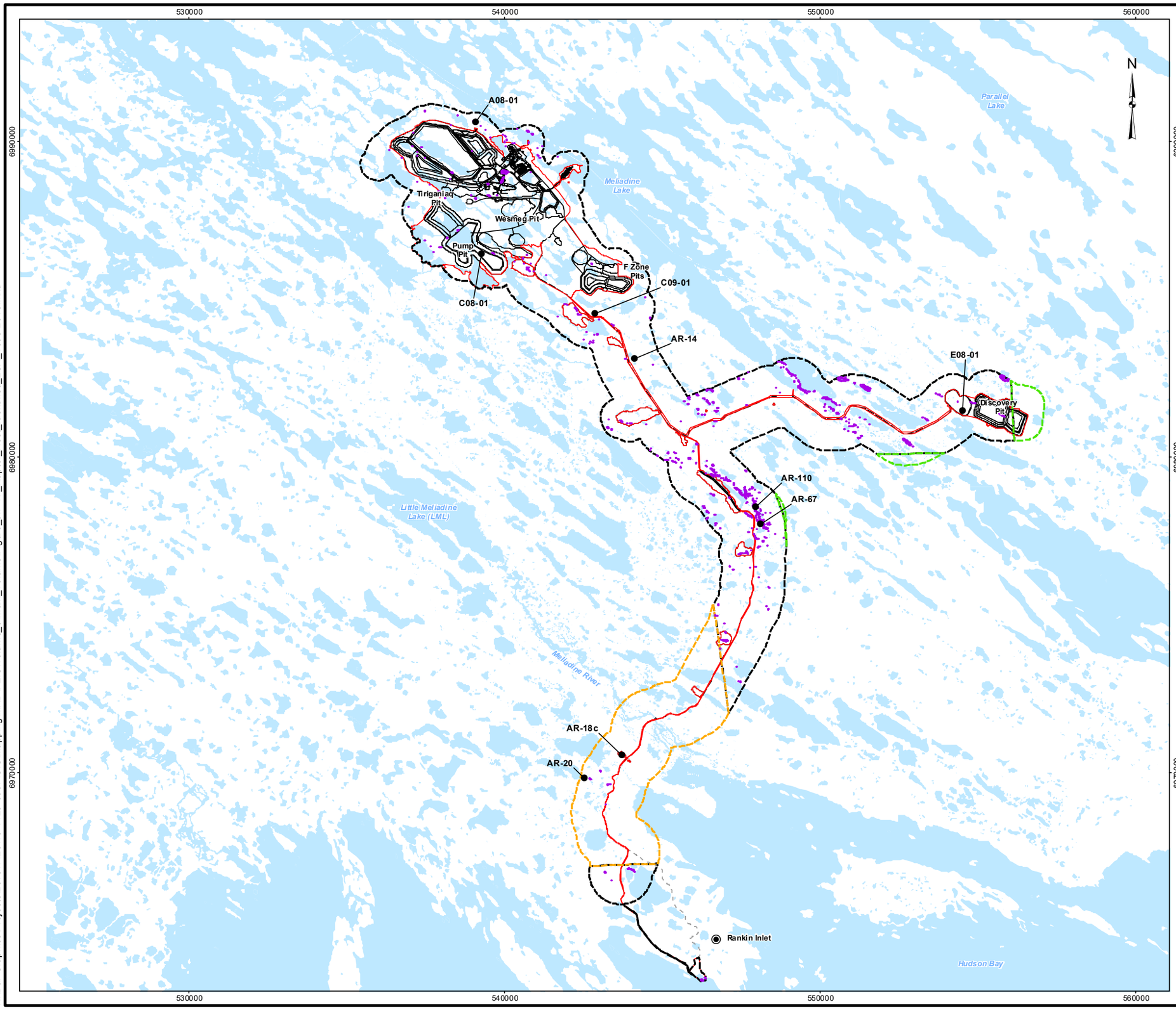
Four of the nine (44.44%) identified raptor nests in the LSA (7.55% of nests in the RSA) (C08-01, E08-01, C09-01, and AR-18c; Figure 6.7-17) are predicted to be removed by the Project footprint. These nests were found to have low occupancy rates during baseline studies (Section 6.7.3.1). Nests E08-01 and C08-01 were only occupied in 2008, while nest C09-01 was only occupied in 2009. Nest site E08-01 is considered a poor-quality nest site (A. Franke, University of Alberta, 2014, pers. comm). The Arctic Raptor Group has identified 40 nests and 7 alternative nest sites within 455 km^2 around Rankin Inlet (A. Franke, University of Alberta, 2012, pers. comm). Therefore, it is likely that the number of nests identified in the LSA and RSA during baseline studies is close to the actual number of nests that are present. AEM has consulted with the Arctic Raptor Group to determine the location of raptor nests in the RSA and to mitigate effects to raptor nests that may be influenced by the Project. A nest specific mitigation strategy will be employed (SD 6-4).

The construction of the AWAR may have a more adverse effect on raptor nests than the construction of the mine itself. The AWAR right-of-way is located on rocky outcrops to limit encounters with permafrost. These rocky outcrops could be suitable raptor nesting habitat. Likewise, construction materials for road building will need to be quarried and the location of appropriate rock materials (e.g., rocky outcrops) could result in the removal of suitable raptor nesting habitat. Roads required for future developments are also likely to be routed along rocky outcrops and so may also result in direct effects to raptor nests. The Arctic Raptor Group will be contacted to assist in identifying nests in advance of future road developments to prevent the destruction of raptor nest sites. AEM will also leave ledges for nesting (i.e. inactive quarries) and possibly construct platforms with guidance from the Arctic Raptor Group.

Conversely, open pits and cliffs in quarries could be used by nesting raptors during operations or post-closure. Since 2004, there have been 8 peregrine falcon nesting attempts among 5 open pits at the Ekati diamond mine, and all 5 Ekati pits had nesting birds in 2006 (BHPB 2007). Young have been detected in some of these nests (BHPB 2003; BHPB 2007). At the Meadowbank Mine, peregrine falcons have moved into new cliff-like habitat created at quarries along the all-weather private road, successfully rearing young in 2009 (Gebauer and Associates 2010).

Adult peregrine falcon survival rates near Rankin Inlet are high (Franke et al. 2011), although reproductive success has been declining over time (Franke et al. 2010; Anctil et al. 2012). This decline in reproductive success has also been noted in other Arctic areas (Coulton et al. 2013), and may be related to increased precipitation during the spring (Franke et al. 2010; Anctil et al. 2012; Coulton et al. 2013) when chicks are most vulnerable to hypothermia. Weather is expected to have a greater effect on raptor productivity and survival than human activities (Franke et al. 2010; Franke et al. 2011; Anctil et al. 2012). However, effects from human activities may be additive to those from weather (A. Franke, University of Alberta, 2012, pers. comm.).

Raptors are likely to be affected by transboundary effects from human disturbances during migration and over the winter. However, the cumulative effect from the Project when considered with transboundary developments and activities is expected to be negligible because the changes from the Project are predicted to be small.



LEGEND

- Observerd Raptor Nest Location
- Proposed Project Infrastructure
- All-weather Access Road (AWAR)
- Road - New
- Road - Existing
- Watercourse
- Waterbody
- Terrestrial Disturbance
- Slope >33 Degrees

Local Study Area (LSA)

- Photosat (1 metre DEM) Boundary
- Comaplex (5 metre DEM) Boundary
- No Data (no detailed DEM available)

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).
Wildlife data obtained from field survey, and the Government of Nunavut through AEM.
Datum: NAD 83 Projection: UTM Zone 15

DRAFT

2.5 0 2.5
KILOMETRES

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

LOCATION OF RAPTOR NESTS IDENTIFIED WITHIN THE LOCAL STUDY AREA, 1998-2013

Golder Associates

PROJECT NO.	13-1428-0007		FILE No.	
DESIGN	KD	26 Feb. 2014	SCALE AS SHOWN	REV. 0
GIS	SGR	26 Feb. 2014		
CHECK				
REVIEW				

FIGURE 6.7-17

N:\Bur-Graphics\Projects\2013\1428\13-1428-0007\GIS\Mapping\MXD\EIS\Volume_6\Main_Volume\Figure_6.7-17_Raptor_Nest_Identified_LSA_1998-2013.mxd

6.7.8.2 Habitat Quality, Behaviour, and Movement

- **Sensory disturbance can change the amount of different quality habitats, and alter bird movement and behaviour (distribution)**

6.7.8.2.1 Methods

Indirect changes to habitat quality from sensory disturbance (e.g., noise, lights, and the presence of human activity) associated with the Project have the potential to affect the population size and distribution of raptors in the RSA. Raptors have been shown to exhibit some degree of sensitivity to human disturbance during the breeding season (Craighead and Mindell 1981; Richardson and Miller 1997). Set-back distances for human activities (buffer zones) of 800 to 1 600 m from peregrine falcon nests have been recommended to reduce disturbance to nesting falcons (Richardson and Miller 1997). The median buffer distance recommended is 800 m. Changes to the quality of steep cliff habitat (i.e., potential raptor nesting habitat) from indirect (or sensory) Project effects were calculated by removing all slopes greater than or equal to 33 degrees that occurred within 800 m of the Project footprint. See Section 6.7.8.1.1 for rationale of, and methods for, determining slopes in the LSA. To assess indirect effects from the Project footprint on raptor nests that have been identified in the LSA, the number of intersections between nest buffers (800 m) and the footprint was determined using a GIS platform.

The Wolf deposit, located north-west of the Tiriganiaq deposit, is currently known, but still requires some exploration work to be better defined and included in the mine plan. Currently, the Wolf deposit does not have sufficient proven reserves to be economically mined and so was not included as a development or as part of the Project. An environmental impact assessment (including a cumulative effects analysis) for the Wolf deposit will be completed in the future if the deposit becomes economically feasible to be developed in the future.

Prey abundance also influences the quality of raptor nesting habitat. Raptors forage on ptarmigan, passerines, shorebirds, waterbirds, and rodents (Dekker 1987; Court et al 1988; Rosenfield et al. 1995; Stevens et al. 2009). L'Hérault (2011) found that peregrine falcons in the Rankin Inlet region shifted their diet as the breeding season progressed; rodents were taken more during the early breeding season, and passerines were consumed more during the late breeding season. This may be due to the increased availability of fledged birds during the late season and a decrease in rodents as a result of predation throughout the season. Raptors are central place foragers, and thus energy costs associated with foraging increase proportionally with travelling distance to foraging grounds. Thus, high quality nesting habitat has abundant preferred prey species within close proximity to nest sites.

While information is not available on rodent populations in the RSA, the density of upland birds in the LSA and RSA, and the density of waterbirds in the RSA was determined from data collected during baseline surveys (see Sections 6.7.6 and 6.7.7 for details). Effects from the Project on waterbirds in the LSA were determined qualitatively based on the distribution of open water in the LSA. Effects from the Project on upland birds in the LSA were estimated using relative abundance (density) data from baseline studies (Table 6.7-16). All upland bird calculations were completed using raster file types within a GIS platform. Analysis was similar to that completed in Section 6.7.7, except the calculations of abundance of upland bird prey was completed within the LSA, not the RSA.

6.7.8.2.2 Results

There are 2.33 ha of steep cliff habitat in the LSA under baseline conditions. Indirect (or sensory) effects from the Project are predicted to influence 92.37% of steep cliff habitat in the LSA. Most of this sensory disturbance from the Project will be from the AWAR as the right-of-way will be located on rocky outcrops to limit encounters with permafrost. These rocky outcrops could be suitable raptor nesting habitat. The amount of suitable raptor habitat that could be influenced by sensory disturbance is a conservative estimate because sensory effects are likely to have a greater effect on nests that are on the sides of cliffs facing the footprint than those facing away from the footprint. Also, habitat loss from indirect effects was predicted at a local scale, not a regional scale, because of absence of digital elevation model data for the RSA. Within the RSA, the coast likely has a large amount of cliff habitat. Also, raptors do not only use steep cliff habitat for nesting; small rock outcrops and frost heaves can also be used (A. Franke, University of Alberta, 2012, pers. comm.). Raptors can also habituate to human disturbance and territoriality and other factors influence where raptors nest (Court et al. 1988; Poole and Bromley 1988). Therefore, it is likely that the amount of habitat that will be lost from sensory effects is less than 92.37%.

Nine of the 53 raptor nests (16.98%) that have been identified in the RSA have 800 m buffers that overlap the Project footprint (Figure 6.7-17). If individuals that use these nests are sensitive to human disturbance, nest occupancy and success may be reduced at these 9 nests. Most potential nest sites that have been identified in the RSA belong to rough-legged hawks and peregrine falcons (Table 6.7-19, Figure 6.7-12). A study near 2 diamond mines in the barren-ground tundra of the NT concluded that natural factors (i.e., rainfall and prey abundance) had a larger influence on peregrine falcon, gyrfalcon, and rough-legged hawk nest occupancy and success than did human-related factors (Coulton et al. 2013). Indeed, raptors were found to have higher nest occupancy at nests located in close proximity to mines. AEM will consult with the Arctic Raptor Group to determine the location of raptor nests in the RSA and to mitigate effects to raptor nests that may be influenced by the Project.

Raptors can habituate to human disturbance. Peregrine falcons commonly nest in urban environments (White et al. 2002). There have been several attempts by peregrine falcons, gyrfalcons, and rough-legged hawks to nest within both active and abandoned open pits at the Ekati and Diavik diamond mines in the NT. Peregrine falcons made nesting attempts in open pits at Diavik diamond mine in 2005 and 2006 (DDMI 2007). Since 2004, there have been 8 such occurrences among 5 open pits at the Ekati diamond mine, and all 5 Ekati pits had nesting birds in 2006 (BHPB 2007). In some cases, young have been detected in these nests (BHPB 2003; BHPB 2007). Nesting on pit walls has become so common at the Ekati diamond mine that a monitoring program has been implemented. At the Meadowbank Mine, peregrine falcons have moved in to new cliff-like habitat created at quarries along the all-weather access road, successfully rearing young in 2009 (Gebauer and Associates 2010).

The type of sensory disturbance may also influence avoidance behaviour responses raptors. Rough-legged hawks were found to flush more readily when approached by humans on foot than by vehicles. Hawks flushed when humans on foot were, on average, 177 m (range 55 to 900 m) from the nest versus flushing when vehicles were, on average, 71 m (range 9 to 170 m) from the nest (Holmes et al. 1993). It is unlikely that nests along the AWAR will be approached by humans on foot, except if it is required for monitoring purposes. Therefore, effects from sensory disturbance are likely to be less than predicted by the analysis. No literature on the effects of in-ground or in-water vibrations (e.g., from blasting activities) to raptors could be found.

Sensory disturbance can also influence avoidance behaviour responses of raptor prey (e.g., upland birds and waterbirds). Overall waterbird abundance in the RSA is predicted to decrease by 0.77% and 1.69% from direct and indirect effects associated with the Phase 1 AWAR and Project, respectively, relative to the baseline case (Tables 6.7-32 and 6.7-33). Although waterbird abundance in the LSA is expected to decrease due to sensory disturbance, open water habitat is not limited within the RSA and waterbirds are expected to continue to breed in open water habitats in the RSA. As open water covers approximately 28% of the RSA, with many waterbodies close to the Project, waterbird abundance is expected to remain near baseline levels. Overall upland bird abundance in the RSA is predicted to decrease by 1.09% and 1.64% from direct and indirect effects associated with the Phase 1 AWAR and Project, respectively, relative to the baseline case (Tables 6.7-35 and 6.7-36). Overall upland bird abundance in the LSA is expected to decrease by 23.76% and 41.72% from direct and indirect effects associated with the Phase 1 AWAR and Project, respectively, relative to the baseline case (Tables 6.7-37 and 6.7-38). Three of the 7 nests (F08-01 and both nests labelled PEFA) identified in the LSA are located within or near areas of high upland breeding bird density under baseline conditions (Figure 6.7-18). These three nests are not expected to be directly affected (i.e., removed) by the Project footprint. The decrease in upland bird abundance near these three nests may negatively affect nest occupancy and productivity. However, raptors are highly mobile and so are expected to be able to access areas outside of the ZOI that are not influenced by sensory disturbance (i.e., have a higher abundance of prey). Also, raptors do not prey exclusively on upland birds and waterbirds; they also consume small mammals, such as voles and mice. Bissonette and Rosa (2009) did not find a ZOI around roads for small mammals; therefore, the Project may not influence the abundance and distribution of small mammals in the LSA.

Projected noise level results from mine operations and the AWAR will slightly exceed benchmarks, except around Iqalugaarjuup Nunanga Territorial Park (Table 6.7-24). A summary of noise levels, not adjusted for human hearing sensitivity (i.e., total amount of noise energy emitted), at certain distances from Project activities are shown in Table 6.7-25. The results indicate that Project-related noises (from the mine, AWAR, and Rankin Inlet infrastructure) will not be distinguishable from the natural environment by birds that are 5 km or more from the Project. Noise levels within 1.5 km of the mine, Rankin Inlet infrastructure, and AWAR are predicted to be slightly above baseline values.

Adult peregrine falcon survival rates near Rankin Inlet are high (Franke et al. 2011), although reproductive success has been declining over time (Franke et al. 2010; Anctil et al. 2012). This decline in reproductive success has also been noted in other Arctic areas (Coulton et al. 2013), and may be related to increased precipitation during the spring (Franke et al. 2010; Anctil et al. 2012; Coulton et al. 2013) when chicks are most vulnerable to hypothermia. Weather is expected to have a greater effect on raptor productivity and survival than human activities (Franke et al. 2010; Franke et al. 2011; Anctil et al. 2012). However, effects from human activities may be additive to those from weather (A. Franke, University of Alberta, 2012, pers. comm.).

Raptors are likely to be affected by transboundary effects from human disturbances during migration and over the winter. However, the cumulative effect from the Project when considered with transboundary developments and activities is expected to be negligible because the changes from the Project are predicted to be small.

Table 6.7-37: Relative Changes in the Abundance of Upland Birds in the Local Study Area from Direct Effects from Reference to the Project

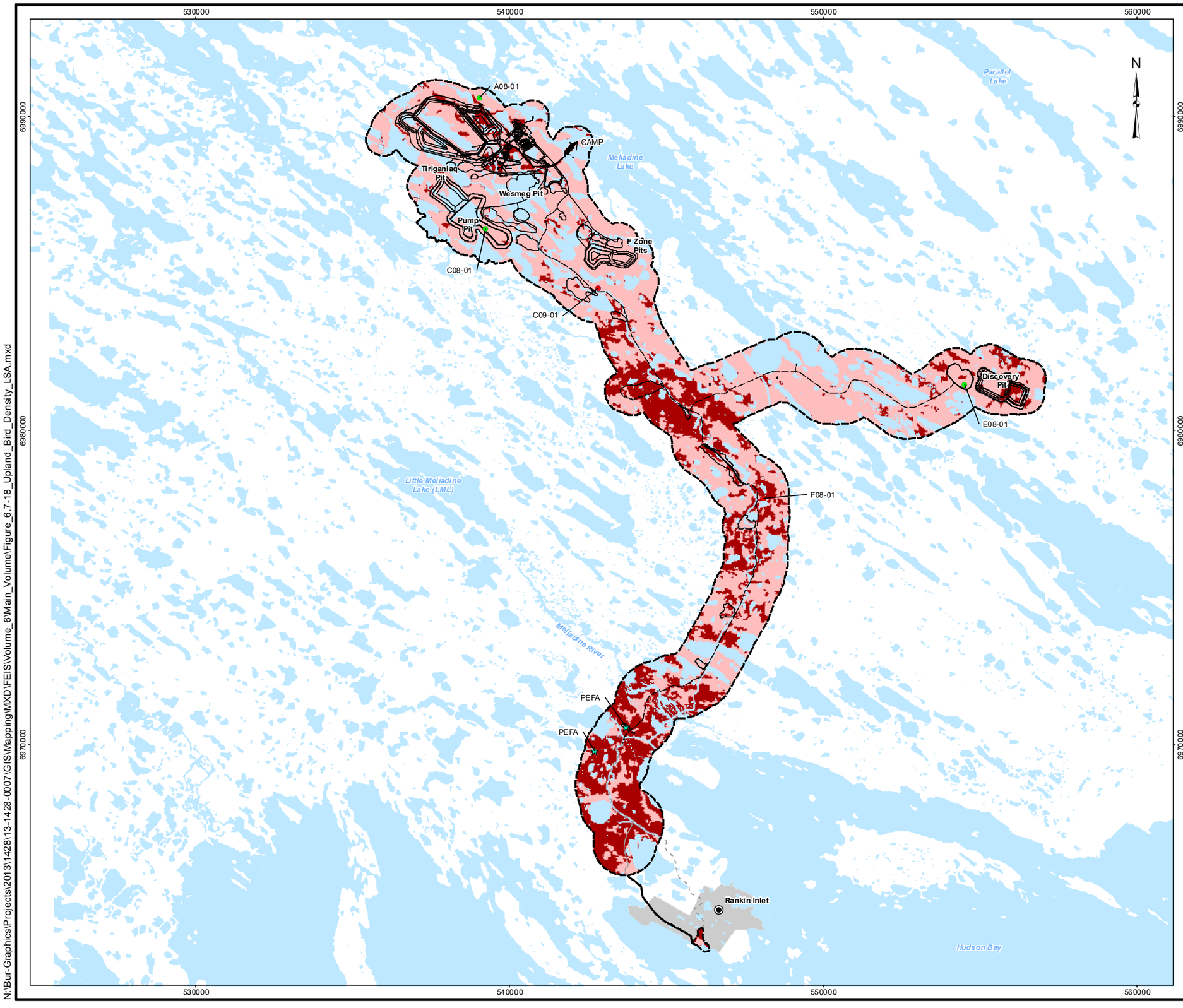
Habitat Type	Area (ha)	Bird Abundance under Reference Conditions	% Change Reference to Baseline (30% CV)	% Change Baseline to Phase 1 AWAR (30% CV)	% Change Phase 1 AWAR to Project (30% CV)	% Change Baseline to Project (30% CV)	% Cumulative Change from Reference (30% CV)
Bare Ground (Rock Outcrop)	220.41	269	-13.31(-3.99)	-0.14(-0.04)	-16.79(-5.04)	-16.91(-5.07)	-27.97(-8.39)
Heath Boulder	959.13	1385	-3.96(-1.19)	-0.54(-0.16)	-7.70(-2.31)	-8.20(-2.46)	-11.83(-3.55)
Heath Lichen – *Cetraria*	224.64	129	-1.80(-0.54)	-0.73(-0.22)	-38.39(-11.52)	-38.84(-11.65)	-39.94(-11.98)
Heath Lichen – Hair Lichen	145.53	200	-5.81(-1.74)	-0.33(-0.10)	-15.88(-4.76)	-16.15(-4.85)	-21.03(-6.31)
Heath Tundra	5 878.26	5225	-3.98(-1.19)	-0.26(-0.08)	-29.74(-8.92)	-29.92(-8.98)	-32.71(-9.81)
Low Shrub	48.60	65	-2.59(-0.78)	-0.57(-0.17)	-31.74(-9.52)	-32.13(-9.64)	-33.89(-10.17)
Tussock Hummock	1 214.82	1620	-4.05(-1.22)	-0.46(-0.14)	-16.20(-4.86)	-16.59(-4.98)	-19.97(-5.99)
Water	1 907.10	0	0	0	0	0	0
Total	**10 598.49**	**8894**	**-4.24(-1.27)**	**-0.35(-0.10)**	**-23.49(-7.05)**	**-23.76(-7.13)**	**-26.99(-8.10)**

Notes: AWAR = All-weather access road; % = percent; CV = coefficient of variation;

Table 6.7-38: Relative Changes in the Abundance of Upland Birds in the Local Study Area from Indirect Effects from Reference to the Project

Habitat Type	Area (ha)	Bird Abundance under Reference Conditions	% Change Reference to Baseline (30% CV)	% Change Baseline to Phase 1 AWAR (30% CV)	% Change Phase 1 AWAR to Project (30% CV)	% Change Baseline to Project (30% CV)	% Cumulative Change from Reference (30% CV)
Bare Ground (Rock Outcrop)	220.41	269	-45.61(-13.68)	-2.04(-0.61)	-21.87(-6.56)	-23.46(-7.04)	-58.37(-17.51)
Heath Boulder	959.13	1385	-35.23(-10.57)	-7.93(-2.38)	-16.67(-5.00)	-23.27(-6.98)	-50.31(-15.09)
Heath Lichen – *Cetraria*	224.64	129	-20.30(-6.09)	-6.65(-2.00)	-54.80(-16.44)	-57.81(-17.34)	-66.37(-19.91)
Heath Lichen – Hair Lichen	145.53	200	-23.26(-6.98)	-11.93(-3.58)	-34.11(-10.23)	-41.97(-12.59)	-55.47(-16.64)
Heath Tundra	5 878.26	5225	-20.85(-6.25)	-2.58(-0.77)	-47.70(-14.31)	-49.05(-14.72)	-59.67(-17.90)
Low Shrub	48.60	65	-15.36(-4.61)	-0.90(-0.27)	-49.05(-14.71)	-49.51(-14.85)	-57.26(-17.18)
Tussock Hummock	1 214.82	1620	-28.33(-8.50)	-4.67(-1.40)	-26.14(-7.84)	-29.58(-8.88)	-49.53(-14.86)
Water	1 907.10	0	0	0	0	0	0
Total	**10 598.49**	**8894**	**-25.18(-7.55)**	**-3.87(-1.16)**	**-39.37(-11.81)**	**-41.72(-12.52)**	**-56.40(-16.92)**

Notes: AWAR = All-weather access road; % = percent; CV = coefficient of variation



LEGEND

- Raptor Nest Location - Found by Others
- Raptor Nest Location - 2011
- Raptor Nest Location - 2009
- Raptor Nest Location - 2008
- Raptor Nest Location - 1998
- Local Study Area (LSA)
- Municipal Boundary
- Proposed Project Infrastructure
- All-weather Access Road (AWAR)
- Road - New
- Road - Existing
- Watercourse
- Waterbody

Upland Bird Density - Baseline

- Low Density
- High Density

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).
Datum: NAD 83 Projection: UTM Zone 15

2.5 0 2.5
KILOMETRES

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

UPLAND BREEDING BIRD DENSITY WITHIN THE LOCAL STUDY AREA: BASELINE CASE

Golder Associates

PROJECT NO.		10-1373-0076	FILE No.	
DESIGN	LD	26 Nov. 2012	SCALE AS SHOWN	REV. 0
GIS	JW	27 Nov. 2012		
CHECK	LY	14 Jan. 2013		
REVIEW	DW	14 Jan. 2013		

FIGURE 6.7-18

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6.7.9 Effects on the Abundance and Distribution of Listed bird Species

There are 3 SARA listed bird species of concern (red knot, peregrine falcon and short-eared owls) that have the potential to occur in the RSA (Table 6.7-3) (SARA 2013). The Project is not expected to have any significant adverse effects on the abundance or distribution of these brid species.

Red knots were not detected in the RSA in surveys between 2008 and 2011. However, red knots pass along the southwest coast of Hudson Bay during migration, and nest in shrubby areas (e.g., low shrub habitat) on Mansel, Coats, and Southampton islands to the northeast of the RSA (COSEWIC 2007, Harrington 2001). Therefore, they may occur in the RSA. Incremental loss and fragmentation of habitat, and sensory disturbance from the Project are predicted to have a negative and negligible to low magnitude effect on red knots, respectively. Further details on effects to upland breeding birds and shorebirds can be found in Section 6.7.7.1.2 and 6.7.7.2.2. Impacts will be minimized using environmental design features such as minimizing the footprint; the use of insulation, baffles, and noise suppressors on equipment; and water management to minimize impacts to shorelines (SD 6-4, Section 3.1). Trends in shorebird species richness, distribution, and abundance will be monitored using PRISM survey methods (CWS 2008) both near the Project footprint, and outside the zone of influence of the Project footprint (SD 6-4, Section 4.9), to monitor potential impacts and develop appropriate mitigations.

Peregrine falcons are confirmed to be breeding in the RSA. Incremental habitat loss from the Project is expected to have a moderate level effect on peregrine falcon populations in the LSA, and sensory disturbance from the Project is predicted to have a high magnitude effect. Peregrine falcons nest on steep cliffs and large boulders in barren-ground tundra environments (White et al. 2002). The assessment of effects quantified the amount of cliff habitat impacted directly and indirectly by the Project, so is a conservative estimate. Sensory effects from the Project are predicted to be reversible within a few years following closure (long term). A decrease in upland bird abundance due to sensory disturbance is expected near three known raptor nests, which may negatively affect nest occupancy and productivity. However, raptors are highly mobile and are expected to access areas outside of the Zone of Influence (ZOI) that are not influenced by sensory disturbance (i.e., have a higher abundance of prey). They also consume small mammals, such as voles and mice, which may not be affected by Project sensory disturbance, but were not quantified for this assessment. Discussion of effects to peregrine falcon can be found in Section 6.7.8.1.2 and Section 6.7.8.2.2. AEM has engaged Alastair Franke of the Arctic Raptors Research Program (http://www.arcticraptors.ca/) to develop and implement the raptor monitoring program (Franke 2012). Thresholds for the raptor monitoring program will be developed in conjunction with Dr. Franke and GN DoE personnel, but will likely be one mining-attributed nest failure per year, after which, mitigation efficacy and additional mitigation strategies will be reviewed and considered (SD 6-4, Section 4.7).

The abundance of short-eared owls observed near the Project during baseline surveys was low (Section 6.7.3.3.1), which is likely due to natural limited availability of quality nesting habitat. Changes to habitat quality from the Project are anticipated to have a negligible effect on the abundance and distribution of short-eared owl populations, and changes to habitat quantity are expected to be low. Effects from sensory disturbance on short-eared owls are predicted to slightly exceed baseline values, and may result in a localized decrease in occupancy of habitats near the Project and associated infrastructure.

Upon approval of the Project, a TEMMP (SD 6-4) will be implemented as a requirement of the Guidelines for the FEIS (NIRB, 2012) and in part to limit effects to listed bird species, determine the effectiveness of mitigation, and test impact predictions. The principal goal of the Program is to provide information required for the Project to adaptively manage potential impacts to species, including listed bird species. In addition, the TEMMP will be designed to provide a process for regulators, communities, and other people interested in the Project to participate in the development and review of listed bird effects mitigation and monitoring.

6.7.10 Residual Effects Summary

6.7.10.1 Habitat Quantity and Fragmentation

Previous and existing developments have removed between 2.67 and 291.55 ha (between 0.08% and 4.68%) of habitats in the RSA, relative to reference conditions. The Phase 1 AWAR is predicted to remove less than or equal to 13.82 ha (less than or equal to 0.11%) of habitats in the RSA, relative to baseline conditions. The total area of the Project footprint is estimated to be 2950 ha. The Project footprint is predicted to remove between 14.06 and 1608.43 ha (between 0.40% and 4.67%) of habitats in the RSA, relative to Phase 1 AWAR conditions. Cumulative alteration of habitats in the RSA from reference through reasonably foreseeable developments is expected to be between 17.53 and 1 974.76 ha (between 0.50% and 6.76%).

Subarctic ecosystems are slow to recover from disturbance and the open pits, TSF, attenuation ponds, other ponds, ditches, and the waste rock storage facilities will be permanent features on the landscape, covering approximately 670 ha. Therefore, permanent habitat loss is predicted to be 0.27% of the RSA. Approximately 1 884 ha (74%) of the land disturbed by the Project and Phase 1 AWAR will be reclaimed to lichen rock communities, waterbodies, or scarified natural re-vegetation. The Project is predicted to permanently affect 7.64 ha (53.40%), 9.23 ha (4.82%), 120.35 ha (23.38%), 5.38 ha (7.13%), and 496.41 ha (30.60%) of low shrub, tussock hummock, water, health boulder, and heath tundra habitats, respectively.

Increasing development on the landscape has also resulted in changes to the number of habitat patches in the RSA. Important habitats are low shrub, tussock hummock, and water for waterbird species, and heath boulder, heath tundra, and tussock hummock for upland birds. For any of these 5 habitats, previous and existing developments have increased the number of habitat patches on the landscape for each habitat type by between 0.06% and 2.84% relative to reference conditions. Relative, incremental changes to the number of important habitat patches from the Project footprint are predicted to be less than 0.75%. Cumulative changes to the number of important upland bird and waterbird habitat patches from previous, existing, and future developments are expected to be less than 5.33%, relative to reference conditions.

Habitat-specific changes in the distance between important upland bird and waterbird habitats (i.e., low shrub, tussock hummock, water, heath boulder, and heath tundra) patches from previous and existing developments were estimated to be less than 2.65%, relative to reference conditions. The Phase 1 AWAR is predicted to decrease the distance between important upland bird and waterbird habitat patches by between 0.05% and 1.40%, relative to baseline conditions. Development of the Project is expected to change the distance between similar patches on the landscape by less than or equal to 0.54%, relative to Phase 1 AWAR conditions. Cumulative habitat-specific changes in the distance between similar patches from previous, existing, and future developments are less than 4.84% for important upland bird and waterbird habitats in the RSA, relative to reference conditions.

Direct habitat loss from the Project footprint is predicted to remove 4 of the 53 raptor nests (7.55%) that have been identified in the RSA. The footprint is predicted to remove 18.79% of steep cliff habitat that is present in the LSA under baseline conditions. The cumulative direct effects on raptor nests could not be quantified; however, roads in the RSA tend to be built in high elevation areas to avoid permafrost. These high elevation areas may provide suitable raptor nesting habitat. Therefore, if new roads are going to be constructed in the RSA there could be direct effects to raptor nests. Adult peregrine falcon survival rates near Rankin Inlet are high (Franke et al. 2011), although reproductive success has been declining over time (Franke et al. 2010; Anctil et al. 2012). Weather is expected to have a greater effect on raptor productivity and survival than human activities (Franke et al. 2010; Franke et al. 2011; Anctil et al. 2012). However, effects from human activities may be additive to those from weather (A. Franke, University of Alberta, 2012, pers. comm.). AEM will leave ledges for nesting (i.e. inactive quarries) and possibly construct platforms with guidance from the Arctic Raptor Group.

Direct effects from previous, existing, and future developments on waterbird populations were estimated using relative abundance (density) data from baseline studies. Direct habitat loss from previous and existing developments decreased habitat-specific waterbird abundance by less than 0.30% for all habitat types. Habitat-specific decreases in waterbird abundance with the development of the Phase 1 AWAR are predicted to be less than or equal to 0.02%, relative to baseline conditions, and with the development of the Project, less than 0.80% for all habitat types, relative to the Phase 1 AWAR case. Cumulative loss of specific habitats from reference conditions to the future case is expected to decrease total waterbird abundance in the RSA by between 0.53% and 1.12%, relative to the reference case.

Direct effects from previous, existing, and future developments (including the Project) on upland bird populations were also estimated using relative abundance (density) data from baseline studies. Direct habitat loss from previous and existing developments decreased habitat-specific upland bird abundance by less than 4.70% for all habitat types. Habitat-specific decreases in upland bird abundance are predicted to be between 0.01% and 0.11% with the development of the Phase 1 AWAR, relative to baseline conditions. With the development of the Project, habitat-specific decreases in bird abundance are predicted to be less than 1.55% for all habitat types relative to the Phase 1 AWAR case, except for heath lichen – *Cetraria* habitat, which is expected to have an abundance decrease of 4.96%. Cumulative loss of specific habitats from reference conditions to the future case is expected to decrease total upland bird abundance in the RSA by between 0.53% and 7.02%, relative to the reference case.

6.7.10.2 Habitat Quality, Movement, and Behaviour

In addition to direct habitat effects, indirect changes to habitat quality from the Project have the potential to affect the population size and distribution of birds through altered movement and avoidance behaviour. To estimate indirect habitat effects on birds, habitat changes were quantified from reference conditions through application of the Project and reasonably foreseeable developments. Because most bird species are likely to exhibit some degree of sensitivity to human disturbance, zones of influence to estimate indirect effects (e.g., sensory disturbance from noise and human activities) from the Project and other active projects in the LSA and RSA were estimated. Indirect effects on raptors were only analyzed in the LSA. The ZOI used in the raptor analysis was an 800 m buffer surrounding the Project footprint. To provide a conservative estimate of indirect effects on raptor populations, complete loss of steep cliff habitat within the ZOI was assumed. To assess the degree to which the Project footprint would interact with known, potential raptor nests, the frequency of overlap

of nest buffers (800 m) and the footprint was determined using a GIS platform. The indirect effects from noise on raptors were analyzed separately using a qualitative analysis.

Habitat quality analyses for upland birds and waterbirds were completed in the RSA. The ZOI used in the waterbird analysis was a 200 m buffer surrounding the Project footprint and other development (active and non-active) footprints. To provide a conservative estimate of indirect effects on waterbird populations, complete loss of low shrub, tussock hummock, and water habitat within the ZOI was assumed. Indirect effects on upland bird populations were estimated using a curvilinear one-asymptote relationship and a 1 km ZOI. Upland bird densities were reduced (but not completely removed) within the ZOI. The indirect effects from noise on raptors were analyzed separately using a qualitative analysis.

Indirect (or sensory) effects were found to have a greater effect on raptors, waterbirds, and upland birds in the LSA and RSA than direct effects from habitat loss. Nine raptor nests (16.98% of located potential nest sites in the RSA) may be influenced by sensory effects. It is also predicted that sensory effects from the Project will influence 92.37% of steep cliff habitat in the LSA. The relative amount of steep cliff habitat in the RSA that is expected to be influenced by sensory disturbance from the Project and future developments could not be determined because digital elevation model data were not available at the RSA scale. The routing of roads for future developments is likely to be along rocky outcrops to avoid areas of permafrost. This routing is likely to negatively affect raptors because rocky outcrops can provide suitable raptor nesting habitat.

Overall waterbird and upland bird abundance in the RSA is predicted to decrease by less than 3% from direct and indirect effects associated with the Phase 1 AWAR and Project, relative to the baseline case. Overall upland bird abundance in the LSA is expected to decrease by 23.76% and 41.72% from direct and indirect effects associated with the Phase 1 AWAR and Project, respectively, relative to the baseline case. However, upland bird density in the LSA is relatively low because habitats that support a higher density of upland birds (i.e., bare ground, heath boulder, low shrub, and tussock hummock habitats) only cover approximately 23% of the LSA. Although waterbirds may be displaced from open water habitat in the LSA, they are still expected to breed in near the Project in the RSA, and abundance is expected to remain near baseline levels.

Effects to raptor populations in the RSA are not expected because raptors are highly mobile and so are expected to be able to access areas outside of the ZOI that are not influenced by sensory disturbance (i.e., have a higher abundance of bird prey). Raptors do not prey exclusively on upland birds and waterbirds; they also consume small mammals, such as voles and mice. Bissonette and Rosa (2009) did not find a ZOI around roads for small mammals; therefore, the Project may not influence the abundance and distribution of small mammals in the LSA.

Adult peregrine falcon survival rates near Rankin Inlet are high (Franke et al. 2011), although reproductive success has been declining over time (Franke et al. 2010; Anctil et al. 2012). Weather is expected to have a greater effect on raptor productivity and survival than human activities (Franke et al. 2010; Franke et al. 2011; Anctil et al. 2012). However, effects from human activities may be additive to those from weather (A. Franke, University of Alberta, 2012, pers. comm.).

Habitat-specific changes in waterbird abundance from indirect effects associated with previous and existing developments range between 0.62% and 1.72%, relative to reference conditions. Habitat-specific decreases in waterbird abundance from indirect effects associated the development of the Phase 1 AWAR, are predicted to be between 0.12% and 0.71%, relative to baseline conditions, and from the Project by between 0.80% and

1.91%, relative to the Phase 1 AWAR case. Cumulative, habitat-specific decreases are predicted to be between 1.60% and 3.48%, relative to reference conditions.

Habitat-specific changes in upland bird abundance from sensory disturbance associated with previous and existing developments range between 0.67% and 11.19%, relative to reference conditions. Indirect effects from the Phase 1 AWAR are predicted to reduce habitat-specific upland bird abundance by between 0.01% and 1.76%, relative to baseline conditions, and the Project by between 0.38% and 6.18%, relative to Phase 1 AWAR conditions. Cumulative, habitat-specific decreases from indirect effects are predicted to be between 1.75% and 16.56%, relative to reference conditions.

Projected noise levels from mine operations and the AWAR will slightly exceed benchmarks, except around Iqalugaarjuup Nunanga Territorial Park. A summary of noise levels, not adjusted for human hearing sensitivity (i.e., total amount of noise energy emitted), at certain distances from Project activities are shown in Table 6.7-25. The results indicate that Project-related noises (from the mine, AWAR, and Rankin Inlet infrastructure) will not be distinguishable from the natural environment by birds that are 5 km or more from the Project. Noise levels within 1.5 km of the mine, Rankin Inlet infrastructure, and AWAR are predicted to be slightly above baseline values. Various studies have documented a decrease in upland and waterbird abundance within 1 km of human infrastructure (Benitez-Lopez et al. 2010). Raptor species have been shown to be attracted to areas of human disturbance (Benitez-Lopez et al. 2010; Coulton et al. 2013). Bird habitat quality is expected to decrease and this decrease may slightly exceed the changes to habitat quality that occur during baseline conditions. No literature on the effects of in-ground or in-water vibrations (e.g., from blasting activities) to upland breeding birds and raptors could be found. Lacroix et al. (2003) found no effect on vibrations from seismic activity on movements and diving behaviour of long-tailed ducks (*Clangula hyemalis*).

6.7.11 Cumulative Effects of Climate Change

A review of changing climate potential was completed for the climate stations nearest the Project development (FEIS Volume 5, Section 5.4). This review considered past weather records to provide guidance for predicting future conditions. Climate modelling is a complex process that involves the mathematical representation of global land, sea and atmosphere interactions over a long period. The results of global climate models are subject to many uncertainties and interpretations. The climate change assessment used various climate scenarios to partially address this concern. Since the models are susceptible to inter-decadal variability, the analysis used the average of 30 years of data, centred on a decade of interest. Climate normals were compared to future projections periods to determine whether climate variables are expected to change (FEIS Volume 5, Section 5.4.).

Rankin Inlet climate trend analysis indicates significant warming in average annual spring and winter temperatures from 1981 to 2010. The change per decade has been an increase of 1.1°C in average spring temperature and 1.7°C increase in average winter temperatures. There has also been a significant increase in winter precipitation of 6.3 mm snow water equivalent per decade over this time. In Baker Lake, the location of a more complete historical climate record, significant changes in climate from 1981 to 2010 included an increase in the winter temperature of 1.1°C per decade and an increase of 0.6°C per decade in the annual average temperature.

Forecasts for Baker Lake predict a warmer and wetter climate for the period 2041 to 2070 and 2071 to 2100 based on multiple global climate models and climate change scenarios. Increased temperatures are forecast to be 3 to 3.5°C and 4.5 to 5°C higher when averaged over 2041 to 2070 and 2071 to 2100, respectively. The corresponding precipitation increases are expected to be 30 to 50 mm and 35 to 55 mm, respectively. These precipitation projections are within the annual recorded range of precipitation values for the last 30 years in Baker Lake.

Warming can increase the thickness of the active permafrost layer. Overall, warming could cause thawing of ice-rich permafrost, potentially resulting in thaw waterbodies and subsidence (shifting downward) of the land surface. Increasing temperatures may also lead to more freezing rain. Freeze thaw cycles may increase based on increases in winter precipitation and average temperatures, and higher rainfall volume in summer may lead to more frequent heavy rain events.

Changes in climate can have direct effects on birds; however, changes can also affect their resources, predators and competitors, creating a suite of indirect effects (Humphries 2009). Climate change is expected to decrease raptor productivity because of increased precipitation during spring storms (Coulton et al. 2010). Altricial young (e.g., raptor chicks) have poor thermoregulatory abilities (i.e., they cannot generate their own heat; Marjoniemi 2001) and so have increased risk of mortality when they become cold and wet (e.g., when parents leave the nest to forage). Therefore, changes in the timing and the amount of precipitation from climate change could have negative effects on raptor productivity. Changes in the timing and amount of rainfall may also negatively affect the productivity of upland bird and waterbird species, especially those species that have altricial young.

Adult peregrine falcon survival during fall migration can be negatively affected by increased rainfall and decreased temperature (Franke et al. 2011). It has been suggested that changes in local weather patterns (including those from climate change) have the greatest potential to influence peregrine falcon nest occupancy and survival (Franke et al. 2010). Climate change is likely to have a greater effect on raptor populations in the Arctic than effects from the Project, but Project-effects are likely to be additive to effects from climate change (A. Franke, 2012, University of Alberta, pers. comm.).

Climate change is also expected to increase the frequency and intensity of wildfire and enable plants to expand their ranges northward. As fires increase and plants move north, bird species that have historically nested in more southern environments may also expand their ranges. These range expansions may increase competition for nesting sites and forage resources with bird species that have historically nested in Arctic areas.

Increased temperatures may lead to earlier plant and insect emergence (Parmesan 2006; Herms 2012). Bird migrations are thought to be mainly cued by changes in day length (Hagan et al. 1991). Therefore, as the climate becomes warmer, bird migrations may become out of sync with plant and insect emergence, which may lead to a decline in reproductive success (Strode 2003). Conversely, climate change is expected to increase the abundance and distribution of insects (Weladji and Holland 2003; Vors and Boyce 2009). Therefore, insectivorous birds may not be as negatively affected by climate change as herbivorous species.

6.7.12 Related Effects to People

From the early to mid-1900s, people in Rankin Inlet and Whale Cove supplemented their food supplies through ice fishing in the early spring. Ducks, and both snow and Canadian geese were also hunted in the spring, and goose and duck eggs were harvested (Volume 9, Section 9.3.1.3.1.2). Elders have commented that the area

around Meliadine Lake is a good goose and other waterfowl hunting area in the fall (Volume 9, Section (Appendix 9.3-A).

The decrease in the availability of birds for harvesting from direct and indirect effects from the Project is predicted to be within the range of baseline values. People that hunt in the RSA should not observe a change in the availability of birds due to effects from the Project, relative to current natural cycles in populations. Effects are expected to last from construction through perpetuity, but are not expected to be measureable at the population level.

In NU, bird species are managed mostly by controlling the hunting season for resident and non-resident hunters (Department of Environment 2012) or through bird migratory hunting regulations (Environment Canada 2012). The hunting rights of Aboriginal people in NU are based on traditional use and are different from those of other hunters. There is a general lack of interest in harvesting raptor species in NU (Wildlife Research Section 2007) and Traditional Knowledge in the region suggests that raptors are not hunted (FEIS Volume 9, Section 9.3 Traditional Activity and Knowledge).

With the development of AWAR, hunters would be able to make more use of vehicles to access areas in the RSA. However, there is currently access in this area through the use of snow machines in the winter months and ATVs in the summer months. Although, the development of the AWAR will increase the access into the RSA during the entire year, harvesting of birds would like continue to occur periodically during traditional and non-traditional hunting seasons.

Currently, the community of Rankin Inlet is estimated to harvest 300 birds each year (FEIS Volume 9, Section 9.3, Table 9.3-15) and harvesting pressure is unlikely to be a limiting factor for bird populations in the RSA. In addition, there are existing trails that can be used to access the RSA for harvesting of waterbirds and ptarmigan. Should harvesting on the AWAR reach a level of concern, the Department of Environment could enact regulations to control harvesting. As such, it is expected that the incremental and cumulative increase in the harvest of birds from the increased ease of access afforded by the AWAR will be within the range or approach the upper limits of baseline harvesting values.

6.7.13 Residual Impact Classification

6.7.13.1 Methods

The following criteria suggested in the Guidelines for the Project (NIRB 2012) are used to assess the residual impacts from the Project.

- direction or nature of the impacts;
- magnitude and complexity;
- geographic extent;
- frequency;
- duration;
- reversibility; and
- likelihood or probability of effects.

The term “effect”, as used in the effects analyses and residual effects summary, is regarded as an “impact” in the residual impact classification; therefore, all residual effects are discussed and classified in terms of impacts to birds in the residual impact classification.

For birds, the assessment and classification of residual impacts was based on the predicted cumulative changes from reference conditions through application of the Project and into the future case. All sources of information (i.e. existing and collected data, new analyses, existing publications, and IQ) were considered equally in the classification of residual impacts. The spatial boundary of the assessment for Project impacts is at the regional scale. The incremental effects from the Project relative to 2012 baseline conditions are also classified. Essentially, the only difference in the outcome of impact criteria between cumulative and incremental effects from the Project is in the magnitude and geographic extent of impacts. The magnitude for cumulative impacts involves changes from reference conditions through application of the Project and into the future case, while incremental impacts are based on changes from the Project relative to 2012 baseline values. Cumulative impacts from the Project and other developments influence the entire annual range of bird populations (i.e., regional scale). In contrast, the geographic extent of incremental impacts from the Project may have a local or regional influence on bird populations.

Effects statements are used to focus the analysis of changes to birds that are associated with one or more primary pathways. The residual effects summary (Section 6.7.9) presents a numerical assessment for criteria such as magnitude, geographic extent, duration, and frequency. From the summary of residual effects, pathways associated with each effects statement are then classified using scales (categorical values such negligible, low, or high) for each impact criterion (e.g., magnitude).

To provide transparency, the definitions for these scales were ecologically or logically based on birds. Although professional judgement is inevitable in some cases, a strong effort was made to classify impacts using scientific principles, supporting evidence, and IQ. The scale for the residual impact criteria for classifying effects from the Project are specifically defined for birds, and definitions for each criterion are provided in Table 6.7-39. Additional details on magnitude and complexity, duration, and geographic extent are provided below.

Table 6.7-39: Definitions of Criteria Used in the Residual Impact Classification of Pathways

Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Likelihood
Negative: less favourable relative to baseline values **Positive:** an improvement over baseline values or conditions	**Negligible:** no predicted detectable change from baseline values **Low:** impact is predicted to be within the range of baseline values **Moderate:** impact is predicted to be at or slightly exceeds the limits of baseline values **High:** impact is predicted to be beyond the upper or lower limit of baseline values so that there is likely a change of state from baseline conditions	**Local:** small-scale direct and indirect impacts from the Project (e.g., footprint, and dust deposition) **Regional:** the predicted maximum spatial extent of combined direct and indirect impacts from the Project that exceed local-scale effects (can include cumulative direct and indirect impacts from the Project and other developments at the regional scale) **Beyond Regional:** cumulative local and regional impacts from the Project and other developments extend beyond the regional scale	**Short-term:** impact is reversible at end of construction **Medium-term:** impact is reversible at end of closure **Long-term:** impact is reversible within a defined length of time beyond closure **Unknown**: impact may be reversible however the length of time cannot be defined **Permanent**: impact will last into perpetuity	**Isolated:** impact confined to a specific discrete period **Periodic:** impact occurs intermittently but repeatedly over the assessment period **Continuous:** impact will occur continually over the assessment period	**Reversible:** Impact will not result in a permanent change of state of the population compared to “similar” environments not influenced by the Project **Irreversible:** impact is not reversible (i.e., duration of impact is unknown or permanent)	**Unlikely:** the impact is likely to occur less than one in 100 years **Possible:** the impact will have at least one chance of occurring in the next 100 years **Likely:** the impact will have at least one chance of occurring in the next 10 years **Highly Likely:** the impact is very probable (100% chance) within a year

Magnitude and Complexity

Magnitude (i.e., intensity of the impact) for Project-specific (incremental) effects is scaled to the expected change from 2012 baseline conditions from application of the Project. Magnitude for cumulative effects is scaled to the expected quantified and/or qualified change from reference conditions (no development) through application of the Project and reasonably foreseeable developments. Complexity is the degree of intricacy relative to the baseline condition, and is a measure of the number of interconnected or interwoven components. The degree of complexity is incorporated within the assessment of magnitude. The interconnected components were assessed by examining the change relative to baseline for all the interconnected components. Baseline conditions represent the historical and current environmental selection pressures that have shaped the observed patterns in birds. Environmental selection pressures include both natural (e.g., weather, predation) and human-related factors (e.g., mineral development), with more than one pressure at any time. Relative to ecological time and space, baseline conditions are in a constant state of change. Thus, baseline conditions can be thought of as a distribution of probability values, and the location of the value (e.g., middle or ends of the distribution) is dependent on which environmental factors are currently playing a key role in the state of the bird populations at a particular moment in time.

The approach used to classify the magnitude of changes in measurement endpoints (and related impacts) was based on the degree of complexity attached to the measurement endpoint, scientific literature and professional opinion, and incorporated conservatism. The definition of magnitude provided in Table 6.7-39 is applicable for more qualitative results (e.g., impacts on bird movement and avoidance behaviour, and related impacts to people). For quantitative analyses and results (e.g., loss and fragmentation of habitat, and changes to habitat suitability), the following definition for magnitude is applied:

- negligible: less than a 1% change due to the Project relative to baseline values;
- low: 1 to 10% change due to the Project relative to baseline values;
- moderate: greater than 10 to 20% change due to the Project relative to baseline values; and
- high: more than 20% change due to the Project relative to baseline values.

The proposed scale is consistent with the 20% rule for the severity of effects from chemical exposure on varying spatial scales of ecological effects (i.e., a 20% change in a measurement endpoint constitutes an ecological effect) (Suter et al. 1995; Munkittrick et al. 2009). The scale is also consistent with and below thresholds identified by empirical and theoretical work on the relationship between loss of suitable habitat and the likelihood of population decline (Andrén 1994, 1999; Fahrig 1997; Mönkkönen and Reunanen 1999; Flather and Bevers 2002). These studies suggested that critical thresholds for changes in rates of population parameters in non-tropical bird and mammal species occur between 10% and 60% of original habitat. In a recent review, Swift and Hannon (2010) found that most empirical studies demonstrated negative effects on insects, plants, birds, and mammals when the amount of habitat lost from the landscape was greater than 70%.

Geographic Extent

Geographic extent is the area or distance influenced by the direct and indirect effects from the Project, and is different from the spatial boundary (i.e., study area) used for the effects analysis and impact assessment. The study area for the effects analysis represents the maximum area used for the assessment and is related to the spatial distribution and movement (i.e., population boundary) of birds.

Alternatively, the geographic extent of impacts can occur on a number of scales within the spatial boundary of the assessment. Geographic extent for classifying impacts is based on three scales: local, regional, and beyond regional. Local-scale impacts mostly represent incremental (Project-specific) changes to bird population size and distribution that are directly related to the Project footprint and activities (e.g., physical disturbance to vegetation [habitat], and mortality of individual animals). Local impacts may also include small-scale indirect effects such as dust deposition on vegetation and sensory disturbance.

Changes at the regional scale are largely associated with the predicted maximum extent of incremental impacts from the Project on birds, such as changes to habitat quality that occur beyond the local scale (i.e., more than 1 km from the Project). Changes at the regional scale also can result from the incremental and cumulative impacts from the Project and other developments on bird populations. Cumulative impacts from the Project and other developments on traditional and non-traditional use of birds also occur at the regional scale. Beyond regional scale effects are associated with cumulative changes to populations that range over very large areas (e.g., migratory birds).

Duration

Duration has 2 components. It is the amount of time between the start and end of a Project activity plus the time required for the impact to be reversible.

By definition, impacts that are short-term, medium-term, or long-term in duration are reversible. Project activities may end at closure, but the impact on birds may continue beyond Project closure. Some impacts may be reversible soon after removal of the stressor, such as effects on air quality from equipment operation (a medium-term impact).

For birds, the amount of time required for the impact to be reversed (i.e., duration of the effect) is presented in context of the number of life spans that bird may be influenced. The anticipated duration of effects on birds are then used to determine the number of human generations that may be affected by the related changes to traditional and non-traditional land use practices (e.g., harvesting). In this manner, the impact assessment links the duration of Project impacts on birds to the amount of time that human use of ecological resources may be influenced.

For impacts that are permanent, the duration of the effect is determined to be irreversible. An example of an irreversible impact includes the localized loss of vegetation and habitat types due to the open pits and the waste rock storage facilities.

6.7.13.2 Results

Incremental loss and fragmentation of habitat from the Project are predicted to have a negative and negligible to low magnitude effect on upland bird and waterbird populations in the RSA (Table 6.7-40). Incremental habitat loss from the Project footprint is expected to have a moderate magnitude effect on raptor populations. However it is not likely that the total amount of steep cliff habitat that is predicted to be removed by the Project will be entirely used by raptors for nesting because territoriality and other factors influence where raptors nest. Habitat loss from the Project is expected to be a local scale effect but fragmentation is a landscape-scale process and so is expected to have effects on bird populations at the regional scale. Progressive reclamation is expected to be completed throughout the operation of the Project and effects from these reclaimed areas are expected to be

reversed within 5 years following closure (long-term). Cumulative habitat loss and fragmentation from previous, existing, and future developments in the RSA are expected to have negative effects on bird populations that are negligible to moderate in magnitude. Cumulative effects are expected to be regional in geographic extent.

Permanent changes to bird habitat from open pits, and the tailings and waste rock storage facilities are expected to have negative and negligible magnitude effects on bird populations in the RSA (Table 6.7-40). Incremental Project effects from permanent habitat loss are expected to be local in geographic extent, while effects from permanent habitat fragmentation are expected to be regional in extent. As the open pits, and tailings and the waste rock facilities are expected to be permanent features on the landscape after Project decommissioning and closure, effects to bird populations are predicted to be long term. Cumulative effects from habitat loss and fragmentation from previous, existing, and future developments are predicted to be negligible to low in magnitude and regional in geographic extent.

Sensory disturbance from the Project is predicted to have a high magnitude effect on raptor populations in the LSA (Table 6.7-40). Indirect effects from the Project are expected to be local in geographic extent. Although effects to steep cliff habitat could not be determined at the RSA scale, cumulative indirect effects from previous, existing, and future developments are expected to have low magnitude effects on raptor populations. Cumulative sensory effects are expected to be regional in extent. Sensory effects from the Project are predicted to be reversible within a few years following closure (long term). Sensory effects from the Project are expected to be continuous from construction through active closure.

Sensory disturbance from the Project is predicted to have negligible to low magnitude effects on upland bird and waterbird populations in the RSA (Table 6.7-40). Indirect effects from the Project are expected to be local in geographic extent. Cumulative indirect effects from previous, existing, and future developments are predicted to have low to moderate magnitude effects on upland bird and waterbird populations. Cumulative sensory effects are expected to be regional in extent. Sensory effects from the Project are predicted to be reversible within a few years following closure (long term). Sensory effects from the Project are expected to be continuous from construction through active closure.

Changes in the availability of birds for traditional and non-traditional use from the development of the Project are expected to have negative effects on bird populations that are negligible to low in magnitude but regional in geographic extent (Table 6.7-40). Cumulative effects from changes in the availability of birds for human use are predicted to be low in magnitude and regional in geographic extent. Effects are expected to be reversible in the long term. Effects are expected to occur periodically during traditional and non-traditional hunting seasons.

The duration of the impacts to birds is expected to last for 20 to 25 years, which is equivalent to between 5 and 13 bird life spans (assuming average life span of between 2 and 5 years [Birds of North American Online 2012]).

Table 6.7-40: Summary of Residual Impact Classification on Abundance and Distribution of Bird Populations and Related Effects to People

Effects Pathway	Direction	Magnitude		Geographic Extent		Duration	Frequency	Reversibility	Likelihood
		Incremental	Cumulative	Incremental	Cumulative				
Raptors									
Direct loss and fragmentation of bird habitat from the physical footprint of Project infrastructure from construction through active closure	negative	moderate	low to moderate	regional	regional	long-term	continuous	reversible	highly likely
Upland Birds and Waterbirds									
Direct loss and fragmentation of bird habitat from the physical footprint of Project infrastructure from construction through active closure	negative	negligible to low	negligible to low	regional	regional	long-term	continuous	reversible	highly likely
Raptors									
Permanent changes in bird habitat following closure of the mine site and supporting infrastructure	negative	moderate	low to moderate	regional	regional	long-term	continuous	reversible	highly likely
Upland Birds and Waterbirds									
Permanent changes in bird habitat following closure of the mine site and supporting infrastructure	negative	negligible	negligible	regional	regional	long-term	continuous	reversible	highly likely
Raptors									
Sensory disturbance can change the amount of different quality habitats, and alter bird movement and avoidance behaviour (distribution)	negative	high	low	local	regional	long-term	continuous	reversible	likely

Table 6.7-40: Summary of Residual Impact Classification on Abundance and Distribution of Bird Populations and Related Effects to People (continued)

Effects Pathway	Direction	Magnitude		Geographic Extent		Duration	Frequency	Reversibility	Likelihood
		Incremental	Cumulative	Incremental	Cumulative				
Upland Birds									
Sensory disturbance can change the amount of different quality habitats, and alter bird movement and avoidance behaviour (distribution)	negative	negligible to low	low to moderate	local	regional	long-term	continuous	reversible	likely
Waterbirds									
Sensory disturbance can change the amount of different quality habitats, and alter bird movement and avoidance behaviour (distribution)	negative	negligible to low	low	local	regional	long-term	continuous	reversible	likely
Upland Birds, Waterbirds, and Raptors									
Effects on population size and distribution changes the availability of birds for traditional and non-traditional use	negative	negligible	low	regional	regional	long-term	continuous	reversible	likely

6.7.14 Environmental Significance

6.7.14.1 Methods

The evaluation of significance for biophysical VECs considers the entire set of pathways that influence a particular assessment endpoint. The relative contribution of each pathway is then used to determine the significance of the Project on assessment endpoints. For example, a pathway with a high magnitude, large geographic extent, and long-term duration would be given more weight in determining significance relative to pathways with smaller scale effects. The pathways that are predicted to have the greatest influence on changes to assessment endpoints are assumed to contribute the most to the determination of environmental significance.

Quantitative and qualitative key factors were considered in the determination of environmental significance as follows:

- results from the residual impact classification of primary pathways;
  - magnitude, geographic extent, and duration (which includes reversibility) of the impact were the principal criteria used, with frequency and likelihood as modifiers; and
  - professional judgment and ecological principles, such as resilience, were used to predict the duration and associated reversibility of impacts.
- ecological or socio-economic context/value;
- historical, cultural, and archaeological significance of the geographic area likely to be affected by the Project; and
- value attached to the individual VEC, based on consultation with potentially affected communities and relevant individuals and organizations.

Environmental significance is used to identify predicted impacts that have sufficient magnitude, duration, and geographic extent to cause fundamental changes to birds. The following definitions are used for assessing the significance of impacts on the persistence of birds, and the associated continued opportunity for traditional use of birds.

- **Not significant** – impacts are measurable at the individual level, and strong enough to be detectable at the population level, but are not likely to decrease resilience and increase the risk to population maintenance and opportunities for traditional and non-traditional use.
- **Significant** – impacts are measurable at the population level and likely to decrease resilience and increase the risk to population maintenance and impact opportunities for traditional and non-traditional use. A number of high magnitude and irreversible impacts at the population level (regional scale) would likely be significant.

6.7.14.2 Results

Project pathways influencing bird populations were determined to be negligible to high, local to regional in geographic extent, and long-term in duration (Table 6.7-40). The range in scales in the residual impact classification reflected the number of pathways and related mechanisms that were predicted to affect bird species, particularly raptors. Pathways included direct impacts related to habitat quantity and fragmentation, and indirect impacts from the Project on the quality of habitat. The probability of impacts occurring is predicted to be likely to highly likely for Project pathways (Table 6.7-40), which does not change the expected magnitude and duration (or environmental significance). The frequency of impacts is anticipated to occur continuously throughout construction and operation.

The incremental and cumulative impacts from the Project are predicted to not significantly influence the maintenance of the abundance and distribution of bird populations. The scale of impacts from the Project pathways, independently or combined, are anticipated not to be large enough to cause irreversible changes at the population level, nor decrease the resilience of the VECs. For example, long-term pathways, such as direct habitat loss, are associated with impacts that have a negligible to moderate magnitude at the regional scale. Impacts from sensory disturbance which can change habitat quality have a low to moderate impact at the regional scale but are reversible. Thus, the Project is expected to only impact individuals that move through and use habitats within 1 km of the development footprint. Bird densities in the RSA were relatively low and the Project should only affect a small portion of waterbird, upland bird, and raptor populations.

The incremental changes to the quantity, quality, and spatial distribution of habitats should not have a significant impact on the structure and function of populations and communities in the ecosystem relative to natural factors occurring over the same period of time and space. Consequently, the Project should not have a significant adverse impact on the continued opportunity for traditional and non-traditional use of birds in the region.

6.7.15 Uncertainty

The purpose of the uncertainty section is to identify the key sources of uncertainty in the impact assessment and to discuss how uncertainty has been addressed to increase the level of confidence that impacts are not worse than predicted. Confidence in the assessment of environmental significance is related to the following elements:

- adequacy of baseline data for understanding current conditions and future changes unrelated to the Project (e.g., extent of future developments, climate change, catastrophic events);
- model inputs (e.g., ZOI and disturbance coefficients from developments);
- understanding of Project-related impacts on complex ecosystems that contain interactions across different scales of time and space (e.g., exactly how the Project will influence raptors); and
- knowledge of the effectiveness of the environmental design features and mitigation for reducing or removing impacts (e.g., revegetation of bird habitat).

Ecosystems are complex, characterized by interactions across multiple scales, nonlinearity, self-organization, and emergent properties (Boyce 1992; Holling 1992; Levin 1998; Wu and Marceau 2002). These characteristics can confound our understanding of ecosystem processes and limit our capacity to make predictions on, for

example, population sizes. One of the challenges is to aggregate and simplify available ecological knowledge, retain what is essential and disregard that which is not essential at the particular scale of interest.

A critical component of this assessment was to link spatial patterns of habitat on the landscape to the abundance and distribution of birds. The combined use of fragmentation statistics and conservative estimates of sensory disturbance effects should limit imprecision of predictions. In other words, there should be limited uncertainty in predictions of no effects (due to the Project) on abundance and distribution of VECs because the correlative relationships with disturbance have been exaggerated.

In this assessment, there is uncertainty surrounding the effects to raptors. Although 50 potential raptor nesting sites were located in the RSA during baseline studies and using information provided by the GN, it is unlikely that all of these potential sites are actual nest sites (A. Franke, University of Alberta, 2012, pers. comm.). Similarly, the incremental and cumulative indirect effects analysis for raptors could not be completed at the RSA scale because some data were not available at the regional scale. Therefore, the relative amount of habitat that is predicted to be affected by sensory effects could not be determined. Although there is predicted to be a large amount of steep cliff habitat influenced by sensory effects in the LSA, this effect is not likely to be as large when put into context of the RSA.

Like all scientific results and inferences, residual impact predictions must be tempered with uncertainty associated with the data and the current knowledge of the system. It is anticipated that the baseline data is moderately sufficient for understanding current conditions, and that there is a moderate level of understanding of Project-related impacts on the ecosystem. However, forecasting a future that may be outside the range of observable baseline environmental conditions is clearly challenging (because of climate change for example; Walther et al. 2002). Thus, there is less certainty in long-term predictions of reversibility (e.g., over periods extending beyond 100 years). However, there is a high level of confidence that the regional landscape will be different with or without the Project in future decades.

6.7.16 Monitoring and Follow-Up

Upon approval of the Project, a TEMMP (SD 6-4) will be implemented in part to limit effects to bird and bird habitat, determine the effectiveness of mitigation, and test impact predictions. The principal goal of the Program is to provide information required for the Project to adaptively manage the Project to protect the environment including birds and bird habitat. In addition, the TEMMP will be designed to provide a process for regulators, communities, and other people interested in the Project to participate in the development and review of bird effects mitigation and monitoring.

A specific objective of TEMMP is cooperating with the Arctic Raptor Project to locate and monitor active raptor nests in the LSA and RSA. Data collected during this monitoring program will be used to determine, if necessary, nest-specific mitigations in consultation with the GN.

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APPENDIX 6.3-A

Terrain Unit Descriptions and Interpretations

Table 6.3-A-1: Terrain Unit Descriptions and Interpretations

New Terrain Number	Terrain Type	Terrain Description	Ground Ice Conditions/ Soil Drainage[a]	Typical Active Layer Processes	Thaw Stability	Freezing Stability	Frozen Stability	Potential Need for Permafrost Design and Construction Methods	Hazard for Thaw and/or Freezing Induced Displacement[b]/ Aggregate Suitability
1	sWr to gWr likely over Mb	Relict beach ridges likely overlying till, occasionally with minor areas of bedrock or weathered (frost-shattered) bedrock.	Limited, but may occur at depth. W	Stable	Stable Minor thaw settlement possible.	Stable Minor heave and uplift at ground surface.	Stable Frost creep may occur under loading	L-M	L Good to adequate variable deposit thickness
2A	sWrbvt to gWrbvt likely over Mb	Relict beach deposits of varying depth likely overlying till and locally weathered or frost-shattered bedrock and/or bedrock. May form blankets, single or multiple terraces, beach platforms, or flights of low, subdued beach ridges.	Limited near surface, but may occur at depth. W/MW	Stable	Stable Minor thaw settlement possible.	Stable to Minor heave and uplift at ground surface.	Stable Frost creep may occur under loading	L-M	L Good to adequate may be relatively shallow
2B	sWbvt to gWbvt likely over Mb	Relict beach deposits of varying depth likely overlying till and locally weathered (frost-shattered) bedrock and/or bedrock. May include minor areas of washed till.	Limited near surface, likely at depth. MW/I.	Frost Heave Frost Sorting Frost Jacking Thaw Settlement	Stable Minor thaw settlement possible.	Stable to Minor heave and uplift at ground surface.	Stable Frost creep may occur under loading	M	L-M Adequate, ground water may be encountered near surface
2C	sWbvt to gWbvt likely over Mb	As above	Possible near surface, likely at depth. I or I/P	Frost heave Frost sorting Frost Jacking Thaw settlement	Thaw settlement likely under loading	Frost heave may result in uplift of ground surface	Frost creep may occur under loading	M-H	M Poor due to high water table, likely overlying till
2D	sWbvt to gWbvt likely over Mb	As above	Limited near surface, but likely at depth. P or P/I	Frost heave Frost sorting Frost Jacking Thaw settlement	Thaw settlement likely under loading	Frost heave may result in uplift of ground surface	Frost creep may occur under loading	M-H	M-H Poor due to high water table, likely overlying fine-textured till
2E	sWbvt to gWbvt likely over Mb	As above.	Possible near surface and likely at depth. P/VP or VP/P	Frost heave Frost sorting Frost Jacking Thaw settlement	Thaw settlement likely under loading	Frost heave may result in uplift of ground surface	Frost creep may occur under loading	M-H	H Poor due to high water table, likely overlying fine-textured till

Table 6.3-A-1: Terrain Unit Descriptions and Interpretations (continued)

New Terrain Number	Terrain Type	Terrain Description	Ground Ice Conditions/ Soil Drainage[a]	Typical Active Layer Processes	Thaw Stability	Freezing Stability	Frozen Stability	Potential Need for Permafrost Design and Construction Methods	Hazard for Thaw and/or Freezing Induced Displacement[b]/ Aggregate Suitability
3A	sWlp to gWlp	Sandy to gravelly deltaic terrace and or ridges. May include moderately to steeply sloping areas Locally may include beach deposits or wave washed morainal surfaces.	Limited near surface, but may occur at depth. W	Stable	Stable Minor thaw settlement possible.	Stable Minor heave and uplift at ground surface.	Stable Frost creep may occur under loading	L-M	L Good to adequate may be relatively shallow
3B	sWlp to gWlp	Sandy to gravelly deltaic levels and/or plains, locally undulating. May include gently to moderately sloping areas. Locally may include beach deposits and/or wave washed morainal surfaces.	Limited near surface, but may occur at depth. W/MW	Stable	Stable Minor thaw settlement possible.	Stable Minor heave and uplift at ground surface.	Stable Frost creep may occur under loading	M	L-M Good to adequate may be relatively shallow
3C	sWlp to gWlp	Sandy to gravelly deltaic level and/or plain. Shallow, discontinuous organic veneers may be present locally. Locally may include beach deposits.	Limited near surface, but likely at depth. I/P	Frost heave Frost sorting Frost Jacking Thaw settlement	Thaw settlement likely under loading	Frost heave may result in uplift of ground surface	Frost creep may occur under loading	M-H	M Poor
3D	sWlp to gWlp	Sandy to gravelly deltaic level and/or plain. Shallow, discontinuous organic veneers may be present locally. Locally may include beach or stream deposits.	Limited near surface, but likely at depth. P, but locally may be I or VP	Frost heave Frost sorting Frost Jacking Thaw settlement	Thaw settlement likely under loading	Frost heave may result in uplift of ground surface	Frost creep may occur under loading	M-H	H Poor
4A	Wbv/Mbv-W to Mbv/Wbv-W	Mixtures of sandy to gravelly marine sediments and sandy to gravelly marine washed tills. The washed till surface often comprises a sandy to gravelly material but locally may comprise a silty fine sandy material. In either case these materials likely overlie finer textured till.	Limited near surface, but likely at depth. W/MW	Frost creep Frost heave Frost sorting Frost Jacking Thaw settlement	Minor to moderate thaw settlement possible under loading	Frost heave may result in some uplift of ground surface	Frost creep may occur under loading	M	L- M Adequate to poor, likely quite shallow over fine-textured till

Table 6.3-A-1: Terrain Unit Descriptions and Interpretations (continued)

New Terrain Number	Terrain Type	Terrain Description	Ground Ice Conditions/ Soil Drainage[a]	Typical Active Layer Processes	Thaw Stability	Freezing Stability	Frozen Stability	Potential Need for Permafrost Design and Construction Methods	Hazard for Thaw and/or Freezing Induced Displacement[b]/ Aggregate Suitability
4B	Wbv/Mbv-W to Mbv/Wbv-W	As above	Limited near surface, but likely to occur at depth MW/I or I/MW or I	Frost creep Frost heave Frost sorting Frost Jacking Thaw settlement	Minor to moderate thaw settlement possible under loading	Frost heave may result in some uplift of ground surface	Frost creep may occur under loading	M-H	M Adequate to poor, likely quite shallow over fine-textured till
4C	Wbv/Mbv-W to Mbv/Wbv-W	As above	Likely present I/P, P/I, P	Frost creep Frost heave Frost sorting Frost Jacking Thaw settlement	Thaw settlement likely under loading	Frost heave may result in uplift of ground surface	Frost creep may occur under loading	M-H	M-H Poor, likely overlying fine-textued till.
4D	Wbv/Mbv-W to Mbv/Wbv-W	As above	Likely present P/VP. VP/P	Frost creep Frost heave Frost sorting Frost Jacking Thaw settlement	Thaw settlement likely under loading	Frost heave may result in uplift of ground surface	Frost creep may occur under loading	M-H	H-VH Poor, likely overlying fine-textued till
5A	Mbv-W and/or Mb-W	Blankets and/or veneers of marine washed, gravelly to lesser sandy till, or marine sands and/or gravels overlying till. Occasional very minor areas of weathered bedrock and/or very minor bedrock outcrops. Likely in a high energy shoreline environment for a period of time.	Limited near surface, but likely at depth W-MW	Frost creep Frost heave Frost sorting Frost Jacking Thaw settlement	Thaw settlement likely under loading	Frost heave may result in uplift of ground surface	Frost creep may occur under loading	M-H	L- M Adequate to poor. Likely shallow veneers over fine-textured till.
5B	Mbv-W and/or Mb-W	As above	Likely present MW/I	Frost creep Frost heave Frost sorting Frost Jacking Thaw settlement	Thaw settlement likely under loading	Frost heave may result in uplift of ground surface	Frost creep may occur under loading	M-H	M Adequate to poor. Likely quite shallow over fine-textured till.

Table 6.3-A-1: Terrain Unit Descriptions and Interpretations (continued)

New Terrain Number	Terrain Type	Terrain Description	Ground Ice Conditions/ Soil Drainage[a]	Typical Active Layer Processes	Thaw Stability	Freezing Stability	Frozen Stability	Potential Need for Permafrost Design and Construction Methods	Hazard for Thaw and/or Freezing Induced Displacement[b]/ Aggregate Suitability
5C	Mbv-W and/or Mb-W	Blankets of wave washed, silty fine sandy to fine sandy silty till, and/or marine sands or gravels overlying till. Occasional very minor areas of weathered bedrock, rarely with very minor bedrock outcrops. Shallow, discontinuous organic veneers may be present These areas were likely in a near-shore environment for a period of time (*i.e.*, below the low-tide line).	Likely present I/P	Frost creep Frost heave Frost sorting Frost Jacking Thaw settlement	Thaw settlement likely under loading	Frost heave may result in uplift of ground surface	Frost creep may occur under loading	M-H	M-H Poor, likely shallow veneers overlying fine-textured till.
5D	Mbv-W and/or Mb-W	As above.	Likely present/ P/I	Frost creep Frost heave Frost sorting Thaw settlement	Thaw settlement likely under loading.	Frost heave will result in uplift of ground surface	Frost creep may occur under loading	M-H	H Poor, likely shallow veneers overlying fine-textured till.
5E	Mbv-W and/or Mb-W	As above.	Likely present P, P//I	Frost creep Frost heave Frost sorting Frost Jacking Thaw settlement	Thaw settlement likely under loading.	Frost heave will result in uplift of ground surface	Frost creep may occur under loading	M-H	H-VH Poor, likely shallow veneers overlying fine-textured till.
5F	Mbv-W and/or Mb-W	Blankets and veneers of marine washed till and/or marine sands or gravels overlying till. Lag boulders often present, shallow, discontinuous organic veneers usually present. Likely a near-shore environment. In some areas washing may have occurred in fresh water.	Likely present P/VP or VP/P small ponds or streams often present.	Frost creep Frost heave Frost sorting Frost Jacking Thaw settlement	Thaw settlement likely under loading.	Frost heave may result in uplift of ground surface	Frost creep may occur under loading	M-H	VH Poor

Table 6.3-A-1: Terrain Unit Descriptions and Interpretations (continued)

New Terrain Number	Terrain Type	Terrain Description	Ground Ice Conditions/ Soil Drainage[a]	Typical Active Layer Processes	Thaw Stability	Freezing Stability	Frozen Stability	Potential Need for Permafrost Design and Construction Methods	Hazard for Thaw and/or Freezing Induced Displacement[b]/ Aggregate Suitability
6A	F^{G}r-W	Gravelly glaciofluvial ridges (eskers) washed or altered by wave action.	Limited, but may occur at depth. W/MW	Stable	Stable Minor thaw settlement possible.	Stable Minor heave and uplift at ground surface.	Stable Frost creep may occur under loading	L-M	L Good to adequate
6B	F^{G}bs-W	Sandy to gravelly glaciofluvial slopes washed or altered by marine wave action. Slope gradients can range from gently to steeply sloping.	Limited, but may occur at depth. W/MW	Stable	Stable Minor thaw settlement possible.	Stable Minor heave and uplift at ground surface.	Stable Frost creep may occur under loading	L-M	L Good to adequate
7A	Flt	Gravelly fluvial levels and or terraces, occasionally flooded.	Limited, but may occur at depth. W/MW	Stable	Stable Minor thaw settlement possible.	Stable Minor heave and uplift at ground surface.	Stable Frost creep may occur under loading	L-M	L Not applicable.
7B	gFl-sFl	Gravelly fluvial levels and or terraces. Subject to periodic flooding and/or tidal inundation.	Likely present I or I//P	Frost heave Frost sorting Frost Jacking Thaw settlement	Thaw settlement likely under loading	Frost heave may result in uplift of ground surface	Frost creep may occur under loading	M-H	M Not applicable.
8	arDbv	Veneers and blankets of weathered (frost-shattered) bedrock and occasionally minor washed till or marine veneers or minor bedrock outcrops.	Limited W, locally MW or I	Frost Shattering Frost Wedging	Stable	Stable to Minor Instability	Stable	L	L Adequate to poor with bedrock likely at shallow depths
9A	Dbv/Mbv/R Dbv/Wbv/R	Veneers and/or blankets of weathered bedrock with lesser veneers and/or blankets of washed till or marine sands and gravels Minor bedrock outcrops.	Limited, but may occur at depth in deeper soils W/MW locally may be I	Frost Shattering Frost Wedging	Stable	Stable to Minor Instability	Stable	L-M	L-M Bedrock at or near surface
9B	Dbv/Mbv/R Dbv/Wbv/R	As above.	Likely present MW-I and/or I-P	Frost Shattering Frost Wedging Frost Jacking Thaw settlement	Stable Thaw settlement possible.	Stable to Minor Instability	Frost creep may occur under loading	L-M	M Bedrock at or near surface

Table 6.3-A-1: Terrain Unit Descriptions and Interpretations (continued)

New Terrain Number	Terrain Type	Terrain Description	Ground Ice Conditions/ Soil Drainage[a]	Typical Active Layer Processes	Thaw Stability	Freezing Stability	Frozen Stability	Potential Need for Permafrost Design and Construction Methods	Hazard for Thaw and/or Freezing Induced Displacement[b]/ Aggregate Suitability
10	Dbv/Wv//R or Dbv/Mv//R	Dominated by areas of weathered bedrock with lesser discontinuous veneers or blankets of washed till or sandy or gravelly marine sediments. Very minor bedrock outcrops,	Limited, but may occur at depth in deeper soils W/MW, locally may be I	Frost Shattering Frost Wedging	Stable	Stable to Minor Instability	Stable	L	L-M Bedrock at or near surface
11	Rri//Dv	Irregular bedrock outcrops and/or ridges and minor areas of weathered bedrock and/or colluvium.	Unlikely R/W	Frost Shattering Frost Wedging	Stable	Stable	Stable	L	L Bedrock at or near surface
12A	Mbv/Dbv or Wbv/Dbv or Mbv•Wbv/Dbv	Blankets and veneers of marine washed till and/or marine sands and or gravels and locally with weathered bedrock occasionally with minor bedrock outcrops	Limited, likely at depth in deeper soils W/MW	Frost Shattering Frost Wedging	Stable	Stable to Minor Instability	Stable	L-M	L-M Bedrock may be near surface
12B	Mbv/Dbv or Wbv/Dbv or Mbv•Wbv/Dbv	Blankets and veneers of marine washed till and/or marine sands and or gravels and locally with weathered bedrock occasionally with minor bedrock outcrops	Likely present MW/I or I/MW	Frost Shattering Frost Wedging Frost Jacking Thaw settlement	Stable Thaw settlement possible.	Stable to Minor Instability	Frost creep may occur under loading	L-M	M Bedrock may be near surface
12C	Mbv/Dbv or Wbv/Dbv or Mbv•Wbv/Dbv	Blankets and veneers of marine washed till and/or marine sands and or gravels and locally with weathered bedrock occasionally with minor bedrock outcrops	Likely present I/P or P/I	Frost Shattering Frost Wedging Frost Jacking Thaw settlement	Stable Thaw settlement possible.	Stable to Minor Instability	Frost creep may occur under loading	M-H	H Bedrock may be near surface

[a] Soil drainage class R=rapidly, W=well, MW=moderately well, I=imperfectly, P=poorly, VP=very poorly., Slashes (/) indicate dominance as for terrain symbols

[b] Note that the hazard ratings for thaw and freezing induced displacement are generalized interpretations. Conditions may vary substantively across map units. For example, bedrock dominated areas containing areas of weathered bedrock or washed till are classified as a low hazard but may contain localized areas with a moderate or high displacement hazard. Assume various periglacial and/or permafrost processes are active on all terrain types

APPENDIX 6.3-B

Terrain Classification Codes and Terminology

April 2014
Report No. Doc 288-1314280007 Ver. 0

Terrain Classification Legend[1]

Table 6.3-B-1: Texture – Terrain Classification

Symbol	Name	Size (mm)	Other Characteristics
a	blocks	>256	angular particles
b	boulders	>256	rounded & subrounded particles
k	cobble	64-256	rounded & subrounded particles
p	pebbles	2-64	rounded & subrounded particles
s	sand	2-.062	
z	silt	.062-.002	
c	clay	<.002	
d	mixed fragments	>2	mix of rounded and angular particles
g	gravel	>2	mix of boulders, cobbles and pebbles
x	angular fragments	>2	mix of rubble and blocks
r	rubble	2-256	angular particles
m	mud	<.062	mix of clay and silt
y	shells	-	shells or shell fragments
e	fibric	well-preserved fibre: (40%) identifies after rubbing	
u	mesic	intermediate decomposition between fibric and mesic	
h	humic	decomposed organic material; (10%) identified after rubbing	

Table 6.3-B-2: Deliminters – Terrain Classification

Symbol	Name	Definition
•	bullet	components are approximately equal
/	single slash	approximately 60/40 component in front is dominant
//	double slash	approximately 80//20 component in front considerably more extensive

[1] Howes, D.E., and E. Kenk. 1997. Terrain Classification System for British Columbia (Revised Edition), Ministry of Environment, Ministry of Crown Lands, Victoria, BC, Canada.

Table 6.3-B-3: Surficial Materials – Terrain Classification

Symbol	Name	Assumed Status of Formative Process	Description
A	anthropogenic	(A)	Man-made or man-modified material
C	colluvial	(A)	Products of mass wastage
D	weathered rock	(A)	In situ bedrock
E	eolian	(I)	Materials deposited by wind action
F	fluvial	(I)	River deposits
F^G	glaciofluvial	(I)	Fluvial materials deposited by meltwater streams
I	ice	(A)	Permanent snow; glaciers and icefields
L	lacustrine	(I)	Lake sediments: includes littoral deposits
L^G	glaciolacustrine	(I)	Sediments deposited in glacial lakes
M	morainal	(I)	Material deposited directly by glaciers
O	organic	(A)	Accumulation/decay of vegetative matter
R	bedrock	(-)	Outcrops/rocks covered by less than 10 cm
U	undifferentiated	(-)	Layered sequence three materials or more
V	volcanic	(I)	Unconsolidated pyroclastic sediments
W	marine	(I)	Marine sediments: includes littoral deposits
W^G	glaciomarine	(I)	Sediments of glacial origin deposited in a marine environment

Table 6.3-B-4: Qualifiiers – Terrain Classification

Symbol	Name	Description
G	glacial	Used to qualify surficial material where there is evidence that glacier ice affected the mode of deposition of material
A	active	Used to qualify surficial material and geomorphological processes with regard to their current state of activity
I	inactive	

Table 6.3-B-5: Surface Expressions – Terrain Classification

Symbol	Name	Description
a	moderate slope	Unidirectional surface: 16 to 26°
b	blanket	A mantle of unconsolidated materials: >1 m thick
c	cone	A cone or sector of a cone: >15°
d	depression	A sharply demarked hollow
f	fan	A sector of a cone: up to 15°
h	hummocky	Hillocks and hollows, irregular plan: 15 to 35°
j	gentle slope	Unidirectional surface: 4 to 15°
k	moderately steep	Unidirectional surface 27 to 35°
m	rolling	Elongate hillocks: parallel in plan: 3 to 15°
p	plain	Unidirectional surface: 0 to 3 °
r	ridged	Elongated hillocks: parallel in plan: 15 to 35°
s	steep	Steep slopes: >35°
t	terraced	Step like topography
u	undulating	Hillocks and hollows: irregular in plan: 0 to 15°
v	veneer	Mantle of unconsolidated material: 10 cm to 1 m thick
w	mantle of variable thickness	Surficial material of variable thickness: (0 to about 3 m)
x	thin veneer	Similar to veneer (2-20 cm thick)

Table 6.3-B-6: Geomorphological Processes – Terrain Classification

Symbol	Name	Assumed Status of Formative Process	Description
A	avalanches	(A)	Terrain modified by snow avalanches
B	braiding	(A)	Diverging/converging channels: unvegetated bars
C	cryoturbation	(A)	Sediments modifies by frost heaving and churning
D	deflation	(A)	removal of sand and silt by wind action
E	channelled	(I)	channel formation by glacial meltwater
F	slow mass movement	(A)	slow down-slope movement of masses of cohesive or non-cohesive material and/or bedrock
H	kettled	(I)	depressions due to the melting of buried glacier ice
I	irregular channel	(A)	a single, clearly defined main channel displaying irregular turns and bends
J	anastamosing channel	(A)	A channel zone where channels diverge and converge around vegetated islands
K	karst	(A)	Processes associated with the solution of carbonates
L	surface seepage	(A)	Abundant surface seepage
M	meandering channels	(A)	Channels characterized by regular patterns of bends with uniformed amplitude and wave length
N	nivation	(A)	Erosion beneath and along the margin of snow patches
P	piping	(A)	subterranean erosion by flowing water
R	rapid mass movement	(A)	rapid downslope movement of dry, moist or saturated debris
S	solifluction	(A)	slow downslope movement of saturated overburden across a frozen or otherwise impermeable substrate
U	inundation	(A)	Seasonally under water due to high water table
V	gully erosion	(A)	Parellel/subparallel ravines due to erosion by various processes
W	washing	(A)	removal of fines by waves and running water
X	permafrost	(A)	Processes controlled by the presence of permafrost
Z	periglacial processes	(A)	Solifluction, cryoturbation and nivation processes occurring within a single unit

APPENDIX 6.3-C

Terrain Type Map Unit Figures

537000 6991000 538000 539000 540000

6991000 536000 6990000 540000

536000 537000 6989000 538000 539000

LEGEND

- All-weather Access Road (AWAR)
- As Built Road (April 2007)
- 500m Study Buffer

Terrain Code *

- 1 - Beach Ridge
- 2 - Beach Deposit
- 3 - Deltaic Terrace, Level, and/or Ridge, Plain
- 4 - Marine Sediment and Washed Till
- 5 - Blanket and Veneer of Washed Till
- 6 - Gaciofluvial Ridge or Slope
- 7 - Fluvial Level and/or Terrace
- 8 - Weathered Bedrock
- 9 - Weathered Bedrock and Washed Till or Marine Sediments, Lesser Bedrock
- 10 - Weathered Bedrock and Washed Till or Marine Sediment, Minor Bedrock
- 11 - Bedrock and Weathered Bedrock
- 12 - Washed Till and/or Marine Sediment, Weathered Bedrock
- LAKE

* See Figure 1 For Terrain Code Definitions

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).

Datum: NAD 83 Projection: UTM Zone 15

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METRES

PROJECT

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

TERRAIN CODE MAP 1 OF 17

Golder Associates

PROJECT NO. 10-1373-0076			FILE No.	
DESIGN	CJC	16 Oct. 2012	SCALE AS SHOWN	REV. 0
GIS	JW	16 Oct. 2012	6-3-C-1	
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LEGEND

- All-weather Access Road (AWAR)
- As Built Road (April 2007)
- 500m Study Buffer

Terrain Code *

- 1 - Beach Ridge
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- 8 - Weathered Bedrock
- 9 - Weathered Bedrock and Washed Till or Marine Sediments, Lesser Bedrock
- 10 - Weathered Bedrock and Washed Till or Marine Sediment, Minor Bedrock
- 11 - Bedrock and Weathered Bedrock
- 12 - Washed Till and/or Marine Sediment, Weathered Bedrock
- LAKE

* See Figure 1 For Terrain Code Definitions

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).

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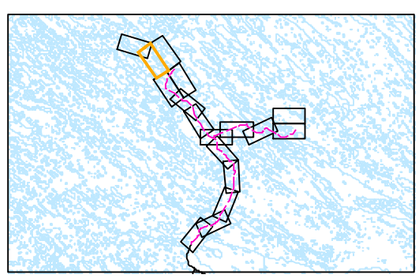

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METRES

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

TERRAIN CODE MAP 2 OF 17

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6990000 540000 6988000 541000

LEGEND

- All-weather Access Road (AWAR)
- As Built Road (April 2007)
- 500m Study Buffer

Terrain Code *

- 1 - Beach Ridge
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- 7 - Fluvial Level and/or Terrace
- 8 - Weathered Bedrock
- 9 - Weathered Bedrock and Washed Till or Marine Sediments, Lesser Bedrock
- 10 - Weathered Bedrock and Washed Till or Marine Sediment, Minor Bedrock
- 11 - Bedrock and Weathered Bedrock
- 12 - Washed Till and/or Marine Sediment, Weathered Bedrock
- LAKE

* See Figure 1 For Terrain Code Definitions

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).

Datum: NAD 83 Projection: UTM Zone 15

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METRES

PROJECT

AGNICO EAGLE

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MELIADINE GOLD PROJECT
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TITLE

TERRAIN CODE MAP 3 OF 17

Golder Associates

PROJECT NO. 10-1373-0076			FILE No.	
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LEGEND

- All-weather Access Road (AWAR)
- As Built Road (April 2007)
- 500m Study Buffer

Terrain Code *

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- 12 - Washed Till and/or Marine Sediment, Weathered Bedrock
- LAKE

* See Figure 1 For Terrain Code Definitions

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).

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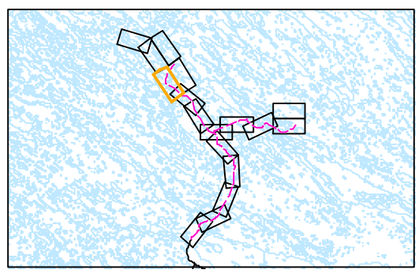

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METRES

PROJECT

AGNICO EAGLE

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TITLE

TERRAIN CODE
MAP 4 OF 17

Golder Associates

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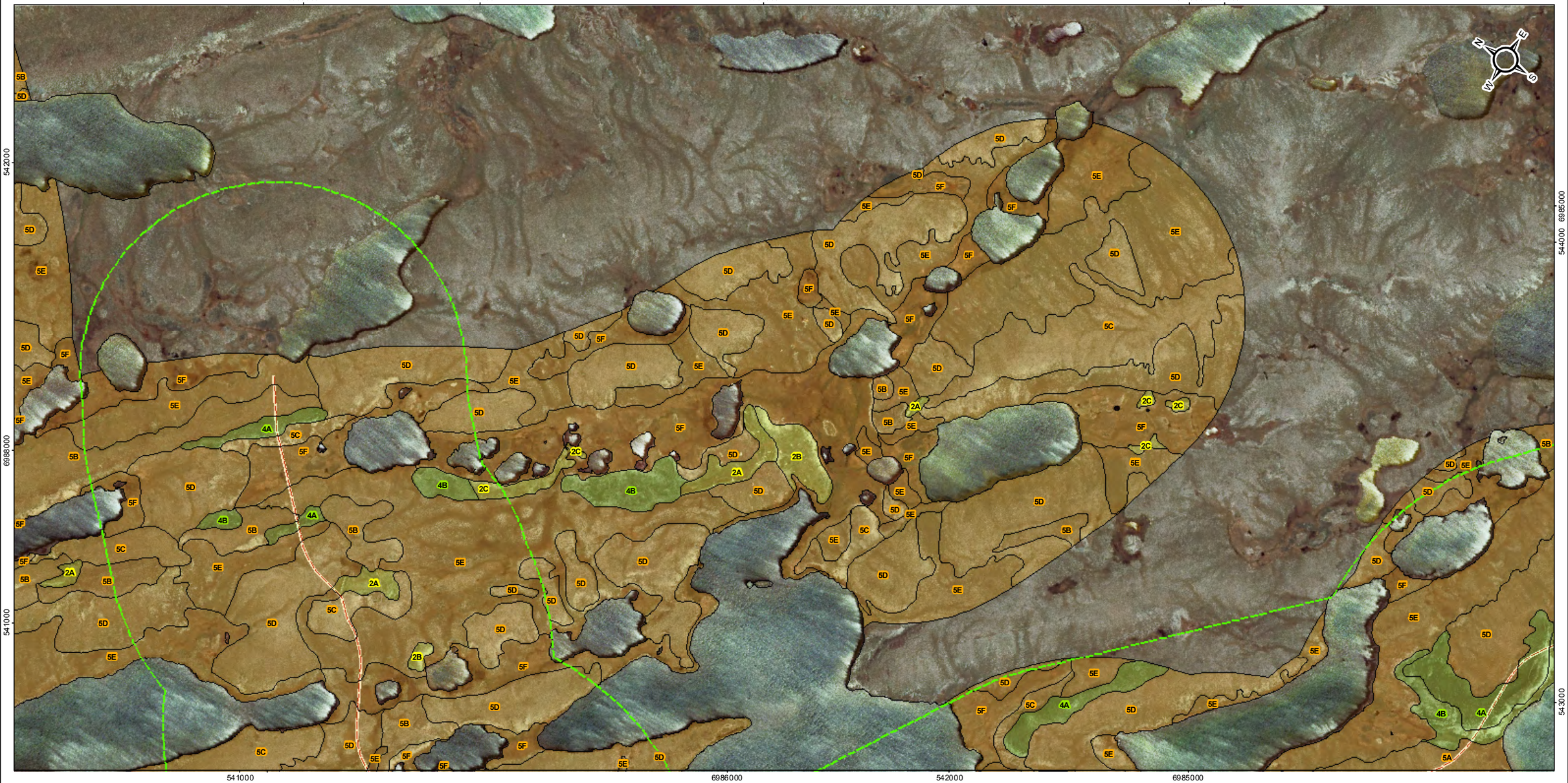

LEGEND

- All-weather Access Road (AWAR)
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- 500m Study Buffer

Terrain Code *

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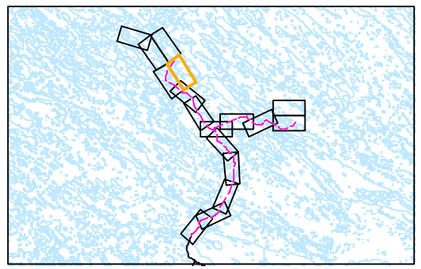
- 7 - Fluvial Level and/or Terrace
- 8 - Weathered Bedrock
- 9 - Weathered Bedrock and Washed Till or Marine Sediments, Lesser Bedrock
- 10 - Weathered Bedrock and Washed Till or Marine Sediment, Minor Bedrock
- 11 - Bedrock and Weathered Bedrock
- 12 - Washed Till and/or Marine Sediment, Weathered Bedrock
- LAKE

* See Figure 1 For Terrain Code Definitions

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).

Datum: NAD 83 Projection: UTM Zone 15



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METRES

PROJECT

AGNICO EAGLE

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MELIADINE GOLD PROJECT
NUNAVUT

TITLE

TERRAIN CODE MAP 5 OF 17

Golder Associates

PROJECT NO. 10-1373-0076			FILE No.		
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CHECK	CJC	18 Jan. 2013			
REVIEW	DW	18 Jan. 2013			

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LEGEND

- All-weather Access Road (AWAR)
- As Built Road (April 2007)
- 500m Study Buffer

Terrain Code *

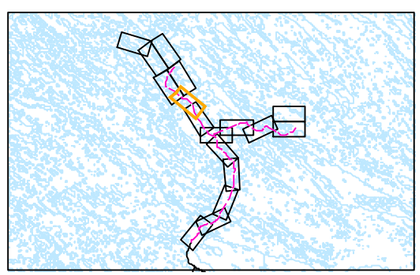
- 1 - Beach Ridge
- 2 - Beach Deposit
- 3 - Deltaic Terrace, Level, and/or Ridge, Plain
- 4 - Marine Sediment and Washed Till
- 5 - Blanket and Veneer of Washed Till
- 6 - Gaciofluvial Ridge or Slope
- 7 - Fluvial Level and/or Terrace
- 8 - Weathered Bedrock
- 9 - Weathered Bedrock and Washed Till or Marine Sediments, Lesser Bedrock
- 10 - Weathered Bedrock and Washed Till or Marine Sediment, Minor Bedrock
- 11 - Bedrock and Weathered Bedrock
- 12 - Washed Till and/or Marine Sediment, Weathered Bedrock
- LAKE

* See Figure 1 For Terrain Code Definitions

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).

Datum: NAD 83 Projection: UTM Zone 15



250 0 250

METRES

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

TERRAIN CODE MAP 6 OF 17

Golder Associates

PROJECT NO.	10-1373-0076		FILE No.	
DESIGN	CJC	16 Oct. 2012	SCALE AS SHOWN	REV. 0
GIS	JW	16 Oct. 2012	6-3-C-6	
CHECK	CJC	18 Jan. 2013		
REVIEW	DW	18 Jan. 2013		

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546000 6981000 545000

6983000 543000 6982000 544000

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LEGEND

- All-weather Access Road (AWAR)
- As Built Road (April 2007)
- 500m Study Buffer

Terrain Code *

- 1 - Beach Ridge
- 2 - Beach Deposit
- 3 - Deltaic Terrace, Level, and/or Ridge, Plain
- 4 - Marine Sediment and Washed Till
- 5 - Blanket and Veneer of Washed Till
- 6 - Gaciofluvial Ridge or Slope
- 7 - Fluvial Level and/or Terrace
- 8 - Weathered Bedrock
- 9 - Weathered Bedrock and Washed Till or Marine Sediments, Lesser Bedrock
- 10 - Weathered Bedrock and Washed Till or Marine Sediment, Minor Bedrock
- 11 - Bedrock and Weathered Bedrock
- 12 - Washed Till and/or Marine Sediment, Weathered Bedrock
- LAKE

* See Figure 1 For Terrain Code Definitions

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).

Datum: NAD 83 Projection: UTM Zone 15

250 0 250

METRES

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

TERRAIN CODE
MAP 7 OF 17

Golder Associates

PROJECT NO. 10-1373-0076			FILE No.		
DESIGN	CJC	16 Oct. 2012	SCALE AS SHOWN	REV.	0
GIS	JW	16 Oct. 2012	6-3-C-7		
CHECK	CJC	18 Jan. 2013			
REVIEW	DW	18 Jan. 2013			

545000 546000 547000 548000

6981000

6980000

N

W E

S

LEGEND

- All-weather Access Road (AWAR)
- As Built Road (April 2007)
- 500m Study Buffer

Terrain Code *

- 1 - Beach Ridge
- 2 - Beach Deposit
- 3 - Deltaic Terrace, Level, and/or Ridge, Plain
- 4 - Marine Sediment and Washed Till
- 5 - Blanket and Veneer of Washed Till
- 6 - Gaciofluvial Ridge or Slope
- 7 - Fluvial Level and/or Terrace
- 8 - Weathered Bedrock
- 9 - Weathered Bedrock and Washed Till or Marine Sediments, Lesser Bedrock
- 10 - Weathered Bedrock and Washed Till or Marine Sediment, Minor Bedrock
- 11 - Bedrock and Weathered Bedrock
- 12 - Washed Till and/or Marine Sediment, Weathered Bedrock
- LAKE

* See Figure 1 For Terrain Code Definitions

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).

Datum: NAD 83 Projection: UTM Zone 15

250 0 250

METRES

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

TERRAIN CODE MAP 8 OF 17

Golder Associates

PROJECT NO. 10-1373-0076			FILE No.	
DESIGN	CJC	16 Oct. 2012	SCALE AS SHOWN	REV. 0
GIS	JW	16 Oct. 2012	6-3-C-8	
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547000 548000 549000 550000

6982000

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N

W E

S

LEGEND

- All-weather Access Road (AWAR)
- As Built Road (April 2007)
- 500m Study Buffer

Terrain Code *

- 1 - Beach Ridge
- 2 - Beach Deposit
- 3 - Deltaic Terrace, Level, and/or Ridge, Plain
- 4 - Marine Sediment and Washed Till
- 5 - Blanket and Veneer of Washed Till
- 6 - Gaciofluvial Ridge or Slope
- 7 - Fluvial Level and/or Terrace
- 8 - Weathered Bedrock
- 9 - Weathered Bedrock and Washed Till or Marine Sediments, Lesser Bedrock
- 10 - Weathered Bedrock and Washed Till or Marine Sediment, Minor Bedrock
- 11 - Bedrock and Weathered Bedrock
- 12 - Washed Till and/or Marine Sediment, Weathered Bedrock
- LAKE

* See Figure 1 For Terrain Code Definitions

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).

Datum: NAD 83 Projection: UTM Zone 15

250 0 250

METRES

PROJECT

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

TERRAIN CODE MAP 9 OF 17

Golder Associates

PROJECT NO. 10-1373-0076			FILE No.	
DESIGN	CJC	16 Oct. 2012	SCALE AS SHOWN	REV. 0
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549000 6982000 550000 551000 6983000

6981000 6980000 549000 552000 6982000

N W E S

550000 551000 552000 6981000

250 0 250

METRES

LEGEND

- All-weather Access Road (AWAR)
- As Built Road (April 2007)
- 500m Study Buffer

Terrain Code *

- 1 - Beach Ridge
- 2 - Beach Deposit
- 3 - Deltaic Terrace, Level, and/or Ridge, Plain
- 4 - Marine Sediment and Washed Till
- 5 - Blanket and Veneer of Washed Till
- 6 - Gaciofluvial Ridge or Slope
- 7 - Fluvial Level and/or Terrace
- 8 - Weathered Bedrock
- 9 - Weathered Bedrock and Washed Till or Marine Sediments, Lesser Bedrock
- 10 - Weathered Bedrock and Washed Till or Marine Sediment, Minor Bedrock
- 11 - Bedrock and Weathered Bedrock
- 12 - Washed Till and/or Marine Sediment, Weathered Bedrock
- LAKE

* See Figure 1 For Terrain Code Definitions

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).

Datum: NAD 83 Projection: UTM Zone 15

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

TERRAIN CODE MAP 10 OF 17

Golder Associates

PROJECT NO. 10-1373-0076			FILE No.	
DESIGN	CJC	16 Oct. 2012	SCALE AS SHOWN	REV. 0
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552000 553000 554000 555000

698000 698000

698200 698200

N W E S

LEGEND

- All-weather Access Road (AWAR)
- As Built Road (April 2007)
- 500m Study Buffer

Terrain Code *

- 1 - Beach Ridge
- 2 - Beach Deposit
- 3 - Deltaic Terrace, Level, and/or Ridge, Plain
- 4 - Marine Sediment and Washed Till
- 5 - Blanket and Veneer of Washed Till
- 6 - Gaciofluvial Ridge or Slope
- 7 - Fluvial Level and/or Terrace
- 8 - Weathered Bedrock
- 9 - Weathered Bedrock and Washed Till or Marine Sediments, Lesser Bedrock
- 10 - Weathered Bedrock and Washed Till or Marine Sediment, Minor Bedrock
- 11 - Bedrock and Weathered Bedrock
- 12 - Washed Till and/or Marine Sediment, Weathered Bedrock
- LAKE

* See Figure 1 For Terrain Code Definitions

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).

Datum: NAD 83 Projection: UTM Zone 15

250 0 250

METRES

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

TERRAIN CODE MAP 11 OF 17

Golder Associates

PROJECT NO. 10-1373-0076			FILE No.	
DESIGN	CJC	16 Oct. 2012	SCALE AS SHOWN	REV. 0
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552000 553000 554000 555000

6982000

6981000

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W E

S

LEGEND

- All-weather Access Road (AWAR)
- As Built Road (April 2007)
- 500m Study Buffer

Terrain Code *

- 1 - Beach Ridge
- 2 - Beach Deposit
- 3 - Deltaic Terrace, Level, and/or Ridge, Plain
- 4 - Marine Sediment and Washed Till
- 5 - Blanket and Veneer of Washed Till
- 6 - Gaciofluvial Ridge or Slope
- 7 - Fluvial Level and/or Terrace
- 8 - Weathered Bedrock
- 9 - Weathered Bedrock and Washed Till or Marine Sediments, Lesser Bedrock
- 10 - Weathered Bedrock and Washed Till or Marine Sediment, Minor Bedrock
- 11 - Bedrock and Weathered Bedrock
- 12 - Washed Till and/or Marine Sediment, Weathered Bedrock
- LAKE

* See Figure 1 For Terrain Code Definitions

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).

Datum: NAD 83 Projection: UTM Zone 15

250 0 250

METRES

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

TERRAIN CODE MAP 12 OF 17

Golder Associates

PROJECT NO.	10-1373-0076		FILE No.		
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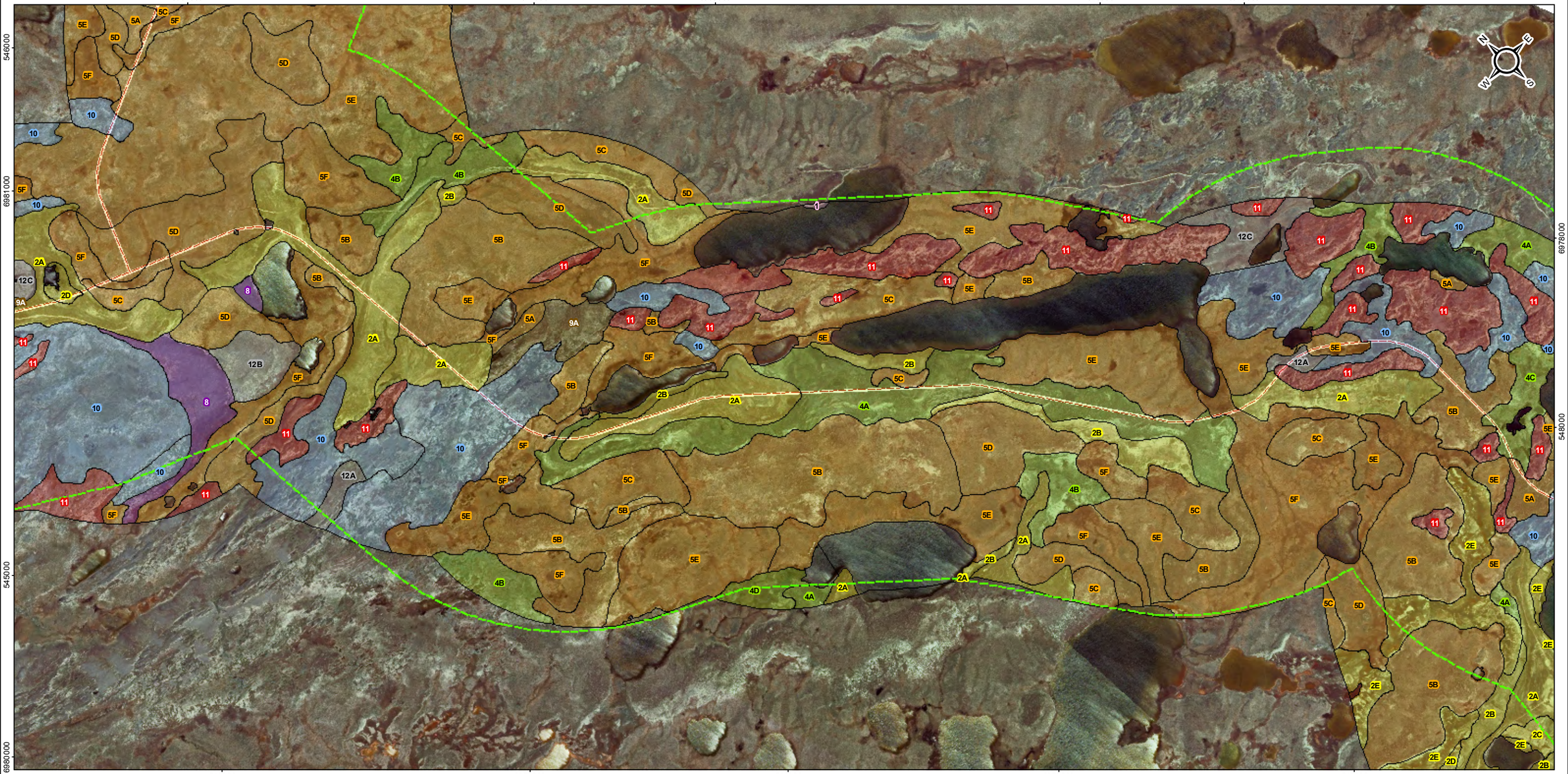


LEGEND

- All-weather Access Road (AWAR)
- As Built Road (April 2007)
- 500m Study Buffer

Terrain Code *

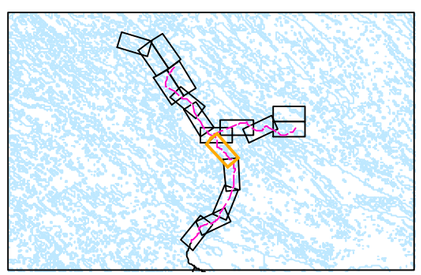
- 1 - Beach Ridge
- 2 - Beach Deposit
- 3 - Deltaic Terrace, Level, and/or Ridge, Plain
- 4 - Marine Sediment and Washed Till
- 5 - Blanket and Veneer of Washed Till
- 6 - Gaciofluvial Ridge or Slope
- 7 - Fluvial Level and/or Terrace
- 8 - Weathered Bedrock
- 9 - Weathered Bedrock and Washed Till or Marine Sediments, Lesser Bedrock
- 10 - Weathered Bedrock and Washed Till or Marine Sediment, Minor Bedrock
- 11 - Bedrock and Weathered Bedrock
- 12 - Washed Till and/or Marine Sediment, Weathered Bedrock
- LAKE

* See Figure 1 For Terrain Code Definitions

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).

Datum: NAD 83 Projection: UTM Zone 15



250 0 250

METRES

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

TERRAIN CODE
MAP 13 OF 17

Golder Associates

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6978000 6977000 6976000 6975000

548000

547000

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LEGEND

- All-weather Access Road (AWAR)
- As Built Road (April 2007)
- 500m Study Buffer

Terrain Code *

- 1 - Beach Ridge
- 2 - Beach Deposit
- 3 - Deltaic Terrace, Level, and/or Ridge, Plain
- 4 - Marine Sediment and Washed Till
- 5 - Blanket and Veneer of Washed Till
- 6 - Gaciofluvial Ridge or Slope
- 7 - Fluvial Level and/or Terrace
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- 9 - Weathered Bedrock and Washed Till or Marine Sediments, Lesser Bedrock
- 10 - Weathered Bedrock and Washed Till or Marine Sediment, Minor Bedrock
- 11 - Bedrock and Weathered Bedrock
- 12 - Washed Till and/or Marine Sediment, Weathered Bedrock
- LAKE

* See Figure 1 For Terrain Code Definitions

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).

Datum: NAD 83 Projection: UTM Zone 15

250 0 250

METRES

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

TERRAIN CODE MAP 14 OF 17

Golder Associates

PROJECT NO. 10-1373-0076			FILE No.		
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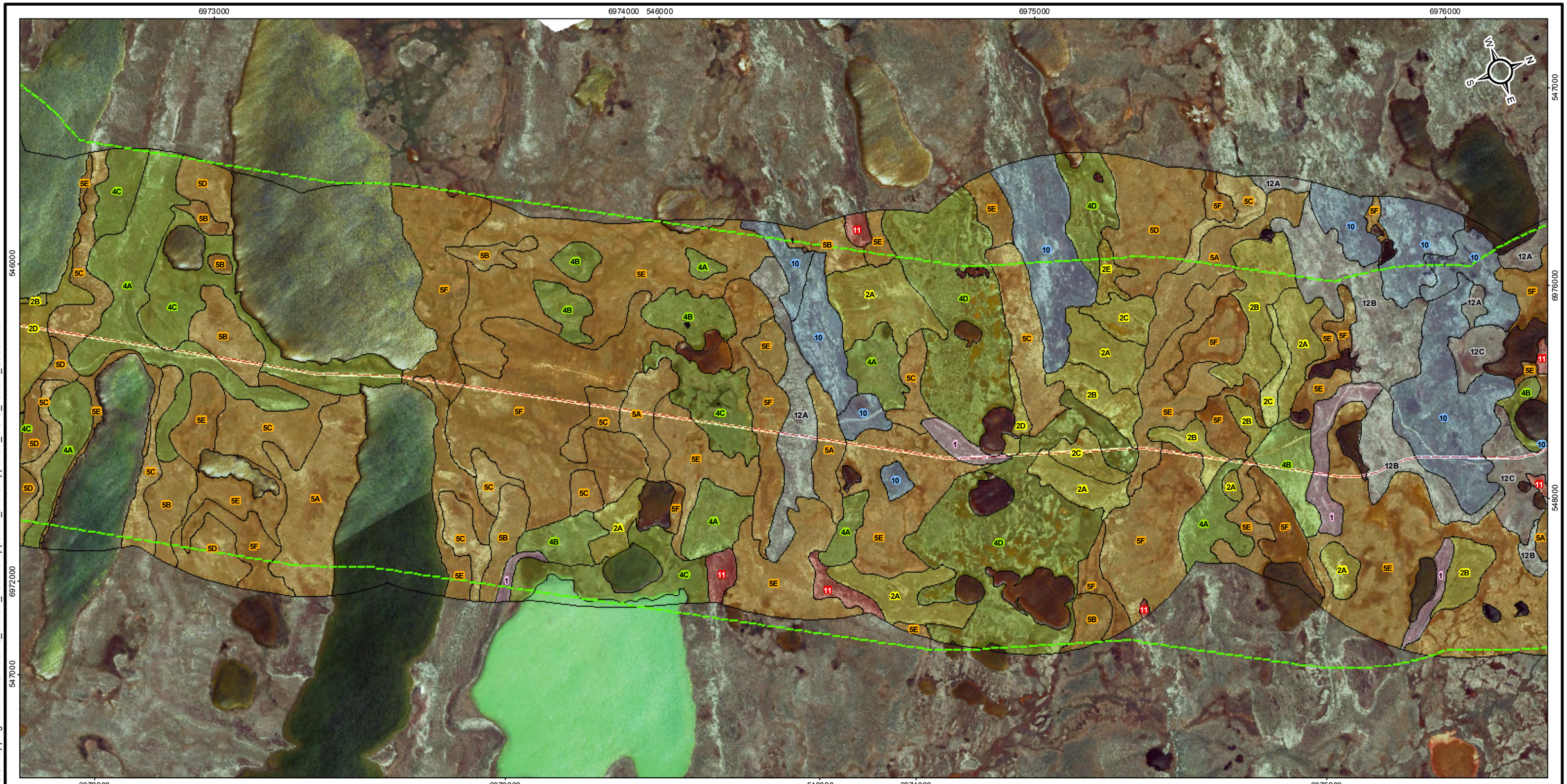


LEGEND

- All-weather Access Road (AWAR)
- As Built Road (April 2007)
- 500m Study Buffer

Terrain Code *

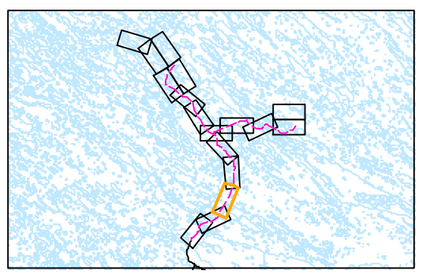
- 1 - Beach Ridge
- 2 - Beach Deposit
- 3 - Deltaic Terrace, Level, and/or Ridge, Plain
- 4 - Marine Sediment and Washed Till
- 5 - Blanket and Veneer of Washed Till
- 6 - Gaciofluvial Ridge or Slope
- 7 - Fluvial Level and/or Terrace
- 8 - Weathered Bedrock
- 9 - Weathered Bedrock and Washed Till or Marine Sediments, Lesser Bedrock
- 10 - Weathered Bedrock and Washed Till or Marine Sediment, Minor Bedrock
- 11 - Bedrock and Weathered Bedrock
- 12 - Washed Till and/or Marine Sediment, Weathered Bedrock
- LAKE

* See Figure 1 For Terrain Code Definitions

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).

Datum: NAD 83 Projection: UTM Zone 15



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METRES

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

TERRAIN CODE
MAP 15 OF 17

Golder Associates

PROJECT NO. 10-1373-0076			FILE No.	
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REVIEW	DW	18 Jan. 2013		

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6972000 6973000 6971000 544000 545000 546000 547000 548000

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LEGEND

- All-weather Access Road (AWAR)
- As Built Road (April 2007)
- 500m Study Buffer

Terrain Code *

- 1 - Beach Ridge
- 2 - Beach Deposit
- 3 - Deltaic Terrace, Level, and/or Ridge, Plain
- 4 - Marine Sediment and Washed Till
- 5 - Blanket and Veneer of Washed Till
- 6 - Gaciofluvial Ridge or Slope
- 7 - Fluvial Level and/or Terrace
- 8 - Weathered Bedrock
- 9 - Weathered Bedrock and Washed Till or Marine Sediments, Lesser Bedrock
- 10 - Weathered Bedrock and Washed Till or Marine Sediment, Minor Bedrock
- 11 - Bedrock and Weathered Bedrock
- 12 - Washed Till and/or Marine Sediment, Weathered Bedrock
- LAKE

* See Figure 1 For Terrain Code Definitions

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).

Datum: NAD 83 Projection: UTM Zone 15

250 0 250

METRES

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

TERRAIN CODE
MAP 16 OF 17

Golder Associates

PROJECT NO. 10-1373-0076			FILE No.	
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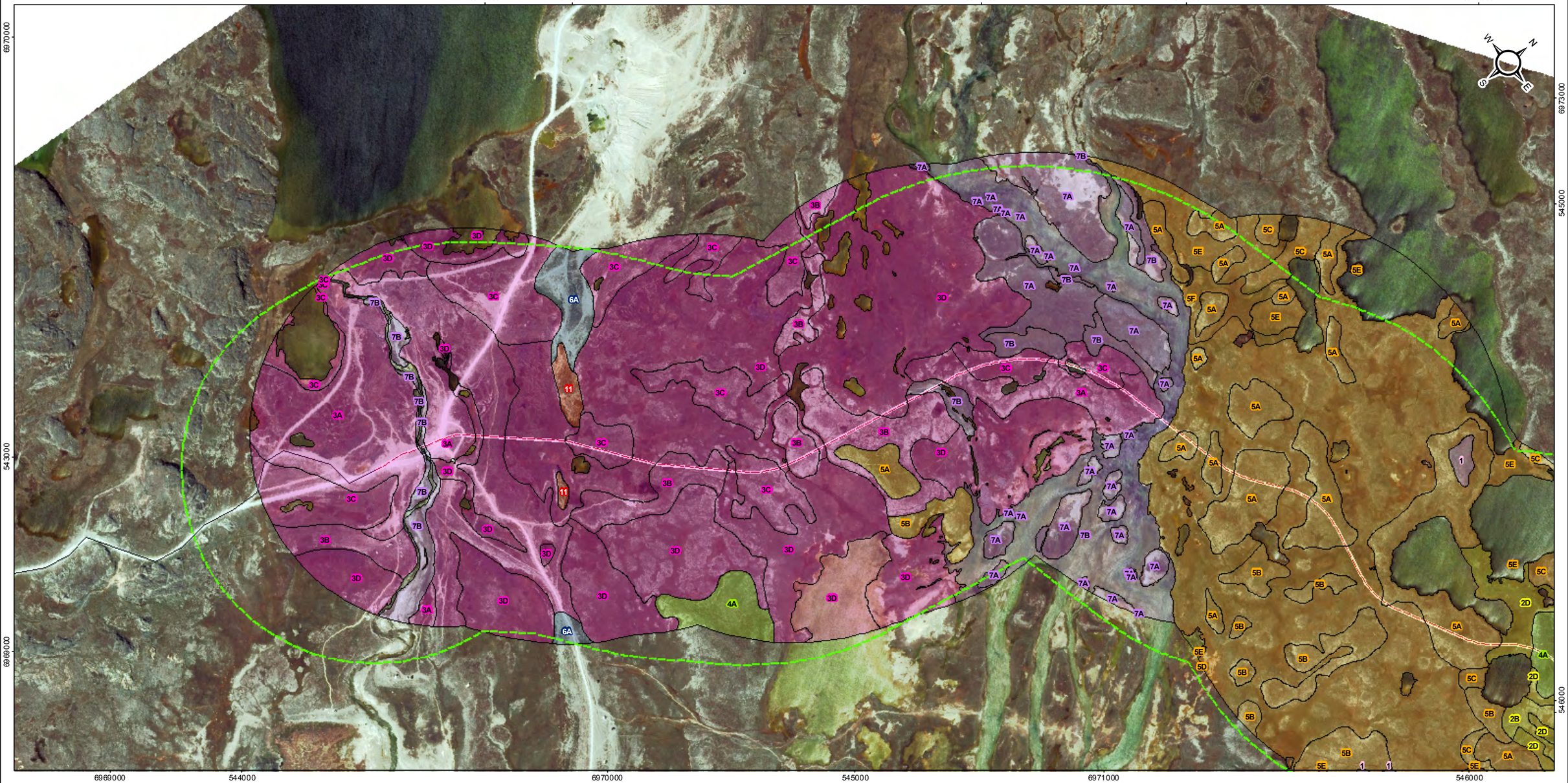

6969000 544000 6970000 545000 6971000 546000

LEGEND

- All-weather Access Road (AWAR)
- As Built Road (April 2007)
- 500m Study Buffer

Terrain Code *

- 1 - Beach Ridge
- 2 - Beach Deposit
- 3 - Deltaic Terrace, Level, and/or Ridge, Plain
- 4 - Marine Sediment and Washed Till
- 5 - Blanket and Veneer of Washed Till
- 6 - Gaciofluvial Ridge or Slope
- 7 - Fluvial Level and/or Terrace
- 8 - Weathered Bedrock
- 9 - Weathered Bedrock and Washed Till or Marine Sediments, Lesser Bedrock
- 10 - Weathered Bedrock and Washed Till or Marine Sediment, Minor Bedrock
- 11 - Bedrock and Weathered Bedrock
- 12 - Washed Till and/or Marine Sediment, Weathered Bedrock
- LAKE

* See Figure 1 For Terrain Code Definitions

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).

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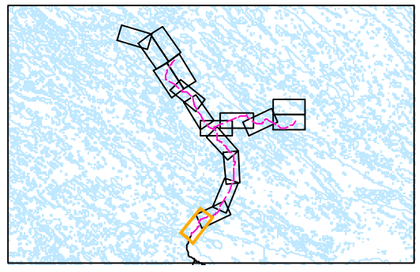

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METRES

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

TERRAIN CODE MAP 17 OF 17

Golder Associates

PROJECT NO. 10-1373-0076			FILE No.		
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REVIEW	DW	18 Jan. 2013			

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APPENDIX 6.3-D

Freeze and Thaw Induced Displacement Hazard Figures

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539000 6987000 541000 6990000 538000

538000 6989000 6988000 539000 6987000 540000

LEGEND

- All-weather Access Road (AWAR)
- Existing Road
- As Built Road (April 2007)
- 500m Study Buffer

Freeze and Thaw Induced Displacement Hazard Mapping

- Low
- Low - Medium
- Medium
- Medium - High
- High
- High - Very High
- Very High
- Lake

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).

Datum: NAD 83 Projection: UTM Zone 15

250 0 250

METRES

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

DISPLACEMENT HAZARD MAPPING MAP 2 OF 17

Golder Associates

PROJECT NO.	10-1373-0076		FILE No.		
DESIGN	CJC	16 Oct. 2012	SCALE AS SHOWN	REV.	0
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REVIEW	DW	18 Jan. 2013			

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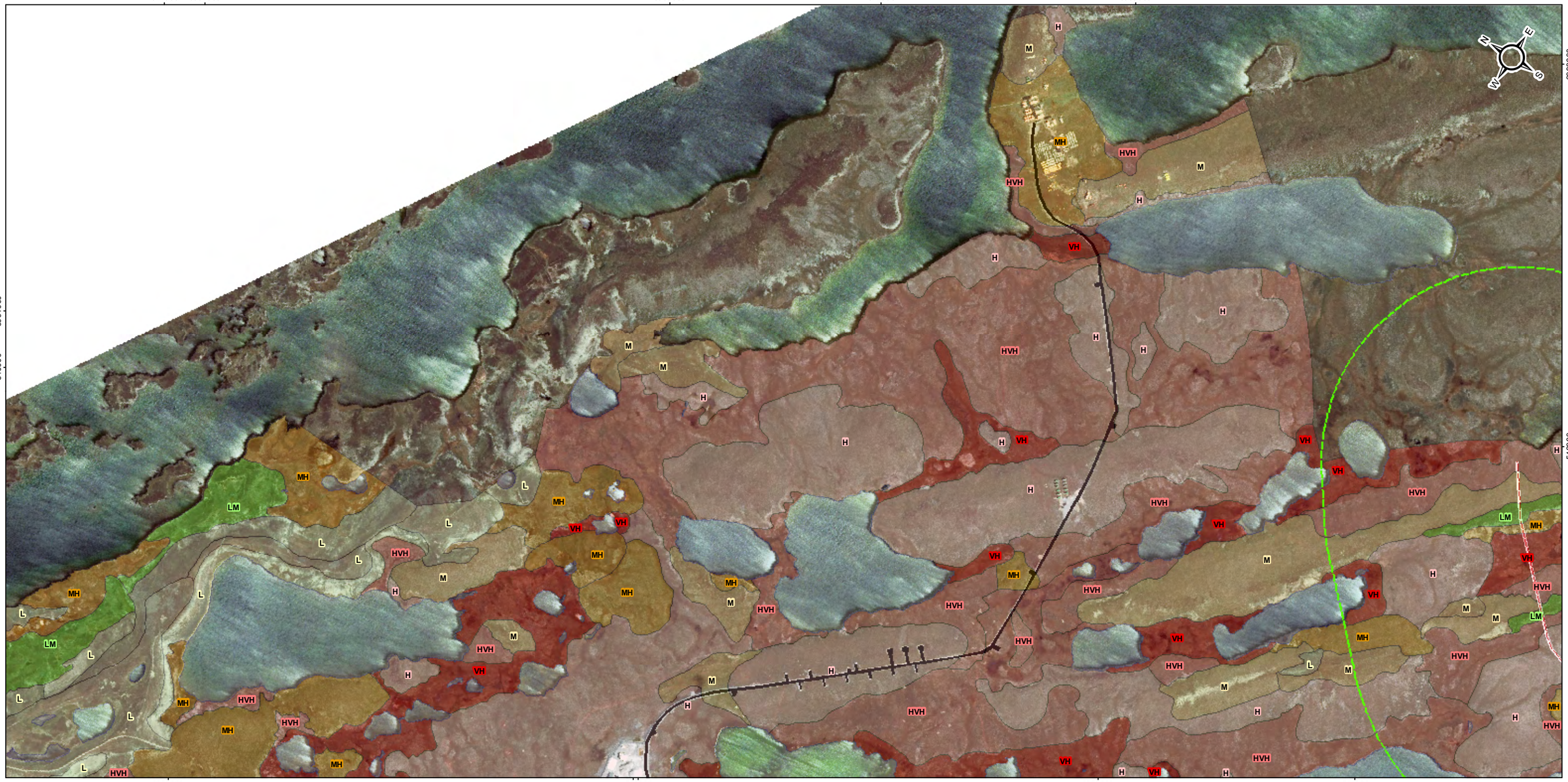


6990000 540000 6988000 541000

LEGEND

- All-weather Access Road (AWAR)
- Existing Road
- As Built Road (April 2007)
- 500m Study Buffer

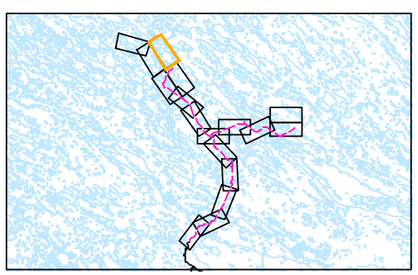
Freeze and Thaw Induced Displacement Hazard Mapping

- Low
- Low - Medium
- Medium
- Medium - High
- High
- High - Very High
- Very High
- Lake

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).

Datum: NAD 83 Projection: UTM Zone 15



250 0 250

METRES

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

DISPLACEMENT HAZARD MAPPING MAP 3 OF 17

Golder Associates

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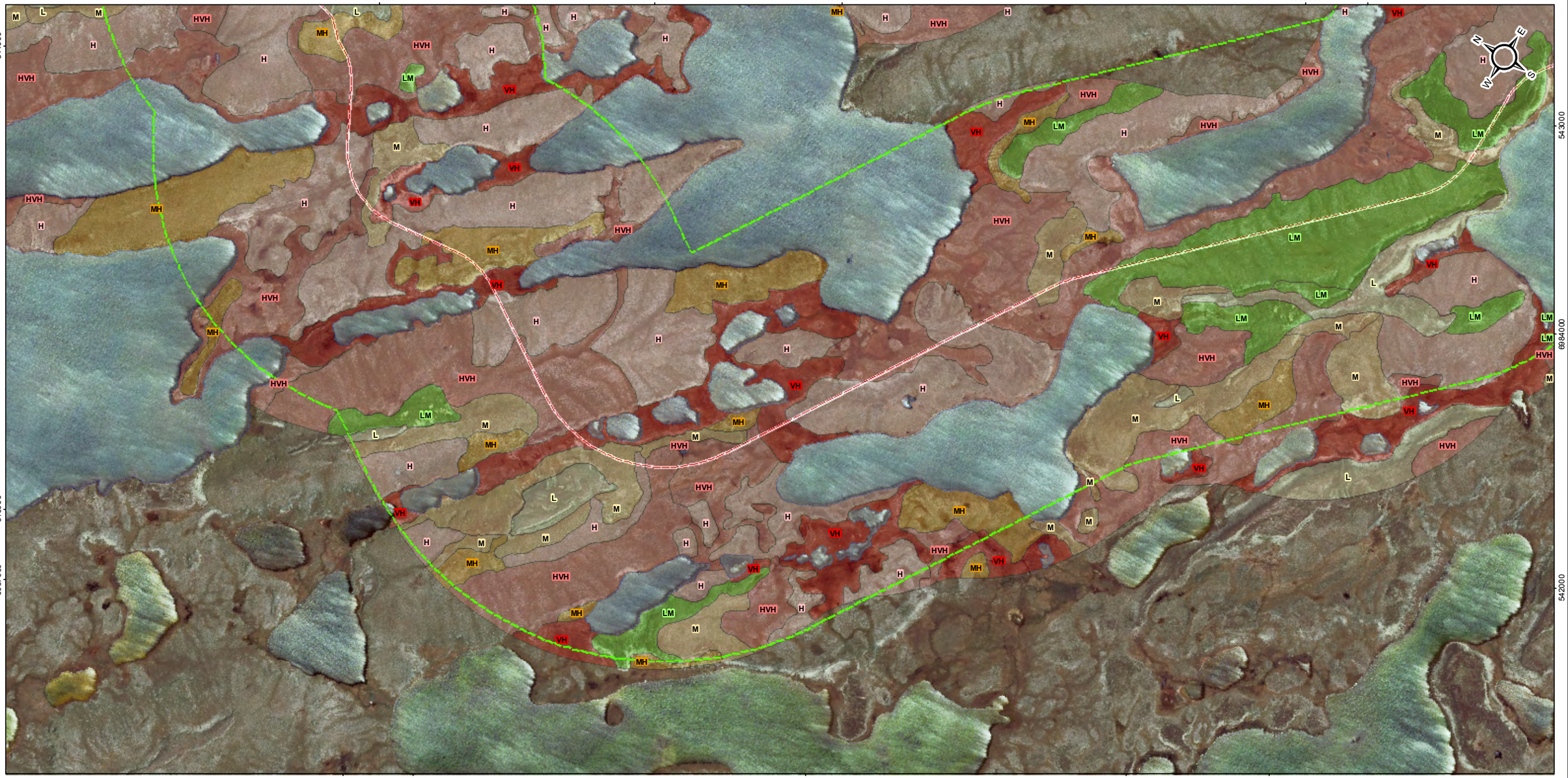


LEGEND

- All-weather Access Road (AWAR)
- Existing Road
- As Built Road (April 2007)
- 500m Study Buffer

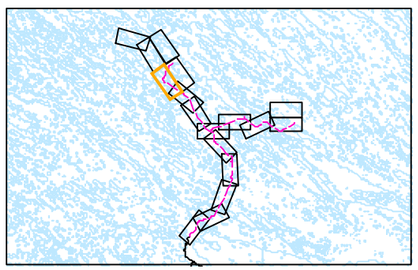
Freeze and Thaw Induced Displacement Hazard Mapping

- Low
- Low - Medium
- Medium
- Medium - High
- High
- High - Very High
- Very High
- Lake

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).

Datum: NAD 83 Projection: UTM Zone 15



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METRES

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

DISPLACEMENT HAZARD MAPPING MAP 4 OF 17

Golder Associates

PROJECT NO. 10-1373-0076			FILE No.	
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6-3-D-4

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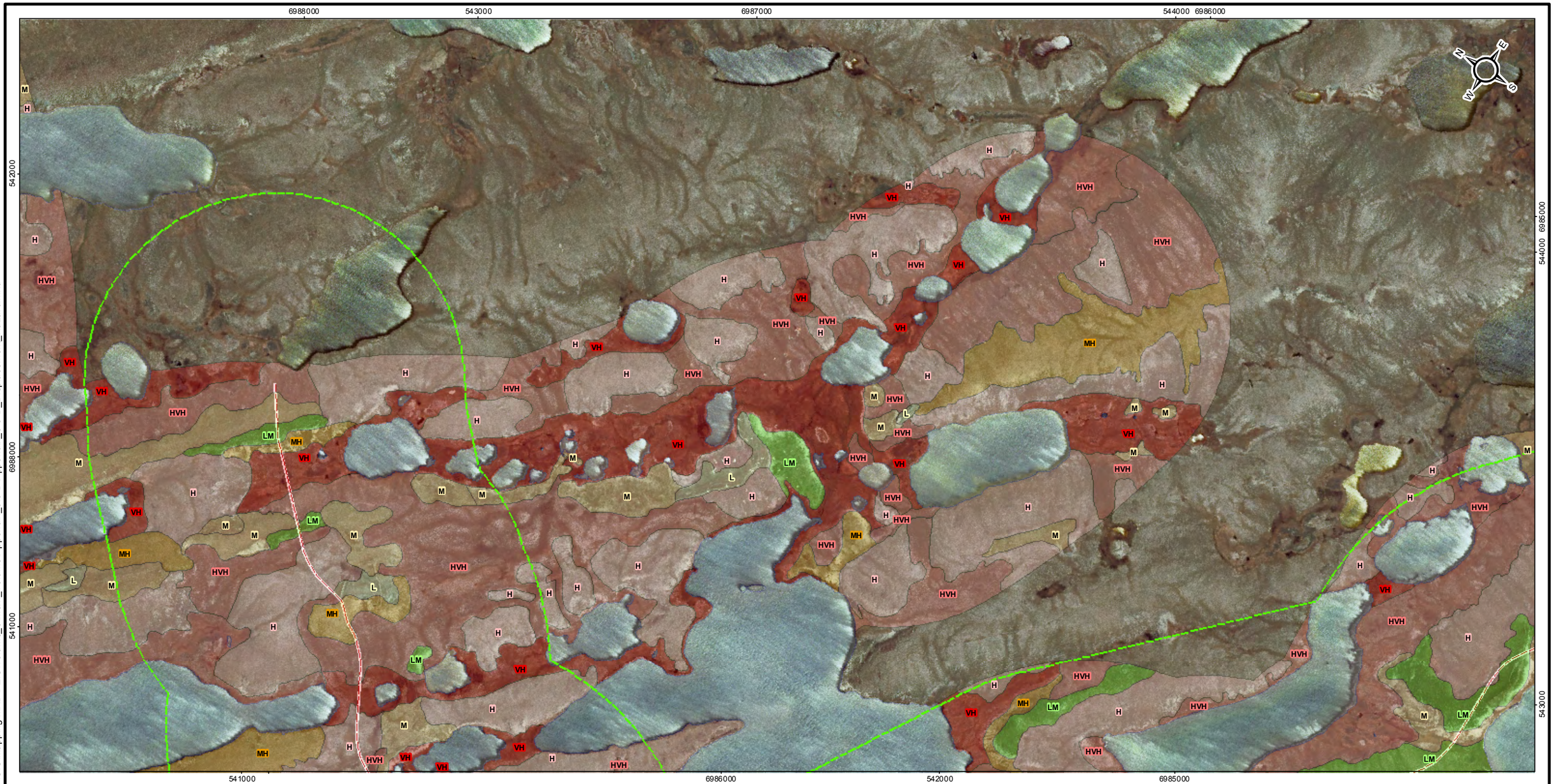

LEGEND

- All-weather Access Road (AWAR)
- Existing Road
- As Built Road (April 2007)
- 500m Study Buffer

Freeze and Thaw Induced Displacement Hazard Mapping

- Low
- Low - Medium
- Medium
- Medium - High
- High
- High - Very High
- Very High
- Lake

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).

Datum: NAD 83 Projection: UTM Zone 15

250 0 250

METRES

PROJECT

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

DISPLACEMENT HAZARD MAPPING MAP 5 OF 17

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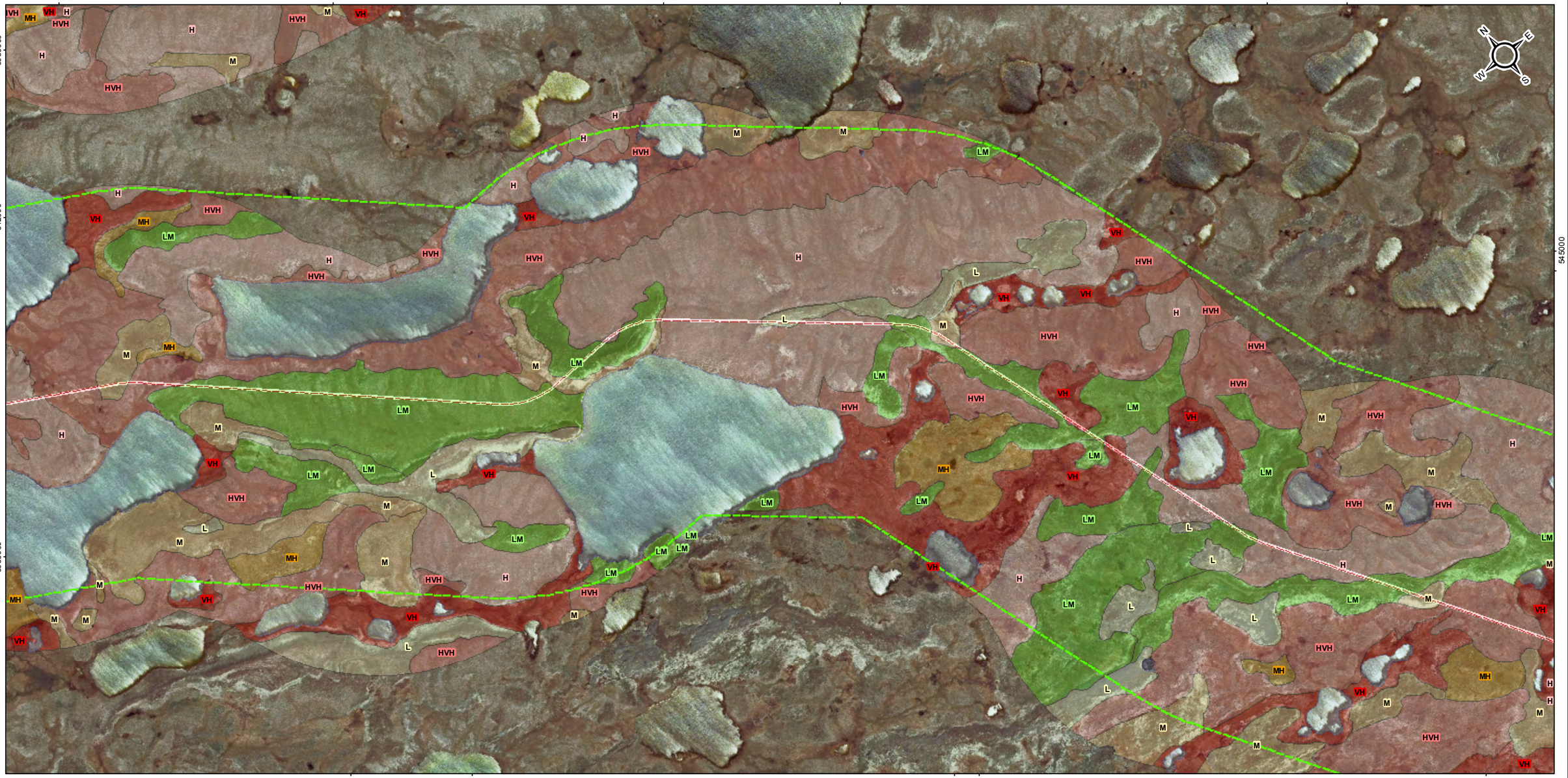


LEGEND

- All-weather Access Road (AWAR)
- Existing Road
- As Built Road (April 2007)
- 500m Study Buffer

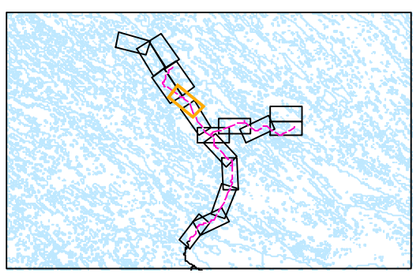
Freeze and Thaw Induced Displacement Hazard Mapping

- Low
- Low - Medium
- Medium
- Medium - High
- High
- High - Very High
- Very High
- Lake

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).

Datum: NAD 83 Projection: UTM Zone 15



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METRES

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

DISPLACEMENT HAZARD MAPPING MAP 6 OF 17

Golder Associates

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546000 6981000 545000

6983000 543000 6982000 544000

LEGEND

- All-weather Access Road (AWAR)
- Existing Road
- As Built Road (April 2007)
- 500m Study Buffer

Freeze and Thaw Induced Displacement Hazard Mapping

- Low
- Low - Medium
- Medium
- Medium - High
- High
- High - Very High
- Very High
- Lake

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).

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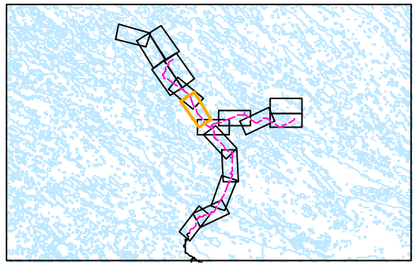

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METRES

PROJECT

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

DISPLACEMENT HAZARD MAPPING MAP 7 OF 17

Golder Associates

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W E

S

LEGEND

- All-weather Access Road (AWAR)
- Existing Road
- As Built Road (April 2007)
- 500m Study Buffer

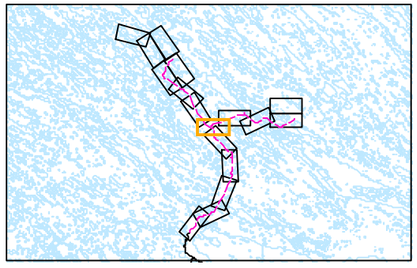
Freeze and Thaw Induced Displacement Hazard Mapping

- Low
- Low - Medium
- Medium
- Medium - High
- High
- High - Very High
- Very High
- Lake

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).

Datum: NAD 83 Projection: UTM Zone 15



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METRES

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

DISPLACEMENT HAZARD MAPPING MAP 8 OF 17

Golder Associates

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547000 548000 549000 550000

6982000

6981000

N W E S

LEGEND

- All-weather Access Road (AWAR)
- Existing Road
- As Built Road (April 2007)
- 500m Study Buffer

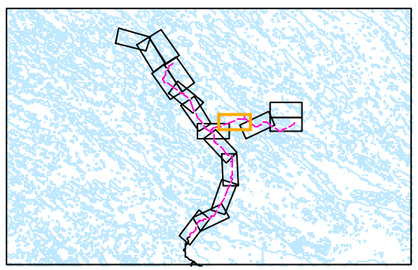
Freeze and Thaw Induced Displacement Hazard Mapping

- Low
- Low - Medium
- Medium
- Medium - High
- High
- High - Very High
- Very High
- Lake

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).

Datum: NAD 83 Projection: UTM Zone 15



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METRES

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

DISPLACEMENT HAZARD MAPPING MAP 9 OF 17

Golder Associates

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6981000 6980000 549000 552000 6982000

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N

W E

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LEGEND

All-weather Access Road (AWAR)
Existing Road
As Built Road (April 2007)
500m Study Buffer

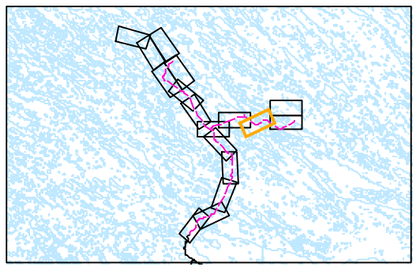
Freeze and Thaw Induced Displacement Hazard Mapping

Low
Low - Medium
Medium
Medium - High
High
High - Very High
Very High
Lake

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).

Datum: NAD 83 Projection: UTM Zone 15



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METRES

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

DISPLACEMENT HAZARD MAPPING MAP 10 OF 17

Golder Associates

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698000 (top) 698000 (bottom)

682000 (left) 682000 (right)

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HVH MH M HVH H VH LM LM HVH MH M H VH LM MH M HVH MH M H VH HVH M M L M H MH H HVH MH M H HVH M VH H HVH MH M M HVH H VH MH M L M LM MH M L VH MH M H VH HVH M M L M H MH M HVH VH VH M M HVH VH M M H M M HVH MH M

552000 553000 554000 555000

6982000

6981000

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W E

S

LEGEND

- All-weather Access Road (AWAR)
- Existing Road
- As Built Road (April 2007)
- 500m Study Buffer

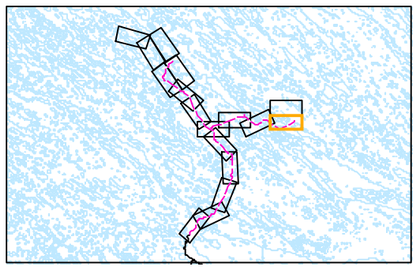
Freeze and Thaw Induced Displacement Hazard Mapping

- Low
- Low - Medium
- Medium
- Medium - High
- High
- High - Very High
- Very High
- Lake

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).

Datum: NAD 83 Projection: UTM Zone 15



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METRES

PROJECT

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

DISPLACEMENT HAZARD MAPPING MAP 12 OF 17

Golder Associates

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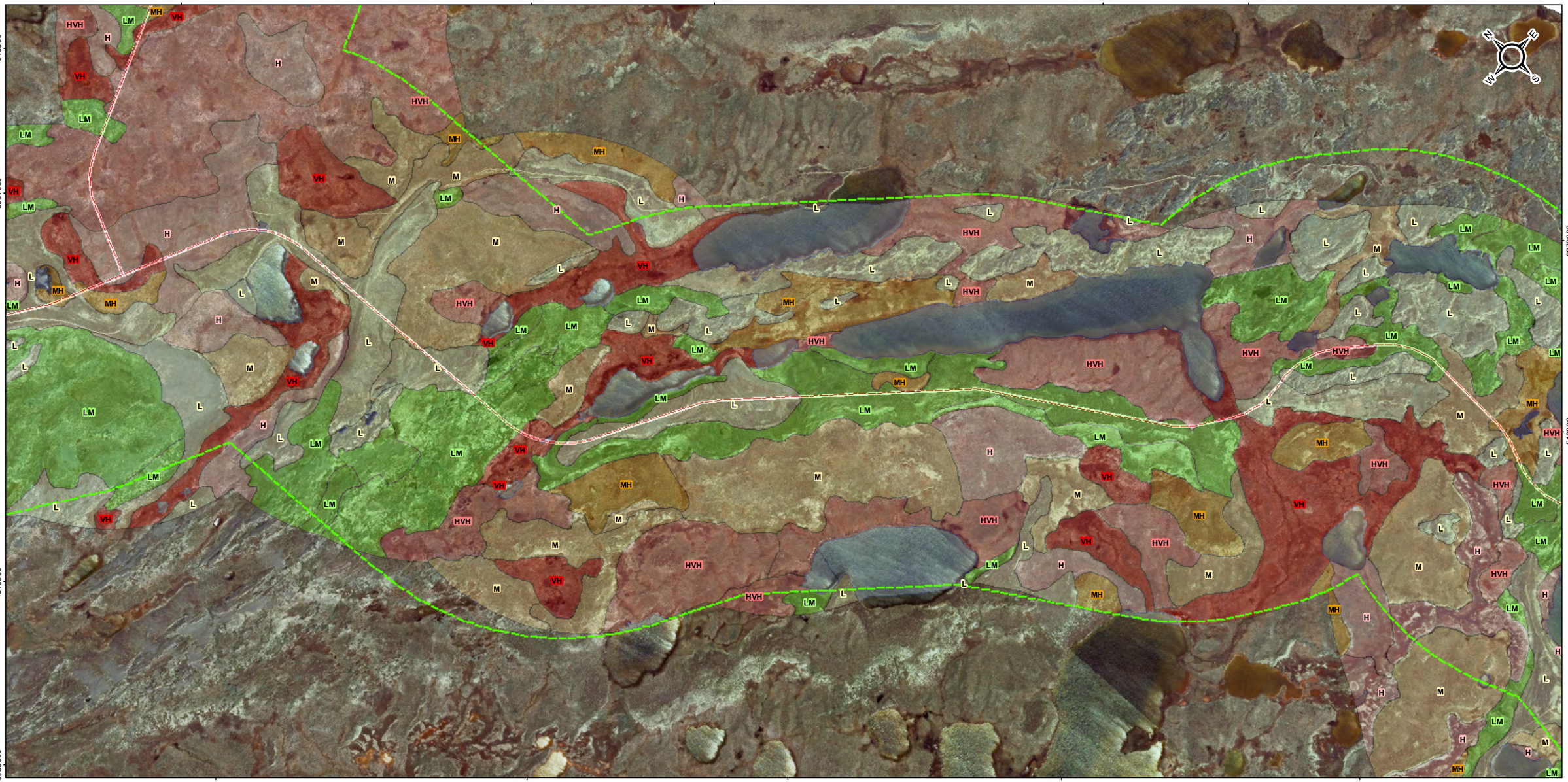

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LEGEND

- All-weather Access Road (AWAR)
- Existing Road
- As Built Road (April 2007)
- 500m Study Buffer

Freeze and Thaw Induced Displacement Hazard Mapping

- Low
- Low - Medium
- Medium
- Medium - High
- High
- High - Very High
- Very High
- Lake

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).

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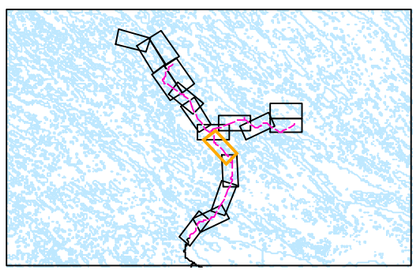

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METRES

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

DISPLACEMENT HAZARD MAPPING MAP 13 OF 17

Golder Associates

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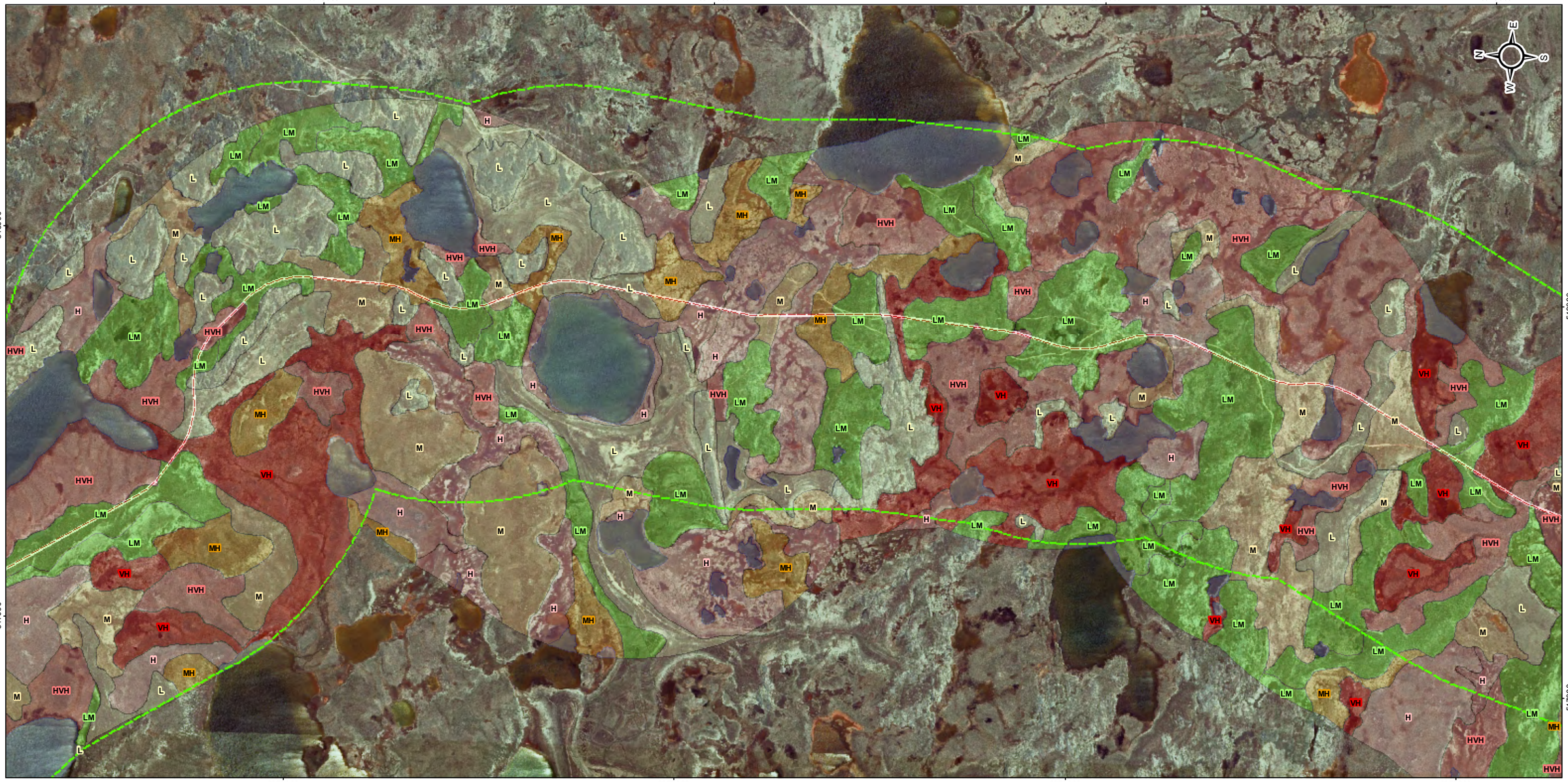

LEGEND

- All-weather Access Road (AWAR)
- Existing Road
- As Built Road (April 2007)
- 500m Study Buffer

Freeze and Thaw Induced Displacement Hazard Mapping

- Low
- Low - Medium
- Medium
- Medium - High
- High
- High - Very High
- Very High
- Lake

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).

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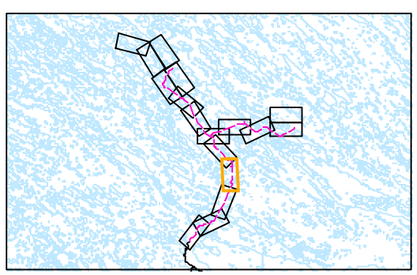

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METRES

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

DISPLACEMENT HAZARD MAPPING MAP 14 OF 17

Golder Associates

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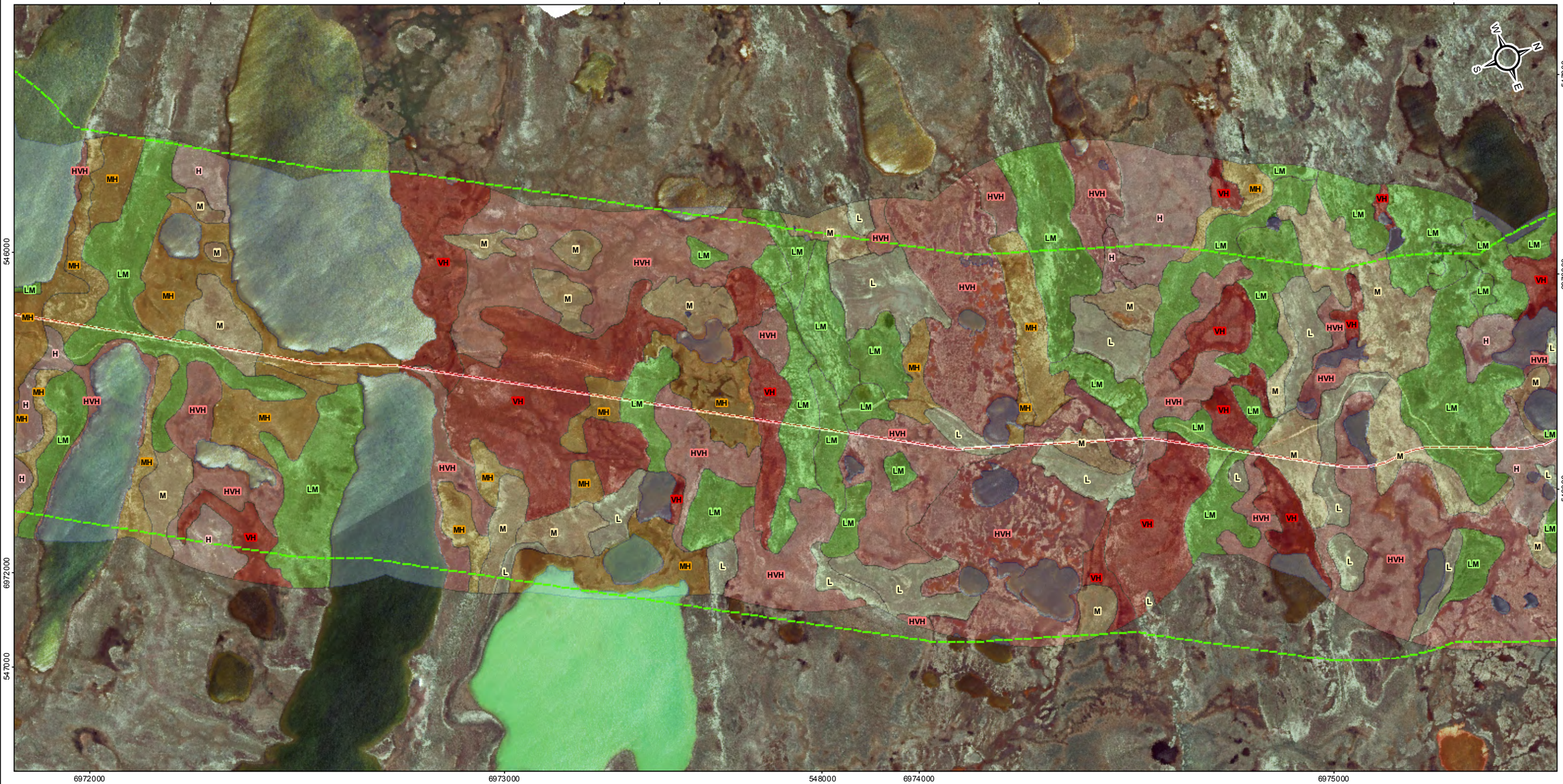
546000 547000 6976000 548000



6972000 6973000 548000 6974000 6975000

LEGEND

- All-weather Access Road (AWAR)
- Existing Road
- As Built Road (April 2007)
- 500m Study Buffer

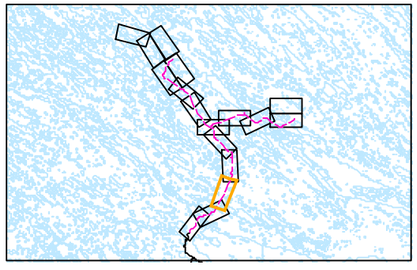
Freeze and Thaw Induced Displacement Hazard Mapping

- Low
- Low - Medium
- Medium
- Medium - High
- High
- High - Very High
- Very High
- Lake

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).

Datum: NAD 83 Projection: UTM Zone 15



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METRES

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

DISPLACEMENT HAZARD MAPPING MAP 15 OF 17

Golder Associates

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6972000 6973000 544000 6971000 548000

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LEGEND

- All-weather Access Road (AWAR)
- Existing Road
- As Built Road (April 2007)
- 500m Study Buffer

Freeze and Thaw Induced Displacement Hazard Mapping

- Low
- Low - Medium
- Medium
- Medium - High
- High
- High - Very High
- Very High
- Lake

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).

Datum: NAD 83 Projection: UTM Zone 15

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METRES

PROJECT

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

DISPLACEMENT HAZARD MAPPING MAP 16 OF 17

PROJECT NO. 10-1373-0076			FILE No.		
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LEGEND

- All-weather Access Road (AWAR)
- Existing Road
- As Built Road (April 2007)
- 500m Study Buffer

Freeze and Thaw Induced Displacement Hazard Mapping

- Low
- Low - Medium
- Medium
- Medium - High
- High
- High - Very High
- Very High
- Lake

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).

Datum: NAD 83 Projection: UTM Zone 15

250 0 250

METRES

PROJECT

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

DISPLACEMENT HAZARD MAPPING MAP 17 OF 17

PROJECT NO. 10-1373-0076			FILE No.		
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REVIEW	DW	18 Jan. 2013			

Golder Associates

APPENDIX 6.3-E

Tailings Storage Facility Thermal Model

TECHNICAL MEMORANDUM

DATE October 23, 2012 **PROJECT No.** Doc 356-1013730076 Ver. 0

TO File

FROM Gerd Janssens and John Cunning **EMAIL** Gerd_Janssens@golder.com; John_Cunning@golder.com

TAILINGS STORAGE FACILITY THERMAL ANALYSES SUMMARY - MELIADINE GOLD PROJECT

1.0 INTRODUCTION

Agnico-Eagle Mines Limited (AEM) is proposing the development of a tailings storage facility as part of the Meliadine Gold Project. The tailings deposit is to be constructed within the area of Lake B7, with some of the tailings placed within the lake basin. The proposed location and construction of the facility is presented in the preliminary design report (Golder 2012).

This memorandum presents the results of a simplified thermal modeling of the tailings deposit that was carried out to predict the approximate time required to freeze the tailings deposit and the underlying foundation. The effect of long term climate change is considered as part of the analyses.

2.0 BASELINE THERMAL MODEL

Baseline thermal analyses were carried out in 2010 as part of the feasibility study (Golder 2010). The analyses estimated thermal ground conditions beneath Lake B7 and pointed to the existence of a talik under the lake.

As part of the baseline thermal analyses, the existing site conditions including available climate data, hydrological and ground temperature profiles were reviewed. These are incorporated into the current thermal model.

The ground surface temperature function from the baseline model and used in the current analyses is summarised in Table 1.

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Table 1: Mean Monthly Ground Temperature

Month	Ground Temperature (°C) Measured at 5 cm depth at Meliadine West Site, 1997 to 2001
January	-25.3
February	-24.3
March	-19.5
April	-14.5
May	-6.9
June	2.5
July	8.4
August	7.9
September	4.0
October	-1.3
November	-8.2
December	-17.9
Annual Average	**-7.9**

3.0 THERMAL ANALYSES

The thermal model was prepared using TEMP/W by Geoslope International Ltd.

A simplified one dimensional thermal model was prepared with two foundations scenarios:

- Within the lake basin – The ground profile assumed consisted of a 6 m thick saturated till overlying a 3 m thick zone of weathered bedrock underlain by 300 m of bedrock; and
- Ground adjacent to the Lake – The ground profile assumed was a 2.5 m thick surface layer of sand and gravel, underlain by a 6 m thick till layer and a 3 m thick zone of weathered bedrock above 300 m of bedrock.

The depth of tailings within the proposed tailings deposit was assumed to be 27 m, which occurs at the deepest portion of the lake at an elevation (El.) of 58 m (tailings top elevation assumed at El. 85 m). The tailings on ground adjacent to the lake were assumed to have a depth of 21 m, with the original ground surface at El. 64 m and the tailings at El. 85 m.

A minimum 3 m thick rockfill cap is planned to be placed over the tailings at the end of operations; therefore, the top layer was included in the models.

The profiles for the two scenarios are shown in Figure 1.

3.1 Material Thermal Properties

The foundation soil and bedrock properties were taken from the Meliadine baseline thermal model (Golder 2010). The tailings and rockfill cap properties were taken from a thermal analysis completed for the Meadowbank Gold Project (Golder 2008).

Table 2 presents a summary of the thermal properties for the materials used in the models.

Table 2: Material Thermal Properties

Material	Degree of Saturation (%)	Volumetric Water Content (%)	Thermal Conductivity (W/m °C)		Volumetric Heat Capacity (MJ/m^3 °C)	
			Frozen	Unfrozen	Frozen	Unfrozen
Till (saturated)	100	27	2.3	1.6	2.0	2.5
Sand and Gravel (Unsaturated)	45	15	1.7	1.7	1.6	1.9
Sand and Gravel (Saturated)	100	34	3.3	2.1	2.0	2.7
Weathered Bedrock	100	12	2.9	2.9	2.4	2.4
Bedrock – Lower zone	100	2	2.9	2.9	2.4	2.4
Tailings	100	50	2.9	1.9	2.1	3
Rockfill cover	1	5	1.9	1.3	1.8	2.1

3.2 Initial Steady State Model

An initial steady state model was run to calculate the current ground conditions, prior to the placement of tailings. Thermal properties presented in Table 2 were used in the model.

The boundary conditions were set such that the ground conditions are similar to what was estimated by the baseline model (Golder 2010).

For the scenario where the tailings are placed in the lake basin, constant boundary conditions are set resulting in the ground being initially unfrozen at a constant temperature of 1°C down to El.-250 m.

For the scenario where the tailings are placed on ground adjacent to the lake, a constant ground surface temperature of -7.9°C (the current annual average) and a constant bedrock temperature of -0.5°C at El. -250 m is assumed. This results in the ground being initially frozen down to El.-250 m.

The results of the initial model are similar to those within the baseline thermal model with a talik underneath the lake.

3.3 Transient 100 year Model

A transient model was run for a period of 100 years with the full tailings deposit present at time zero. Thermal properties presented in Table 2 were used in the model.

The full tailings deposit was considered to be placed instantaneously at an initial temperature of 6°C. This is considered conservative as the tailings would be placed in layers; progressively freezing depending on the time of year the tailings layers were placed.

To investigate the potential effect of climate change, an additional case with increasing surface temperature was considered for the two scenarios. The climate change considered follows the worst case “high sensitivity” model described by the Intergovernmental Panel on Climate Change (IPCC 2007). This model predicts an increase of 6.4°C in the maximum air temperature by the year 2100 for a site located at 65°N latitude. For the transient thermal model, the 6.4°C temperature increase is assumed to occur uniformly over the 100 year period.

3.3.1 Boundary Conditions

The thermal models were developed using the following boundary conditions:

- Lower boundary: geothermal heat flux of 0.052 W/m^2 applied at the base of the bedrock; based on a bedrock thermal conductivity of 2.9 W/m °C and a geothermal gradient of 0.018 °C/m;
- Upper boundary: a ground temperature function based on the site measured ground temperature at 5 cm depth (see Table 1) with a mean annual ground temperature of -7.9°C; and
- Upper boundary (sensitivity case): a ground temperature function taking into account climate change by applying uniform increase of 6.4°C over 100 years to the current measured ground temperature function.

3.3.2 Results

The model results for the two scenarios, assuming tailings placed within the current Lake B7 area and on ground adjacent to Lake B7, are presented below.

Table 3 summarises computed number of years required for freezing of tailings and foundation materials for the model scenario with tailings placed within the current Lake B7 area for both current temperatures and temperatures affected by climate change.

Table 3: Time required to Freeze Tailings and Foundation - Within Lake B7

Location in Section	Approximate Time to Freeze (years)	
	Current average temperature	Assuming Climate Change
Mid-depth of tailings (El. 71.5 m)	12	12
Base of Tailings (El. 58 m)	28	28
Bedrock surface (El. 52 m)	40	41
Bedrock 66 m below tailings surface (El.19 m)	95	100

The evolution of temperature with depth at select times for the tailings placed within the lake basin is presented in Figure 2. The temperature profiles shown are for warmer months between May and October.

The progression of the freezing front within the tailings and foundation is plotted with time in Figure 3 for the tailings placed within the lake, and for both current temperatures and temperatures affected by climate change. The average freezing rate for each material is presented in Table 4.

Table 4: Average Freezing Rate - Within Lake B7

Material	Freezing Rate (m / year)	
	Current average temperature	Assuming Climate Change
Tailings	-0.98	-0.97
Till	-0.77	-0.76
Bedrock (including surface fractured Rock)	-0.59	-0.57
Total Average for 100 years	-0.66	-0.64

Table 5 summarises computed number of years required for freezing of the tailings and re-freezing of the foundation for the model scenario with tailings placed on ground adjacent to the lake, for both current temperatures and temperatures affected by climate change.

Table 5: Time required to Freeze Tailings and Foundation – On Ground Adjacent to the Lake

Location in Section	Approximate Time to Freeze (years)	
	Current average temperature	Assuming Climate Change
Mid-depth of tailings (El. 74.5 m)	3	3
Base of Tailings (El. 64 m)	Less than 1 year	Less than 1 year
Bedrock surface (El. 55.5 m)	Remains Frozen	Remains Frozen

The evolution of temperature with depth at select times for the tailings placed on ground is presented in Figure 4. The temperature profiles shown are for warmer months between May and October. The model shows the temperature of the foundation soil increases after placement of the tailings but does not thaw.

4.0 CONCLUSIONS

A simplified one dimensional thermal model of the proposed tailings deposit within Lake B7 indicated that complete freezing of the tailings, foundation soils and bedrock will occur with time even with consideration of climate change. The model also suggested that minimal warming of the original ground would be expected in permafrost areas.

The model presented in this memorandum constitutes an initial simplified approach to provide general understanding of the freezing process that would develop within tailings deposited on ground and within the lake. The model results should be refined during future stages of the project to incorporate the tailings dyke, the impact of the tailings deposition, water management, and seepage on the freezing process.

Yours very truly,

GOLDER ASSOCIATES LTD.

ORIGINAL SIGNED

Gerd Janssens
Geotechnical Specialist

ORIGINAL SIGNED

John Cunning, P.Eng.
Senior Geotechnical Engineer

GJ/JCC/lw

Attachments: Figures 1 to 4

https://capws.golder.com/sites/capws2/1114280011meliadine/eis tasks/_ddear lead/06_terrestrial enviro/appendices/permafrost/appendix_c_tsf_thermalmodel/doc 356-1013730076 1023_12 tm tsf thermal analyses - mel ver b.docx

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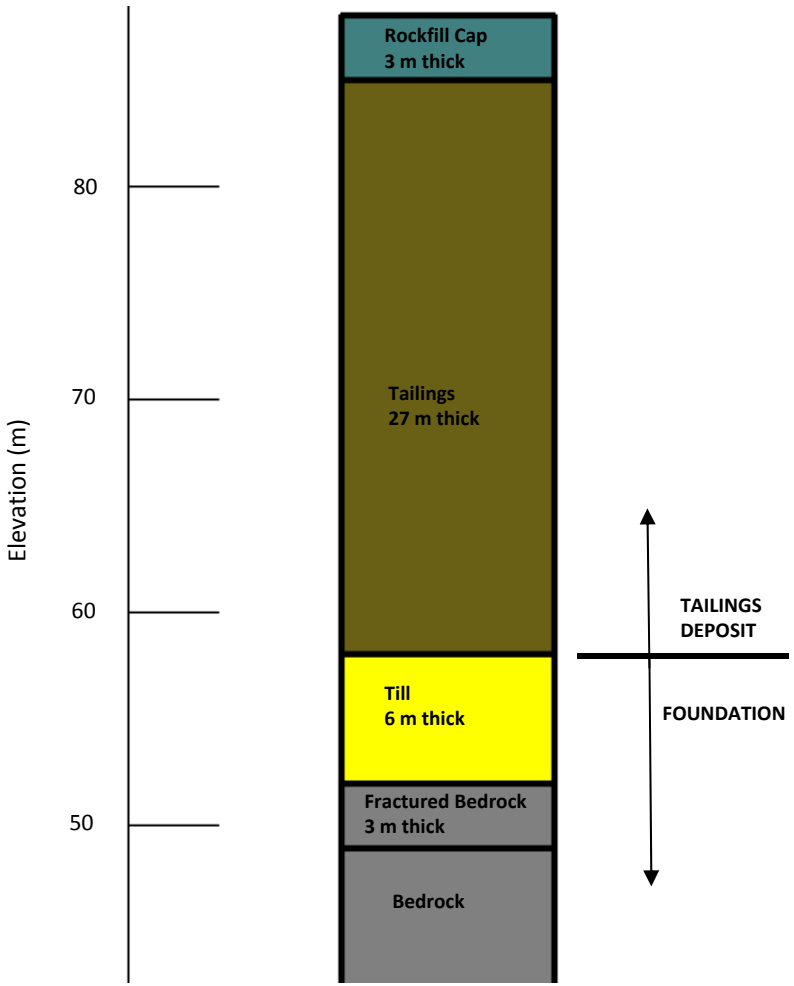
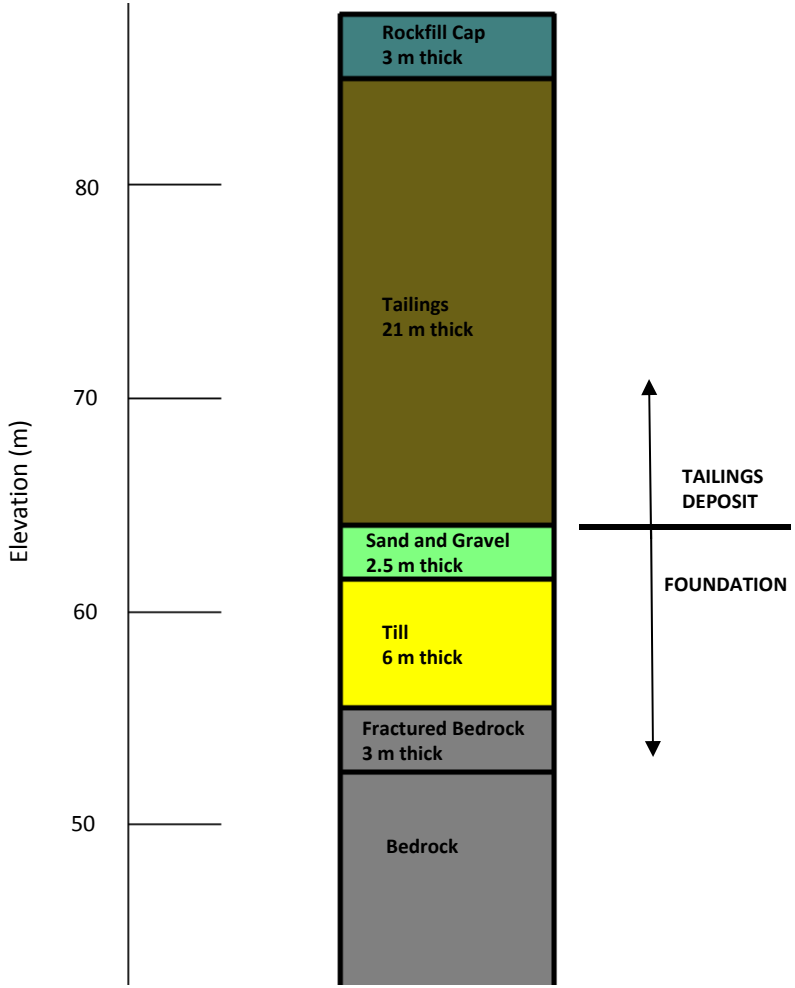
IPCC, Intergovernmental Panel on Climate Change, 2007. Climate Change, 2007, The Physical Science basis. Summary for Policy Makers. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Available: Http://www.ipcc.ch/

FILE: \\golder.gds\gal\Burnaby\Active_2010\1373\10-1373-0076 Meliadine EIS\Phase 3000 Terrestrial\Task 2200 Permafrost\Thermal Modelling



PROFILE WITHIN LAKE B7



PROFILE ON GROUND ADJACENT TO LAKE

PROJECT

AGNICO-EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

1-D THERMAL ANALYSIS
TAILINGS STORAGE FACILITY
TAILINGS AND FOUNDATION PROFILE

Golder Associates

PROJECT No.	10-1373-0076	PHASE No.	8000
DESIGN	GJ 3OCT12	SCALE	NTS
CADD	GJ 3OCT12	REV.	
CHECK	DRW 8JAN13		
REVIEW	DRW 8JAN13		

FIGURE 1

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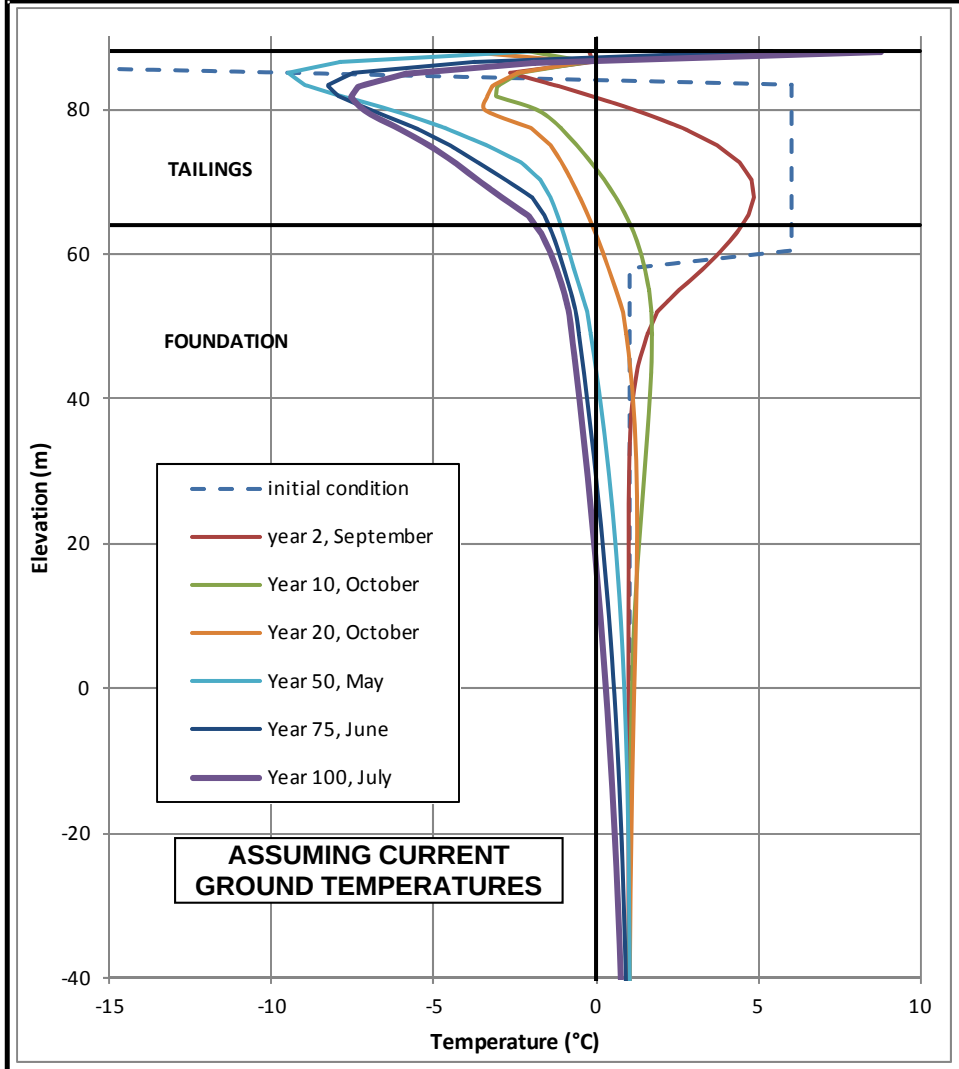

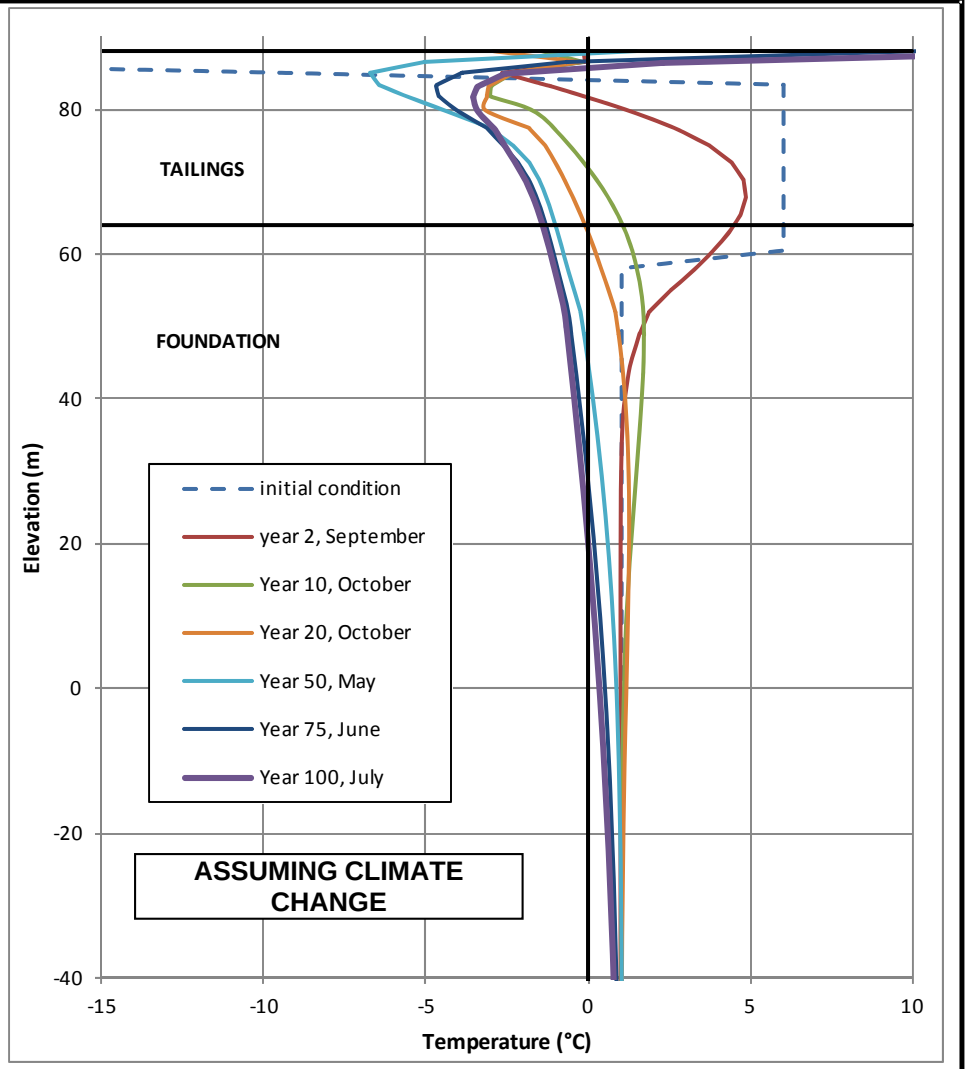

NOTES:

1. Current ground temperatures are based on ground temperatures at a depth of 5 cm measured at Meliadine West Site between 1997 and 2001
2. Climate change assumes a uniform increase in temperature of 6.4°C over the next 100 years (IPCC, 2007 suggest a range of 2.4°C to 6.4°C increase in global average for a site located at 65°N).

PROJECT

AGNICO-EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

1-D THERMAL ANALYSIS TAILINGS STORAGE FACILITY TAILINGS COLUMN WITHIN LAKE B7

Golder Associates

PROJECT No.	10-1373-0076	PHASE No.	8000
DESIGN	GJ 3OCT12	SCALE	NTS
CADD	GJ 3OCT12	REV.	
CHECK	DRW 8JAN13		
REVIEW	DRW 8JAN13		

FIGURE 2

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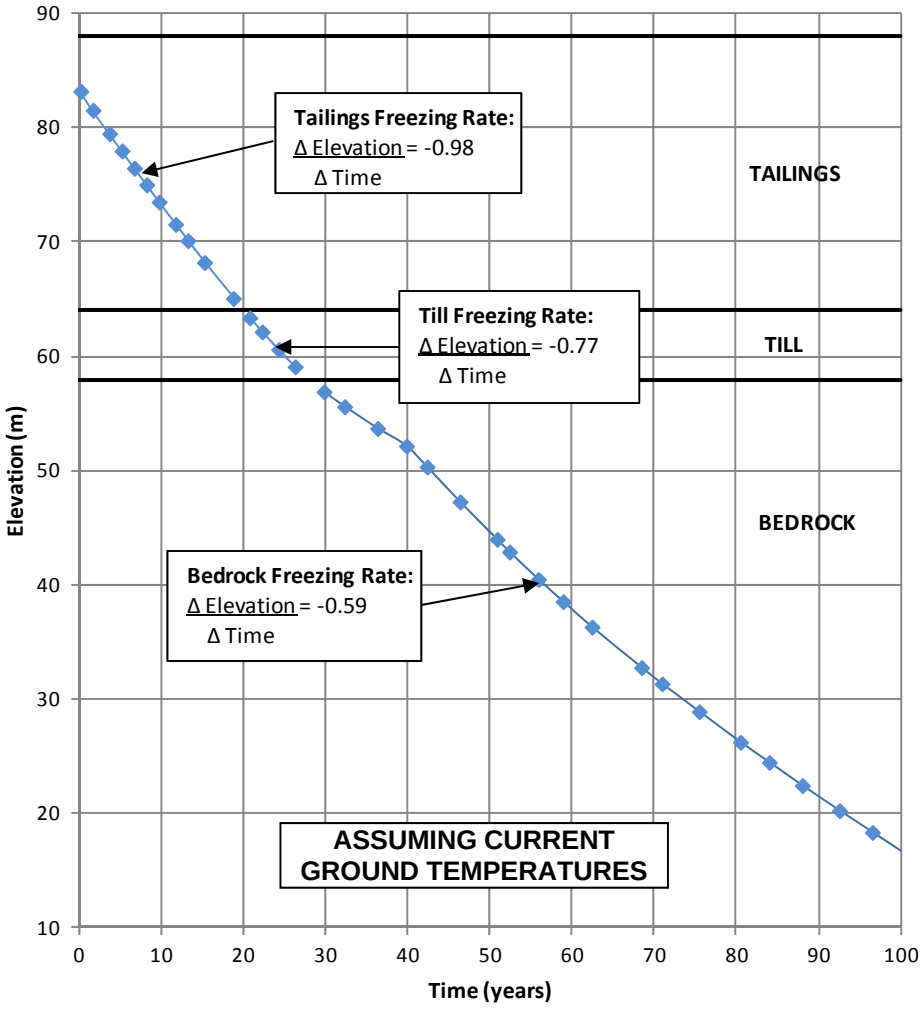

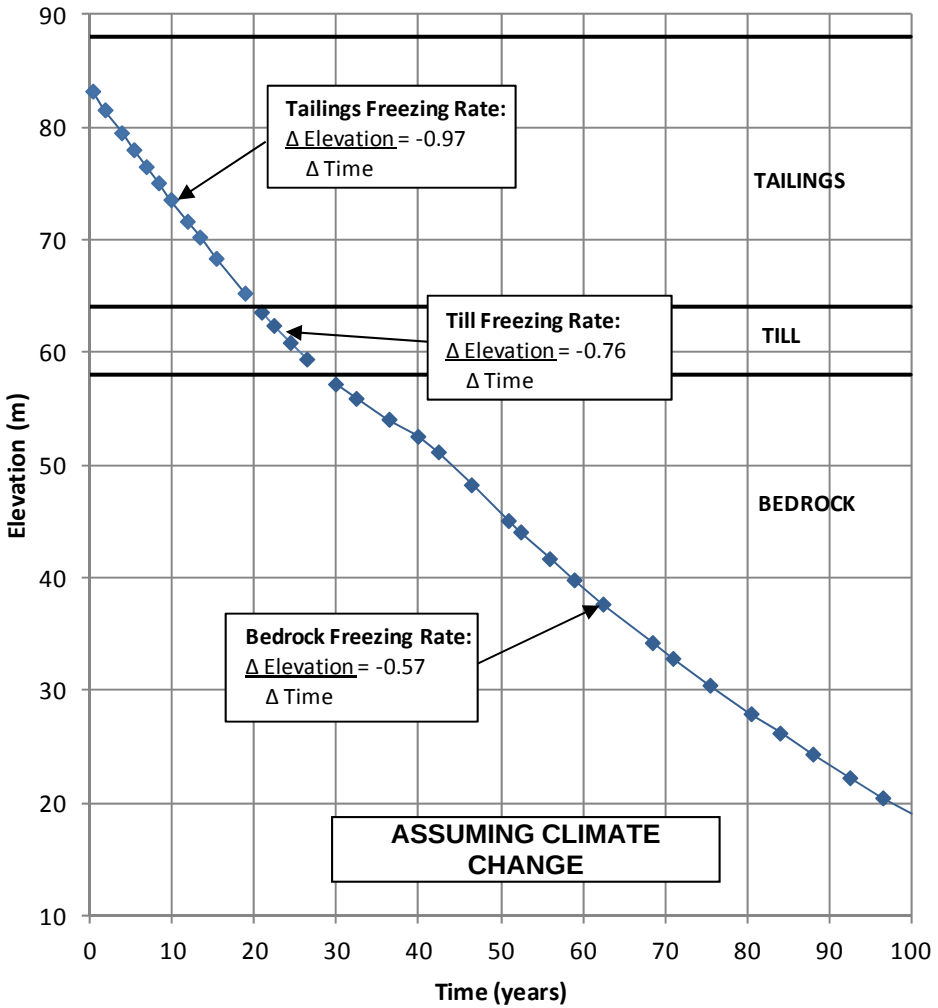

NOTES:

1. Freezing point assumed at 0°C.
2. Current ground temperatures are based on ground temperatures at a depth of 5 cm measured at Meliadine West Site between 1997 and 2001
3. Climate change assumes a uniform increase in temperature of 6.4°C over the next 100 years (IPCC, 2007 suggest a range of 2.4°C to 6.4°C increase in global average).

PROJECT

AGNICO-EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

1-D THERMAL ANALYSIS TAILINGS STORAGE FACILITY FREEZING RATE WITHIN LAKE BASIN

Golder Associates

PROJECT No.	10-1373-0076	PHASE No.	8000
DESIGN	GJ 3OCT12	SCALE	NTS
CADD	GJ 3OCT12	REV.	
CHECK	DRW 8JAN13		
REVIEW	DRW 8JAN13		

FIGURE 3

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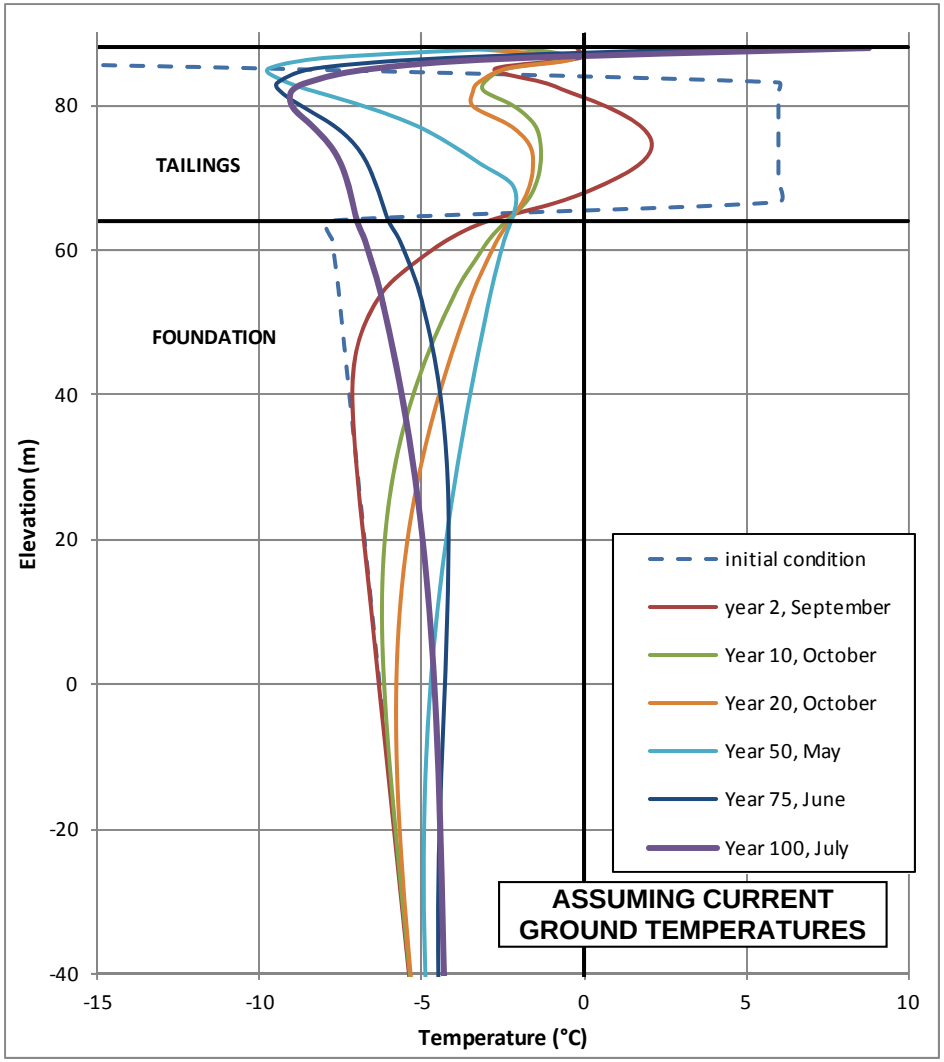

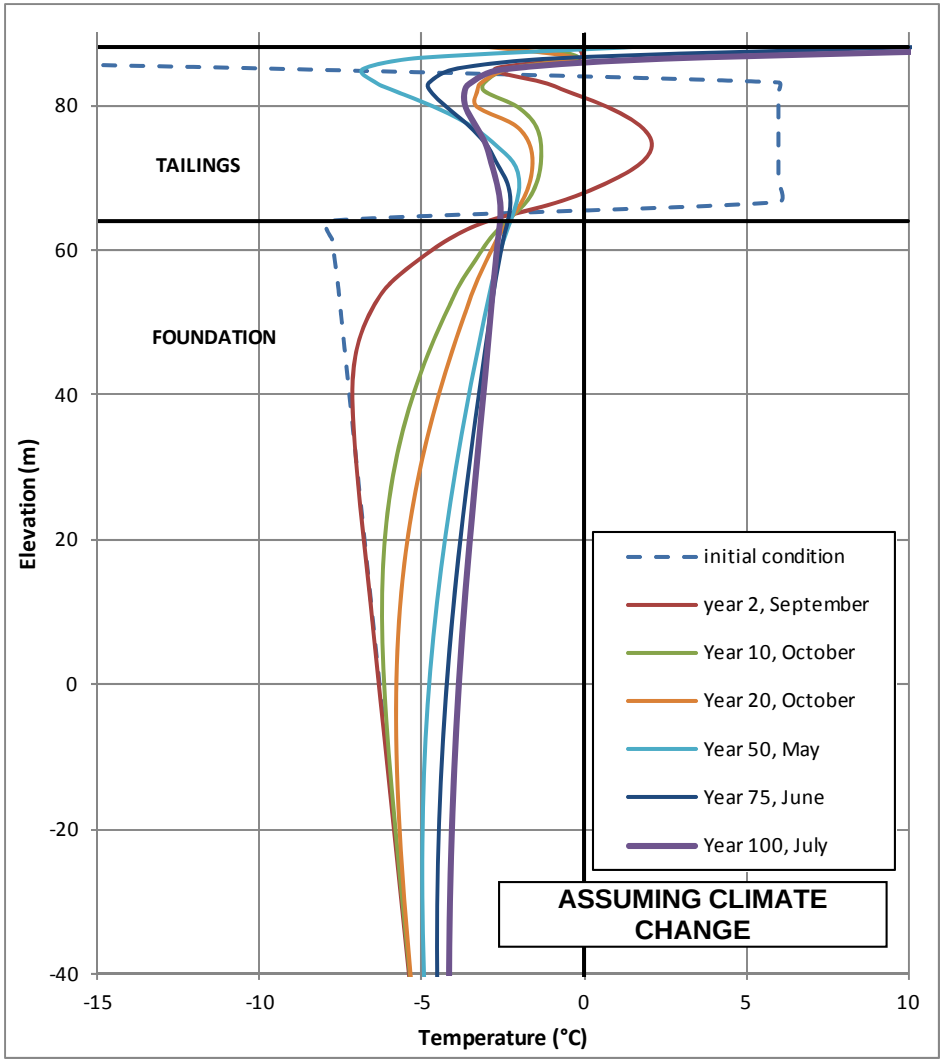

NOTES:

1. Current ground temperatures are based on ground temperatures at a depth of 5 cm measured at Meliadine West Site between 1997 and 2001
2. Climate change assumes a uniform increase in temperature of 6.4°C over the next 100 years (IPCC, 2007 suggest a range of 2.4°C to 6.4°C increase in global average for a site located at 65°N).

PROJECT

AGNICO-EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

1-D THERMAL ANALYSIS
TAILINGS STORAGE FACILITY
TAILINGS COLUMN ON GROUND

Golder Associates

PROJECT No.	10-1373-0076	PHASE No.	8000
DESIGN	GJ 3OCT12	SCALE	NTS
CADD	GJ 3OCT12	REV.	
CHECK	DRW 8JAN13		
REVIEW	DRW 8JAN13		

FIGURE 4

APPENDIX 6.3-F

General Site Conditions

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APPENDICES

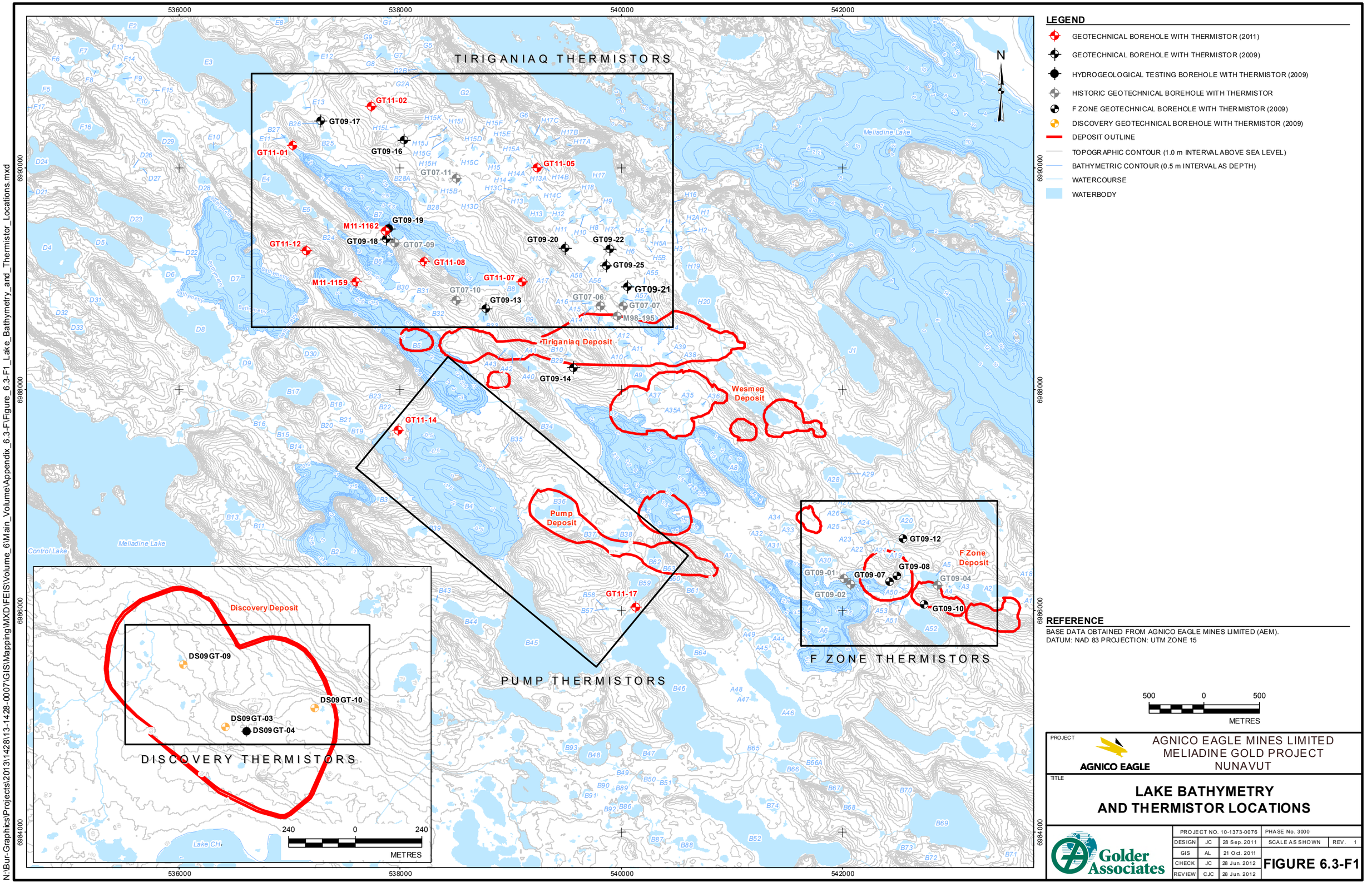
No table of contents entries found.

1.0 GENERAL SITE CONDITIONS

The following sections describe the general site conditions of the Meliadine Project. All the information presented in this summary appendix is presented in full, including references, in FEIS SD 6-1 Permafrost Thermal Regime Baseline Studies – Meliadine Gold Project, Nunavut".

1.1 Topography and Lake Bathymetry

The lake surface elevations in the Meliadine Project area range from about 51 meters above sea level (masl) at Meliadine Lake to about 74 masl for local small perched lakes. Kettle lakes, and other lakes formed by glacio-fluvial processes or glacial processes, are common throughout the Project area. The locations of the main lakes in the Project area, their bathymetry, and the locations of thermistors are shown in Figure 6.3-F1.



LEGEND

- GEOTECHNICAL BOREHOLE WITH THERMISTOR (2011)
- GEOTECHNICAL BOREHOLE WITH THERMISTOR (2009)
- HYDROGEOLOGICAL TESTING BOREHOLE WITH THERMISTOR (2009)
- HISTORIC GEOTECHNICAL BOREHOLE WITH THERMISTOR
- F ZONE GEOTECHNICAL BOREHOLE WITH THERMISTOR (2009)
- DISCOVERY GEOTECHNICAL BOREHOLE WITH THERMISTOR (2009)
- DEPOSIT OUTLINE
- TOPOGRAPHIC CONTOUR (1.0 m INTERVAL ABOVE SEA LEVEL)
- BATHYMETRIC CONTOUR (0.5 m INTERVAL AS DEPTH)
- WATERCOURSE
- WATERBODY

REFERENCE

BASE DATA OBTAINED FROM AGNICO EAGLE MINES LIMITED (AEM).
DATUM: NAD 83 PROJECTION: UTM ZONE 15

500 0 500
METRES

PROJECT
AGNICO EAGLE
AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE
LAKE BATHYMETRY AND THERMISTOR LOCATIONS

Golder Associates

PROJECT NO. 10-1373-0076			PHASE No. 3000		
DESIGN	JC	28 Sep. 2011	SCALE AS SHOWN	REV.	1
GIS	AL	21 Oct. 2011			
CHECK	JC	28 Jun. 2012	**FIGURE 6.3-F1**		
REVIEW	CJC	28 Jun. 2012			

N:\Bur-Graphics\Projects\2013\1428\13-1428-0007\GIS\Mapping\MXD\FEIS\Volume_6\Main_Volume\Appendix_6.3-F\Figure_6.3-F1_Lake_Bathymetry_and_Thermistor_Locations.mxd

Table 6.3-F1 presents naming codes for waterbodies in the Project area.

Table 6.3F-1: Naming System for Watersheds and Waterbodies in the Meliadine Project Area

Naming Code	Description
A, B, C, D, E, F, G, H, I, J	Watersheds within Peninsula on Meliadine Lake*
CH	Chickenhead Lake
CON	Control Lake
DR	Diana River
HB	Hudson Bay
HSL	Horseshoe Lake (part of LML drainage)
LML	Little Meliadine Lake
ML	Meliadine Lake
ML-C	Meliadine Lake (Central Basin)
ML-E	Meliadine Lake (East Basin)
ML-MR	Meliadine Lake outlet to Meliadine River
ML-PL	Meliadine Lake outlet to Peter Lake
ML-S	Meliadine Lake (South Basin)
ML-SE	Meliadine Lake (Southeast portion of South Basin)
ML-W	Meliadine Lake (West Basin)
MR	Meliadine River
MR-L	Lower Meliadine River (downstream of LML)
MR-U	Upper Meliadine River (between LML and ML)
PAR	Parallel Lake
PB	Prairie Bay (part of Hudson Bay)
PL	Peter Lake

Figure 6.3F-1 includes the bathymetric contour data for selected lakes. Table 6.3F-2 presents a summary of mean and maximum depths for lakes in the Meliadine River Watershed area.

Table 6.3F-2: Mean and Maximum Lake Depths in the Meliadine River Watershed Area

Water-body	Depth (m)	
	Mean	Max
A1	n.d.	2
A6	1.5	4.3
A8	1.6	4.2
A54	0.6	1.3
B2	1.6	3.4
B4	0.9	2.4
B5	1.6	3.4
B6	1.4	4
B7	1.5	5.1
B9	0.8	1.3
B10	0.3	0.8
D1	1.2	2.5
D3	n.d.	2.3
D4	n.d.	2.5[a]
D5	n.d.	2
D7	1.6	2.8
G2	n.d.	2.5
Control	n.d.	>4.3

Table 6.3F-2: Mean and Maximum Lake Depths in the Meliadine River Watershed Area (continued)

Water-body	Depth (m)	
	Mean	Max
ML (Meliadine Lake)	n.d.	n.d.
ML-E (Meliadine Lake – East)	4.5	21.2
ML-S (Meliadine Lake – South)	4.3	22.2
PL (Peter Lake)	n.d.	23.5[b]
LML (Little Meliadine Lake)	n.d.	>14.8

a From Hubert and Associates Ltd. (1996)
b Maximum encountered depth in Peter Lake (Kidd et al., 1998)

1.2 Surface Geomorphology and Bedrock Geology

Local overburden in the Project area typically consists of silt, sand and gravel deposits of various thicknesses overlying till with cobbles and boulders. A thin layer of organics covers much of the area.

Bedrock in the Project area consists of a stratigraphic sequence of clastic sediments, oxide iron formation, siltstones, graphitic argillite, and mafic volcanic flows.

1.3 Climate

The Meliadine Project is located in the Kivalliq Region of Nunavut, near the northern borders of the Southern Arctic terrestrial ecozone, and within the Arctic tundra climate region. Within this region daylight reaches a minimum of 4 hours per day in winter, and a maximum of 20 hours per day in summer. The climate is extreme with long, cold winters and short, cool summers. Temperatures are cool, with mean temperatures of 12°C in July and -31°C in January. The mean annual air temperature of the site is approximately -10°C.

The Meteorological Service of Canada (MSC) operates climate stations across the Canadian Provinces and Territories. Long term climate data are available from the regional climate station at Rankin Inlet, which is considered to be relevant and representative of the Project climate conditions given its close proximity to the Project. Table 6.3F-3 summarizes regional MSC climate stations within 90 km of the Project.

Table 6.3F-3: Regional MSC Climate Stations within 90 km of Meliadine Gold Project

Station Name	MSC Station Number	Period of Record	Latitude	Longitude	Distance from Project
Rankin Inlet*	2303400	1954 to 1962	92° 04.0’	62° 48.0’	30 km South
Rankin Inlet A	2303401	1981 to 2009	92° 07.2’	62° 49.2’	30 km South
Rankin Inlet ARTC*	2303403	1976	92° 05.0’	62° 49.0’	30 km South
Chesterfield*	2300700	1930 to 1981	90° 43.0’	63° 20.0’	80 km North
Chesterfield Inlet*	2300705	1921 to 1931	90° 50.0’	63° 45.0’	80 km North
Chesterfield Inlet A	2300707	1985 to 2007	90° 43.8’	63° 21.0’	80 km North
Whale Cove*	2303985	1974 to 1984	92° 36.0’	62° 11.0’	90 km South
Whale Cove A	2303986	1985 – 2007	92° 36.0’	62° 14.4’	90 km South

* incomplete records

1.3.1 Temperatures

Table 6.3F-4 presents a summary of site climate data for air temperature, ground temperature at 5 cm depth and precipitation (rainfall) from the site weather station.

Table 6.3F-4: Summary of Meliadine Gold Project Site Climate Data

Air Temperature				Ground Temperature at 5 cm Depth
Month	Average Monthly		Mean	Mean (May 1997 to Aug. 2001)
	Max (°C)	Min (°C)	(°C)	(°C)
January	-28.5	-35.3	-31.4	-25.3
February	-23.1	-32.2	-27.8	-24.3
March	-18.0	-26.9	-21.7	-19.5
April	-9.3	-19.8	-14.0	-14.5
May	-0.3	-7.9	-3.8	-6.9
June	10.6	0.3	5.0	2.5
July	17.0	7.3	12.1	8.4
August	14.6	7.2	10.7	7.9
September	7.0	1.9	4.3	4.0
October	-2.2	-7.0	-5.0	-1.3
November	-11.4	-19.2	-15.1	-8.2
December	-21.7	-29.0	-24.9	-17.9
Annual Average			**-9.3**	**-7.9**

Monthly air temperatures from 1981 to 2009 are presented in Table 6.3F-5 for Rankin Inlet A climate station.

Table 6.3F-5: Summary of Ranking Inlet A Mean Monthly Air Temperature, 1981 to 2009

Month	Warmest and Coldest Day in the Month (°C)		Daily (°C)		Monthly Means (°C)
	Extremes		Means		
	Maximum	Minimum	Maximum	Minimum	
January	0.0	-46.1	-19.8	-37.2	-30.9
February	-4.4	-49.8	-24	-35.3	-30.1
March	1.3	-43.4	-18.8	-30.8	-25.1
April	3.4	-35.7	-10.4	-20.2	-15.7
May	14.1	-23.8	-1.2	-10.8	-5.9
June	26.1	-9.4	6.7	0.1	4.1
July	28.9	-1.9	14.9	6.9	10.5

Table 6.3F-5: Summary of Ranking Inlet A Mean Monthly Air Temperature, 1981 to 2009 Cont'd

Month	Warmest and Coldest Day in the Month (°C)		Daily (°C)		Monthly Means (°C)
	Extremes		Means		
	Maximum	Minimum	Maximum	Minimum	
August	30.5	-1.4	11.2	7.7	9.7
September	20.6	-9.0	6.8	1.3	3.8
October*	9.3	-27.4	1.7	-9.9	-4.6
November*	0.9	-36.5	-10.2	-23.6	-17.2
December*	-2.0	-43.6	-19.4	-33.3	-25.9
Annual Extremes	**30.5**	**-49.8**	**14.9**	**-37.2**	**-10.4**

Note: * = 2009 data not available

1.3.2 Precipitation

Table 6.3F-6 presents the mean monthly rainfall, snowfall and precipitation at the Rankin Inlet A climate station recorded from 1981 to 2009, and mean monthly rainfall at the Meliadine Project site recorded in the summer months from 1997 to 2001.

Table 6.3F-6: Summary of Mean Monthly and Annual Precipitation

Month	Rankin Inlet A Climate Station (1981 to 2009)[1]			Meliadine Project Site (1997 to 2001)[2]
	Rainfall (mm)	Snowfall (cm)	Precipitation (mm)	Rainfall (mm)
January	0.0	8.6	8.4	-
February	0.0	8.7	8.4	-
March	0.0	12.4	12.2	-
April	1.2	19.2	20	-
May	6.8	12.8	19.1	-
June	23.4	4.7	28.0	30.9
July	38.7	0.1	38.8	34.9
August	56.4	0.2	56.5	52.9
September	40.0	3.8	43.8	36.3
October*	13.7	24.6	37.9	-
November*	0.3	22.2	21.6	-
December*	0.0	12.6	12.0	-
Annual Total	**180.6**	**128.8**	**305.5**	**-**

Notes: 1. *= 2009 data not available; and
2. - Denotes not reported; and snowfall not recorded.

1.3.3 Wind Speed and Direction

The recorded prevailing winds at the Rankin Inlet A climate station are from north-northwest and north, as shown in the following Figure 6.3F-2. The values for wind speed frequency are presented in Table 6.3F-7.

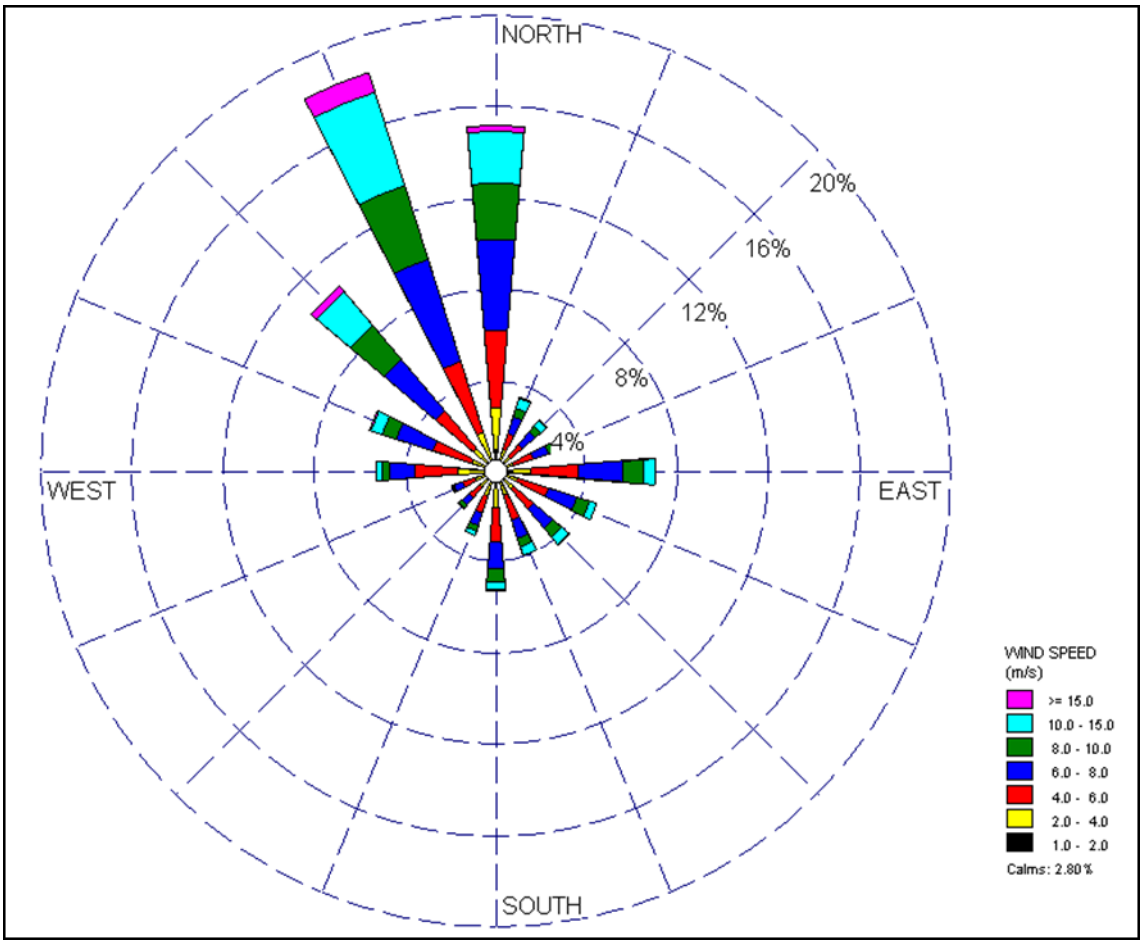


Figure 6.3F-2: Ranking Inlet A Mean Wind Speed and Direction - Frequency Rose

Table 6.3F-7: Ranking Inlet A Mean Wind Rose Speed and Direction Frequencies, 1981 to 2008

Direction		Wind Classes (m/s)							
Cardinal or Intermediate	Sector Midpoint (°)	1.0 - 2.0	2.0 - 4.0	4.0 - 6.0	6.0 - 8.0	8.0 - 10.0	10.0 - 15.0	>= 15.0	Total (%)
N	0	0.99	1.81	3.40	3.96	2.45	2.25	0.28	15.14
NNE	22.5	0.48	0.56	0.72	0.75	0.43	0.44	0.07	3.45
NE	45	0.35	0.49	0.72	0.71	0.34	0.33	0.06	3.00
ENE	67.5	0.33	0.54	0.86	0.75	0.34	0.29	0.06	3.17
E	90	0.49	1.05	2.11	1.95	0.85	0.52	0.04	7.01
ESE	112.5	0.29	0.73	1.44	1.31	0.56	0.33	0.02	4.68
SE	135	0.32	0.69	1.21	1.12	0.47	0.43	0.02	4.26
SSE	157.5	0.35	0.77	1.17	0.82	0.40	0.35	0.02	3.88
S	180	0.58	1.04	1.47	1.18	0.57	0.38	0.02	5.24
SSW	202.5	0.43	0.73	0.78	0.59	0.28	0.18	0.01	3.00
SW	225	0.39	0.59	0.59	0.38	0.16	0.09	0.01	2.21
WSW	247.5	0.36	0.61	0.61	0.33	0.10	0.06	0.00	2.07
W	270	0.54	1.18	1.87	1.09	0.33	0.24	0.02	5.27
WNW	292.5	0.33	0.78	1.79	1.69	0.67	0.51	0.09	5.86
NW	315	0.36	0.94	2.19	2.96	1.92	1.94	0.31	10.62
NNW	337.5	0.53	1.29	3.25	4.68	3.34	4.32	0.89	18.30
	Sub-Total	**7.12**	**13.80**	**24.18**	**24.27**	**13.21**	**12.66**	**1.92**	**97.16**
								Calms	**2.52**
								Missing/Incomplete	**0.32**
								Total	**100.00**

Note: °= degrees; m/s= metres per second.

1.3.4 Relative Humidity

Rankin Inlet A climate station is humid throughout the year, with peaks typically occurring during the months of May and October and lows during January and February. Table 6.3F-8 provides a summary of the mean relative humidity values recorded at the Project site and Rankin Inlet A climate stations for the period of 1981 to 2008.

Table 6.3F-8: Mean Relative Humidity Recorded at Rankin Inlet A and Meliadine Camp, 1981 to 2008

Month	Mean Monthly Relative Humidity [%]				
	Meliadine Camp				Rankin Inlet A
	1997	1998	1999	2000	1981 to 2008
January	Not recorded	70.8	78.3	Not recorded	66.6
February	Not recorded	78.4	83.9	Not recorded	67.0
March	Not recorded	77.9	84.3	Not recorded	70.2
April	88.5	88.5	91.2	Not recorded	78.9
May	85.7	91.4	93.1	Not recorded	86.1
June	80.1	85.6	84.8	86.8	80.8
July	74.2	81.3	81.2	78.2	77.2
August	81.0	89.5	85.7	85.5	81.2
September	Not recorded	94.2	89.3	89.6	84.0
October	93.5	94.5	Not recorded	Not recorded	86.7
November	89.6	95.4	Not recorded	Not recorded	77.9
December	84.4	83.6	Not recorded	Not recorded	70.2
Annual*	**84.6**	**85.9**	**85.8**	**85.0**	**77.3**

Note: *= based on recorded data
%= percent

1.3.5 Solar Radiation

The intensity of solar radiation is related to the length of the day in the north. Net solar radiation (the difference between the incoming solar radiation and the reflected radiation) data were collected at the climate station installed at Meliadine Camp and is reported for the years of 1997, 1999 and 2000 in the following table.

Table 6.3F-9: Mean Net Solar Radiation at Meliadine Camp, 1997, 1999, and 2000

	Monthly Mean Net Radiation ($MJ/m^2/d$)		
	1997	1999	2000
June	13.5	14.3	10.4
July	12.1	11.0	13.5
August	8.6	7.4	7.2
September	Not recorded	3.9	3.8

Note: $MJ/m^2/d$ = megajoules per square metre per day.

1.4 Lake Water Temperature and Lake Ice Thickness

Lake water temperature data were collected from 1997 through to 2000, including lake water temperature profiles recorded in the spring and summer of 1997, 1998 and 1999. The monthly means, ranges, and mean diurnal fluctuations of lake water temperatures measured in summer months from 1998 to 2000 are summarized in Table 6.3F-10.

Table 6.3F-10: Summer Lake Water Temperatures, June to September of 1998 to 2000

Lake	Jun-98			Jul-98			Aug-98			Sep-98		
	Mean	Range	Fluct.*	Mean	Range	Fluct.	Mean	Range	Fluct.	Mean	Range	Fluct.
A8	7.9	4.0 to 13.0	3.5	13.3	8.6 to 18.1	2.4	12.6	7.8 to 18.3	1.9	6.9	2.5 to 10.8	1.1
B2	7.4	3.7 to 13.3	2.8	13.6	8.6 to 19.7	2.7	12.9	8.6 to 19.1	2.1	7.1	2.6 to 11.2	1.3
B5	6.3	2.2 to 12.3	3.5	13.4	8.9 to 18.9	2.3	12.8	8.4 to 18.8	1.9	7.1	2.8 to 10.9	1.1
ML-SE	9.1	5.3 to 12.9	3.6	13.4	8.0 to 18.8	2.8	12.6	6.8 to 18.8	2.3	6.8	2.2 to 11.1	1.3
ML-E	4.7	4.0 to 6.1	1.2	10.6	3.5 to 15.2	1.4	13.1	9.6 to 16.2	1.0	8	4.1 to 10.9	1.2
PL	4.5	2.2 to 6.1	1.8	9.0	1.7 to 14.2	2.0	13.1	9.8 to 16.3	1.0	8.8	4.7 to 11.7	0.9
Lake	**Jun-99**			**Jul-99**			**Aug-99**			**Sep-99**		
	Mean	Range	Fluct.	Mean	Range	Fluct.	Mean	Range	Fluct.	Mean	Range	Fluct.
A6	5.4	0.8 to 12.1	2.6	12.8	8.9 to 17.8	2.1	11.4	6.1 to 15.9	1.8	5.4	4.7 to 6.5	1.0
B2	4.8	0.4 to 11.2	2.4	12.9	9.0 to 17.8	2.2	11.6	5.9 to 16.2	1.8	5.5	4.9 to 6.1	1.1
ML-SE	6.4	1.4 to 12.1	3.6	12.5	8.6 to 17.2	2.6	11.5	5.9 to 16.6	1.9	5.3	4.9 to 5.9	0.8
Con	4.4	1.0 to 9.8	2.1	12.7	7.7 to 16.8	1.6	11.9	7.1 to 15.7	1.4	6.6	6.1 to 7.3	0.9
Lake	**Jun-00**			**Jul-00**			**Aug-00**			**Sep-00**		
	Mean	Range	Fluct.	Mean	Range	Fluct.	Mean	Range	Fluct.	Mean	Range	Fluct.
A6	2.4	0.7 to 4.9	1.9	12.1	2.9 to 21.3	2.6	13.0	4.4 to 21.4	1.9	4.8	-0.1 to 9.2	1.4
B2	1.8	0.6 to 4.6	1.5	12.4	2.4 to 20.8	2.9	13.1	4.6 to 21.1	1.8	5.4	0.0 to 8.7	1.4
ML-SE	3.0	1.3 to 7.1	2.6	12.4	3.4 to 21.1	3.8	13.1	5.2 to 20.5	2.2	5.6	-0.1 to 9.7	1.6
Con	4.8	3.8 to 5.9	1.1	11.8	3.7 to 21.1	2.1	13.5	5.1 to 20.3	1.3	5.6	-0.1 to 8.7	1.0

* Mean daily temperature fluctuation (daily maximum - daily minimum).

Table 6.3F-11 summarizes the temperature ranges for the temperature profiles measured during the open water period for a number of lakes in the Project area.

Table 6.3F-11: Temperature Range in the Water Column of Lakes in the Meliadine Study Area, 1997 to 1999

Lake	Maximum Depth (m)	Jul-97		Aug-97		Apr-98		Jul-98		Aug/Sep-98		Jul-99	
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
ML-E	14.7	13.2	13.9	11.2	15.3	-0.2	2.8	9.9	9.9	9.7	9.7		
ML-S	6.3	14.3	14.6	11.4	13.2	-0.2	1.6	12.6	13.1				
ML-SE	3.1					-0.2	1.2	11.0	11.4			11.2	11.7
ML-W	8.5	13.9	14.3	11.4	13.6	0.1	1.2	12.4	12.9				
LML	14.8					0.0	2.0	12.2	14.0	10.2	10.5		
PL	18.8					0.4	2.7	9.5	11.9				
A1	1.8			14.7	14.9								
A6	4.0	18.2	19.0	15.1	15.7	0.0	2.1	14.3	15.1			9.8	9.9
A8	3.6	16.4	17.7	14.2	14.3	-0.2	1.8	12.3	12.7				
B2	3.0	16.0	17.4	14.8	15.3	-0.2	0.8	9.7	9.8	8.9	8.9	10.9	11.1
B5	2.7	15.1	15.1	15.1	15.1	-0.2	0.0	9.9	10.0	8.9	8.9	10.2	10.5
B7	3.8	14.3	14.3	14.3	15.1	-0.1	1.7	9.7	9.7	9.6	10.3		
D1	2.2			15.7	16.7	-0.2	-0.2						
D7	2.3	13.5	14.0	15.2	15.8	-0.2	0.3						
G2	2.3	17.3	17.4	16.0	16.0								
Con	4.3							14.5	14.7			11.9	12.6

Late-winter ice thicknesses on freshwater lakes in the Meliadine Gold Project area over the period of record are presented in Table 6.3F-12. Ice covers usually appeared by the end of October and were completely formed in early November. The spring ice melt typically began in mid-June and was complete by early July.

Table 6.3F-12: Lake Ice Thicknesses and Depths Measured for the Meliadine Gold Project Area

Area	Site ID or Water Body[1]	Surface Area[2] (ha)	Date Sampled	UTM Zone 15, NAD83[3]		Source[4]	Ice Thickness (m)	Lake Depth including Ice at Sampling Location (m)
				Easting	Northing			
Meliadine Lake	ML-E	10 689	Apr-98	543253	6988595	RL&L 1999	1.8	11.5
	ML-E		Apr-09	543184	6987869	Golder 2009b	1.7	5.4
	ML-A		Apr-09	544654	6986157	Golder 2009b	1.8	5.1
	BOOT-2		Apr-09	542070	6989338	Golder 2009b	1.9	10.1
	ML-W		Apr-98	524265	7001352	RL&L 1999	2.3	4.2
	ML-S		Apr-98	532241	6989347	RL&L 1999	1.8	5.0
	ML-L		May-98	530573	6995553	AEE 1998b	2.0	-
			May-00	530573	6995553	AMEC 2000	2.0	-
	ML-SE		Apr-98	535954	6986565	RL&L 1999	1.8	3.0
			Apr-09	535824	6986364	Golder 2009b	1.7	3.1
Tiriganiaq, Wesmeg and Pump Deposits	Lake A8	90.5	Apr-98	540084	6987478	RL&L 1999	1.8	3.0
			Apr-09	540181	6987142	Golder 2009b	1.6	2.7
	Lake B2	49.4	Apr-98	537412	6986604	RL&L 1999	1.8	2.5
			May-98	-	-	AEE 1998b	1.9	-
			May-99	-	-	AEE 1999	1.3	-
			May-00	-	-	AMEC 2000	1.4	-
	Lake B4	85.8	May-98	-	-	AEE 1998b	1.0	-
			May-99	-	-	AEE 1999	1.3	-
	Lake B5	56.7	Apr-98	537989	6988649	RL&L 1999	1.8	2.2
			May-98	-	-	AEE 1998b	2.1	-
			May-99	-	-	AEE 1999	1.3	-
			Apr-09	538281	6988153	Golder 2009b	1.6	2.6
	Lake B6	11.8	Apr-09	537758	6989218	Golder 2009b	1.7	3.5
	Lake B7	57.9	Apr-98	537731	6989737	RL&L 1999	1.8	3.2
			May-98	-	-	AEE 1998b	2.0	-
			May-99	-	-	AEE 1999	1.2	-
			Apr-09	537811	6989603	Golder 2009b	1.8	3.8
			May-00	-	-	AMEC 2000	2.0	-
F Zone Deposit	Lake A1	16.4	May-98	-	-	AEE 1998b	1.8	-
			May-00	-	-	AMEC 2000	1.8	-
	Lake A6	55.3	Apr-98	541998	6986004	RL&L 1999	1.7	3.8
			May-98	-	-	AEE 1998b	1.6	-
			Apr-09	541777	6985645	Golder 2009b	1.7	4.2
Discovery Deposit	Lake CH	135	Apr-09	555108	6980408	Golder 2009b	1.7	9.0

Notes: - data not available.
1. Lake locations shown in Figure 2, and detailed measurement site ID shown in Golder (2009b).
2. Surface area for Meliadine Lake includes the entire lake.
3. UTM coordinates from RL&L 1998 were converted from NAD27.
4. RL&L is RL&L Environmental Services Ltd.; AEE is Amec Earth and Environmental Ltd.

Additional data on ice thickness in the Peninsula lakes and ponds (in basins B, D and E) were collected in April 2011. These data are summarized in Table 6.3F-13. Typically, smaller lakes have thicker accumulations of snow than do larger lakes, which have an increased surface area exposed to wind sweeping and sunlight. The data in Table 6.3F-13 and Figure 6.3F-3 below suggest there is no significant correlation between lake size, and hence snow thickness and ice thickness at the time the data were collected.

Table 6.3F-13: Lake Ice Thickness and Depth Measured for the Meliadine Gold Project Area in April 2011

Area	Site ID or Water Body	Surface Area[2] (ha)	Date Sampled	UTM Zone 15, NAD83		Ice Thickness[3] (m)	Lake Depth[3] (m)
				Easting	Northing		
Tiriganiaq, Wesmeg and Pump Deposits	Lake B2	49.4	11-Apr-2011	537262	6986682	1.65	3.16
	Lake B4	85.8	11-Apr-2011	538698	6986905	1.68	1.95
	Lake B5	56.7	9-Apr-2011	538288	6988171	1.62	2.75
	Lake B6	11.8	9-Apr-2011	537753	6989226	1.68	3.00
	Lake B7	57.9	9-Apr-2011	537738	6989793	1.66	2.25
	Lake B45	47.4	11-Apr-2011	539092	6985496	1.51	1.62
	Lake E3	56.8	9-Apr-2011	536450	6990898	1.71	4.22
	Lake E4	8.5	9-Apr-2011	536836	6989878	1.63	2.80
Other[1]	Lake B52	33.4	11-Apr-2011	541472	6983741	1.52	2.73
	Lake B53	15.7	11-Apr-2011	541432	6983365	1.58	2.01
	Lake B69	25.0	11-Apr-2011	542844	6984060	1.55	3.64
	Lake D7	73.5	9-Apr-2011	536638	6988797	1.35	2.65

Notes:
1. Lakes on the Peninsula, but not directly affected by the Project.
2. Surface area values are from Table 7.5-8 in Section 7.5.4.2.2.2 of Volume 7 (Freshwater Environment).
3. Ice thickness and lake depth data are from Appendix B2 of SD7-2 (2011 Aquatic Baseline Studies). Lake depths were measured at the sampling station and include the ice cover.

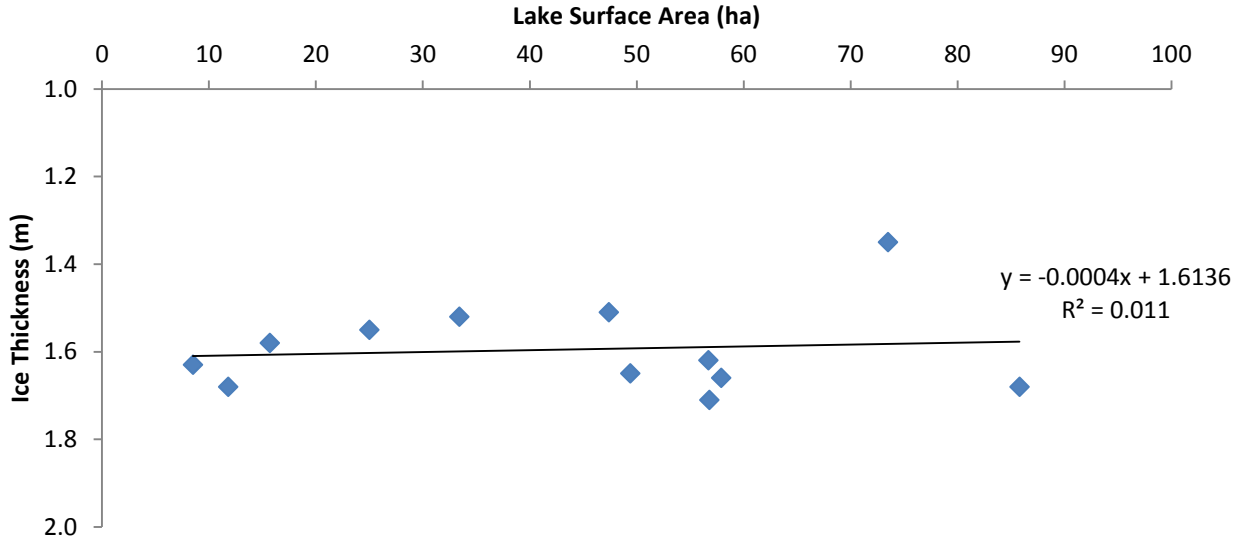


Figure 6.3F-3: Relationship between Lake Surface Area and Ice Thickness

2.0 SITE PERMAFROST CONDITIONS

The tables presented in the following sections summarize estimates of geothermal properties based on data collected from the thermistors installed at the various locations in the Project area. Figure 6.3F-4 presents the thermistor locations relative to terrain descriptions and soil drainage conditions. Figure 6.3F-5 presents the thermistor locations relative to plant community classification. Figure 6.3F-6 presents the thermistor locations and summaries of important geothermal characteristics for each thermistor. Figure 6.3F-7 summarizes the thermistor locations and summaries of the National Research Council of Canada (1979) permafrost soil classification and excess water or ice content for selected boreholes where this information was logged.

Terrain Code	Simplified Terrain Description	Soil Drainage
1	Beach ridges	Well
2A	Beach deposits	Well to moderately well
2B	Beach deposits	Moderately well to imperfectly
2C	Beach deposits	Imperfectly to poorly
2D	Beach deposits	Poorly to imperfectly
2E	Beach deposits	Poorly to very poorly
3A	Deltaic terraces and/or ridges	Well
3B	Deltaic levels and/or plains	Well to moderately well-
3C	Deltaic levels and/or plains	Imperfectly to poorly
3D	Deltaic levels and/or plains	Poorly drained
4A	Marine sediments and washed till	Well to moderately well
4B	Marine sediments and washed till	Moderately well to imperfectly
4C	Marine sediments and washed till	Imperfectly to poorly
4D	Marine sediments and washed till	Poorly to very poorly
5A	Blankets and veneers of washed till	Well to moderately well
5B	Blankets and veneers of washed till	Moderately well to imperfectly
5C	Blankets and veneers of washed till	Imperfectly to poorly
5D	Blankets and veneers of washed till	Poorly to imperfectly
5E	Blankets and veneers of washed till	Poorly
5F	Blankets and veneers of washed till, minor organic veneers	Poorly to very poorly
6A	Glaciofluvial ridges	Well
6B	Glaciofluvial slopes	Well to moderately well
7A	Fluvial levels and or terraces	Well to moderately well
7B	Fluvial levels and or terraces	Imperfectly to poorly
8	Weathered bedrock	Well drained
9A	Weathered bedrock and washed till or marine sediments, lesser bedrock	Well to moderately well
9B	Weathered bedrock and washed till or marine sediments, lesser bedrock	Moderately well to imperfectly to poorly
10	Weathered bedrock, washed till or marine sediments, minor bedrock	Well to moderately well
11	Bedrock and weathered bedrock.	Rapidly to well
12A	Washed till and/or marine sediments, weathered bedrock	Well to moderately well
12B	Washed till and/or marine sediments, weathered bedrock	Moderately well to imperfectly
12C	Washed till and/or marine sediments, weathered bedrock	Imperfectly to poorly

536000 538000 540000 542000

6990000 6988000 6986000 6984000

TIRIGANIAQ THERMISTORS

PUMP THERMISTORS

F ZONE THERMISTORS

DISCOVERY THERMISTORS

GT11-02 GT09-17 GT11-01 GT09-16 GT11-05 GT07-11 GT09-19 M11-1162 GT09-18 GT11-12 GT07-09 GT11-08 M11-1159 GT11-07 GT09-20 GT09-22 GT09-25 GT09-21 GT07-07 M98-195 GT09-13 GT07-10 GT07-06 GT09-14 GT11-14 GT11-17 GT09-12 GT09-02 GT09-07 GT09-08 GT09-04 GT09-01 GT09-10

DS09GT-09 DS09GT-10 DS09GT-03 DS09GT-04

240 0 240 METRES

N

LEGEND

- BOREHOLE WITH THERMISTOR
- DEPOSIT OUTLINE
- PROPOSED SERVICE ROAD
- AS BUILT ROAD (APRIL 2007)
- 500m STUDY BUFFER

TERRAIN CODE *

- 1 - Beach Ridge
- 2 - Beach Deposit
- 3 - Deltaic Terrace, Level, and/or Ridge, Plain
- 4 - Marine Sediment and Washed Till
- 5 - Blanket and Veneer of Washed Till
- 6 - Gaciofluvial Ridge or Slope
- 7 - Fluvial Level and/or Terrace
- 8 - Weathered Bedrock
- 9 - Weathered Bedrock and Washed Till or Marine Sediments, Lesser Bedrock
- 10 - Weathered Bedrock and Washed Till or Marine Sediment, Minor Bedrock
- 11 - Bedrock and Weathered Bedrock
- 12 - Washed Till and/or Marine Sediment, Weathered Bedrock
- LAKE

REFERENCE

BASE DATA OBTAINED FROM AGNICO EAGLE MINES LIMITED.
PROJECTION: UTM ZONE 15 DATUM: NAD 83

600 0 600 METRES

PROJECT
AGNICO EAGLE
AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE
THERMISTOR BOREHOLES AND TERRAIN CLASSIFICATION

Golder Associates

PROJECT NO. 13-1428-0007			PHASE No. 5000		
DESIGN	CC	28 Jun. 2013	SCALE AS SHOWN	REV.	1
GIS	MM	03 Jul. 2013			
CHECK	CC	03 Jul. 2013	FIGURE 6.3-F4		
REVIEW	DRW	03 Jul. 2013			

N:\Bur-Graphics\Projects\2013\1428\13-1428-0007\GIS\Mapping\MXD\FEIS\Volume 6\Main Volume\Appendix 6.3-F\Figure 6.3-F4 Thermistor Boreholes and Terrain Classification.mxd

HISTORIC GEOTECHNICAL BOREHOLE WITH THERMISTOR	
GT07-06	Sedge Community
GT07-07	Sedge Community
GT07-09	Sedge Community
GT07-10	Lichen-Heath (Cetraria Lichen)
GT07-11	Water
GT09-01	Heath Tundra Community
GT09-02	Water
GT09-04	Water
M98-195	Heath Tundra Community
F ZONE GEOTECHNICAL BOREHOLE WITH THERMISTOR (2009)	
GT09-07	Heath Tundra Community
GT09-08	Heath Tundra Community
GT09-10	Heath Tundra Community
GT09-12	Sedge Community
GEOTECHNICAL BOREHOLES 2011	
GT11-01	Sedge Community
GT11-02	Heath Tundra Community
GT11-05	Heath Tundra Community
GT11-07	Heath Tundra Community
GT11-08	Heath Tundra Community
GT11-12	Sedge Community
GT11-14	Sedge Community
GT11-17	Sedge Community
M11-1159	Lichen-Heath (Cetraria Lichen)
M11-1162	Heath Tundra Community
HYDROGEOLOGICAL TESTING BOREHOLE WITH THERMISTOR (2009)	
GT09-19	Lichen-Heath (Cetraria Lichen)
GEOTECHNICAL BOREHOLE WITH THERMISTOR (2009)	
GT09-13	Sedge Community
GT09-14	Heath Tundra Community
GT09-16	Heath Tundra Community
GT09-17	Sedge Community
GT09-18	Sedge Community
GT09-20	Heath Tundra Community
GT09-21	Sedge Community
GT09-22	Heath Tundra Community
GT09-25	Heath Tundra Community
DISCOVERY DEPOSIT	
DS09GT-03	Sedge Community
DS09GT-04	Sedge Community
DS09GT-09	Birch Seep
DS09GT-10	Sedge Community

TIRIGANIAQ THERMISTORS

PUMP THERMISTORS

F ZONE THERMISTORS

DISCOVERY THERMISTORS

Tiriganiaq Deposit

Wesmeg Deposit

Pump Deposit

F-Zone Deposit

Discovery Deposit

Meliadine Lake

Control Lake

Lake CH

N

LEGEND

- BOREHOLE WITH THERMISTOR
- DEPOSIT OUTLINE
- TOPOGRAPHIC CONTOUR (1.0 m INTERVAL ABOVE SEA LEVEL)
- BATHYMETRIC CONTOUR (0.5 m INTERVAL AS DEPTH)
- WATERCOURSE
- WATERBODY

PLANT COMMUNITY CLASSIFICATION

- BIRCH SEEP
- DISTURBED
- HEATH TUNDRA COMMUNITY
- LICHEN-HEATH (CETRARIA LICHEN)
- LICHEN-HEATH (HAIR LICHEN)
- LICHEN-ROCK COMMUNITY
- RIPARIAN WILLOW OR BIRCH
- SEDGE COMMUNITY
- UNVEGETATED (SAND)
- WATER

REFERENCE

BASE DATA OBTAINED FROM AGNICO EAGLE MINES LIMITED (AEM).
DATUM: NAD 83 PROJECTION: UTM ZONE 15
VOLUME 6.0 TERRESTRIAL ENVIRONMENT
AND IMPACT ASSESSMENT – DRAFT
ENVIRONMENTAL IMPACT STATEMENT –
MELIADINE GOLD PROJECT, NUNAVUT
FIGURES 6.5-3A AND 6.5-3B, MARCH 2013

600 0 600
METRES

240 0 240
METRES

PROJECT
AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE
THERMISTOR BOREHOLE LOCATIONS AND PLANT COMMUNITY CLASSIFICATION

Golder Associates

PROJECT NO. 13-1428-0007			PHASE No. 7000/7300	
DESIGN	CC	28 Jun. 2013	SCALE AS SHOWN	REV. 1
GIS	MM	03 Jul. 2013		
CHECK	CC	03 Jul. 2013		
REVIEW	DRW	03 Jul. 2013		

FIGURE 6.3-F5

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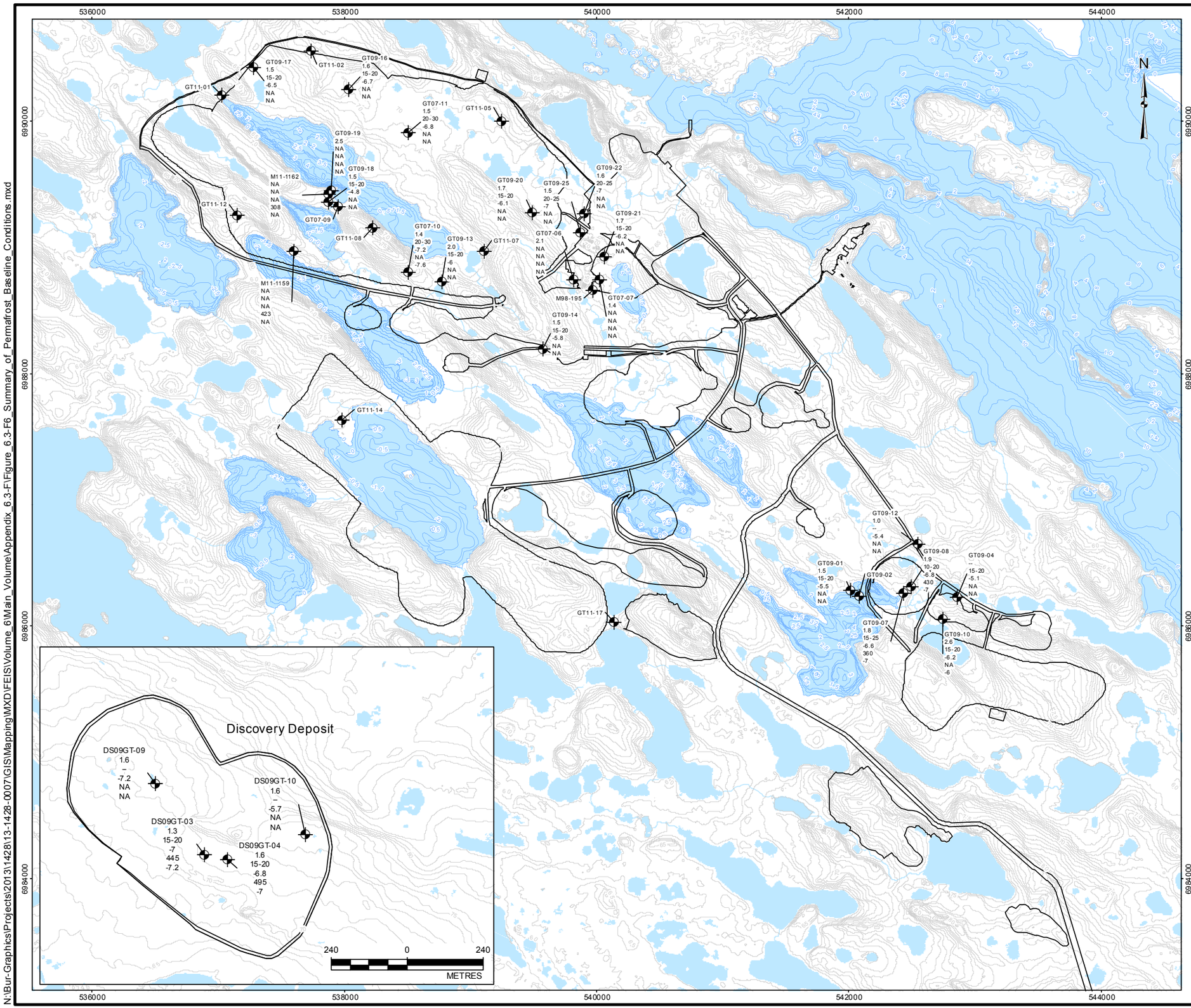

LEGEND

- BOREHOLE WITH THERMISTOR
- PROPOSED PROJECT INFRASTRUCTURE
- TOPOGRAPHIC CONTOUR (1.0 m INTERVAL ABOVE SEA LEVEL)
- BATHYMETRIC CONTOUR (0.5 m INTERVAL AS DEPTH)
- WATERCOURSE
- WATERBODY

LABELS

GT11-01 BOREHOLE ID WITH THERMISTOR

1.6	ACTIVE LAYER VERTICAL DEPTH (m)
20-25	ZERO ANNUAL AMPLITUDE DEPTH (m)
-7	ZERO ANNUAL AMPLITUDE TEMPERATURE (°C)
423	ESTIMATED VERTICAL DEPTH OF PERMAFROST (m)
-7.6	ESTIMATED MEAN ANNUAL SURFACE TEMPERATURE (°C)

NOTES

1. PERMAFROST BASELINE CONDITIONS SUMMARIZED FROM SUPPORTING DOCUMENT SD 6-1 DOC 225, PERMAFROST THERMAL REGIME BASELINE STUDIES, MELIADINE GOLD PROJECT, 25 SEPTEMBER 2012, SECTION 4.2, TABLES 18, 19, AND 20.
2. A DASH IN A FIELD INDICATES NO AVAILABLE DATA.

REFERENCE

BASE DATA OBTAINED FROM AGNICO EAGLE MINES LIMITED (AEM).
DATUM: NAD 83 PROJECTION: UTM ZONE 15

600 0 600
METRES

PROJECT
AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE
SUMMARY OF PERMAFROST BASELINE CONDITIONS

Golder Associates

PROJECT NO. 13-1428-0007			PHASE NO. 5000	
DESIGN	FA	21 Jun. 2013	SCALE AS SHOWN	REV.
GIS	KI	21 Jun. 2013		
CHECK	LY	21 Jun. 2013	FIGURE 6.3-F6	
REVIEW	DRW	21 Jun. 2013		

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538000 540000 542000 544000

6990000 6988000 6986000 6984000

GT11-01
Vs, Vr, Vc
4

GT09-17
Vr, Vx
–

GT11-02
Vs, Vr
7.3-12

GT11-03
I & S
458.5

GT11-10
NF, Nbn
2.9-452.8

GT11-04
Vs, Nbe
0.2-25.5

GT11-05
Vr, Vx, Nbe, I & S, Nbn
1.5-519.1

GT11-09
I & S, Vr, Nbe
2.5-61.3

GT07-09
Nbn, Vc, Nbe, Vs, Ice
–

GT11-06
Nbe, Vs, Nbn, Vr
21

GT11-12
Vc, Nbn
–

GT09-18
Vr
–

GT11-08
Vc, Nbn, Nbe, Vr
8.1-140.6

GT11-07
–
11.8

GT11-13
Nbn
44.7

GT07-10
Nfm Nbn, Vs
–

GT09-13
Nbn
–

GT11-11
Vr, Vc, I & S, Nbn
19.2

GT09-14
I & S, Vc, Vr, Vx, Nbn
–

GT11-14
Nbn, Vc
2.7-2.9

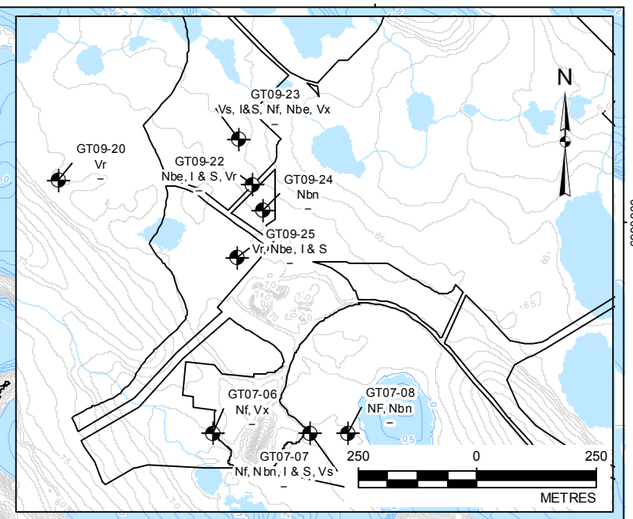
GT11-15
Vr, Vs, Nbn
48.1

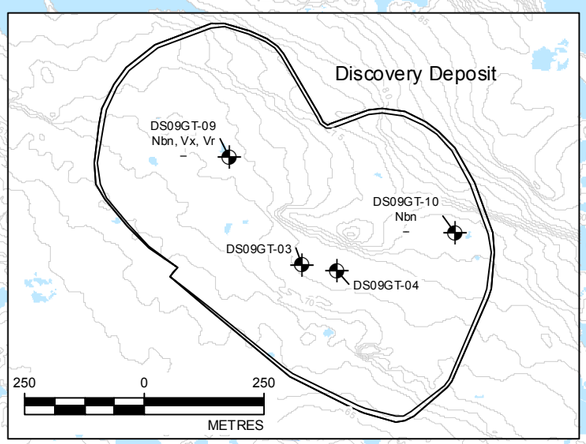
GT11-16
Nbn, Vs
3.4-5.7

GT11-17
Vc, Nbn
52.8

GT09-11
I & S, Vx
88.8

GT09-10
Vr, Vx
51.4





LEGEND

- BOREHOLE WITH THERMISTOR
- PROPOSED PROJECT INFRASTRUCTURE
- TOPOGRAPHIC CONTOUR (1.0 m INTERVAL ABOVE SEA LEVEL)
- BATHYMETRIC CONTOUR (0.5 M INTERVAL AS DEPTH)
- WATERCOURSE
- WATERBODY

LABELS

GT11-01 BOREHOLE ID

Vs, Vr NATIONAL RESEARCH COUNCIL FIELD DESCRIPTION OF PERMAFROST

7.3-12 RANGE IN EXCESS WATER CONTENT (ICE CONTENT, %)

NOTES

1. REFERENCE: NATIONAL RESEARCH COUNCIL OF CANADA, 1979. GUIDE TO A FIELD DESCRIPTION OF PERMAFROST FOR ENGINEERING PURPOSES.
2. A DASH IN A FIELD INDICATES NO AVAILABLE DATA.
3. PERMAFROST SOIL DESCRIPTIONS SUMMARIZED FROM SUPPORTING DOCUMENT SD 6-1 DOC 225, PERMAFROST THERMAL REGIME BASELINE STUDIES, MELIADINE GOLD PROJECT, 25 SEPTEMBER 2012, SECTION 4.3, TABLES 24, 25, AND 26.
4. EXCESS WATER (ICE) CONTENT SUMMARIZED FROM SUPPORTING DOCUMENT 2-4A DOC 273, FACTUAL REPORT ON 2011 GEOTECHNICAL DRILLING PROGRAM, VERSION 0, 07 JUNE 2012.

REFERENCE

BASE DATA OBTAINED FROM AGNICO EAGLE MINES LIMITED (AEM).
DATUM: NAD 83 PROJECTION: UTM ZONE 15

600 0 600
METRES

PROJECT
AGNICO EAGLE
AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE
SUMMARY OF NRC (1979) PERMAFROST SOIL CLASSIFICATION AND EXCESS WATER (ICE) CONTENT FROM SELECTED BOREHOLES

Golder Associates

PROJECT NO. 13-1428-0007			PHASE NO. 5000	
DESIGN	FA	21 Jun. 2013	SCALE AS SHOWN	REV.
GIS	KI	21 Jun. 2013		
CHECK	LY	21 Jun. 2013		
REVIEW	DRW	21 Jun. 2013		

FIGURE 6.3-F7

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2.1.1 Tiriganiaq Thermistors

The following table summarizes the geothermal properties estimated from the thermistor data obtained from the Tiriganiaq Deposit area.

Table 6.3F-14: Summary of Geothermal Properties and Terrain Types for Tiriganiaq Thermistors

Borehole Number	Maximum Vertical Thermistor Depth Below Ground Surface (m)	Estimated Depth of Zero Annual Amplitude (m)	Zero Amplitude Temperature (°C)	Geothermal Gradient (°C/m)	Estimated Mean Annual Surface Temperature[5] (°C)	Estimated Vertical Depth of Active Layer (m)	Estimated Vertical Depth of Permafrost[4] (m)	Terrain Type (Ref. Volume 6 FEIS, Appendix 6.3)	Vegetation (Ref. Volume 6 FEIS Figures 6.5-3a, 6.5-3b)	Comments[1]
GT07-06	8.5	N/A	N/A	N/A	N/A	2.1	N/A	Mbv-W and/or Mb-W	Sedge	See Note 2a
GT07-07	8.5	N/A	N/A	N/A	N/A	1.4	N/A	Mbv-W and/or MbW	Sedge	See Note 2a
GT07-09	8.5	N/A	N/A	N/A	N/A	N/A	N/A	Mbv-W and/or Mb-W	Sedge	See Note 2a
GT07-10	44.0	20 to 30	-7.2	N/A	-7.6	1.4	N/A	Mbv-W and/or Mb-W	Licehn-Heath (Cetraria Lichen)	Geothermal gradient not clear, and may vary in deeper ground; See Note 2
GT07-11	44.0	20 to 30	-6.8	N/A	-7.0	1.5	N/A	Mbv-W and/or Mb-W	Water	Geothermal gradient not clear, and may vary in deeper ground; See Note 2a
GT09-13	20.0	15 to 20	-6.0	N/A	N/A	2.0	N/A	Mbv-W and/or Mb-W	Sedge	See Note 2a
GT09-14	25.5	15 to 20	-5.8	N/A	N/A	1.5	N/A	Mbv-W and/or Mb-W	Heath Tundra	See Note 2a
GT09-16	20.6	15 to 20	-6.7	N/A	N/A	1.6	N/A	Mbv-W and/or Mb-W	Heath Tundra	See Note 2a
GT09-17	20.5	15 to 20	-6.5	N/A	N/A	1.5	N/A	Wbv/Mbv-W to Mbv/Wbv-W	Sedge	See Note 2a
GT09-18	20.0	15 to 20	-4.8	N/A	N/A	1.5	N/A	Mbv-W and/or Mb-W	Sedge	See Note 2a
GT09-19	151.8	N/A	N/A	N/A	N/A	2.5	N/A	Mbv-W and/or Mb-W	Licehn-Heath (Cetraria Lichen)	Below Lake B7, See Note 2b
GT09-20	20.0	15 to 20	-6.1	N/A	N/A	1.7	N/A	Mbv-W and/or Mb-W	Heath Tundra	See Note 2a

Table 6.3F-14: Summary of Geothermal Properties and Terrain Types for Tiriganiaq Thermistors Cont'd

Borehole Number	Maximum Vertical Thermistor Depth Below Ground Surface (m)	Estimated Depth of Zero Annual Amplitude (m)	Zero Amplitude Temperature (°C)	Geothermal Gradient (°C/m)	Estimated Mean Annual Surface Temperature[5] (°C)	Estimated Vertical Depth of Active Layer (m)	Estimated Vertical Depth of Permafrost[4] (m)	Terrain Type (Ref. Volume 6 FEIS, Appendix 6.3)	Vegetation (Ref. Volume 6 FEIS Figures 6.5-3a, 6.5-3b)	Comments[1]
GT09-21	20.0	15 to 20	-6.2	N/A	N/A	1.7	N/A	Mbv-W and/or Mb-W	Sedge	See Note 2a
GT09-22	25.0	20 to 25	-7.0	N/A	N/A	1.6	N/A	Mbv-W and/or Mb-W	Heath Tundra	See Note 2a
GT09-25	25.0	20 to 25	-7.0	N/A	N/A	1.5	N/A	Mbv-W and/or Mb-W	Heath Tundra	See Note 2a
M11-1159	521.7	N/A	N/A	0.012	N/A	N/A	423	Outside of terrain mapping area	Licehn-Heath (Cetraria Lichen)	Top node installed approximately 60 m depth; installed towards lake; see Note 2b.
M11-1162	553.5	N/A	N/A	0.013	N/A	N/A	308	Mbv-W and/or Mb-W	Heath Tundra	Top node installed approximately 15 m depth; installed towards lake; see Note 2b.
GT11-01	19.2	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Mbv-W and/or Mb-W	Sedge	See Note 3.
GT11-02	20.0	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Mbv-W and/or Mb-W	Heath Tundra	See Note 3.
GT11-05	24.6	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Wbv/Mbv-W to Mbv/Wbv-W	Heath Tundra	See Note 3.
GT11-07	25.0	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Mbv-W and/or Mb-W	Heath Tundra	See Note 3.
GT11-08	20.0	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Mbv-W and/or Mb-W	Heath Tundra	See Note 3.
GT11-12	20.0	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Outside of terrain mapping area	Sedge	See Note 3.

Notes:
1. Geothermal properties obtained from thermistor plots, where shown.
2. "N/A" indicates the estimations of certain geothermal properties are not applicable due to (a) insufficient depth of the thermistor cable; (b) proximity of installation to lake body.
3. Insufficient data have been collected to estimate certain geothermal properties, and may indicate that equilibrium conditions have not been reached.
4. Permafrost depth estimated by projecting the temperatures of the lower portion of the thermistor to 0 °C using a best fit line and the estimated geothermal gradient.
5. Mean annual surface temperature estimated by projection of geothermal gradient to ground surface.

2.1.2 F Zone Thermistors

The following table summarizes the geothermal properties estimated from the thermistor data obtained from the F Zone Deposit area.

Table 6.3F-15: Summary of Geothermal Properties and Terrain Types for F Zone Thermistors

Borehole Number	Maximum Vertical Thermistor Depth Below Ground Surface (m)	Estimated Depth of Zero Annual Amplitude (m)	Zero Amplitude Temperature (ºC)	Geothermal Gradient (ºC/m)	Estimated Mean Annual Surface Temperature [5] (ºC)	Estimated Vertical Depth of Active Layer (m)	Estimated Vertical Depth of Permafrost [4] (m)	Terrain Type	Vegetation (Ref. Volume 6 FEIS Figures 6.5-3a, 6.5-3b)	Comments [1]
GT09-01	19.5	15 to 20	-5.5	N/A	N/A	1.5	N/A	Mbv-W and/or Mb-W	Heath Tundra	Near Lake A6; see Note 2b
GT09-02	8.0	N/A	N/A	N/A	N/A	Insufficient Data	N/A	Mbv-W and/or Mb-W	Water	In Lake A6 and too shallow; see Note 2a and b
GT09-04	19.5	15 to 20	-5.1	N/A	N/A	Insufficient Data	N/A	Mbv-W and/or Mb-W	Water	Near Lake A5; see Note 2b
GT09-07	130.0	15 to 25	-6.6	0.02	-7.0	1.8	360	sWrbvt to gWrbvt likely over Mb	Sedge	
GT09-08	139.0	10 to 20	-6.8	0.017	-7.0	1.9	430	sWrbvt to gWrbvt likely over Mb	Heath Tundra	
GT09-10	20.0	15 to 20	-6.2	N/A	-6.0	2.6	N/A	Mbv-W and/or Mb-W	Licehn-Heath (Cetraria Lichen)	See Note 2a
GT09-12	20.0	Insufficient Data	-5.4	N/A	N/A	1.0	N/A	Mbv-W and/or Mb-W	Sedge	See Note 2a

Notes:
1. Geothermal properties obtained from thermistor plots, where shown.
2. "N/A" indicates the estimations of certain geothermal properties are not applicable due to (a) insufficient depth of the thermistor cable; (b) proximity of installation to lake body.
3. Insufficient data have been collected to estimate certain geothermal properties, and may indicate that equilibrium conditions have not been reached.
4. Permafrost depth estimated by projecting the temperatures of the lower portion of the thermistor to 0 ºC using a best fit line and the estimated geothermal gradient.
5. Mean annual surface temperature estimated by projection of geothermal gradient to ground surface.

2.1.3 Discovery Thermistors

The following table summarizes the geothermal properties estimated from the thermistor data obtained from the Discovery Deposit area.

Table 6.3F-16: Summary of Geothermal Properties for and Terrain Types Discovery Thermistors

Borehole Number	Maximum Vertical Thermistor Depth Below Ground Surface (m)	Estimated Depth of Zero Annual Amplitude (m)	Zero Amplitude Temperature (ºC)	Geothermal Gradient (ºC/m)	Estimated Mean Annual Surface Temperature [4] (ºC)	Estimated Vertical Depth of Active Layer (m)	Estimated Vertical Depth of Permafrost [3] (m)	Terrain Type	Vegetation (Ref. Volume 6 FEIS Figures 6.5-3a, 6.5-3b)	Comments[1]
DS09GT-03	128.8	15 to 20	-7.0	0.017	-7.2	1.3	445	Mbv-W and/or Mb-W	Sedge	
DS09GT-04	128.0	15 to 20	-6.8	0.015	-7.0	1.6	495	Mbv-W and/or Mb-W	Sedge	Thermistor with datalogger
DS09GT-09	20.0	Insufficient Data	-7.2	N/A	N/A	1.6	N/A	sWbvt to gWbvt likely over Mb	Birch Seep	See Note 2a
DS09GT-10	20.0	Insufficient Data	-5.1	N/A	N/A	1.6	N/A	Mbv-W and/or Mb-W	Sedge	See Note 2a

Notes:
1. Geothermal properties obtained from thermistor plots, where shown.
2. "N/A" indicates the estimations of certain geothermal properties are not applicable due to (a) insufficient depth of the thermistor cable; (b) proximity of installation to lake body.
3. Permafrost depth estimated by projecting the temperatures of the lower portion of the thermistor to 0 ºC using a best fit line and the estimated geothermal gradient.
4. Mean annual surface temperature estimated by projection of geothermal gradient to ground surface.

2.1.4 Pump Thermistors

The following table summarizes geothermal properties for the Pump thermistors based on the currently available data.

Table 6.3F-17: Summary of Geothermal Properties and Terrain Types for Pump Thermistors

Borehole Number	Maximum Vertical Thermistor Depth Below Ground Surface (m)	Estimated Depth of Zero Annual Amplitude (m)	Zero Amplitude Temperature (ºC)	Ground Temperature Gradient (ºC/m)	Estimated Mean Annual Surface Temperature[5] (ºC)	Estimated Vertical Depth of Active Layer (m)	Estimated Vertical Depth of Permafrost[4] (m)	Terrain Type (Ref. Volume 6 FEIS, Appendix 6.3)	Vegetation (Ref. Volume 6 FEIS Figures 6.5-3a, 6.5-3b)	Comments[1]
GT11-14	19.6	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	No data	Sedge	See Note 3.
GT11-17	25.0	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	No data	Sedge	See Note 3.

Notes:
1. Geothermal properties obtained from thermistor plots, where shown.
2. "N/A" indicates the estimations of certain geothermal properties are not applicable due to (a) insufficient depth of the thermistor cable; (b) proximity of installation to lake body.
3. Insufficient data have been collected to estimate certain geothermal properties, and may indicate that equilibrium conditions have not been reached.
4. Permafrost depth estimated by projecting the temperatures of the lower portion of the thermistor to 0 ºC using a best fit line and the estimated geothermal gradient.
5. Mean annual surface temperature estimated by projection of geothermal gradient to ground surface.

2.1.5 Background Thermistor in Borehole M98-195

The following table presents a summary of permafrost information estimated using the data from this thermistor.

Table 6.3F-18: Summary of Permafrost Conditions at Borehole M98-195

Borehole Number	Thermistor		Depth of Zero Annual Amplitude (m)	Zero Amplitude Temperature(m)	Geothermal Gradient[1] (ºC/m)	Estimated Mean Annual Surface Temperature[2] (ºC)	Vertical Depth of Active Layer (m)	Estimated Vertical Depth of Permafrost[3] (m)
	Number	Maximum Vertical Depth Below Ground Surface (m)						
M98-195	EBA #1146	437.1	22	-7.5	0.018	-8.7	3	470

Notes:
1. Based on thermistor data below approximately 120 m depth.
2. Estimated by projecting the best fit line of the geothermal gradient to surface.
3. Estimated by projecting the thermistor temperatures below 120 m depth to 0 ^{o}C using a best fit line and the estimated geothermal gradient.

2.2 Description of Permafrost Soils

The following presents a summary of field descriptions for permafrost soils according to the borehole logs shown in SRK (2007).

Table 6.3F-19: Summary of 2007 Site Investigation of Permafrost Soils

Borehole Number	Depth (m)		National Research Council Field Description of Permafrost**	Comments
	From	To		
GT07-06	0	0.08	Nf	
GT07-06	0.35	0.85	Vx	
GT07-07	0	0.07	Nf	
GT07-07	0.07	0.5	Nbn	
GT07-07	0.6	0.75	Nbn	
GT07-07	0.75	0.85	Vs	Stratified ice lenses average 1 mm thick, spaced 3 mm apart
GT07-07	0.85	1.4	ICE+SILTY SAND	75% ice with soil inclusions
GT07-07	1.8	2.4	Vs	~40% ice with ice lenses 2 mm thick spaced 4 mm apart
GT07-08	0	0.2	Nf	
GT07-08	0.27	0.57	Nbn	
GT07-08	0.57	1.5	Nbn	
GT07-08	2.05	2.2	Nbn	
GT07-08	2.2	4.1		No Visible Ice
GT07-09	0	0.2	Nbn	
GT07-09	0.2	0.54	Nbn	
GT07-09	0.54	1.02	Vc	
GT07-09	1.02	1.34	Vc	
GT07-09	1.34	1.5	Nbn	
GT07-09	1.5	1.6	Nbe	<1% excess ice
GT07-09	1.6	2.2	Vs	30% ice, stratified ice with irregular spacing (avg 1.5 mm) and thickness (avg. 1 mm)
GT07-09	5.2	5.4	Nbn	
GT07-09	5.68	5.72	ICE	4 cm joint in the bedrock filled with ice
GT07-10	0.1	0.4	Nf	
GT07-10	6	7	Nbn	
GT07-10	7.9	8.6	Nbn	
GT07-10	8.9	9.4	Vs	1 mm thick with an average spacing of 1 mm
GT07-10	9.9	10.9	Nbn	
GT07-10	10.9	11.5	Nbn	

Notes:
1. Ice thickness equal to or less than 1 inch: Vr - visible, random or irregularly oriented ice formations; Vs - visible, stratified or distinctly oriented ice formations; Vx –visible, individual ice crystals or inclusions.
2. Ice not visible: Nf-poorly bonded or friable; Nbn – ice not visible by eye, well bonded and no excess ice; Nbe – ice not visible by eye, well bonded excess ice.
3. Ice thickness greater than 1 inch: ICE+ soil type – ice with soil inclusions; ICE – ice without soil inclusions.

A summary of field descriptions for permafrost soils encountered during the 2009 summer geotechnical investigations is presented in the following table.

Table 6.3F-20: Summary of 2009 Site Investigation of Permafrost Soils

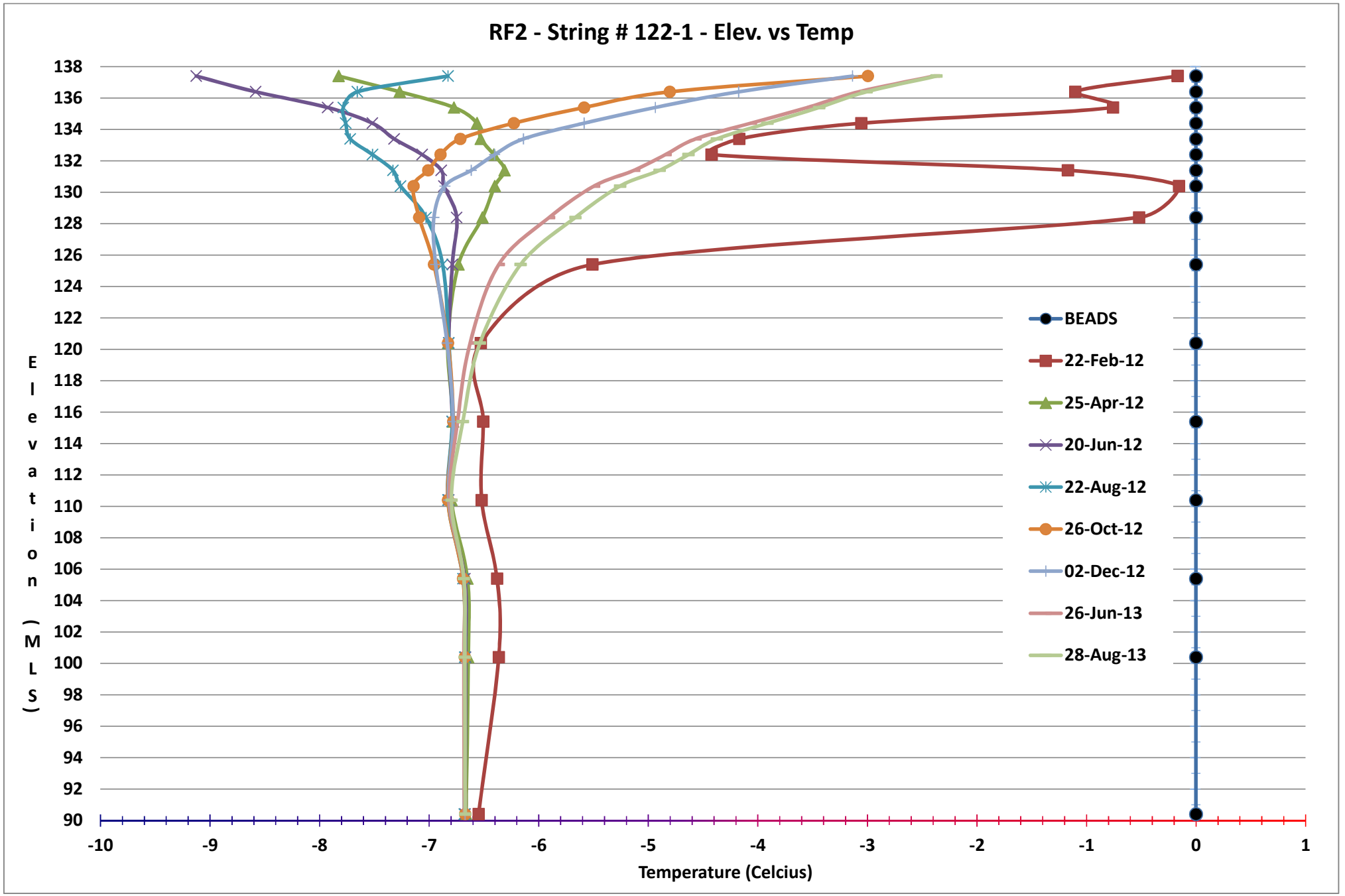
Borehole Number	Depth (m)		National Research Council Field Description of Permafrost**	Comments
	From	To		
GT09-10	1.3	1.8	Vr	Ice to 1 cm thick
GT09-10	2.25	2.5	Vx	
GT09-11	0.95	1.3	ICE +SAND	Granular structure and colourless ice
GT09-11	1.3	1.53	Vx	
GT09-11	1.53	2.08	ICE +SAND	Granular structure and colourless ice
GT09-13	5.15	5.8	Nbn	
GT09-14	1.15	1.45	ICE +SAND	Grey to colourless, clear to cloudy. 85%-90% of sample is visible ice
GT09-14	1.45	1.75	ICE +SILT	Hard, grey cloudy
GT09-14	1.75	1.92	Vc	
GT09-14	1.92	2.2	Vr	
GT09-14	2.25	2.79	Vx	
GT09-14	7.92	8.24	Nbn	
GT09-17	0.3	0.85	Vr	Two ice inclusions >2.5 cm
GT09-17	0.85	1.2	Vr	
GT09-17	1.2	1.65	Vx	
GT09-18	1.35	1.66	Vr	Approaching soil limit, clear crystals
GT09-20	0.9	1.35	Vr	
GT09-22	0.84	1.09	Nbe	
GT09-22	1.09	1.19	ICE +SAND AND GRAVEL	
GT09-22	1.19	1.34	Vr	Ice crystals with sand
GT09-22	1.42	1.52	ICE +SAND	
GT09-23	0.9	0.95	Vs	
GT09-23	0.95	1.25	ICE +SAND to Nbe	
GT09-23	1.25	1.35	ICE	Milky to clear
GT09-23	1.45	1.8	Nf, Nbe, Vx	
GT09-24	0.35	0.71	Nbn	
GT09-25	0.35	1.3	Vr	
GT09-25	1.3	1.57	Nbe	
GT09-25	1.57	1.71	ICE +SAND	Hard, grey cloudy
GT09-25	1.71	2.04	Vr	
DS09GT-06	0.53	0.54	Nbn	
DS09GT-07	0.91	1.19	Nbn & Nf	
DS09GT-08	0.61	1.22	Nbn	
DS09GT-09	0.46	0.55	Nbn & Vx	
DS09GT-09	0.55	0.65	Vr	
DS09GT-10	1.26	1.3	Nbn	

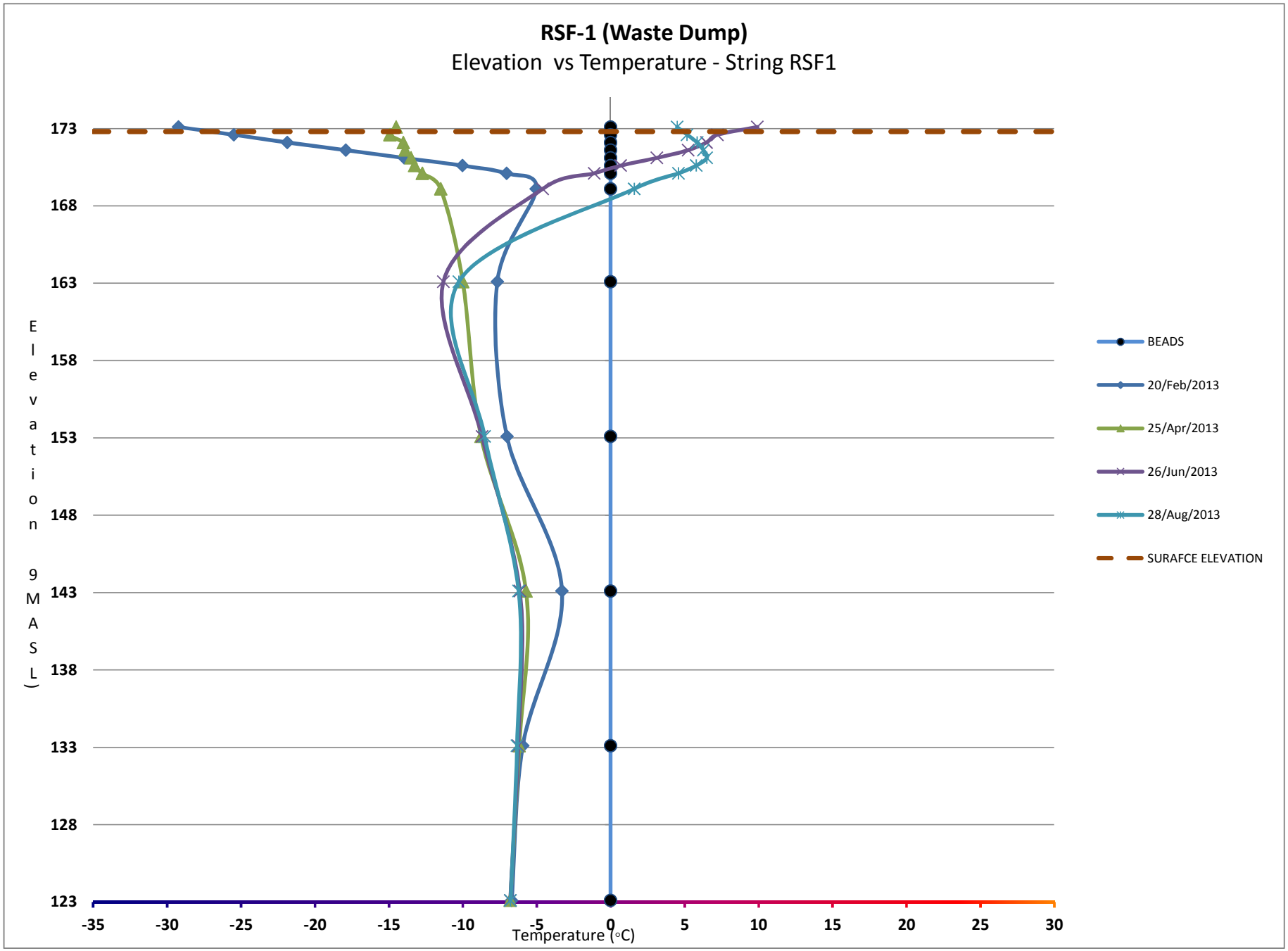
Notes:
1. Ice thickness equal to or less than 1 inch: Vr - visible, random or irregularly oriented ice formations; Vs - visible, stratified or distinctly oriented ice formations; Vx –visible, individual ice crystals or inclusions.
2. Ice not visible: Nf-poorly bonded or friable; Nbn – ice not visible by eye, well bonded and no excess ice; Nbe – ice not visible by eye, well bonded excess ice.
3. Ice thickness greater than 1 inch: ICE+ soil type – ice with soil inclusions; ICE – ice without soil inclusions.

APPENDIX 6.3-G

Meadowbank Mine RSF-1 Thermal Profile

Waste Dump, RF1 and RF2


RF2 - String # 122-1 - Elev. vs Temp
Elevation (MLS)
138
136
134
132
130
128
126
124
122
120
118
116
114
112
110
108
106
104
102
100
98
96
94
92
90
-10
-9
-8
-7
-6
-5
-4
-3
-2
-1
0
1
Temperature (Celcius)
BEADS
22-Feb-12
25-Apr-12
20-Jun-12
22-Aug-12
26-Oct-12
02-Dec-12
26-Jun-13
28-Aug-13


RSF-1 (Waste Dump)
Elevation vs Temperature - String RSF1
Elevation (m ASL)
173
168
163
158
153
148
143
138
133
128
123
-35
-30
-25
-20
-15
-10
-5
0
5
10
15
20
25
30
Temperature (◦C)
BEADS
20/Feb/2013
25/Apr/2013
26/Jun/2013
28/Aug/2013
SURAFCE ELEVATION

APPENDIX 6.7-A

2011 Meliadine Bird Data Summary

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1.0 BACKGROUND

Agnico-Eagle Mines Limited (AEM) is proposing to construct and operate a gold mine, known as the Meliadine Gold Project (Project), 25 kilometres (km) north of Rankin Inlet, and 80 km south of the Chesterfield Inlet in the Kivalliq Region of Nunavut. The proposed Project site is located on a peninsula between the east, south, and west basins of Meliadine Lake on Inuit Owned Land.

Wildlife and vegetation studies have been undertaken since the mid-1990s when Western Mining Corporation International Ltd. (WMC) undertook a multi-year gold exploration program in the Project area. This report summarizes the bird survey data collected in 2011.

2.0 UPLAND BIRD SURVEY

The objective of upland game bird point count surveys was to determine the composition and abundance of upland bird species and their habitat associations inside and outside the Project footprint. Point counts are best suited for collecting data on songbirds because they primarily detect birds by sound (i.e., singing birds). Upland bird (i.e., songbird and shorebird) surveys estimate population densities and species composition of the bird community (Robbins 1970). Breeding bird censuses also provide habitat-specific density data and can be used to measure the effect of land-use practices on breeding bird populations from a habitat perspective.

In 2011, 75 point counts or plots were completed within and immediately adjacent to the Wolf and Pump Lake areas. Plots were located a minimum of 100 metres (m) apart on each transect with approximately 100 m between transects. The distance between plots and between transects reduced the likelihood of re-counting individuals from adjacent plots, which would artificially inflate the number of birds in the area (Figure 6.7-A1).

Surveys were performed using standard point count procedures between the hours of 2 a.m. and 10 a.m. to coincide with peak bird activity (i.e., actively singing males). All birds seen or heard in the 50 m radius plot within 3 and 5 minute intervals were recorded. Birds recorded within 3 minutes can be used to supply data to the annual North American Breeding Survey (Environment Canada 2004). Birds recorded within 5 minutes were used for analysis and to create a species list for the Project. Flyovers and birds observed outside of the plot were recorded as incidentals and used to develop a comprehensive species list, but were excluded from the analysis of plot data. Data recorded included plot location, observation number, time of observation, species, number of individuals, habitat (based on dominant land cover type; Matthews et al. 2001), and behavioural activity (i.e., flushed, territorial calls or displays, nest or nest with eggs, flyovers). Four habitat types were surveyed (Table 6.7-A-1). The numbers of plots per habitat type were selected based on relative proportions of habitats within the potential mine footprint; therefore, most plots were in heath tundra habitat.

Table 6.7-A-1: Upland Bird Survey Plot Habitat Types Surveyed, 2011

Habitat Type	2011	
	n	%
Heath boulder	7	9
Heath tundra	53	71
Sedge wetland	6	8
Tussock hummock	9	12
Total	**75**	**100**

Note: n = number of plots surveyed, % = percent

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533000 534000 535000 536000 537000 538000

6991000 6990000 6989000 6988000 6987000

AEMB58 AEMB60 AEMB62 AEMB64 AEMB66 AEMB68 AEMB70 AEMB72 AEMB73 AEMB75 AEMB06 AEMB05 AEMB04 AEMB03 AEMB02 AEMB01 AEMB53 AEMB55 AEMB57 AEMB59 AEMB52 AEMB54 AEMB56 AEMB51 AEMB50 AEMB49 AEMB48 AEMB47 AEMB46 AEMB45 AEMB44 AEMB43 AEMB42 AEMB41 AEMB40 AEMB07 AEMB08 AEMB69 AEMB71 AEMB61 AEMB63 AEMB65 AEMB37 AEMB39 AEMB36 AEMB38 AEMB34 AEMB32 AEMB30 AEMB35 AEMB33 AEMB26 AEMB24 AEMB28 AEMB22 AEMB20 AEMB31 AEMB27 AEMB21 AEMB19 AEMB25 AEMB29 AEMB23 AEMB77 AEMB09 AEMB11 AEMB10 AEMB13 AEMB12 AEMB15 AEMB14 AEMB17 AEMB16 AEMB18

AEMP01 AEMP02 AEMP03 AEMP04 AEMP05 AEMP06 AEMP07 AEMP08 AEMP09 AEMP10 AEMP11 AEMP12 AEMP13

N

LEGEND

- Upland Bird Survey
- Shorebird Survey Area
- Proposed Project Infrastructure
- All-weather Access Road (AWAR)
- Road - New
- Road - Existing
- Topographic Contour
- Watercourse
- Waterbody

REFERENCE

Wildlife data obtained from field survey. Base data obtained from Agnico Eagle Mines Limited (AEM).
Datum: NAD 83 Projection: UTM Zone 15

500 0 500
METRES

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

2011 UPLAND AND SHOREBIRD SURVEY LOCATIONS

Golder Associates

PROJECT NO.	10-1373-0076		FILE No.	
DESIGN	LY	09 Nov. 2012	SCALE AS SHOWN	REV. 0
GIS	DSC	09 Nov. 2012		
CHECK	LY	18 Jan. 2013		
REVIEW	DW	18 Jan. 2013		

FIGURE 6.7-A1

Species richness was calculated as the maximum number of bird species observed within each habitat type. Observations where birds were counted in the plot, but could not be identified to species, were included in density estimates but excluded from the species richness estimate.

Four species of upland songbirds and shorebirds were recorded within the plots (Table 6.7-A-2). Lapland Longspurs (*Calcarius lapponicus*), Horned Larks (*Eremophila alpestris),* Sandhill Crane (*Grus canadensis)*, and Savannah Sparrows (*Passerculus sandwichensis)* were observed. Of the 75 plots surveyed, 30 had no species observations. Birds may have been present within these plots but remained silent or birds may have been absent.

Table 6.7-A-2: Total Number of Individual Observations and Species Richness Inside Plots, 2011

Species	Scientific Name	Total
Horned Lark	*Eremophila alpestris*	11
Lapland Longspur	*Calcarius lapponicus*	10
Sandhill Crane	*Grus Canadensis*	2
Savannah Sparrow	*Passerculus sandwichensis*	22
Species Richness	-	4

Note: - = not applicable

Species richness ranged from zero to 4 from point counts completed within the different habitat types. When species richness was examined by habitat type, more species were observed in heath tundra, followed by heath boulder and sedge wetland. Tussock/hummock had no species observations within the plots.

Four additional species of upland songbirds and shorebirds were observed incidentally during the 2011 surveys. These observations included species outside of the 50 m radius plot and those that flew over or through during the point count surveys or after the 5 minute sampling period (Table 6.7-A-3). Incidental species observed included herring gull (*Larus argentatus)*, horned lark (*Eremophila alpestris)*, lapland longspur (*Calcarius lapponicus)*, long-tailed duck (*Clangula hyemalis)*, pacific loon (*Gavia pacifica)*, sandhill crane (*Grus canadensis)*, savannah sparrow (*Passerculus sandwichensis)*, and tundra swan (*Cygnus columbianus)*.

Table 6.7-A-3: Total Number of Individual Incidental Observations, 2011

Species	Scientific Name	Total
Herring Gull	*Larus argentatus*	4
Horned Lark	*Eremophila alpestris*	8
Lapland Longspur	*Calcarius lapponicus*	17
Long-tailed Duck	*Clangula hyemalis*	8
Pacific Loon	*Gavia pacifica*	8
Sandhill Crane	*Grus canadensis*	9
Savannah Sparrow	*Passerculus sandwichensis*	17
Tundra Swan	*Cygnus columbianus*	4
Total		**75**

Note: - = not applicable

3.0 SHOREBIRD SURVEY

The objective of the 2011 shorebird surveys was to determine shorebird species presence in the study area and their habitat associations following protocols outlined in the Program for Regional and International Shorebird Monitoring (PRISM) survey methods. The objective of PRISM is to estimate the size of breeding populations of shorebirds; describe the distribution, abundance, and habitat relationships of shorebird species; monitor trends in shorebird population size; monitor shorebird numbers at migration stopover locations; and assist managers in conservation goals (Bart et al. 2005). The PRISM survey methods are consistent across North America so data can be compiled and compared across the continent. Trends in population size can be monitored during the breeding season on the breeding grounds, as populations are stable rather than mobile (i.e., territorial not migrating) (Bart et al. 2005).

In 2011, shorebird surveys were completed following the rapid survey method as described in the 2008 PRISM manual (Canadian Wildlife Service [CWS] 2008). Plot size was 300 m by 400 m (12 hectare [ha] area) with plots falling as much as possible into a single habitat type (Figure 6.7-A1).

Thirteen plots were selected based on proximity to the Wolf Lake and Pump Lake areas and shorebird habitat suitability. To complete the rapid survey, each plot was systematically investigated by a pair of surveyors, recording all bird sign (i.e., birds, nests, other sign) on a plot map. Each survey took approximately one hour to complete. Surveyors walked slowly through the plot along a 400 m long transect. At the end of each 400 m transect, surveyors walked 50 m along the plot perimeter and then made another pass through the plot along another 400 m transect (CWS 2008). Surveyors were separated by approximately 25 m while walking transects so that any bird on transect was never further than 12.5 m from one of the 2 surveyors. During these 4 transect passes (i.e., 2 by each observer), each observer focused on the immediate 12.5 m on either side of their transects (i.e., the immediate 25 m surrounding area) providing 33% coverage of each plot. In contrast to the passive upland bird point counts, which detected birds by sound, the shorebird surveys relied on actively flushing birds, as shorebirds tend to be more cryptic than songbirds.

For each survey, plots were drawn on map sheets provided by the CWS, and Global Positioning System (GPS) coordinates for plot corners were recorded. Maps included boundaries of habitat types, pond outlines, and other prominent features. Each shorebird and songbird observation record was designated as a pair, male, female, or individual of unknown sex. Presence was also recorded for bird species other than shorebirds or songbirds that were encountered in the plot. Nests and probable nests, including a description of nest characteristics, were documented using another data sheet. Habitat data sheets were also completed for each plot describing the major habitat type(s) in the plot.

After each survey, a rapid survey summary form was prepared from the information recorded. On this form, observed nests, probable nests (based on bird behaviour), pairs and singles of each songbird and shorebird species were recorded. This summary provides the total number of resident birds recorded for each plot during the summer.

Six shorebird species and one peregrine falcon were recorded in the Wolf Lake and Pump Lake areas, including Horned Lark, Lapland Longspur, Red-breasted Merganser, Savannah Sparrow, Semipalmated Sandpiper, and Herring Gull (Table 6.7-A-4). All 7 species were recorded during PRISM surveys. The highest number of individuals counted in one plot was 3. Of the 13 PRISM plots surveyed, 4 had no species observations.

Table 6.7-A-4: PRISM Survey Observations, 2011

Shorebird Species Observed	Probable Nests	Pairs	Males	Females	Unknown Sex
Herring Gull	-	-	-	-	2
Horned Lark	2	1	-	-	10
Lapland Longspur	-	3	-	1	3
Peregrine Falcon	-	-	-	-	1
Red-breasted Merganser	-	-	-	1	-
Savannah Sparrow	-	1	-	-	4
Semipalmated Sandpiper	-	1	-	-	-
Total	**2**	**6**	**-**	**2**	**20**

Note: - = not applicable

Two probable horned lark nests were observed during the PRISM surveys. Fledgling chicks were observed in one location and adults displaying active breeding behaviour (carrying food) were observed in a second area. The small number of observations and lack of breeding confirmation of many shorebird species may be related to the relative lack of good shorebird nesting habitat in the area as well as the small number of plots surveyed.

4.0 RAPTOR SURVEY

Raptors have often been identified as indicators of environmental change and their distribution, abundance and productivity have been used to assess the impact of human activities (Bildstein 2001). The selection of a breeding site in the spring is a sensitive stage of the raptor reproductive period. Effects of disturbance may become evident with reduced nest site occupancy (Fyfe and Oldendorff 1976). The Rankin Inlet area supports the highest density of breeding Peregrine Falcons in the Arctic region (Ferguson 1987; Franke et al. 2011). Nesting occurs on cliffs surrounding the community, and has been the subject of long-term and intensive studies (Johnstone 1998; Court et al. 1988). The Peregrine Falcon and Short-eared Owl are listed as “Special Concern” by COSEWIC (2012) and SARA (2012, internet site), and are listed as “May be at Risk” and “Sensitive”, respectively, by the Government of Nunavut (2000).

In July 2011, eight nest sites were surveyed during a combined aerial and ground survey (Table 6.7-A-5). Previously identified nests were located using GPS coordinates. If nests were not able to be identified as occupied or unoccupied from the air, the field crew would land and observe the potential nesting site using a spotting scope. The raptor eyries on the cliffs near the Wolf Lake and Pump Lake areas were surveyed (Figure 6.7-A2). Of the 8 nests located, one Peregrine Falcon nest was occupied (F08-01, 02, 03), 2 Peregrine Falcon nests were unoccupied (G98-01, G98-02), 4 Rough-legged Hawk nests were unoccupied (C00-02, C09-01, J98-01, J98-02), and one nest of unknown species was unoccupied (G08-02).

N:\Bur-Graphics\Projects\2013\1428\13-1428-0007\GIS\Mapping\MXD\FEIS\Volume_6\Main_Volume\Appendix_6.7-A\Figure_6.7-A2_2011_Observed_Raptor_Nest_Site_Locations.mxd

530000 535000 540000 545000 550000

6990000 6985000 6980000 6975000 6970000

N

Meliadine Lake

Tiriganiaq Pit

Wesmeg Pit

Pump Pit

F-Zone Pits

J98-01

J98-02

C09-01

C00-02

F08-01,02,03

Little Meliadine Lake (LML)

Meliadine River

G08-02

G98-01

G98-02

LEGEND

- Raptor Nest
- Proposed Project Infrastructure
- All-weather Access Road (AWAR)
- Road - New
- Road - Existing
- Watercourse
- Waterbody

REFERENCE

Wildlife data obtained from field survey. Base data obtained from Agnico Eagle Mines Limited (AEM).
Datum: NAD 83 Projection: UTM Zone 15

1.8 0 1.8
KILOMETRES

PROJECT
AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

AGNICO EAGLE

TITLE
2011 OBSERVED RAPTOR NEST SITE LOCATIONS

Golder Associates

PROJECT NO.	10-1373-0076		FILE No.	
DESIGN	LY	09 Nov. 2012	SCALE AS SHOWN	REV. 0
GIS	DSC	09 Nov. 2012		
CHECK	LY	18 Jan. 2013		
REVIEW	DW	18 Jan. 2013		

FIGURE 6.7-A2

Table 6.7-A-5: Raptor Nest Sites Surveyed and Occupancy, 2011

Species	# Nests Surveyed	# Nests Occupied	Average Occupancy Rate per Species (%)
Peregrine Falcon	3	1	33
Rough-legged Hawk	4	0	0
Gyrfalcon	0	0	-
Short-eared Owl	0	0	-
Unidentified Raptor	1	0	0
Total	**8**	**1**	**-**
Occupancy Rate (%)	12.5		-

Note: % = percent; "-"indicates not applicable

5.0 SUMMARY

During the bird surveys in July 2011, 12 different bird species were observed as a result of specific survey effort or as incidental observations, including the following:

- Herring gull;
- Horned lark;
- Lapland longspur;
- Peregrine falcon;
- Red-breasted merganser;
- Rough-legged hawk;
- Sandhill crane;
- Savannah sparrow;
- Semipalmated sandpiper;
- Long-tailed duck;
- Pacific loon; and
- Tundra swan.

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