Cominco

# POLARIS MINE

## DECOMMISSIONING AND RECLAMATION PLAN

### VOLUME 1 OF 4

ᒪᕈᓕᕿᒥ ᐅᔭᕋᒃᓯᐅᕐᕕᒃ

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ᓯᕗᓕᕐᕙᖓ ᓯᑕᒪᐃᓕᖄᖓᔪᓂᑦ

# POLARIS MINE
# DECOMMISSIONING AND RECLAMATION PLAN

## Volume 1 of 4
## Decommissioning and Reclamation Plan

*Prepared for*
**Cominco Ltd.**

*Prepared by:*
**Gartner Lee Limited**

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2. Landfill Closure Report, Gartner Lee Limited, March 2001.
3. Garrow lake Dam – Effect of Removal on Lake stability and Outflow Water Quality, AXYS Environmental Consulting Ltd., March 2001.
4. Garrow Lake Dam Decommissioning, EBA Engineering Consultants Ltd., March 2001.
5. Decommissioning of Dock at Polaris Mine, Westmar Consultants Inc., March 2001.
6. Human Health and Ecological Risk Assessment of Cominco's Polaris Mine on Little Cornwallis Island: Derivation of Soil Quality Remediation Objectives, Cantox Environmental Inc., March 12, 2001.

## Volume 3

1999 Environmental Site Assessment, Gartner Lee Limited, June 2000.

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2000 Environmental Site Assessment, Gartner Lee Limited, March 2001.

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ᐳᓕᐊᓅᓐ ᐅᕝᕋᒃᓯᐅᕐᕕᒃ ᒪᕿᓕᕆᒥᑐᖅ ᕿᑭᑕᕐᒥ. ᓄᓇᐅᑉ ᐊᑕᓂᑦ ᐅᔾᕋᒃᑕᕐᑐᐃᑦ ᓴᕕᒃᓴᕐᒥᒃ-ᐊᕿᓂᓴᕐᒥᑐ ᐱᖃᑕᕐᑐᑦ ᓇᒥᓂᕐᑯᑎᑦᔭᐅᑐᓂ ᐅᔾᕋᓯᐅᕐᕕᒃ ᑲᒥᑯᑯᓄᑦ ᐊᒪᑐ ᑕᐃᒪᖓᓂ ᐊᐅᓚᓂᖅᑐᖅ 1981ᒥᑦ. ᐊᕿᓯᓯᒪᔪ ᐳᓕᐊᓅᓐ ᐅᔾᕋᒃᓯᐅᕐᕕᒃ ᐅᔾᕋᒃᑕᖅᑕᕆᓂᓕᕐᓗᓂ ᓴᕕᒃᓴᕐᒥᒃ ᐊᕿᓂᖅᓴᕐᒥᒃᑐ 2002ᖑᓕᕐᐸᑦ. ᐱᒪᓄᐅᖅᑕᐅᔪᖅ ᒪᑐᓂᓄᓂᐊᑕᖓᑕ ᐅᔾᕋᒃᓯᐅᕐᕕᐅᑉ ᐃᒪᐃᑐᕗᖅ ᐅᔾᕋᒃᓯᐅᕐᕕᐅᔫᑉ ᐅᑎᕐᑎᑕᐅᑐᓂ ᖃᓄᐃᑐᓂᓄᓚᐅᑕᖓᓄᑦ ᓴᐳᖨᓯᒪᔪᓇᕐᑐᓂ ᐊᓂᐊᑕᕐᓇᕐᑐᓂᑦ ᐊᑕᕐᓇᑐᓂᑐᓃᑦ ᓄᓇᕗᕐᒥᐅᓄᑦ ᐊᒪᑐ ᐊᕙᑎᖓ ᐳᓕᐊᓅᓐ ᐅᔾᕋᒃᓯᐅᕕᐅᔫᑉ. ᑲᒥᑯᑦ ᑐᓂᕈᑎᕆᓯᒪᒪᑕ ᑲᔪᓯᑎᓯᕐᑯᔩᑐᑎᒃ ᑕᒪᑐᒥᖓ ᐊᕿᓱᐃᓂᑯᑦ ᐅᐸᑐᖓᐃᔭᕐᓯᒪᑎᐊᑐᑎᒃ ᐅᔾᕋᓯᐅᕕᐅᔫᑉ ᒪᑐᔭᐅᓂᓴᖓ ᐊᕿᓱᑕᐅᓯᒪᔪᑦ ᒪᓕᑕᐅᓯᐊᑐᑎᒃ ᐃᓱᒪᕆᑐᕆᑦ ᖃᓄ ᐊᑐᕐᑕᐅᖃᑕᓚᐅᒪᖔ ᑕᒪᓂᒥᐅᑦ ᐃᓄᖕᒋᓄᑦ. ᑕᓇ ᐊᕿᓯᒪᔭᖓᑦ ᐊᖕᒋᑕᐅᔭᓄᐊᖄᑐᖅ ᓇᒪᒋᔭᐅᑐᓂ ᓄᓇᕗᑦ ᐃᒪᓕᓄᐦᖕᒋᑕ ᑲᑎᒪᐦᖕᒋᓄᑦ, ᐃᓄᓕᓄᐦᑐᖅ-ᑯᓄᑦ, ᓄᓇᕗᑦ ᑲᐅᒪᑯᖕᒋᓄᑦ ᐃᓄᐃᑐ ᓄᓇᓕᒥᐅᖕᒋᓄᑦ ᓲᕐᑐ ᕋᓴᑐᒥᐅᓄ ᑯᓄᓯᕕᐅᒥᐅᓄᑐ.

ᐅᑯᐊ ᓇᐃᓇᕐᓯᒪᔪᑦ ᐃᓕᒋᔭᖕᒋᑦ ᐊᕿᑕᐅᓯᒪᔪᑦ ᒪᓕᑕᐅᔪᒪᑐᑎᒃ ᐅᑎᕐᑎᑕᐅᓇᓱᒃᑎᑐᒍ ᖃᓄᐃᑐᓂᓄᓚᐅᑕᖓᓄᑦ ᐳᓕᐊᓅᓐᒥ ᐅᔾᕋᒃᓯᐅᕐᕕᒥ:

1. ᐅᔾᕋᒃᓯᐅᕐᓂᖅ ᐱᔭᓄᐸᑦ ᓄᓇᐅᑉ ᐊᑕᓂ ᐊᑐᕐᑕᐅᖃᑦᑐᓕᒫᑦ ᐃᖕᒋᕋᔪᑎᕈᔪᐃᑐ ᐊᐅᓚᕐᑎᑕᐅᑐᐃᓇᓄᐊᓖᑦ ᐳᓕᐊᓅᓐ ᐅᔾᕋᒃᓯᐅᕐᕕᐅᔪᕐᒥᑦ ᐊᓯᖕᒋᖕᒋᓄᑦ ᐅᔾᕋᓯᐅᕐᕕᒧᐊᑕᐅᑐᓂᑐᓃᑦ ᐅᕙᑐᓃᑦ ᓴᑐᒪᕐᓴᑕᐅ-ᑐᓂ ᐃᒍᑎᕐᑕᐅᑐᓂ ᐊᒪᑐ ᓴᐅᔭᐅᑐᓂ ᓴᐅᔭᐅᓯᒪᐃᓇᕐᓂᐊᓕᕐᑐᓂ. ᐳᓕᐊᓅᓐ ᐅᔾᕋᒃᓯᐅᕐᕕᒃ 300ᒥᑕᓂᒃ ᐃᑎᑎᕆᔪᕐᒥᒃ ᓄᓇᐅᑉ ᐊᑕᓂᑎᕆᓕᕐᑐᖅ ᖁᐊᖑᐃᓇᕐᑐᕐᒥ. ᑕᓇ ᑕᐃᒪᐃᑐᓂᖓ ᑕᐃᒪᐃᓕᖓᐃᓇᕐᓂᐊᓕᕐ-ᑐᑎᒃ ᓴ ᐅᔭᐅᓯᒪᓂᐊᓕᕐᑐᑦ ᐅᔾᕋᒃᓯᐅᕕᐅᔪᓂ ᐊᒪᑐ ᐅᔾᕋᓯᐅᕕᐅᔪᐃᑦ ᐹᖕᒋᑦ ᐅᑯᐊᖕᒋᑦ ᒪᑐᐃᑕᐅᑲᓂᓂᐊᕈ-ᓂᕐᑐᑎᒃ ᒪᑐᔭᐅ ᔮᕐᑐᑦ.

2. ᑲᒥᑯᑦ ᐱᔭᓄᓯᕋᑕᕐᑐᑦ ᖃᐅᔨᓴᕐᑕᐅᔪᐊᑐᑎᒃ ᖃᐅᔨᓴᑕᐅᓂᕐᒥᒃ ᐳᓕᐊᓅᓐ ᐅᔾᕋᒃᓯᐅᕐᕕᒥ ᓇᑐᓇᕈᓂ-ᕐᑯᑐᕆᑦ ᓇᓂᒪᖕᒌᑦ ᐅᔾᕋᓯᐅᕐᑕᖓᓂ ᓄᓇᖓ ᓯᑯᒪᖕᒌᑦ ᐊᒪᑐ ᐅᕐᓯᐊᑐᕈᔪᓂᑦ ᓇᓕᐊ ᓄᓇ ᓯᑯᒪᖕᒌᑦ. ᑕᑯᐊ ᓄᓇᐃᑦ ᓯᑯᑕᐅᔪᑦ ᓴᑐᒪᕐᓴᑕᐅᔮᕐᑐᑦ ᑕᐃᑯᖓ ᑎᑭᐅᑎᕆᐊᕐᑐᒍ ᓴᐳᔨᐅᓯᒪᔪᓇᕐᑯᑐᕆᑦ ᐊᕙᑎᕗᑦ ᐃᓄᐃᑦᑐ. ᐊᕿᓯᓯᒪᔪᑦ ᑲᔪᓯᑎᑐᒪᑐᒍ ᑕᐃᓇ ᓯᑯᑕᐅᓯᒪᔪᖅ ᓄᓇ ᓄᓇᐅᑉ ᐊᑕᓄᑦ ᓴᐅᔭᐅᔪᒪᑐᓂ ᑕᐃᑯᖓ ᖁᐊᖑᐃᓇᕐᑐᕐᒧᑦ ᑕᐃᑲᓂ ᓴᐅᔭᐅᐸᑦ ᑕᐃᑲᓂᖕᒋᓇᕐᑯᑐᒍ ᑎᑭᑕᐅᔪᓇᖕᒋᑐᕐᒨᑦ ᑕᑯᓴᐅᔪᕐᒥᑦ ᐊᕙᑎᑎᓂᑦ ᑕᐃᒪᖓᓕᒫᖅ.

3. ᐊᒥᐊᑯᕐᑐᑯᖕᒋᑦ ᐅᕙᕋᓯᐅᕕᐅᑉ ᐳᓕᐊᓅᓐᒥᑦ ᑕᓯᖅ ᑭᐊᕈᒨᕐᑕᐅᓯᒪᔪᑦ ᑕᐃᒪᖓᓂᑦ ᐅᔾᕋᒃᓯᐅᕐᓂᖅ ᒪᑐᐃᓚᐅᓯᒪᒪᑦ 1981ᒥ. ᑭᐊᕈ ᑕᓯᖅ ᐃᒪᖅᑲᒪᑦ ᕿᓂᕐᑐᐊᑐᒥᒃ ᐃᖅᑲᖓᓂ. ᑕᐃᒪᐃᑐᓂᖓᓄᑦ ᐃᖅᑲᖓᓂ ᐊᐅᓚᔪᖅᑲᖕᒋᑐᖅ ᐳᒃᑕᓚᕈᓇᑐᖅᑲᖕᒋᓚᖅ ᑭᐊᕈ ᑕᓯᕐᒥ. ᑕᐃᒪᐃᑐᓂᖓᓄᑦ ᑲᒥᑯᑦ ᐅᔾᕋᒃᓯᐅᑕᖓᑕ ᐊᒥᐊᑯᕐᑐᑯᖕᒋᓂᒃ ᐃᖅᑲᖓᓄᑎᓯᖅᑕᕐᑐᑦ ᑭᐊᕈ ᑕᓯᐅᑉ ᓇᑐᓇᐃᓯᒃᒪᑦ ᑕᐃᑯᐊ ᐊᒥᐊᑯᕐᑐᑯᐃ ᑕᐃᑲᓂᖕᒋᓇ-ᓂᐊᕐᑐᑦ. ᑕᐃᒪᖓᓂᑦ ᒪᑐᐃᓚᐅᓯᒪᒪᑦ ᐅᕙᕋᒃᓯᐅᕐᕕᒃ, ᑲᒥᑯᑦ ᖃᐅᔨᓴᕐᓯᒪᔪᑦ ᐃᒪᖓ ᖃᓄᐃᓕᕐᐸᓕᕐᒪᖔ ᑭᐊᕈ ᑕᓯᐅᑉ ᐊᒪᑐ ᐃᖅᑲᖓ ᑕᓯᐅᑉ ᑕᐃᑯᐊ ᐊᒥᐊᑯᑉᑐᐃᑦ ᑕᐃᑲᓂᖕᒋᓇᕋᑐᐊᒪᖔᑕ.

4. ᐳᑕᓖᕐᑐᕐᒥᒃ ᐱᖅᑲᐅᑎᑯᕕᖅᑲᑐᑦ ᐳᓕᐊᓅᓐ ᐅᔾᕋᒃᓯᐅᕐᕕᒥ ᐃᒪᐃᑐᑕᖅᑲᐅᑐᓂᒃ, ᓴᕕᕋᔾᒃᓴᑯᕕᒥᒃ, ᓯᕐᑐᐊᒥᒃ, ᐃᑯᒪᐅᑎᖅᑲᕕᖓᓂᒃ, ᓴᓇᕕᒥᒃ, ᐊᓄᕋᓄᑦ ᐊᓯᔅᕐᕕᒃᒥᒃ ᐊᒪᑐ ᑎᑎᕋᕕᓂᒃ. ᐊᕿᓯᓯᒪᔪᑦ ᑕᓇ ᐱᖅᑲᐅᑎᑯᕕᖓᑦ ᓴᑐᒪᕐᓴᑕᐅᓖᑐᖅ, ᐃᒍᑎᕐᑕᐅᑐᓂ ᓴᐅᔭᐅᑐᓂᑐ ᐊᐅᐸᕐᑐᖅ ᕿᒥᑯᑐ ᐃᑐᕐᓴᕐᒥ. ᑕᐃᒪᐃᑕᐅᒃᐸᑦ ᑕᒪᓇ ᓯᑯᓇᕐᑐᖅ ᐱᖅᑲᐅᑎᑯᕕᒥᑦ ᓯᐊᒪᔭᖕᒋᒪᑦ ᑕᓄᐅᒥᐅᑕᓄᑦ ᐅᒪᔪᕐᓄᑦ ᐱᔭᕐᑕᐅᓕᕐᐸᑕ ᑕᐃᑲᓂᑐᑦ ᐱᖁᑎᕆᔭᐅᔪᑦ.

5. ᐃᑐᓕᒪᑦᓯᐊᑦ ᐃᒍᑎᕐᑕᐅᓖᕐᑐᑦ ᐃᓚᐅᕈᑎᐅᔪᑐ ᐃᒪᐃᑦ ᐊᒪᑐ ᓯᑯᓇᕐᑐᐃᑦ ᐱᔭᐅᓖᕐᑐᑦ ᑲᑎᑕᐅᑐ-ᑎᒃ ᐊᐅ ᓚᐅᔭᐅᓖᕐᑐᑦ ᖃᑐᓈᑦ ᓄᓇᖓᓄᑦ ᒪᕐᑐᑯᕕᒨᕐᑕᐅᑐᑎᒃ ᑕᐃᑲᓂ ᐅᕙᑐᓂ ᐊᑐᕐᑕᐅᕆᐊᓚᑲᓂᕐᑐᑎ.

6. ᐊᑐᕐᑕᐅᔪᖅ ᒪᓇᐅᔪᖅ ᒪᕐᓗᑰᕐᕕᒃ ᐳᓕᐊᓇᔅᒥ ᐅᔭᕋᒃᓯᐅᕐᕕᒥ ᓴᐅᔭᐅᓛᕐᑐᖅ ᑐᐊᐸᒧᑦ ᐊᒪᓗ ᐊᕿᑭᐊ-ᑕᐅᓗᓂ ᓄᓇᖓ ᒪᕐᓗᑯᐃᑦ ᓴᕿᑲᓂᓚᖁᖏᓗᒋᑦ ᓯᕗᓂᑎᓂ ᐊᒪᓗᑕᐅᖅ ᑕᐃᑯᐊ ᒪᕐᓗᑯᐃᑦ ᐊᕿᑕᐅᓚᑐᑦ ᑕᐃᑯᐊ ᒪᕐᓗᑯᐃ ᖁᐊᑲᓂᕈᓇᓚᕐᓗᑎᒃ ᖁᐊᖑᐃᓇᕐᑑᑉ ᐊᕿᑕᐅᑭᐊᕐᓂᖓᓄᑦ.
7. ᐊᐅᐸᕐᑐᖅ ᕿᒥᑯᓗᒃ ᑐᐊᐸᒃᑕᕐᕕᖓ ᐊᑐᕐᑕᐅᓛᕐᑐᖅ ᐱᒋᐅᖅᑲᕕᐅᓗᓂ ᐃᒃᓗᓂᒃ ᐃᒍᑎᕐᑕᐅᓂᑯᓂᒃ ᐊᓯᖏᓄᓗ ᓲᕐᓗ ᐅᐊᔫᓗᓄᑦ ᓱᑦᓗᓄᓗ. ᑕᒪᕐᒥᓕᒪᓯᐊᖅ ᓴᐅᔭᐅᔪᑦ ᓴᓗᒪᔅᑕᐅᓛᕐᑐᑦ ᑲᒥᑯᑯᓗ ᐊᔨᖑᐊᓂᒃ ᐱᓯᒪᓂᐊᑐᑦ ᑕᑯᓂᖓ ᓴᐅᔭᐅᔪᓂᒃ ᐸᐸᑎᓂᐊᕐᑐᑦ.
8. ᑲᒥᑯᑯᑦ ᖃᐅᔨᓴᐃᓇᕐᓂᐊᑐᑦ ᐳᓕᐊᓇᔅᒥᒃ ᐅᔭᕋᒃᓯᐅᕐᕕᒥᒃ 2011ᒧᑦ ᑎᑭᑐᐃᓇᕋᑕᕐᓗᒍ ᐊᕙᑎᑎᓄᑦ ᓯᑯᓇᕐᑐᖃᓕᖏᑲᓗᐊᒪᖔᑦ. ᑲᒥᑯᑯᑦ ᓄᓇᓕᒥᐅᓂᒃ ᐅᖃᖃᑎᖃᖃᑕᕐᓂᐊᒥᔪᑦ ᑕᐃᓯᒪᓂᐅᓕᕐᐸᑦ ᖃᐅᔨᓴᕐᓂᕐᒥᓂ.

ᑲᒥᑯᑯᑦ ᐊᕿᓯᓯᒪᓂᐊᑐᑦ ᓄᓇᕘᑦ ᐃᓗᐊᓂᕐᒥᐅᑦ ᐃᓚᐅᖃᑕᐅᒐᓗᐊᒪᖓᑕ ᒪᑐᕝᓕᐊᑎᓗᒍ ᐳᓕᐊᓇᔅᒥ ᐅᔭᕋᒃᓯᐅᕐᕕᒥ ᐊᒪᓗ ᓇᓗᓇᐃᓯᓂᐊᑐᑦ ᐅᐊᓇᖓᓂᒥᐅᑕᐅᔪᑦ ᐃᓚᐅᕕᒋᔪᓇᓂᓕᒪᖏᓂ ᐃᓚᐅᒐᓗᐊᒪᖔᑕ. ᑲᒥᑯᑯᑦ ᐅᖃᖃᑎᖃᖃᑕᕐᓂᐊᒥᔪᑦ ᓄᓇᓕᒥᐅᓂᒃ ᑕᐃᒪᖓᓕᒫᖅ ᐃᖏᕋᓂᓇᔭᖏᑕ ᖃᓄᐃᐸᓕᐊᓂᖏᓂ ᐅᔭᕋᒃᓯᐅᕙᐅᔪᖅ ᒪᑐᔭᐅᓯᒪᓂᖓᑕ ᐊᕿᑕᐅᓯᒪᓂᖏᑦ ᒪᓕᑕᐅᑎᓗᒋᑦ.

# Community Summary

The Polaris Mine is located on Little Cornwallis Island. It is an underground zinc-lead mine which is owned by Cominco and has been in continuous operation since 1981. It is planned that the Polaris Mine will stop producing zinc and lead in 2002. An important part of closing this mine will be ensuring that the site is returned to a condition that protects the health and safety of Nunavut residents and the environment around the Polaris Mine. Cominco is committed to ensuring that this occurs through the preparation of a complete Mine Closure Plan that takes into account the historic uses of this area by Inuit people. This plan will be approved by the Nunavut Water Board, DIAND, the Nunavut Government and Inuit communities such as Resolute Bay and Grise Fiord.

The following is a summary of some of the planned reclamation measures for the Polaris Mine:

1. Upon completion of mining all underground equipment and machinery will be either shipped from the Polaris site for use at another mine or will be cleaned and dismantled and stored permanently underground. The Polaris Mine is up to 300 m deep below the ground surface in very cold continuous permafrost. This will act as a permanent vault for the disposal of equipment in mined out areas and all mine entrances will be sealed.
2. Cominco has completed an extensive environmental investigation at the Polaris Mine to determine areas where there is metal contaminated soil and hydrocarbon contaminated soil. These areas of contaminated soil will be cleaned up to a level that protects both the environment and Inuit people. It is proposed that contaminated soil also be put underground where the depth and the cold permafrost will ensure that the soil will remain in isolation from the surrounding environment for all time.
3. The tailings that have been generated from the mining at Polaris have been put in Garrow Lake since the mine opened in 1981. Garrow Lake contains water that is very dense at the bottom of the lake. This means there is no movement of water from the bottom of Garrow Lake to the surface. This has allowed Cominco to put the mine tailings at the bottom of Garrow Lake with the assurance that the tailings will remain there. Since the opening of the mine, Cominco has monitored the water quality at Garrow Lake and at the bottom of the lake to ensure that the tailings are stable and remain in place.
4. There is a barge at the Polaris Mine that contains the mill, warehouse, powerhouse, maintenance shops, change rooms and offices. It is proposed that this barge be cleaned, dismantled and buried in Little Red Dog Pit. This will ensure that any contamination around the Barge will not be introduced into the marine environment during the excavation of this facility.
5. All the buildings will be demolished and all chemicals and other hazardous materials will be collected and transported to a southern disposal facility or will be re-used.
6. The Operational Landfill at the Polaris Mine will be covered with soil and contoured in such a way that surface erosion does not occur. In addition all the material within the landfill will re-freeze due to the re-establishment of permafrost.
7. The Little Red Dog Quarry will be used to dispose of buildings that have been demolished and other surface material such as cables and pipelines. All the material that is buried will be cleaned and Cominco will provide a photographic record of this buried material.

8. Cominco will monitor the Polaris Site until 2011 to ensure there are no environmental problems. Cominco will also consult with communities during this monitoring period.

Cominco will ensure that residents of Nunavut Territory are part of the closure activities at the Polaris Site and will identify northern opportunities where possible. Cominco will also consult with the communities through all phases of this Mine Site Closure Plan.

# Executive Summary

Polaris Mine is a joint venture owned by Cominco Ltd. (77.5%) and Teck Corporation (22.5%). Both companies are Canadian with head offices in Vancouver B.C. Cominco is the sole operator of the mine.

Polaris Mine is located on Little Cornwallis Island (LCI) in the Canadian High Arctic, in the Territory of Nunavut. Situated at about latitude 75°N and longitude 97°W, it is approximately 100 km northwest of Resolute. Polaris Mine is an underground zinc-lead mining operation and the world's most northerly metal mine. The Polaris Mine occupies a total of about 962 hectares of land under surface leases from the Government of Canada.

The Polaris orebody was discovered in the early 1970's. Following socio-economic, engineering and environmental studies, construction of the mine and facilities began in 1980. The first concentrate was produced in late 1981. The mine is due to close in 2002 when mining of the orebody will be complete. On closure approximately 21 million tonnes of ore will have been processed to produce 4.4 million dry tonnes of zinc concentrate and 0.9 million dry tonnes of lead concentrate.

The Polaris facility is a substantial installation with excellent ancillary features. Cominco Ltd. had hoped to extend the life of the operation by development of other expected ore sources in the area. After extensive exploration work over the last 12 years, no economic deposits have been discovered. No alternate uses for the site have been found to date. Cominco Ltd. intends to implement closure plans immediately following cessation of mine production.

This Decommissioning and Reclamation Plan (the Plan) has been prepared on the assumption that all facilities and installations that comprise the Polaris Operations will ultimately be decommissioned, removed or reclaimed under the terms of the land leases. The intent of the land leases to “remove all improvements” is served by the proposed decommissioning and landfilling in the Little Red Dog Quarry of the barge, accommodations complex and other large scrap equipment and buildings (after removal of any hazardous materials/substances).

Use of an on site landfill for disposal of the site improvements has the following benefits:

- Eliminates potential safety hazards by removing improvements from the land;
- Improves visual aesthetics by removal of the improvements;
- Provides an environmentally secure disposal location (non-hazardous material encapsulated in permafrost);
- Reduces the number of ships that must travel through the arctic to transport building debris to the south (and, thereby, reduces the associated environmental and ecological risks);
- In the case of the barge, reduces environmental and ecological risks, complex regulatory approvals and concerns from communities along potential towage routes;
- Eliminates landfilling debris in the South that was created for and used in the North;

- Eliminates landfilling of debris in the South where the materials would potentially be exposed to groundwater;
- The additional volume of fill placed in LRD Quarry aids in contouring the quarry for closure.

**Regulatory Framework**

The Polaris Mine occupies land leased from the Government of Canada under the Territorial Lands Act and the Territorial Lands Regulations. There are five surface leases at the Polaris site, all of which expire on April 30, 2011. Cominco holds three mining leases under the Territorial Lands Act through the Canada Mining Regulations. The surface leases contain various requirements for "Restoration", but the general theme is "to restore the land as near as possible to its original state, including removal of all improvements".

Water use, tailing disposal and effluent discharge at Polaris are governed by a Water License under the jurisdiction of the Nunavut Water Board. The License expires December 31, 2002. The Water License also sets out conditions applying to abandonment and restoration.

Cominco submitted a "Restoration Plan" for the surface leases to the Department of Indian and Northern Affairs (DIAND) in 1984 and received approval by DIAND in 1985. Cominco also submitted a revised "Closure and Reclamation Plan" to the Northwest Territories Water Board in May 1996 in compliance with the requirements of the Water License.

This Plan supersedes the previous submissions and meets the Abandonment and Restoration requirements for the Polaris Mine Water License and the surface leases. It addresses the comments and concerns raised by the regulators in their reviews of previous closure plans and the May 2000 draft of this plan. It also provides updated information on the status of Cominco Ltd.'s Polaris Mine and provides a plan of the work to be completed in the various stages of mine closure.

An environmental monitoring program ("EMP") for the post-reclamation timeframe will be implemented to demonstrate the success of the reclamation work with respect to achieving environmental objectives.

**Objectives**

The general objectives for the Plan have been prepared in accordance with Cominco Ltd.'s Environmental Policy, the regulatory requirements specified on the Land Leases administered by Department of Indian Affairs and Northern Development (DIAND), and the Water License requirements now administered by the Nunavut Water Board (NWB). They are:

- To ensure that the site returns to a condition such that public health and safety, and the environment are protected;
- To provide a working document that addresses the concerns and requirements of all stakeholders during the consultation and implementation stages;
- To eliminate or minimize the requirements for long term care and maintenance;

- To identify those activities required to return the site to an aesthetically acceptable condition.

The Plan will serve as the basis for managing and scheduling the work required for facilities decommissioning and for reclamation activities. Input from regulatory agencies and the local communities was solicited and has been incorporated into the Plan.

**Physical Environment**

The climate is typical of the high arctic with cold winters, short cool summers and very little precipitation. Snow-melt typically begins in June, with break-up of the sea ice occurring from mid July into early August, and freeze-up beginning in September.

The terrain of Little Cornwallis Island consists of very gently rolling low-relief hills and plains rising out of the ocean. The Polaris Mine site area is characterized by a steep west-facing hillside leading from the accommodation complex down to the site of the process barge below.

In the vicinity of the mine site and elsewhere in the surrounding area, overburden forms a thin mantle over the calcareous bedrock. Barren, gravel type surface material predominates at the Polaris Mine site. The Polaris mine site is located within the zone of continuous permafrost. The vegetation of Little Cornwallis Island is classified as "Arctic Tundra". Due to the harsh climate, high winds and shallow soils, vegetation forms are typically dwarfed, low-lying and grow in clusters or as a dense mat. Environmental baseline studies were conducted prior to development of the mine. Environmental sensitivity mapping was used to assess the suitability of various areas within the proposed mine site for development. Vegetation, soils and animal use were considered in the assessment of environmental sensitivity. The active mine site area was developed within the area classified as Bare (coarse textured), characterized as having relatively low biological sensitivity and low susceptibility to mechanical disturbance.

**Historical Land Use**

An archaeological survey in 1977 identified 36 significant sites on LCI. These sites, however, were to the north and east of the mine site. None of the sites are in the areas covered by Cominco's surface leases at the Polaris Mine site.

Population studies over the last 20 years show few Caribou or musk ox resident on LCI. Caribou and musk ox numbers throughout the Arctic islands have been reduced considerably in the last few years due to severe weather conditions. Polar bears are culturally and economically significant to the Inuit and are common in the LCI area.

The Inuit hunters interviewed in a 1997 study indicated that hunting on LCI did continue after the mine was established. However, the widespread declining caribou numbers have resulted in less trips to LCI for hunting. The most recent siting of caribou on LCI was in 1992.

Community interviews that were conducted in 2000 indicated the following with respect to historical land use:

1. LCI has largely been a stop over for residents from Resolute while in transit to Bathurst Island for hunting;
2. Hunting on LCI has occurred in the past on an opportunistic basis with brief stop-overs;
3. The northeastern portion of LCI is viewed as a more favourable area for camping;
4. The Polaris Mine area has previously been a “view area” for polar bears.

**Overview of the Polaris Mine Operations**

The Polaris orebody is situated completely in permafrost, which extends to more than 300 m below surface. Ore minerals are sphalerite (zinc sulphide) and galena (lead sulphide). The waste rock (host rock) is predominantly dolomite with calcite. Hanging wall rocks are shales. The orebody is located as close as 60 m to surface and extends to 300 m below surface. Except for a very small open pit on the north, the ore has been mined by underground methods.

There are two types of rock quarries at the mine site, the Little Red Dog (LRD) Quarry from which limestone aggregate material is extracted and the two shale quarries. Underground mine openings were filled with shales from the surface quarries (backfilling) until 1996. Since 1996, backfilling has employed a mixture of quarried limestone and cement. Backfilling has been an integral part of the mining method to maintain stability of the underground openings. Waste rock mined from underground development is also used as backfill underground eliminating the need for disposal on surface. There is no water underground and therefore pumping water from the mine to surface is not required.

The mined ore is crushed underground and moved by underground conveyor to the mill. The resulting concentrates are stored in a covered storage building through the winter and are shipped to market in the short shipping season. The mill tailing is pumped via a 4 km tailing line to a tailing thickener located above Garrow Lake. Process water is recycled from the thickener back to the mill via a duplicate pipeline. The thickened tailing is deposited in the bottom of Garrow Lake. A frozen-core dam was constructed near the outlet of Garrow Lake in 1990 and 1991 that allows the lake water level to be controlled during mine operations. Fresh water is obtained for the plant and domestic purposes by pipeline from Frustration Lake about 5 km from the mine.

The Polaris mine is an extremely compact mining operation. The process barge contains the mill and most of the service facilities including: power house, maintenance shops, warehouse and offices. The other two main buildings on site are the concentrate storage building and the accommodation building. Diesel fuel oil for power generation and mobile equipment is stored in a tank farm and in tanks located in the barge. There are two landfill sites located approximately 1 km south of the accommodation building and one landfill located approximately 1 km northeast of the accommodation building that have been or are active during mine operations. The Little Red Dog Quarry is proposed to ultimately be used as a landfill during mine reclamation.

The mine has a ship docking facility capable of handling ships up to 44,000 tonnes. Bulk supplies and equipment are transported to the site by ship. The arctic shipping season is restricted to the ice free season between July and October of each year. The mine is also serviced by aircraft from Resolute using the 1200m airstrip located adjacent to the accommodation building.

**Decommissioning, Reclamation and Restoration**

In preparation for closure, Cominco Ltd. commissioned several studies to characterize geotechnical and environmental conditions at the mine site and the receiving environment and to provide direction for remedial measures to be undertaken during decommissioning of the mine. Studies have been undertaken by Gartner Lee Limited regarding a two phase (1999 and 2000) environmental site assessment, design of engineered covers for closure of the landfills and a comparative review of two alternatives for decommissioning of the process barge. A risk-based development of site specific soil quality remediation objectives was undertaken by Cantox Environmental Inc. Studies have also been completed for Plan scheduling and costing (Cascade Management Inc.), demolition volumes and methods; dock reclamation and shoreline stability (Westmar Consultants Inc.), modeling of the chemical stability of Garrow Lake (AXYS Environmental Consulting Ltd.), and decommissioning of the Garrow Lake dam (EBA Engineering Consultants Inc.).

Cominco’s approach to closure planning follows that outlined in the document “Mine Reclamation in Northwest Territories and Yukon”, Northern Water Resources Studies, Indian and Northern Affairs Canada, April 1992. An overview of the decommissioning and reclamation approach for each of the major mine components is presented below.

***Mine Workings***

Once mining has been completed, all underground equipment and machinery will be considered for reuse at another site, offered for sale or left in place in the mine. Any equipment that is not removed from the mine for reuse or salvage will be cleaned of any potentially hazardous waste materials such as fuel, lubricants and batteries. These materials will be handled in accordance with the NWT Hazardous Waste Management Guidelines and disposed properly off-site. Waste oils and lubricants may be burned on-site or may be shipped off-site with other hazardous materials.

Sealing all portals and raises by means of secure plugs and caps will preclude post-reclamation access to the underground mine workings. These installations will be backfilled and graded to conform to the contours of the surrounding area.

Surface subsidence that has occurred over certain older underground openings in the area now referred to as the Reclamation Landfill will be remediated by placement of a simple soil/rock cover that will promote surface runoff and eliminate safety hazards. Future surface subsidence in this area or in other areas is expected to be minimal because of the beneficial effects of backfilling.

Known areas of ore stockpiling will be investigated by mine site geologists and cleaned up. Recommendations will be made to either process the material through the mill or seal the material in the underground mine, depending on the results of inspections and testing.

***Garrow Lake Tailing Facility***

At mine closure, approximately 15 million dry tonnes of process tailing will have been deposited in Garrow Lake located approximately 5 km southeast of the process barge. Garrow Lake is a meromictic lake that is both thermally and chemically stratified with no vertical circulation. The mill tailing is deposited into the bottom layer of Garrow Lake, where the density difference between the bottom layer and the surface layer is the most important factor that prevents the upward movement of the tailing into the surface layer. The anoxic (oxygen-poor), sulphide-rich conditions in the bottom layer also act to contain metals in the tailing in a stable solid phase. The current Water License requires Polaris Operations to monitor the stratification of Garrow Lake and apply the results to a model that will predict the short and long-term stability of the Lake. The model has been updated and the results show that the lake will remain chemically stable after closure. A report on this topic as prepared by AXYS Environmental Consulting Ltd. is included in Volume 2, Supporting Documents. Monitoring will be continued through post-closure to verify the chemical and physical stability of the tailing deposition area.

Once tailing deposition is complete (after production ceases and the mill has been cleaned), the physical structures such as pipelines will be flushed, removed, and disposed in the LRD Quarry. The pipeline right-of-way will be re-contoured as required, in order to restore natural drainage patterns and prevent ponding of surface run-off.

A frozen core dam was constructed during 1990 and 1991 to contain water within Garrow Lake such that water could be discharged from the lake in a controlled manner. Decommissioning will require that the lake water level be lowered to its original elevation and that the centre portion of the dam be removed. This approach will restore the lake and the outflow creek to their pre-mining condition. A report on the reclamation plan for the Garrow Lake dam, as prepared by EBA Engineering Consultants Inc., is included in Volume 2, Supporting Documents.

***Buildings***

Previous Closure Plans have only considered the option of removing the barge from the site by re-floating and towing to a southern location for disposal or re-fitting for another project. The feasibility of re-floating the barge had not been examined in any detail until recently, when it became clear that the concept of re-floating and towing south would present substantial risks from environmental, operational and cost perspectives. An alternate reclamation approach for the barge was developed and compared to the re-floating approach in order to ensure that the environmental and other risks were minimized. The comparative review, as prepared by Gartner Lee Limited, is included in Volume 2, Supporting Documents.

The alternate approach was subsequently selected and forms the basis of this Closure Plan. The selected approach involves demolition and disposal of the process barge on site, dismantling/demolition of the barge superstructure and recovery of saleable equipment, followed by demolition of the barge hull. All demolition materials would be buried on site in the LRD Quarry after removal of chemicals and other hazardous materials. An environmental site assessment identified that the industrial activities conducted in the vicinity of the barge have resulted in metal and hydrocarbon contamination of the active layer surrounding the barge. This material will be removed following mine closure.

Other buildings to be demolished will include: the concentrate storage building, the Bent-Horn fuel conditioning building, the cemented rock-fill plant (CRF), the accommodation complex, and the tailing thickener building. Construction waste from the demolition of the buildings will be disposed in the LRD Quarry, including concrete footings and stub walls. The footprint formerly occupied by the buildings will be backfilled and graded to a stable slope.

Equipment, furniture and other usable materials within the buildings will be considered for re-use by Cominco Ltd., recycling off-site by nearby communities or disposal on-site. Chemicals and hazardous materials, including fuels, will be handled in accordance with the NWT Hazardous Material Guidelines and will be prepared appropriately for shipping off-site for recycling or disposal.

***Fuel Storage and Handling Areas and Distribution Lines***

Fuel remaining in the diesel tanks at mine closure will be transferred to one of the main tanks in the tank farm, from where it will be available for use in reclamation work and, ultimately, removed from the site by oil tanker. Any sludge remaining in the tanks will be removed and burned. The tanks themselves will be purged of vapours prior to dismantling and cleaning, and disposed in the LRD Quarry. The impermeable lining in the tank farm compound will be disposed in the underground workings. The berms surrounding the tank farm area will be graded to prevent diversion or ponding of surface run-off.

The pipelines associated with the fuel tanks will be drained, purged of vapours, cleaned and sectioned for disposal into the LRD Quarry. The pipeline right of ways and culverts under roadways will be graded and re-sloped to prevent ponding of surface run-off.

***Concentrate Load-out Conveyors***

Concentrate load-out support structures, conveyors and ancillary equipment will be removed and dismantled. Steel or equipment not required elsewhere will be cut into sections and disposed into the LRD Quarry.

***Miscellaneous Outbuildings***

Any buildings or equipment not specifically discussed above will be dismantled, removed from the site or disposed into the LRD Quarry. Examples include the firehall, equipment storage sheds and satellite receiving dishes.

***Dock Site***

Several alternatives were considered for decommissioning of the dock and restoration of the shoreline.

The dock structure will be decommissioned by removal of the shiploading tower, conveyorways, surface pipes and electrical utilities followed by cutting off the sheet piles underwater below the low water level, excavating the material from the inside of the cells and removing the sheet piles with a crane.

This method will have minimum impact on the seabed, will remove all above water improvements and will restore the beach to a smooth profile. The reclamation plan for the dock site, as prepared by Westmar Consultants Inc., is included in Volume 2, Supporting Documents.

***Airstrip***

The airstrip will be left largely intact. The related equipment including the radio beacon, runway lights and signs will be removed.

***Freshwater Line and Pumphouse***

The pumphouse at Frustration Lake will be dismantled and the equipment removed. The jetty extending into the lake will be left in place to avoid the impact removal would cause on the aquatic environment. The water storage tank will be dismantled and removed, together with the associated electrical equipment. Its base will be graded to a stable slope. The associated water lines will be dismantled and disposed in the LRD Quarry. Pipeline routes will be re-contoured where required to prevent ponding of surface water and restore natural drainage routes.

***Access Roads and Ramps***

Approximately 40 kilometres of road exist at the site. The major roads are those from the plant site to Frustration Lake and to the tailing thickener and Garrow Lake. There are no stream crossings, except a small culvert crossing over the stream exiting Loon Lake. All culverts will be removed to re-establish natural drainage patterns. Re-contouring will be carried out where graded slopes would otherwise be expected to become unstable in the long-term.

***Sewage System***

The sewage pumps, storage tanks and pipelines will be flushed, removed and disposed into the LRD Quarry.

***Heating (Glycol) Distribution Lines***

The glycol will be drained, collected in drums and either incinerated on-site or shipped for appropriate disposal off-site. The pipes and tanks associated with the heating systems will be cleaned and disposed in the LRD Quarry.

### *Electrical and Communications Cables*

All electrical and communications cables throughout the site will be removed. Cables that are worth recovering for recycling or for re-sale will be shipped off-site. Otherwise, cables will be cut into manageable lengths and disposed in the LRD Quarry.

### *Solid Waste Management Operations*

Two landfills are located approximately one kilometre south of the accommodation building and comprise two separate sections referred to as the Construction Landfill and the Operational Landfill. The Construction Landfill contains non-hazardous solid waste produced during the initial construction of the mine site, is covered with local soils and is not currently in use. Relocation of the Construction Landfill to consolidate it with the Operational Landfill commenced in 2000 as part of Cominco's progressive reclamation work. The relocation is part of the engineered closure plan for the consolidated landfill area. An engineered cover for closure of the consolidated landfill area has been designed to ensure that the waste materials remain frozen within the permafrost layer and that surface contours facilitate drainage. The landfill closure plan (including the recommendation for relocation of the Construction Landfill and the engineered cover for closure of the consolidated landfill area), as prepared by Gartner Lee Limited, is included in Volume 2, Supporting Documents.

The Reclamation Landfill is located approximately one kilometre northeast of the accommodation building. This landfill makes use of an area where surface subsidence above older mine workings has created a surface depression. Decommissioned heavy equipment and other non-hazardous materials are placed into the Reclamation Landfill. Cominco maintains a documented record of all materials that are placed into the Reclamation Landfill including a chain of custody that identifies the operators, supervisors and managers involved. The Reclamation Landfill will be closed by placement of a simple soil/rock cover that will promote surface runoff and eliminate safety hazards.

The LRD Quarry will be used as the disposal location for demolished surface buildings, concrete foundations, decommissioned pipelines, electrical cable and other materials from demolition. No hazardous materials will be placed in the quarry. An engineered cover will be constructed for closure of the LRD Quarry that follows the design for the consolidated Operational Landfill area as described above and as reported in detail by Gartner Lee Limited in Volume 2, Supporting Documents. The closure cover will promote surface runoff and prevent ponding of water.

### *Chemicals*

The inventory of chemicals, reagents, fuels and lubricants will be carefully controlled during the final year of operation to ensure that a minimum volume remains to be managed after mine closure. Remaining inventory will be stored in original containers. Following mine closure, all inventory of chemicals and reagents will be transported off-site and will be:

- Returned to the chemical supplier;
- Sold to another user of the product;

- Used at another Cominco Ltd. facility;
- Shipped to a licensed disposal facility.

***Hazardous Materials***

Environmentally acceptable management procedures will be followed for the handling of each category of hazardous waste. Cominco Ltd. is registered with the Government of Nunavut as a generator of hazardous waste and will be responsible for the classification and labeling of hazardous wastes. Cominco Ltd. will complete waste manifests and ensure that the waste is transported by a registered hazardous waste carrier and received by a registered receiver. Cominco Ltd. will ensure that trained workers are used for the management of hazardous waste and ensure that occupational health and safety and emergency spill response measures are in place.

***Contaminated Soils***

An environmental site assessment (ESA) conducted in 1999 and 2000 by Gartner Lee Limited delineated areas of the mine site containing metal and petroleum hydrocarbon contaminated soils. Options for treatment and disposal were studied. The proposed remediation method for contaminated soils involves excavation and placement in the zone of continuous permafrost within the underground mine. Excavated areas would be re-graded and contoured. The remediation plan for metal contaminated soils recognizes that there are areas where metal concentrations were naturally elevated prior to mining activities due to surface outcropping of mineralized rocks.

A human health and ecological risk assessment was undertaken by Cantox Environmental Inc. that resulted in recommended soil quality remediation objectives of 10,000 ppm for zinc and 2,000 ppm for lead to be used in areas that have been mapped as barren-ground within the active mining area. The risk assessment utilized community historic land use activities on LCI and identified Inuit children as the most sensitive receptor. The development of the site specific SQRO's for lead and zinc was undertaken according to the permitted Federal framework (CCME, 1996).

The generic Federal soil remediation guidelines for parkland standards are applied to areas outside of the immediate active mining area. The Yukon Territory Contaminated Sites Regulation for hydrocarbon contaminated soils of 1,000 μg/g LEPH or HEPH (light or heavy extractable petroleum hydrocarbons) was adopted for the Polaris closure plan.

Complete reports, as prepared by Gartner Lee Limited, that describe each of the 1999 and 2000 Environmental Site Assessments are provided in Volumes 3 and 4, respectively, of the Supporting Documents. The human health and ecological risk assessment conducted by Cantox Environmental Inc. for the development of site-specific soil quality remediation objectives is included in Volume 2, Supporting Documents.

### *Northern Community Benefits*

Throughout the Decommissioning and Reclamation process, Cominco will continue to identify and discuss potential forms of benefit to northern communities including: disposal of assets; decommissioning contracts and employment. Cominco began community involvement with the environmental site assessment and monitoring phase at Polaris. Community meetings have been held to discuss the Plan.

### *Post Closure Site Management and Monitoring*

Cominco will provide a project management team to oversee all activities and to maintain responsibility for the site. Following the completion of the decommissioning and reclamation work, all personnel will leave the island.

Post closure monitoring of the site will be conducted to confirm that the remediation measures provide for a site that is both physically and chemically stable. A post-closure monitoring and visual inspection program has been developed as described in Section 7. It is anticipated that the monitoring program will be conducted for a period of 7 years following completion of reclamation work (to 2011), or until the physical and chemical stability of the site can be demonstrated.

# 1. Introduction

## 1.1 Proponent Information

Polaris Mine is a joint venture owned by Cominco Ltd. (77.5%) and Teck Corporation (22.5%). Cominco Ltd. is the operator of the joint venture. Rio Algom holds a 25% royalty interest in the annual net proceeds from the mine.

Cominco Ltd., a Canadian company incorporated in 1906, is an integrated lead, zinc and copper producer with mines, smelters and refineries in Canada, the United States, and Peru. Cominco's head office is located in Vancouver, British Columbia. Cominco is the largest producer of zinc concentrates in the world and the fourth largest zinc metal refiner.

Cominco Ltd. has gained considerable northern experience through the development and operation of northern mines such as the Black Angel Mine in Greenland; Pine Point Mine and Con Mine in the Northwest Territories; the Polaris Mine in Nunavut and the Red Dog Mine in Alaska.

Cominco Ltd. has been the sole operator of the Polaris Mine.

## 1.2 Licenses and Guidelines

Water use, tailing disposal and effluent discharge at Polaris are governed by Water License N4L2-0262. The Water License was granted by the Northwest Territories Water Board under the Northwest Territories Waters Act. The Nunavut Water Board assumed the responsibility for existing Water Licenses in Nunavut in 1996 under the mandate of the Nunavut Land Claims Agreement Act. However, a Nunavut Water Act has not yet been promulgated.

There have been three Water Licenses at Polaris:

- The first Water License was effective for the period November 1981 to December 1991, with amendments to the Surveillance Network Program in 1983, 1985, and 1987;
- The second Water License was issued for the period January 1992 to December 1993. The short term was requested by Cominco Ltd. to allow time to complete ongoing scientific and environmental studies being carried out to confirm that discharge from Garrow Lake had no impact on the ocean environment in Garrow Bay and to justify increasing the discharge effluent limits;
- The current License came into effect January 1, 1994 and will expire December 31, 2002.

The Polaris Mine occupies land leased from the Government of Canada under the Territorial Lands Act and the Territorial Lands Regulations.

There are five surface leases at the Polaris site as listed below that all expire on April 30, 2011:

- Lease 3472; with an area of 328 hectares incorporates most of the mine facilities, including: the barge; concentrate storage building; accommodation building; landfill sites; backfill quarries; mine openings; the Frustration Lake pumphouse and the tailing thickener;
- Lease 68 H/8-1-3; with an area of 14.29 ha covers a portion of the bed of Crozier Strait and includes the docking infrastructure;
- Lease 68 H/8-3-3; with an area of 67.49 ha, covers the airstrip and some roads and pipelines;
- Lease 68 H/8-8-2; with an area of 403 ha covers the bed of Garrow Lake, which is designated as the tailing deposition area in the lease;
- Lease 68 H/8-9-2; with an area of 148.91 ha, provides a buffer zone around Garrow Lake, the Garrow Lake Dam and Garrow Creek to the ocean.

Cominco holds three mining leases under the Territorial Lands Act through the Canada Mining Regulations, Lease Numbers 2346, 3799, and 3800.

This Decommissioning and Reclamation Plan (the Plan) fulfils the requirements of the Water License and surface leases and follows the “Guidelines for Abandonment and Restoration Planning for Mines in the Northwest Territories” issued by the Northwest Territories Water Board in September 1990.

Cominco’s closure objectives and approach to closure planning follow those outlined in the document “Mine Reclamation in Northwest Territories and Yukon”, Northern Water Resources Studies, Indian and Northern Affairs Canada, April 1992.

## 1.3 Overview of Polaris Mine

Cominco Ltd.'s Polaris Mine is located on Little Cornwallis Island in the Canadian High Arctic. Situated at approximately latitude 75°N and longitude 97°W, it is about 100 km northwest of Resolute, the closest settlement (Figure 1). Polaris is an underground zinc-lead mining operation and the world's most northerly metal mine. The Polaris Mine occupies a total of about 962 hectares of land under surface leases from the Government of Canada. The legal description and lease areas are shown in Figures 2 and 3.

Mineralization was first discovered at Polaris in 1960 during surface mapping for oil exploration. Further exploration led to the discovery of the orebody in the early 1970's. Following lengthy engineering, environmental studies and negotiations with the Canadian Government, construction was initiated in 1980. The first concentrate was produced in late 1981. The mine is due to close in 2002 when mining of the approximately 21 million tonne orebody will be complete.

The development and construction of the mine was highlighted by the construction of the process plant and related facilities on a barge in southern Canada and its subsequent transportation to the site, towed 5,000 km by tugs. The barge was then beached for use as the main plant building at the site.

The orebody is a Mississippi Valley type, situated completely in permafrost. The permafrost extends to more than 300 m below surface. Ore minerals are sphalerite and galena. The waste rock (host rock) is predominantly dolomite with calcite. Hanging wall rocks are shales. The orebody is located as close as 60 m to surface and extends to 300 m below surface. Except for a very small open pit, the ore has been mined by innovative underground methods. The voids from ore mining have been backfilled to maintain rock stability and to allow increased recovery of the ore.

The mined ore is crushed underground and conveyed to the mill. The Polaris concentrator (mill) is a conventional grinding and flotation plant processing just over 1,000,000 tonnes of ore per year and producing between 250,000 and 300,000 wet tonnes of zinc and lead concentrate each year. The concentrates are stored in a covered building through the winter and are shipped to market in the short arctic shipping season. The mill tailing is pumped via a 4 km tailing line to a tailing thickener located above Garrow Lake where process water is largely separated from the tailing solids. Process water is recycled from the thickener back to the mill via a duplicate pipeline. The thickened tailing solids are deposited at the bottom of Garrow Lake. In 1990 and 1991, construction of a frozen core dam was completed at the outlet of Garrow Lake. Summer runoff water is now controlled and, when necessary, the water is siphoned over the dam. Fresh water is obtained for the plant and domestic purposes by pipeline from Frustration Lake about 5 km from the mine.

The Polaris mine is an extremely compact mining operation. The process barge contains the mill and most of the service facilities including power house, maintenance shops, warehouse and offices. The other two main buildings on site are the concentrate storage building and the accommodation building. Diesel fuel oil for power generation and mobile equipment is stored in a tank farm and in the barge bottom tanks. The mine is serviced by aircraft from Resolute using the 1200m airstrip located adjacent to the accommodation building.

The mine has a docking facility capable of handling ships up to 44,000 tonnes. The concentrates produced by the mine are transported to Europe by ship for further processing. Bulk supplies and equipment are also transported to the site by ship. Due to the arctic ice, the shipping season is restricted to between July and October of each year.

# 2. Decommissioning and Reclamation Plan

## 2.1 General

This document is intended to meet the Abandonment and Restoration requirements for the Polaris Mine Water License, held by Cominco Ltd. under the authority of the Nunavut Water Board and for the surface leases held under the authority of the Government of Canada. This document is intended to provide updated information on the status of Cominco Ltd.'s Polaris Mine and to provide a plan of the work to be completed in the various stages of mine closure.

This Decommissioning and Reclamation Plan supercedes the "Closure and Reclamation Plan" submitted to the Northwest Territories Water Board in May 1996 and also the "Restoration Plan" for the surface leases submitted to the Department of Indian and Northern Affairs (DIAND) in 1984 and approved by DIAND in 1985.

Cominco's ultimate objective for the land leases is to obtain the Ministerial release document upon completion of closure. To this end a post closure environmental monitoring plan has been developed that will confirm the effectiveness of the decommissioning work.

## 2.2 Regulatory Requirements

The regulatory requirements for decommissioning, restoration and closure of the Polaris Mine are outlined in the surface leases and the Water License. Restoration requirements for Lease 3472, which covers most of the buildings and disturbed mine area, are outlined in Sections 14 to 19 of the original lease document, as follows:

*14. i) The lessee shall, within two years of the execution of this lease, deliver to the Minister for his review and approval a plan of restoration which, where applicable, shall include but it not limited to the following:*

*a) buildings and other structures*
*b) roads and air strips*
*c) water supply facilities*
*d) tailing disposal facilities*
*e) waste rock disposal sites*
*f) petroleum and chemical storage areas and facilities*
*g) garbage, sewage and waste storage or disposal sites and facilities*
*h) pipelines and electrical transmission installations*
*i) site drainage systems, granular material deposits and open pit areas*
*j) other facilities or sites utilized during the operation*
*k) the land generally*

*and such plan shall be prepared with the objective of restoring the land as near as possible to its original state, including the removal of all improvements.*

*ii) The Minister may at any time during the term of the lease request the lessee to review and update the approved plan of restoration and upon receipt in writing of such a request, the lessee shall submit to the Minister, for his approval and within the time specified, an updated plan of restoration.*

*15. Within six months of the receipt of any plan from the lessee, including an updated plan of restoration, the Minister shall notify the lessee whether or not the plan has been approved.*

*16. Upon the receipt of any plan, including any updated or revised plan of restoration, the Minister may:*

*i) approve the plan submitted*

*ii) reject the plan or any portion thereof and return the plan to the lessee for revision, stating the reasons for the rejection; or*

*iii) require the lessee to include in the plan provisions that, in his opinion, are necessary to meet the objectives in Clause 14 (i).*

*and the lessee shall be advised accordingly in writing.*

*17. Where the Minister notifies the lessee of the rejection of any plan or any portion thereof, the lessee shall, within six (6) months of receipt of such notification, deliver to the Minister a revised plan for approval.*

*18. The lessee shall undertake ongoing restoration during the term of the lease for any land or improvements which are no longer required for the lessee's operations on the land.*

*19. The lessee shall file annually, a progressive report for the preceding year outlining the ongoing restoration completed in conformance with the approved plan of restoration.*

Lease 68 H/8-8-2 (Garrow Lake) requires that the lessee shall deliver up possession of the land in a condition satisfactory to the Minister. The lease also requires the lessee to prepare a "plan of abandonment of the land" for review and approval of the Minister. As with Lease 3472, the Minister shall notify the lessee within 6 months whether or not the plan has been approved.

Lease 68 H/8-1-3 (dock area) requires the lessee to deliver up possession of the land in a condition as near as possible to its original state, including removal of all improvements, unless otherwise authorized by the Minister. The Lease specifies that the dock site includes all structures and equipment necessary for the reception of vessels, including loading, unloading and temporary storage of cargo.

Lease 68 H/8-3-3, (roads and pipelines) in Section 16, requires the 1984 Restoration Plan to be applied to the lease, but also allows the Minister to request a review and update of the Plan at any time during the lease term. The Minister must notify the lessee whether or not the plan has been approved within 6 months of receipt of the Plan.

Lease 68 H/8-9-2 (land around Garrow Lake) contains similar restoration requirements as Lease 3472.

Part G of the Water License sets out the conditions applying to abandonment and restoration. Item 1 of Part G reads as follows:

> *The Licensee shall by July 31, 1996, submit to the Board for approval an "Interim" Abandonment and Restoration Plan in accordance with the Northwest Territories Water Board's "Guidelines for Abandonment and Restoration Planning for Mines in the Northwest Territories, September 1990".*
>
> *In addition to conforming with the Guidelines, the Plan shall also address the following items:*
>
> *a) any significant changes to the physical and chemical properties of Garrow Lake as will be determined by the ongoing data collected with regards to the model for Garrow Lake; and*
> b) *the long term stability of Garrow Lake, including any monitoring that should be done; identification of when the lake will reach equilibrium; and what implications this may have to water quality to be discharged in the future.*

Item 2 of Part G provides for modification of the Plan as required by the Board. In turn, Item 3 requires that the licensee review the plan annually commencing in 1997, and modify it to reflect "…changes with the operation and with technology." The Board must approve any modifications to the Plan.

The license further requires that the licensee shall endeavour to carry out progressive restoration of areas that are abandoned, prior to closure of the facility. In turn, when closure ultimately occurs, the restoration program must be carried out in accordance with the schedule outlined in the Plan, or as otherwise approved by the Board.

Cominco Ltd. submitted a "Closure and Reclamation Plan" in May 1996 in compliance with the requirements of the Water License. This Decommissioning and Reclamation Plan is intended to provide an up to date description of the program which Cominco anticipates will be required to decommission, reclaim and ultimately vacate the Polaris site.

## 2.3 Objectives and Scope of the Plan

The Polaris facility is a substantial installation with excellent ancillary features including a good fresh water supply, 1,200m gravel airstrip, and a deep sea dock. Cominco had hoped to extend the life of the operation by development of other expected ore sources in the area. After extensive exploration work, no economic deposits have been discovered and, although the site is a significant facility in the High Arctic, no alternate uses have been found to date.

Cominco Ltd. believes that, given the remoteness of the site and the inherently high operating costs, the use of the facilities and occupancy of the site must be discontinued when the Polaris ore is depleted. Thus, Cominco intends to begin decommissioning and reclamation immediately following cessation of mine production.

This Decommissioning and Reclamation Plan has been prepared on the assumption that all facilities and installations that comprise the Polaris Operations will ultimately be decommissioned, removed or reclaimed under the terms of the land leases. The intent of the land leases to “remove all improvements” is served by the proposed decommissioning and landfilling in the Little Red Dog Quarry of the barge, accommodations complex and other large scrap equipment and buildings (after removal of any hazardous materials/substances).

Use of an onsite landfill for disposal of the site improvements has the following benefits:

- Eliminates potential safety hazards by removing improvements from the land;
- Improves visual aesthetics by removal of the improvements;
- Provides an environmentally secure disposal location (non-hazardous material encapsulated in permafrost);
- Reduces the number of ships that must travel through the arctic to transport building debris to the south (and, thereby, reduces the associated environmental and ecological risks);
- In the case of the barge, reduces environmental and ecological risks, complex regulatory approvals and concerns from communities along potential towage routes;
- Eliminates landfilling debris in the South that was created for and used in the North;
- Eliminates landfilling of debris in the South where the materials would potentially be exposed to groundwater;
- The additional volume of fill placed in LRD aids in contouring the quarry for closure.

### 2.3.1 Objectives

The following general objectives for the Polaris Decommissioning and Reclamation Plan have been prepared in accordance with Cominco Ltd. Environmental Policy, the regulatory requirements specified on the Land Leases administered by Department of Indian Affairs and Northern Development (DIAND), and the Water License requirements now administered by the Nunavut Water Board (NWB):

- To ensure that the site returns to a condition such that public health and safety, and the environment are protected;
- To provide a working document in which to address the concerns and requirements of all stakeholders during the consultation and implementation stages;
- To ensure that the planned activities during decommissioning are such that the requirements for long term care and maintenance are minimized or eliminated;
- To identify those activities required to return the site to an aesthetically acceptable condition.

### 2.3.2 Scope of Work

An environmental site assessment (ESA) of the leased lands and adjacent areas was carried out in 1999 and 2000 by Gartner Lee Limited to provide direction for remedial planning as reported in Volume 3 (1999 ESA) and Volume 4 (2000 ESA) of the Supporting Documents. The data has served to identify contaminants of concern and to delineate areas of the mine site requiring remediation to meet either site specific, Federal or Territorial Regulatory guidelines for soil quality.

The scope of work for the Plan is as follows:

- To identify and present plans for physical decommissioning work required at the site to eliminate public safety concerns, to restore the site to an aesthetically acceptable condition and to ensure the site is left in a physically stable condition;
- To determine those issues that constitute the critical path for the decommissioning schedule taking into account the climatic and operational constraints of the site;
- To address in a systematic manner concerns arising from the environmental impact of the mining operations and identify issues that require remediation and mitigation;
- To present practical remediation strategies to successfully mitigate site contamination issues;
- To develop site specific remedial objectives using risk assessment principles to ensure the protection of human health and the environment.

The Plan will serve as the basis for the scheduling of further work, in areas where the data analysis indicates that additional information would be beneficial. The Plan will also serve as the basis for managing and scheduling the work required for facilities decommissioning and for remediation activities.

Input from regulatory agencies and the communities of Resolute and Grise Fiord has been obtained through meetings, presentations and individual interviews as described in Section 2.5.

Cominco conducted an internal audit of the Draft Polaris Decommissioning and Reclamation Plan in 2000. This audit was conducted to ensure that the approach being proposed was consistent with Corporate environmental objectives and procedures. Additionally, it provided the opportunity to draw on Cominco Ltd.'s collective experience in closing and remediating minesites. The findings of the audit have been incorporated into this plan.

## 2.4 Cominco's Environmental Policy

Cominco supports the principle of environmentally and socially responsible development. The company recognizes that this is important to employees, shareholders, the communities and the countries in which it operates. The principle is also vital to Cominco's future success as a company. While the minerals extracted and metals produced are essential to the daily needs of an advancing world, the wider implications of business activities must be fully considered.

Cominco recognizes that maintaining a healthy environment goes hand-in-hand with a strong economy. The company understands that in order to prosper over the long-term, we must incorporate environmental considerations into all aspects of our business dealings. This policy was adopted to guide all Cominco employees in the daily performance of their jobs.

1. Cominco will explore, develop, and process resources and market products in an environmentally sound manner.
2. Cominco will provide information to counsel customers, transporters, and others in the safe and proper handling of our products.
3. Appropriate environmental care will be exercised in the planning, development, operating and closure phases of Cominco operations in all jurisdictions. Environmental protection measures appropriate to site specific conditions will be applied in the absence of regulation.
4. Cominco will promote the development of open and constructive partnerships with the public to address environmental concerns and advance necessary protection measures.
5. Cominco will promote the advancement of scientific knowledge to be applied to the identification and effective resolution of real environmental problems.
6. Cominco will encourage pollution prevention, waste minimization, and recycling efforts throughout its worldwide operations.
7. Observance of environmental legislation will be a priority in all company activities.
8. Cominco will conduct audits of operations to ensure adherence to this policy.

## 2.5 Consultation

### 2.5.1 Government Consultation

Cominco formally presented the Draft Closure Plan in Yellowknife and Iqaluit in early June 2000 to officials from the federal government (DIAND, Environment Canada and Department of Fisheries and Oceans), the GNWT, the Nunavut Territorial Government and the Nunavut Water Board. The issues and concerns that were raised during these meetings were considered for planning field activities during the summer months and for the completion of this Final Decommissioning and Reclamation Plan.

### 2.5.2 Community Consultation

Cominco Ltd. recognizes the importance of maintaining on-going dialogue with the local communities most affected by the forthcoming closure and reclamation of the Polaris Mine Site. Starting in 1999, Cominco initiated an environmental assessment of the Polaris Mine site to aid in the planning for closure. From the beginning of this process, Cominco ensured that at least one member of the team conducting the site assessment was a local northern resident. This was to ensure that the process of evaluating the site was done in an open manner and that the local communities would have first hand knowledge and involvement in the process.

As the planning process has progressed, consultations with communities have been conducted in 2000 through Hamlet meetings and through informal discussions with the residents in Resolute and Grise Fiord about reclamation planning for the Polaris Mine. Formal presentations were made in September 2000 to the Resolute Hamlet Council summarizing the Draft Reclamation Plan, including the results of the Environmental Site Assessment (ESA) Program. In November 2000, a meeting was held with the Grise Fiord Hamlet Council. During this meeting, Cominco outlined the Draft Reclamation Plan and the results of the ESA Program. At the Grise Fiord meeting, members of the Hunter-Trappers Organization and QIA were present. In both cases, copies of the draft Plan were provided along with Inuktitut translations of the Executive Summary. The remediation measures proposed in the Draft Reclamation Plan were well received with particular interest in the security of the tailing impoundment in Garrow Lake. Attendees questioned whether the tailing could ever be exposed to air where they could dry and present a dusting problem. These concerns were allayed when the structure and integrity of Garrow Lake was more fully explained. Many voiced appreciation for the opportunity to hear the details of the Plan for themselves. It was generally acknowledged that Cominco Ltd. has been a good corporate citizen, and will be missed once Polaris closes. Many expressed appreciation for the assistance Cominco Ltd. had provided to community members and touring expeditions in the past.

A significant part of each meeting centered on the benefits that could arise to either community from the implementation of the plan. These benefits could include such things as disposal of assets and job opportunities. Attendees were pleased to hear that Cominco Ltd. was intending to encourage contractors to hire northern residents and that the post closure monitoring program could also generate some work for local residents. Some specialized assets will have an application or sufficient residual value that warrants their removal from site and transport to southern facilities. The communities will be consulted on the disposition of the remaining assets such as furniture, recreational equipment, light vehicles, maintenance equipment, and heavy equipment. Many meeting participants have not yet been to Polaris, and it is Cominco's intent to organize trips to the site for interested residents representing each community. This will provide them with a firsthand perspective on features and issues referenced in the Decommissioning and Reclamation Plan, plus provide an opportunity to see the types of assets that could be disposed of at the time of closure. Meeting attendees that had previously been to Polaris however, expressed concern that the Accommodations building would have to be demolished as part of the plan. They were assured that Cominco Ltd. was open to another group or organization coming forward with an alternate use and the resources required to operate and maintain the facility.

Cominco commits to continuing dialogue with the communities as planning for closure progresses. Polaris staff will arrange for meetings in Resolute and Grise Fiord on a regular basis to keep them informed on current planning and progress.

In addition to the above meetings, a series of community interviews with elders, hunters, political leaders and other residents from Resolute and Grise Fiord were also held in November 2000 to discuss land use activities at and around the Polaris Mine site. An interview form was used to guide the discussions and a translator in both Resolute and Grise Fiord participated in the process. A total of 9 community members from Resolute were interviewed and a total of 5 community members were interviewed at Grise Fiord. In an overall sense, the following conclusions were drawn from this process:

1. Little Cornwallis Island (LCI) has largely been a stop-over for residents from Resolute while in transit to Bathurst Island for hunting;
2. Hunting on LCI has occurred in the past on an opportunistic basis with brief stop-overs;
3. The northeastern portion of LCI is viewed as a more favourable area for camping;
4. The Polaris Mine has been an important source of supplies such as fuel for hunters that are travelling to Bathurst Island;
5. The Polaris Mine area has previously been a “view area” for polar bears.

## 2.6 Implementation of the Plan

Working in the Arctic presents many unique challenges. This is especially true with the remote location and harsh environment at the Polaris Mine site. These challenges are at the forefront of the planning process for completion of mining, decommissioning and reclamation at the Polaris mine site.

The greatest constraint on performing the reclamation work is scheduling of the decommissioning and reclamation activities in a way that is not hindered by the short summer and shipping season. The mine is scheduled to complete operations and close in 2002.

Cominco Ltd. has completed three aspects of the closure planning process:

1. Completing an Environmental Site Assessment;
2. Developing a decommissioning and reclamation plan (the ‘Plan’);
3. Seeking regulatory and stakeholder input for the Plan.

The subsequent stages of the process are to obtain regulatory approval, continue community consultation and prepare detailed schedules and contracts for the decommissioning and reclamation work.

A summary of critical path dates and activities are included in the decommissioning and reclamation schedule provided in Table 2.1.

### 2.6.1 Environmental Site Assessment

In 1999, Cominco commissioned Gartner Lee Limited to conduct an assessment of environmental conditions at the mine site and surrounding lands. The assessment was performed in 1999 and 2000. The environmental assessment was initiated early in the closure planning process to provide adequate time to identify and address environmental issues. The assessment has identified the location and scale of environmental issues that require remedial action.

Detailed reports on each of the 1999 and 2000 programs are included in Volume 3 and Volume 4, respectively, of the Supporting Documents. The 1999 Environmental Site Assessment report was previously submitted to both Territorial and Federal regulatory agencies.

### 2.6.2 Decommissioning and Reclamation Plan

This document is the final Polaris Mine Decommissioning and Reclamation Plan. It contains a description of:

- the pre-mining land use;
- environmental setting;
- mine methodology and facilities;
- closure planning work and site investigation work that has occurred to date in preparation for closure including community and government consultations;
- the reclamation work that is proposed including schedules;
- post closure management considerations.

Several stand alone technical reports that address specific technical aspects of the Plan are provided as Supporting Documents in Volumes 2 through 4. These reports address:

- a comparative review of barge decommissioning alternatives;
- design of an engineered landfill cover for closure;
- development of risk based site specific soil quality remediation objectives for lead and zinc;
- modeling of the current and projected chemical stability of Garrow Lake;
- decommissioning of the Garrow Lake dam;
- reclamation of the loading dock including restoration of the shoreline;
- detailed reporting on the 1999 and 2000 environmental site assessment programs.

### 2.6.3 Regulatory and Community Input

This final Plan reflects suggestions, comments and concerns raised by regulators, stakeholders and local communities following the issue of the draft Plan in May 2000 and community meetings in September and October 2000.

| ID | Task Name |
|---|---|
| 1 | **COMPLETION OF MINE / MILL OPERATION** |
| 2 | COMPLETE MINING |
| 3 | COMPLETE MILLING |
| 4 | COMPLETE PRODUCT LOADOUT & SHIPPING |
| 5 | **FRONT END - PLANNING, APPROVALS & DESIGN** |
| 6 | **CLOSURE PLAN & APPROVALS** |
| 7 | INITIAL PLANNING & ENVIRONMENTAL STUDIES |
| 8 | CLOSURE PLAN SUBMITTALS & APPROVALS |
| 9 | WATER LICENCE RENEWAL |
| 10 | **PROJECT PLANNING, DESIGN & PROCUREMENT** |
| 11 | PRELIMINARY PLANNING AND SCOPE DEFINITION |
| 12 | DETAILED PLANNING & SCHEDULING |
| 13 | DEMOLITIONS CONTRACT(S) AWARD |
| 14 | DEMOLITION CONTRACTS PROCUREMENT |
| 15 | **MINE CLOSURE PLANNING & DESIGN** |
| 16 | MILL DEMOLITION PLANNING & DESIGN |
| 17 | STORAGE BUILDING PLANNING & DESIGN |
| 18 | DOCK AND SHORELINE PLANNING & DESIGN |
| 19 | GARROW LAKE PLANNING & DESIGN |
| 20 | MISCELLANEOUS SUPPORT SYSTEMS & FACILITIES |
| 21 | GENERAL SITE CLEANUP & EARTHWORKS |
| 22 | **PRE-CLOSURE RECLAMATION / PREPARATION** |
| 23 | GARROW LAKE DRAWDOWN |
| 24 | PRE CLOSURE DE-COMMISSIONING WORK BY POLARIS |
| 25 | COMPLETE OPERATION & FINAL PRODUCT LOADOUT |
| 26 | COMPLETE OPERATIONS CLEANUP & DEMOBILIZE PERSONNEL |
| 27 | **PROJECT EXECUTION** |
| 28 | **MOBILIZATION & SITE PREPARATION** |
| 29 | OFF-SITE MOBILIZATION OF CONTRACTOR(S) |
| 30 | ON-SITE MOBILIZATION OF CONTRACTOR(S) |
| 31 | **DEMOLITION & RECLAMATION (CONTRACT)** |
| 32 | MINE RECLAMATION |
| 33 | MILL DEMOLITION |
| 34 | STORAGE BUILDING DEMOLITION |
| 35 | LOADOUT AND DOCK DEMOLITION & RECLAMATION |
| 36 | TAILINGS DEMOLITION & GARROW LAKE RECLAMATION |
| 37 | CRF PLANT DEMOLITION |
| 38 | MISC SUPPORT SYSTEMS & FACILITIES DEMOLITION |
| 39 | **MISC. SITE RECLAMATION & EARTHWORKS (CONTRACT)** |
| 40 | Phase 1 Earthworks (First Year) |
| 41 | Phase 2 Earthworks (2nd Year) |
| 42 | Phase 3 Earthworks (Last Year) |
| 43 | **DEMOBILIZATION** |
| 44 | ACCOMMODATION COMPLEX DEMOLITION |
| 45 | CONTRACTOR EQUIPMENT & FACITIES |
| 46 | LAST SHIP OUT OF POLARIS (CONTRACTOR'S EQUIP) |
| 47 | FINAL CLEAN-UP & CONTRACTOR PERSONNEL |
| 48 | **PROJECT CLOSEOUT** |
| 49 | **CLOSURE REPORTS** |
| 50 | ENVIRONMENTAL |
| 51 | PROJECT MANAGEMENT |
| 52 | **POST CLOSURE ENVIRONMENTAL MONITORING (2004 To 2011)** |
| 53 | PROGRAM REQUIREMENTS & PLANNING |
| 54 | IMPLEMENTATION & REPORTING (Ongoing To 2011) |

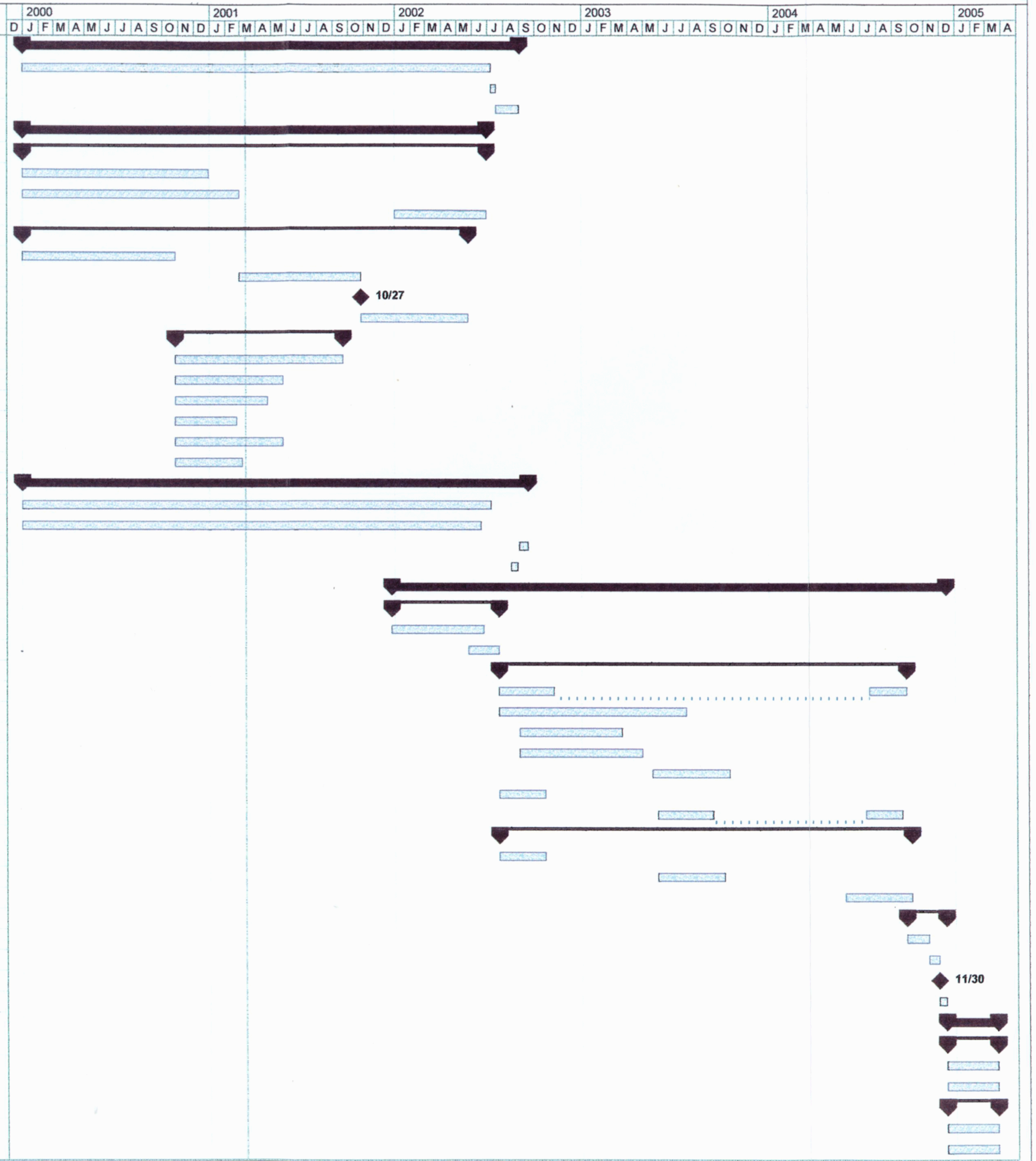


TABLE 2.1
Closure Planning/
Decommissioning
Schedule –
Preliminary

### 2.6.4 Contracts, Detailed Schedules and Decommissioning and Reclamation Work

Decommissioning activities will commence on a practical schedule following mine closure. While these activities will utilize the equipment and resources on site, additional heavy equipment and other materials will be required to complete certain tasks. It will be necessary to have this supplemental equipment and material shipped to the site so that decommissioning and closure activities can begin in 2002. To allow contractors time to organize materials and equipment for shipping in 2002, contracts for the work must be commissioned in 2001.

## Table 2.1 Closure Planning/Decommissioning Schedule - Preliminary

# 3. Physical Environment

## 3.1 Environmental Setting

The Polaris Mine site is located 1,000 km north of the Arctic Circle, at the southern tip of Little Cornwallis Island, in the Canadian High Arctic. The mean annual air temperature is -17 degrees Celsius, with an average frost-free period of 8 days. Summer temperatures may reach a high of 15 degrees Celsius and winter temperatures may reach a minimum of -50 degrees Celsius in February. Snow-melt typically begins in June, with break-up of the sea ice occurring from mid July into early August, and freeze-up beginning in September.

Precipitation levels are low due to the extremely cold temperatures, which lowers the level of absolute humidity and hence the available moisture. Annual precipitation at the mine site is approximately 250 mm, of which approximately 50 mm is in the form of rain and 200 mm is in the form of snow. Winds are predominantly from the north and north-north-east at an average windspeed of 20 km/hour.

The mine site lies adjacent to Garrow and Polaris Bays to the east, Crozier Strait to the west and North Bay to the north. Topography is limited to gently sloping hills. Four lakes are located within the mine site area: Frustration, Lois, Loon and Garrow Lakes. Frustration Lake is used as the potable and fresh water source for the mine site. Garrow Lake, a non-mixing, saline (meromictic) lake, is used for the disposal of tailing.

The surface drainage pattern follows the general topography at the mine site. Low lying terrestrial areas are generally wet or water filled during the summer months due to the presence of permafrost. The location of the air strip represents the high point of land from which slopes trend to the east - toward Loon Lake and the New Quarry; to the west - toward the shipping dock and Crozier Strait; to the north - toward North Bay; and, to the south - toward the Operational Landfill and Polaris Bay.

**Terrain**

Gartner Lee Limited, on behalf of Cominco Ltd., began a phased environmental site assessment, including terrain analysis, in 1999 that was completed in 2000. The results of the terrain analysis, which characterized the surficial materials and geomorphological processes for the vicinity of the Polaris Mine Site, are summarized below.

The Polaris mine area consists of very gently rolling low-relief hills and plains rising out of the ocean. Several large elliptical inland lakes (Garrow, Frustration and Lois Lakes) are found along the eastern edge of the study area. The bulk of the study area is comprised of two peninsulas, Riddle Point and the Polaris Mine site. The ends of both peninsulas are characterized by large hills with relatively steeper slopes leading to the ocean.

The Polaris Mine site area is characterized by a steep west-facing hillside leading from the accommodation complex down to the mill site below. The slopes of Riddle Point are characterized by well developed marine terraces which have some bedrock exposure. The only other areas of steep topography are found along the Frustration Lake outlet creek which has incised a canyon into the bedrock.

The landscape and surficial materials of the Polaris Mine site study area are dominated by marine and glacial processes. Hodgson (1989) suggests that the Little Cornwallis Island area was covered by the Queen Elizabeth Islands Glacial Complex until deglaciation between 8.5 and 10 thousand years ago. At this time, the study area was thought to be under approximately 100 metres of seawater. Since that time, the landscape uplifted, initially very quickly, to its current elevation above sea level. This probably occurred through isostatic rebound as the weight of the glaciers was removed from the landscape. This process of uplift is clearly shown by the prominent raised beach lines (strandlines) seen along the Frustration Lake access road and the Riddle Point area. This glaciation is probably responsible for the very subdued and rounded topography seen in the study area.

In spite of the presence of glaciers in study area, no obvious glacial or glaciomarine deposits are found in the study area. Rather, the study area is dominated by marine sediments overlying bedrock (Hodgson, 1989).

The study area has also been very heavily affected by permafrost and periglacial processes. Permafrost is found throughout the study area. Permafrost features commonly found are large frost wedge polygons which seem to penetrate the friable bedrock and are, perhaps, more common where bedrock is near surface.

The periglacial process consists of frost sorting and mechanical weathering of sediments. Furthermore, micro scale frost features such as frost mounding and stripping are common. On a larger scale, solifluction lobes are commonly found on the hillsides east of North Bay. Perhaps the most significant periglacial process is that of nivation. Nivation refers to “snow patch erosion”, the development of shallow depressions at sites occupied by long lasting snow banks. The down slope areas from zones of nivation often have over-saturated soils due to the abundant water supply from the melting snow banks, as well as common surface rilling caused by surface runoff. A good example of nivation is found on the steeper slopes southwest of Loon Lake.

**Soils**

Soils in the Polaris Mine area are described as polar desert in character, with poorly developed horizons and are classified as Cryosols. In the vicinity of the mine site and elsewhere in the surrounding area, overburden forms a thin mantle over the calcareous bedrock. Barren, gravel type surface material predominates at the Polaris Mine site. Soil pH’s have been reported as alkaline (pH 8) confirming the calcareous nature of the parent materials. Finer textured materials are found in natural depressions, such as the Loon Lake area and others to the east, where vegetated meadow type zones have formed in poorly drained sand to clay materials.

The Polaris mine site is located within the zone of continuous permafrost. The zone overlying the permafrost that freezes and thaws in response to seasonal fluctuations in ambient temperature is referred to as the active layer. The thickness of the active layer is dependent, to varying degrees, upon several factors, including: mean surface temperature, topography, drainage, vegetative cover and soil type. The thickness of the active layer varies from 0.10 to 1.36 metres depending on the soil profile and the thickness of the snow cover.

**Vegetation**

The vegetation of Little Cornwallis Island is classified as "Arctic Tundra". Due to the harsh climate, high winds and shallow soils, vegetation forms are typically dwarfed, low-lying and grow in clusters or as a dense mat. There is considerable variation in the moss and lichen flora, but few species of vascular plants. Vegetative cover tends to be greater on wetter sites in coastal lowlands, along streams and rivers and in sheltered valleys.

BC Research (1975, 1979) conducted a survey of vegetation types in the mine site area as part of their baseline environmental assessment prior to mine development. Six vegetation types were identified within the mine site area by BC Research: Bare (coarse textured), Bare (fine textured), willow, wet meadow, lichen-moss-algae, Bare–lichen-moss-algae.

The active mine site area was located within the Bare (coarse textured) map unit, characterized by a coarse dolomitic stony surface, which is dry and well drained. This unit has relatively low biological sensitivity due to the scarcity of vegetation and the associated low potential for wildlife use. It also has a low susceptibility to mechanical disturbance. The BC Research study found that vegetated areas, represented predominantly by the lichen-moss-algae type, were located no closer than 500 metres from what is now the active mine site area. Figure 4 illustrates the location and extent of each of the six vegetation units identified by BC Research.

Field observations of vegetation recorded during the environmental assessment programs conducted in 1999 and 2000 found that the location, extent and type of plant communities were similar to those identified by B.C. Research in 1974-5. Some of the more common plants observed in 1999 and 2000 included:

- Grasses (*Alopecurus alpinus, Dupontia fisheri, Poa abbreviata* etc.);
- Lichen (*Thamnolia subuliformis*, white and yellow varieties);
- Mosses (*Catascopium nigritum, Distichium capillaceum* etc.);
- Willow (*Salix arctica*);
- Saxifrage (*Saxifraga sp*.);
- Arctic Poppies, (*Papaver laponicum*);
- Dwarf Draba (*Draba alpina*).

Flowering plants were in bloom, at the time of the field surveys in 1999 and 2000. Saxifrage, Arctic poppies, willow and mosses were very common throughout the vegetated areas. Minor occurrences of

Arctic poppies were also observed within the active mine site, on the bare rubbly slopes between the process barge and concentrate storage building.

**Wildlife**

The environmental baseline studies conducted by BC Research (1975, 1979) included a survey of the population and distribution of mammals and birds on Little Cornwallis Island. The following animal and bird species were observed on the island:

- Herbivores: Peary caribou, Musk ox, lemmings and Arctic hares;
- Carnivores: Arctic fox, Arctic wolf and Polar bear;
- Migratory birds: red-throated loons, rock ptarmigan, Eider duck, parasitic and long-tailed Jaegers, Glaucus gull, Arctic tern and Snowy owl.

A recent survey of mammal and bird populations on Little Cornwallis Island was completed in 1997 by Bryant Environmental Consultants Ltd. in support of a Preliminary Environmental Evaluation for the proposed Eclipse deposit located 30 km northeast of Polaris. The information provided on the habitat and behavior of the major mammals identified is summarized below. The Eclipse project was subsequently determined to be uneconomic and was cancelled.

***Lemmings***

The foraging, defecation and burrowing behavior of these small mammals plays an important role in the ecosystem of the High Arctic by influencing the productivity of vegetation, providing inputs of decomposed organic matter and dispersing soil nutrients. The lemming population numbers are subject to cycling, therefore influencing the abundance of wildlife at higher trophic levels.

Lemmings generally feed on willow, supplemented by grasses. The preferred vegetation units for lemming burrows includes the willow and lichen-moss-algae habitats, and to a lesser extent the bare-lichen-moss-algae and wet meadow habitats.

***Arctic Hare***

The Arctic hare is generally found in less abundance in the High Arctic than lemmings. The BC Research study (1975) did not observe any Arctic hares during the summer field work season. The preferred food source for these herbivores is willow, mountain avens and grasses.

***Peary Caribou***

The caribou diet depends on seasonal availability, but consists largely of a combination of willow, herbs, mosses and lichens. They prefer mid-slope habitats where the vegetation is abundant, and the ground conditions are dry. Although the population sizes of caribou herds are known to fluctuate due to climatic conditions, the BC Research study in 1975 observed only a sparse population of Peary caribou on Little Cornwallis Island. A subsequent study conducted in 1997 did not locate any caribou on the island.

### *Musk Ox*

Musk ox feed primarily on sedges and secondarily on willows. Their preferred habitat is the muddy wet meadow vegetation unit. Only 3 musk ox individuals were recorded near the Polaris mine site during the pre-mine environmental baseline study (BC Research, 1975) and no musk ox were located in a subsequent study in 1997. Although the population fluctuates, significant populations of musk ox do not occur in this portion of LCI.

### *Arctic Fox*

Arctic fox are scavengers, and as such include a variety of land-based and marine mammals and birds in their diet. They prey on the eggs and young of nesting birds. Anecdotal observations by mine site personnel indicate that the population of Arctic fox has increased since the mine opened, largely due to increased opportunities for shelter and year round food sources.

### *Arctic Wolf*

Arctic wolves prey on caribou and musk ox, therefore their productivity is related to the abundance of these ungulates. The environmental baseline studies did not observe wolf scats in the mine site area and recorded only one unconfirmed siting of a wolf. Therefore, the mine site area did not represent an important habitat for Arctic Wolves prior to mine development.

### *Polar Bear*

Polar bears depend primarily on marine life for food. Local movements of Polar bears across LCI are frequent, as established by the large number of sightings recorded by the mine site. The presence of bears at the mine site is related to their scavenging behavior and past activity at the landfill area prior to the implementation of bear control measures.

## Surface Geology (Sharp et al, 1996)

The Polaris Mine and other lead-zinc showings in the Cornwallis Islands area, District of Franklin, occur in lower Paleozoic carbonate rocks within the Cornwallis Fold Belt. The favored host strata for the lead-zinc mineralization is the Thumb Mountain Formation, an Ordovician limestone characterized by a lower member that accumulated in a shallow water tidal flat environment and an upper member that formed on a shallow water shelf environment. The Thumb Mountain Formation outcrops extensively on Cornwallis and Little Cornwallis Islands. Overlying the Thumb Mountain Formation are the Irene Bay Formation and the Cape Phillips Formation, both of which are exposed on surface. Erosion has removed any younger strata on Little Cornwallis Island.

Deposits of pebbles, mud and sand of variable thickness characterize the surface geology of the Polaris Mine area. The unconsolidated deposits have been extensively reworked into raised beaches formed during isostatic rebound following deglaciation. The Thumb Mountain and Irene Bay Formations weather into material characterized as well drained gravel. The Cape Phillips Formation weathers to form a much higher proportion of fines (sands and silts).

Outcrops of the lower member of the Thumb Mountain Formation are present near the Ocean on the west side of the peninsula by Crozier Strait. The hillside between the barge and the accommodations building is covered with micritic and fine-grained limestone, with fossil *Tetradium* corals becoming more abundant upward in the section. Surface showings of sphalerite, galena and marcasite stringers and disseminations associated with dolomitized rocks of the upper member of the Thumb Mountain Formation occur in three areas of the mine site as shown in Figure 5. The main sulfide deposit does not outcrop at the surface of the mine site. The outline of the orebody is shown projected to surface on Figure 5.

The Irene Bay formation is a poorly exposed, recessive weathering unit. It can be seen exposed in the southeast wall of the Old Quarry, where it lies in contact with the basal units of the Cape Phillips Formation. The Irene Bay formation consists of interbedded green mudstone (shale), argillaceous gray-green limestone and massive gray limestone. Large intact fossils of gastropods and corals are present, as well as crinoid, brachiopod and trilobite fragments. Marcasite nodules are common and often replace fossils in the lower green mudstone. Approximately 1-2% disseminated pyrite occurs throughout the green mudstone.

The Cape Phillips Formation is a black bituminous carbonate mudstone and is exposed in the new quarry. Orange weathering patches extend along frost shattered fractures. A third quarry area, known as the Little Red Dog Quarry, is located to the southwest of the north showing of the upper member of the Thumb Mountain Formation. This quarry was developed to supply limestone for use as cemented backfill material in the underground.

## 3.2 Historical Land Use

### 3.2.1 Archaeological Sites

The coastal areas of Little Cornwallis Island (LCI) have been the subject of intermittent archaeological investigation for over 20 years.

The first formal archaeological investigation of LCI was completed in the mid 1970's by R. McGlee who examined the southwestern coast of the Island in the vicinity of Cominco's (then) proposed Polaris lead-zinc mine.

In 1977, Dr. P. Schledermann conducted comprehensive aerial and ground surveys of the Crozier Strait, Pullen Strait and McDougall Sound region as part of the environmental mitigation program for the proposed Polar Gas Pipeline.

In 1989, Dr. J. Helmer conducted an archaeological survey of the southeastern shore of LCI adjacent to Cominco's proposed Eclipse Deposit site, 30 km north east of Polaris. This project has since been cancelled.

The Schledermann survey identified 36 sites of archaeological significance on LCI (Figure 6). Most of these sites were to the north and east of the mine site. The closest sites were 1A179 on Riddle Point and 1A178 at the mouth of Frustration Creek. Site 1A178 consisted of tent rings and Site 1A179 consisted of a tent ring and cache. It is important to note that the study did not identify any archaeological sites in the areas covered by Cominco's surface leases at the Polaris Mine site.

In 1997 Cominco commissioned Mr. P.C. Dawson to carry out a brief archaeological survey of selected areas along the west coast of LCI between Royal Point and North Bay. This survey was required to ensure Cominco's 1997 diamond drilling program would avoid archaeological sites.

Eight features of cultural significance were identified during the 1997 survey as shown in Figure 6. As previously found, none of these sites were located within the five surface leases held by Cominco.

### 3.2.2 Historical Land Use

Prior to the development of Polaris Mine, Cominco commissioned an independent consultant to study the potential socio-economic impacts of the mine. The study entitled "Potential Socio-Economic Impacts of the Polaris Mine Project" was published in June 1980 by Outcrop Ltd., Yellowknife, NWT in association with DPA Consulting Limited, Vancouver, British Columbia.

In order to determine the mine's impact on the historical land use activities of hunting and trapping, the study examined the prime hunting areas of the Resolute Inuit. Much of the local information was gathered from interviews with 20 Resolute Inuit residents. An earlier report "Inuit Land Use and Occupancy Project" supplemented the traditional knowledge for the Outcrop study.

Based on the interviews and the Land Use Project report the Outcrop study concluded:

> *"that the mine location will have little impact on the hunting/trapping harvests of the Resolute Inuit since Little Cornwallis Island is a low priority hunting area".*

In 1997, Cominco commissioned a Preliminary Environmental Evaluation for the proposed Eclipse deposit located 30 km northeast of Polaris (Bryant Environmental Consultants Ltd., 1997). The Evaluation included a review of "*Traditional Knowledge and Traditional Land Use*", based on interviews with four Inuit hunters from Resolute. While this Evaluation was concerned with the Eclipse area only, it does provide a good summary of wildlife and Inuit hunting on LCI.

Key points relating to observations of the presence, abundance and population fluctuations of caribou and musk ox, the main species hunted by the Inuit, are summarized below from the above-mentioned studies as well as the BC Research environmental baseline study:

- Small populations of caribou and musk ox move through the Arctic islands to access new feeding areas and are the main terrestrial wildlife hunted by the Inuit on LCI;
- Vegetation surveys of the mine site prior to mine construction (B.C. Research) indicate that the mine is located primarily on "Bare" habitat which has relatively low biological sensitivity and low vulnerability to mechanical disturbance. Vegetation suitable for caribou and musk ox feeding can be found to the north and east of Polaris;
- The populations of caribou and musk ox have fluctuated over the years. Severe weather in 1973/1974 decimated the caribou and the Inuit imposed a hunting moratorium until the mid 1980's. Population studies have shown the caribou resident on LCI to range from 11 in 1975 to 7 in 1987. A study in August 1997 found no caribou, but some signs of recent usage. Caribou numbers throughout the Arctic islands have again been reduced considerably in the last few years due to severe weather conditions in the early winter months of two successive years;
- The population data for musk ox is sketchy. In 1974 the estimated population for LCI was twenty but only three were reported in 1975 by BC Research. Mine personnel reported three in 1992. None were found in the 1997 survey. Again, like caribou, these animals are vulnerable to extreme snow and weather conditions;
- Other smaller mammals exist on LCI. Lemming and arctic fox are reasonably abundant but populations are cyclic. Arctic hare are present in small numbers but are found largely in the vegetated areas immediately north and east of the mine. Wolves have been seen in the area but none were present during the surveys in 1975 and 1997;
- Polar bears are culturally and economically significant to the Inuit and are common in the LCI area. Records of polar bear sightings have been kept at the mine and have been as high as 250 in a winter season. The mine reports less sightings since fencing the burn pit on the landfill site in 1999;
- The Inuit hunters interviewed for the 1997 study indicated that hunting on LCI did continue after the mine was established. However, the declining caribou numbers, due to severe weather, have resulted in less trips to LCI for hunting.

The community interviews that were conducted in 2000 (described in Section 2.5) indicated the following regarding historical land use:

1. LCI has largely been stop over for residents from Resolute while in transit to Bathurst Island for hunting;
2. Hunting on LCI has occurred in the past on an opportunistic basis with brief stop-overs;
3. The northeastern portion of LCI is viewed as a more favourable area for camping;
4. The Polaris Mine area has previously been a "view area" for polar bears.

# 4. Mine Development

## 4.1 Site Development

An exploration camp was constructed in the 1960s just east of Loon Lake. Two Nissan huts from this camp are still in use.

In 1973 and 1974, a small camp was constructed adjacent to the original underground decline portal. This camp consisted of trailer style accommodations for 20 people, a steel equipment building and a temporary shop building. The accommodation building and steel building remain and are used as miscellaneous service buildings.

In 1980, a 100 man trailer camp was constructed just to the north of the original mine portal for accommodation of the construction crew. A small part of this camp survives and is used for mine rescue and fire fighter training. This was followed by underground mine development and construction of the accommodation building, concentrate storage building and the underground crusher and conveyor system.

In order to reduce construction costs and construction time, the process plant and related facilities were constructed on a barge that was towed to the site in 1981. The double-hulled barge was constructed in Quebec in 1980 and outfitted with a process plant and power generators. In July 1981 the barge was towed to Polaris by ice breaking tugs and floated into place in August 1981. A cofferdam was installed and the berthing lagoon was pumped out and backfilled.

The following facilities were constructed later during the operational phase:

- One above ground fuel storage tank in the tank farm (1986);
- The "Bent Horn" fuel conditioning building (1987/8);
- The Cat generator building (1991);
- The CRF (Cemented Rock Fill) Plant (1995).

The waste rock produced from the original underground exploration decline (1973/4) was used to fill the area in front of the portal and along the shoreline. Mineralized (sulphide) material from the exploration excavations within the orebody was stockpiled on the waste rock fill for sampling and potential shipment for metallurgical testwork. One small shipment was made by sea in 1974.

In 1980/81, the waste rock from the pre-production mine development was used for fill around the site and in mine yard construction. All sulphide enriched material mined during this period was stockpiled for mill feed during the startup period.

As discussed above, prior to beaching the process barge a lagoon was excavated to provide access and a landing base for the barge. The excavated material was used for construction of the dock and infill once the barge was positioned and anchored. Minimum excavation was required for construction of the accommodation building, the oil tank farm, and the concentrate storage building. Much of the material excavated was used for fill around the dock area, while some was used for road building and for the airstrip.

After the mine was in operation, most new roads were constructed with material from the backfill quarries and surfaced with crushed material from old raised beaches.

# 4.2 Mining Activities

## 4.2.1 Production and Ore Reserves

### Ore

The Polaris concentrator was commissioned in 1981 and, until December 2000, processed approximately 18.4 million dry tonnes of ore (Table 4.1). This has resulted in production of approximately 3.9 million dry tonnes of zinc concentrate and 0.8 million dry tonnes of lead concentrate. Mineable ore reserves at January 1, 2001 were approximately 1.6 million dry tonnes which will be exhausted in 2002. At that point the mill will have processed approximately 21.1 million dry tonnes to produce 4.4 million dry tonnes of zinc concentrate and 0.9 million dry tonnes of lead concentrate.

**Table 4.1 Polaris Production History**

| Year of Production | Tonnes of Ore milled Dry wt | Mill Feed Grades % Lead | % Zinc | % Iron | Tonnes of lead conc | Tonnes of zinc conc | Tonnes of tailings | Tailings Cubic M | Tailings Grade % Pb | % Zn | % Fe |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1981 | 25,658 | 4.7 | 15.3 | 7.8 | 1,576 | 5,980 | 18,102 | 6,465 | 0.22 | 2.10 | 9.6 |
| 1982 | 495,214 | 5.0 | 17.7 | 5.8 | 43,202 | 134,839 | 317,173 | 113,276 | 0.28 | 1.50 | 9.6 |
| 1983 | 827,582 | 5.9 | 16.8 | 5.8 | 51,149 | 216,528 | 559,905 | 199,966 | 0.25 | 1.00 | 6.1 |
| 1984 | 819,064 | 3.8 | 13.7 | 5.3 | 36,900 | 174,081 | 608,083 | 217,173 | 0.16 | 0.65 | 6.3 |
| 1985 | 935,998 | 3.5 | 13.1 | 5.6 | 39,341 | 190,721 | 705,936 | 252,120 | 0.15 | 0.53 | 6.7 |
| 1986 | 885,843 | 3.1 | 13.3 | 3.8 | 32,031 | 182,116 | 671,696 | 239,891 | 0.11 | 0.42 | 4.4 |
| 1987 | 983,755 | 3.0 | 13.6 | 4.1 | 33,583 | 206,055 | 744,117 | 265,756 | 0.13 | 0.51 | 4.9 |
| 1988 | 1,016,282 | 3.7 | 13.8 | 4.3 | 44,466 | 221,472 | 750,344 | 267,980 | 0.13 | 0.52 | 5.1 |
| 1989 | 1,023,296 | 3.5 | 14.1 | 3.9 | 41,012 | 224,499 | 757,785 | 270,638 | 0.13 | 0.51 | 4.6 |
| 1990 | 1,017,554 | 4.0 | 14.4 | 3.3 | 48,226 | 227,142 | 742,186 | 265,066 | 0.13 | 0.43 | 3.9 |
| 1991 | 1,069,296 | 3.2 | 12.5 | 4.2 | 39,907 | 210,126 | 819,263 | 292,594 | 0.12 | 0.44 | 4.9 |
| 1992 | 1,066,719 | 4.1 | 13.0 | 4.9 | 51,727 | 217,799 | 797,193 | 284,712 | 0.13 | 0.40 | 5.9 |
| 1993 | 1,026,843 | 3.4 | 12.3 | 3.6 | 40,887 | 195,057 | 790,899 | 282,464 | 0.14 | 0.44 | 4.3 |
| 1994 | 1,028,610 | 3.4 | 12.9 | 3.1 | 40,285 | 207,498 | 780,827 | 278,867 | 0.15 | 0.51 | 3.6 |
| 1995 | 1,003,995 | 3.5 | 12.4 | 3.3 | 40,397 | 196,152 | 767,446 | 274,088 | 0.15 | 0.45 | 3.8 |
| 1996 | 1,025,081 | 3.0 | 12.2 | 3.1 | 35,933 | 193,132 | 796,016 | 284,291 | 0.14 | 0.52 | 3.5 |
| 1997 | 1,043,909 | 2.9 | 12.3 | 1.4 | 35,767 | 196,872 | 811,270 | 289,739 | 0.10 | 0.46 | 1.5 |
| 1998 | 1,030,859 | 4.0 | 14.3 | 3.1 | 47,981 | 225,862 | 757,016 | 270,363 | 0.13 | 0.50 | 3.7 |
| 1999 | 1,049,866 | 4.0 | 14.5 | 3.0 | 49,344 | 238,340 | 762,182 | 272,208 | 0.14 | 0.47 | 3.5 |
| 2000 | 1,052,452 | 3.6 | 13.3 | 2.6 | 43,725 | 217,499 | 791,228 | 282,581 | 0.12 | 0.44 | 3.2 |
| | 18,427,876 | | | | 797,439 | 3,881,770 | | | | | |
| 2001 | 1,040,250 | 3.3 | 12.2 | 1.9 | 39,137 | 197,765 | 803,348 | 286,910 | 0.13 | 0.37 | 2.4 |
| 2002 | 583,500 | 2.9 | 11.8 | 1.6 | 19,278 | 107,356 | 456,866 | 163,166 | 0.09 | 0.37 | 2.1 |
| | 21,104,078 | | | | 899,579 | 4,404,390 | | | | | |
| Est. Tonnage & Grade in Garrow Lake to Dec 2000 | | | | | | | 12,957,439 | 4,627,657 | 0.14 | 0.53 | 4.58 |
| Est. Tonnage & Grade in Garrow Lake to Mine Closure 2002 | | | | | | | 15,008,881 | 5,360,315 | 0.14 | 0.51 | 4.31 |

ALL TONNAGE REPORTED AS DRY METRIC TONNES.

**Waste Rock**

During the exploration and pre-production mining phases, waste rock produced underground was stockpiled around the 1972 exploration decline portal, the North portal, and used for fill on the site. This waste was comprised largely of limestone from the host strata for the lead/zinc mineralization and also included some shales from overlying strata.

During the production phase almost all waste rock produced has been used as backfill in the mine openings, with two exceptions. The first exception has been in the use of large pieces of waste as "rip-rap" for protection along the ocean shoreline adjacent to the dock.

The second exception was during the excavation of a storage chamber in the underground mine near the North Portal, in the early 1990's. The chamber is used to store ammonium nitrate, which is used for blasting. The waste rock from this excavation was hauled to the surface and dumped near the portal to provide a temporary storage area for underground supplies. This area has most recently been used, on a seasonal basis, to store lead ore (Section 5.1.4).

**Tailing**

All mill tailing has been deposited in Garrow Lake (Section 5.2.1). At mine closure, approximately 15.0 million dry tonnes (5.4 million $m^3$) of mill tailing, with a grade of 0.14% Pb, 0.51% Zn and 4.31% Fe, will have been deposited in Garrow Lake (Table 4.1).

## 4.2.2 Mining Methods

The mine began production in late 1981. Since 1988, production has been just over 1,000,000 tonnes each year. In 2000, production was 1,052,452 dry tonnes of ore at an average grade of 3.6% Pb and 13.3% Zn, producing 43,725 dry tonnes of lead concentrate and 217,499 dry tonnes of zinc concentrate.

The orebody is a Mississippi Valley type with the main ore minerals being galena (lead sulphide) and sphalerite (zinc sulphide) and the host rock limestone with calcite.

Permafrost and freezing have been the key to success in mining the Polaris orebody. Permafrost extends below the orebody as illustrated on Figure 7. The temperature contours through the underground mine (isotherms) that are illustrated on Figure 7 were confirmed by geothermal modeling as described in Section 5.8.4. The rock is competent in its frozen state. Heat generated during the mining process comes mainly from the diesel powered mobile equipment used in the mine and from mine ventilation in the summer. In order to maintain cold temperatures in the underground during the summer, mine development activities are curtailed allowing mine ventilation volumes to be reduced. In addition, a 450 tonne refrigeration plant was installed at the portal of the main ventilation intake decline in 1984.

Most of the orebody has been mined with sub-level longhole mining employing high productivity rubber-tired mobile equipment. All drilling at the mine is dry. Drill holes are blasted with an ammonium nitrate explosive mixed in the mine. A series of 1.8m diameter raisebore holes are drilled from surface into each mining block to be used for ventilation and backfill.

Backfilling has been an integral part of the mining method to maintain stability and allow ore pillars to be mined. In the early days, surface shales were mined in a quarry, mixed with water and placed in the underground openings to freeze. Since 1996, cemented rock fill (CRF) has largely replaced the frozen shale backfill. The CRF is produced from limestone mined in the Little Red Dog Quarry (LRD) mixed with cement slurry in the CRF plant and dumped underground through the raisebore holes. Waste rock mined in development is also used as backfill.

There is no water underground and, therefore, pumping water from the mine to surface is not required. Occasionally, small amounts of water used with the shale fill remain unfrozen and leak into the haulage drifts. This water is either trucked or pumped to a designated area of the underground mine where it is allowed to freeze.

Underground mobile equipment is refueled in the workplaces by a mobile fuel tank truck each shift. The only permanent fuel tank underground is located in a small underground excavation adjacent to the explosive plant. This 15,000 litre tank is filled from the mobile tank truck as required. Lubricants, grease and glycol are used underground and stored in 205 litre drums in the underground repair shop and the crusher stations.

The primary explosive used for mining is a mixture of ammonium nitrate and fuel oil (ANFO), mixed underground daily as required. The mixing plant is located just below surface, close to the North Portal. The ammonium nitrate is stored in a specially excavated chamber, close to the explosive mixing plant (Figure 8). The ammonium nitrate is packaged in plastic lined 25kg bags and is delivered on shrink wrapped, metal strapped pallets.

The mined ore is crushed underground to -15cm and conveyed to underground storage bins close to the surface.

There has been some surface subsidence above the orebody that is routinely monitored by the use of survey monuments. An assessment of surface subsidence that is described in Section 5.1.2 confirmed that the observed subsidence is the result of early mining practices prior to the implementation of backfilling. The assessment also confirmed that the rate of subsidence is expected to decrease over the remaining mine life provided that backfilling continues, as planned.

### 4.2.3 Milling Process

The mill was originally designed with a throughput capacity of 2,050 tonnes per day. Since 1986, it has been operating at about 2,850 tonnes per day. The mill is a conventional flotation plant that produces two mineral concentrates.

The crushed ore is conveyed to the mill from two underground storage bins. At the mill the ore is crushed to –2cm in the secondary cone crusher and conveyed to the grinding mills, two ball mills operating in parallel.

The ball mill discharge is pumped to the coarse lead flotation cells from where the coarse lead concentrates are sent to the lead thickener. The remainder of the lead flotation circuit consists of rougher, scavenger and three stages of cleaning with the concentrates again flowing to the lead thickener. The zinc flotation circuit has four stages of cleaning. A tower mill is used to re-grind the zinc rougher concentrate to improve metallurgical performance. Zinc cleaner concentrates are pumped to the zinc thickener.

The concentrates are filtered on drum filters and dried in steel rotary dryers heated by the diesel generator exhaust gases. Wet scrubber dust collectors recover dust from the dryer exhausts. The concentrates are conveyed from the dryers to the storage building. The tailing is pumped to the tailing thickener.

The grades of flotation feed, lead and zinc concentrates and final tailing streams, along with other mill streams, are determined continuously by an " on-stream" XRF analyzer.

Chemicals used in the mill as process reagents include sodium cyanide, zinc sulphate, potassium amyl xanthate, MIBC (Methyl Isobutyl Carbinol) and copper sulphate. Reagent usage depends upon the metal content in the mill feed and the tonnage throughput. The reagents are used as follows:

- Sodium Cyanide (NaCN) is used to depress the iron (prevent iron sulphide from rising to the surface of the floatation cells along with the ore minerals), and is usually added at the feed end of each ball mill;
- Zinc Sulphate ($ZnSO_4$) is used to depress the zinc in the lead circuit (prevent zinc sulphide from rising to the surface of the floatation cells and entering the lead mineral concentrate stream);
- Potassium Amyl Xanthate is used in both circuits as a collector for the activated metal sulphide particles;
- MIBC is used as a frother in the flotation circuits;
- Copper Sulphate ($CuSO_4$) is used to activate the zinc in the zinc circuit;
- Percol 351 is used as a flocculant in the concentrate and tailing thickeners.

Chemicals are shipped to the site by ocean freighter and transferred to land for outdoor storage on pallets. All pallets are heavy duty, shrink-wrapped and steel strapped. The mill chemicals are stored outside in a designated, labeled storage area located between the concentrate storage building and the sea container storage. Copper sulphate, lime, zinc sulphate, Percol and calcium chloride are packaged in 25 kg bags. Sodium cyanide is packaged in 100kg steel drums and MIBC in 165kg drums.

All chemicals used in the mill/concentrator process are moved into the process barge for mixing in designated areas in the southeast portion of the process barge. The chemical mixing and dispensing areas for working solutions are surrounded by containment berms and connected to the central collection sump at the base of the barge. Any spills during mixing are promptly swept up or contained within the sump system of the barge building and reused in the reclaim water. Calcium chloride is also mixed in the barge building for use at the surface diamond drilling sites.

## 4.3 Mine Site Layout

The mine site is very compact, with most of the buildings and facilities located in a small area adjacent to the dock and shoreline (Figure 9).

The major structures and facilities are:

- the barge, which contains the mill (concentrator), warehouse, powerhouse, maintenance shops, changerooms and offices. The barge also contains fuel storage tanks in the side and bottom of the hull;
- the accommodations complex containing the camp facilities, employee rooms, kitchen and dining room, gymnasium, swimming pool, nurses station, food warehouse, emergency generator and recreation facilities;
- the concentrate storage building is divided to provide capacity for storage of about 40,000 tonnes lead concentrate and 175,000 tonnes zinc concentrate. This building also contains the concentrate load-out conveyors to feed the shiploader;
- the diesel fuel tank farm, consisting of two diesel tanks, each with a capacity of 5.5 million litres and a small tank with a capacity of 100,000 litres;
- the cemented rockfill (CRF) plant, the newest structure, constructed in 1995 to provide cemented rockfill to the mine. The CRF plant is located on surface above the mine workings;
- tailing thickener building, located adjacent to Garrow Lake;
- loading dock and shiploader, for loading concentrate ships and unloading ocean freight.
- airstrip, 1200 m in length;
- other structures and facilities include several small service buildings; the freshwater pumphouse at Frustration Lake, surface access roads; fresh water pipeline and tailing pipelines and the dam at Garrow Lake.

# 5. Decommissioning and Reclamation

In preparation for closure Cominco Ltd. has commissioned several studies to characterize geotechnical and environmental conditions at the mine site and receiving environment to provide direction for remedial measures to be undertaken during mine closure. To date, Cominco has retained consultants who have completed the following:

- Gartner Lee Limited has conducted a multi-phased environmental assessment of the mine site and receiving environment (ESA) in 1999 and 2000, which included the development of risk-based site specific soil quality remediation objectives (Volumes 3 and 4, Supporting Documents);
- Cantox Environmental Inc. developed risk based, site specific soil quality remediation objectives for lead and zinc;
- Cascade Management Inc., a Project Management Consultant, has been retained to plan, schedule, review cost estimates for closure and prepare tender documents for contract work for closure activities (work in-progress);
- Demolition experts have reviewed detailed building construction drawings and have provided estimates of demolition debris volumes;
- Noble Denton & Associates Inc., marine and engineering consultants & surveyors, have assessed the feasibility of refloating the process barge;
- Gartner Lee Limited has prepared a comparative review of decommissioning alternatives for the barge (Volume 2, Supporting Documents);
- Gartner Lee Limited has prepared a closure plan for the Operational, Construction and Little Red Dog Landfills (Volume 2, Supporting Documents);
- AXYS Environmental Consulting Ltd. has prepared a report on the current and projected long term chemical stability of Garrow Lake (Volume 2, Supporting Documents);
- EBA Engineering Consultants Ltd. has prepared decommissioning plans for the frozen core dam at Garrow Lake (Volume 2, Supporting Documents);
- Westmar Consultants Inc. has reviewed reclamation options for the dock and shoreline stability issues in the vicinity of the ship loading dock and temporary dock structure (Volume 2, Supporting Documents);

## 5.1 Mine Workings

### 5.1.1 Underground Workings

The underground workings in the Polaris mine include access tunnels of approximately 6.5 km in total length, extending from surface to a maximum depth of 310 metres (Figure 8). In addition to mine workings, the underground facilities include an explosives mixing plant, maintenance shops, an electrical shop, crushing stations and machinery. Surface facilities associated with the underground workings consist of a refrigeration plant for cooling mine air, up to 10 surface fans providing ventilation and the CRF plant.

Once mining has been completed, all underground equipment and machinery will be considered for reuse at another site, offered for sale or left in place in the mine. Access to the mine, and the necessary ventilation will be maintained until late in the implementation of the Plan in order to allow any transport and placement of materials underground that may be required.

Any equipment which is not removed from the mine for reuse or salvage will be cleaned of any potentially hazardous waste materials such as fuel, lubricants and batteries. These materials will be disposed of in an appropriate manner (Section 5.6 and 5.7).

Post-reclamation access to the underground workings will be eliminated by sealing all portals, raises, shafts or other entrances by means of secure plugs and caps. Where necessary, these installations will be backfilled and graded to conform to the contours of the surrounding area.

A large number of 1.8m diameter vertical raise bore holes have been drilled from surface into the orebody, 50 to 300 m below surface. These holes are excavated using a raise bore drill to drill a pilot hole down and pull a 1.8 diameter reamer head up to surface. The holes are an integral part of the mining method, providing a means of dumping fill into each working place, a route for ventilation air and an open slot for blasting. When backfilling of the mining areas is completed, the raisebore holes are filled to surface with backfill, creating a permanently frozen waterproof plug. A few raises will be kept open until final closure of the mine to provide ventilation. These raises would then be filled to surface following removal of the ventilation fans. All raisebore holes are recorded on the mine plans.

The underground fuel tank adjacent to the explosives plant and other lubricating oil/grease tanks in the underground shops and crushing stations will be drained, purged, cleaned and sealed in the mine.

### 5.1.2 Subsidence

Some surface subsidence over portions of the ore body has occurred and is routinely monitored by mine personnel. Figure 10 indicates the general extent of the subsidence on plan and section. Subsidence at Polaris Mine stemmed from early mining practices. Once an effective backfill program was implemented, subsidence was brought under control.

Gartner Lee Limited, on behalf of Cominco, solicited advice from BGC Engineering Inc. (BGC) regarding the implications of surface subsidence on mine closure. BGC advised that the subsidence rate can be expected to decrease from the rate observed in recent years provided that an effective backfill program is maintained for the remaining mine life (as planned) and provided that mining is maintained on the cold side of the $-3^{\circ}$ C isotherm (as planned). BGC also advised that the subsidence front can be thought to have reached its probable maximum extent at virtually all locations provided that the same two provisions are met (as planned).

### 5.1.3 Mine Portals

There are four mine portals at the mine site as shown in Figure 11:

- original 1972 exploration portal;
- mill conveyor portal;
- main mine access portal;
- north portal.

These portals are the only entrances to the mine for personnel and vehicles. Access to the mine will be maintained until late in the implementation of the Plan to allow transport and placement of materials underground and recovery of mine stationary equipment, where applicable.

Post-reclamation access to the underground workings will be eliminated by sealing the portals with secure concrete barricades and by backfilling and/or grading the portals to conform to the contours of the surrounding area (Figure 11). The surface contouring and barricades will prevent surface water from entering the mine.

The designs for sealing the mine portals will be submitted for approval from the NWT, WCB Mining Inspection Services, prior to construction.

### 5.1.4 Waste Rock Dumps and Surface Stockpiles

**Waste Rock**

Waste rock from the exploration and pre-development phases of the mine has been stockpiled around the 1972 exploration decline portal and around the North Portal. This material has been used for the construction of the mine yard and to build up the original shoreline. During the production phase almost all waste rock has been used as backfill in the mine.

Waste rock material from the underground mine is comprised of limestone from the host strata and surface shales. Geochemical testing of representative samples of limestone and shale waste rock was conducted in 1999 as part of the environmental site assessment performed by Gartner Lee Limited. The test results indicated these rock types are not acid generating and do not present a risk of metal leaching (Section 5.1.6).

**Surface Stockpiles**

During both the exploration phase and the pre-development phase, mined ore was stockpiled on the waste rock dumps adjacent to the 1972 portal. The majority of the ore stockpiled during the exploration phase was shipped off-site to provide bulk samples for metallurgical test work. The ore stockpiled during the development phase was intended to provide an ore source for the mill during the early production months.

Interviews with long-term Polaris personnel indicate that the ore stockpiles were removed for milling by 1984; however, the site investigation conducted in 1999 and 2000 found evidence of mineralized (sulphide) rock in the general area of the former stockpiles. The sulfide ore will either be processed through the mill or disposed in the underground mine.

A more recent area used for surface stockpiling is associated with the mining of lead ore. The surface waste dump at the North Portal has been used as a temporary storage for this material. These areas of lead ore contamination will be excavated and disposed underground.

### 5.1.5 Surface Quarries

There are two types of backfill quarries at the mine site, the Little Red Dog (LRD) Quarry from which limestone aggregate material is extracted and the two shale quarries.

**LRD Quarry**

The LRD Quarry is required to provide the limestone aggregate material for processing in the CRF Plant. Ultimately the quarry will consist of eight benches at mine closure (Figure 12). In total the quarry is expected to produce about 851,000 cubic meters (2.3 million tonnes) of limestone and overburden. This quarry does not contain any sulphide mineralization and is not a risk for acid-rock drainage (Section 5.1.6).

The ultimate dimensions of the quarry will be about 250 meters in length by 200 meters in width. Because the quarry is on the side of a hill, the quarry "daylights" on the fourth bench, giving a minimum capacity of about 100,000 cubic metres for disposal of demolition materials.

The LRD Quarry will be used as the disposal location for demolished surface buildings, concrete foundations, decommissioned pipelines, electrical cable and other materials from demolition. No hazardous materials will be placed in the quarry. Further details can be found in Section 5.5.4.

After the completion of disposal of demolition materials, an engineered cover will be constructed similar to that designed for the consolidated Operational Landfill area (Section 5.5.2). The cover will be contoured prevent ponding of surface water.

**Shale Quarries**

The old and new quarries have historically produced the backfill material used to fill the mined out areas underground. These quarries do not contain any sulphide mineralization and do not present a risk of acid rock drainage (Section 5.1.6). With the commissioning of the CRF plant to provide cemented rockfill, the level of activity in the New Quarry has declined over the last few years.

The Plan will require the walls and floor of the quarries to be graded to ensure long term stability of the slopes and to limit the ponding of surface water.

### 5.1.6 Metal Leaching /Acid Rock Drainage Issues

The potential for metal leaching and/or acid rock drainage (ML/ARD) was evaluated for several areas of the mine site including: the rock quarries, the surface waste dumps and the underground mine.

In order to confirm that metal leaching and acid rock drainage (ML/ARD) from the exposed rock at the surface quarries and surface waste dumps does not represent an issue of potential environmental concern, representative samples of the four major geologic units were collected for static acid rock drainage potential tests including: acid base accounting (ABA testing), total metals, and water leachable ions. The rock samples were collected from the Little Red Dog Quarry, North Pit, Old Quarry and New Quarry and represent the Lower and Upper Thumb Mountain, Irene Bay, and Cape Phillips Formations, respectively (Section 3.1).

The overall results of the testing indicate that the four rock samples are not acid generating, nor do heavy element concentrations indicate that significant leaching is likely. The tests results are presented in the Report on the 1999 Environmental Assessment Program that is provided in Volume 3 of the Supporting Documents. Specific results of the testing indicated the following:

- The limestone and dolomite samples contain very low sulphur concentrations (<0.1%) and high neutralization potential. The limestone sample had carbonate and neutralization potential close to the theoretical maximum values of 1000 kg $CaCO_3$/t. The neutralization potential for the dolomite sample was close to the theoretical maximum for dolomite of 1090 kg $CaCO_3$/t. Total and leachable metal concentrations were very low. Both the limestone and dolomite samples therefore contain very few impurities and are nearly pure calcite and dolomite;
- The Green and Brown (Bitumen-rich) shale samples both contained higher sulphur concentrations than the limestone and dolomite samples and the green shale contained some sulphate. These samples contained elevated neutralization potential and carbonate content was nearly equivalent to neutralization potential, which indicates that carbonate minerals are the main source of acid buffering capacity in the rock;
- The shale samples contained comparatively higher lead, zinc, cadmium and arsenic concentrations than the limestone and dolomite samples collected at the mine site. This was as expected since these heavy elements are globally more concentrated in shales. None of these elements were readily leachable. Sulphate levels in the leachates were greater than for the limestone and dolomite samples as was expected given the higher total sulphur concentrations in the shale samples.

The majority of the underground mine workings are located in the Thumb Mountain limestone formations discussed above and are not a potential source of ML/ARD. There is no water in the mine and the orebody is totally encased in permafrost. The permafrost zone extends below the level of the lowest mine workings. The Closure Plan requires sealing of all mine portals and raisebore holes thereby preventing surface water from entering the mine. As a result, ML/ARD is virtually certain not to take place in the underground workings.

The tailing, deposited in the bottom of Garrow Lake, is located in an anoxic environment where acid production is not possible and the tailing will remain in this environment in perpetuity. Moreover, the tailing contain less than 10% sulphides by weight and only half of these materials are iron sulphide, predominantly in the form of pyrite. The remainder of the tailing consists of limestone, an acid consuming carbonate. On this basis, the tailing does not pose a risk for the formation of ML/ARD.

## 5.2 Garrow Lake Tailing Impoundment

### 5.2.1 Tailing Disposal History and Methods

Mill tailing has been deposited in Garrow Lake since mill start up in late 1981 (Figure 13). Garrow Lake is a meromictic lake which is both thermally and chemically stratified with no vertical circulation. The lake, with an area of about $4km^2$, has a maximum depth of 46 metres and is stratified into three distinct layers (Figure 13). The surface (or upper mixed layer) contains brackish water with limited populations of aquatic organisms. The halocline is a transition zone where the dissolved oxygen content diminishes and salinity increases with depth and does not support aquatic life. The bottom layer is also devoid of aquatic life, has no dissolved oxygen, contains soluble hydrogen sulphide and has a salinity more than twice that of seawater.

The mill tailing is deposited into the bottom layer of Garrow Lake. The density difference between the bottom layer and the surface layer is the most important factor that prevents the upward movement of the tailing through the halocline. As well, the anoxic, sulphide-rich conditions which prevail in the bottom layer, precipitate the dissolved metals contained in the tailing to form a stable solid phase.

The tailing is carried by a 4 km insulated, heat traced, pipeline from the mill to a tailing thickener located adjacent to Garrow Lake (Figure 9). The 33 m diameter thickener tank, is completely enclosed by insulated steel cladding, and is constructed on an engineered permafrost fill base.

The thickener increases the solids content of the tailing to approximately sixty percent, recycling the overflow water back to the mill for re-use through a reclaim line twinned with the tailing line. The thickened tailing is carried by pipeline to the bottom of Garrow Lake and is deposited at least 26 metres below the surface in accordance with regulatory requirements established under the Water License.

Two thickener discharge pipelines are always available, one active line and one for stand-by. Tailing is discharged from the active line starting at a point furthest from shore until the elevation of the deposit reaches a level just below the 26m horizon. The line is then cut to move the discharge point to a new location (closer to shore), to allow the tailing to discharge to the bottom of the lake once again. This process is repeated until the line cannot be moved any closer to shore. A new line is then installed, parallel to the location of the old line. Cutting of the line and installing new lines is carried out by divers working through the ice, usually in late winter. The standby line is used when the active line is being cut or replaced.

In 1985 and 1989 breaks in the pipeline within the lake resulted in tailing being accidentally discharged into the upper layer of the lake. Accordingly, in 1992 a double walled pipe system was installed, virtually eliminating any possibility of tailing from a pipeline break entering the lake between surface and 26 metres depth. Despite the discharge of almost all tailing below the 26-metre depth, dissolved zinc concentrations in the surface layer had increased from <0.05 mg/L in 1981 to an average 0.41 mg/L in 1991. The increase in dissolved zinc concentrations in the surface layer was attributed to the tailing line breaks in 1985 and 1989. The concentration of dissolved zinc in the surface layer has decreased since 1991 and has stabilized at an average of 0.28 mg/L in 1999 and 2000.

The original Water License contained a contingency clause, requiring installation of a dam on the Garrow Lake outflow if the metal concentrations in the surface layer increased to the level of the License effluent discharge limits. Although the zinc concentration remained below the License limit, this clause was acted on in 1990/91 in response to the increase in the concentration of zinc in the surface layer following the pipeline breaks in 1985 and 1989. A containment dam was built across the outlet of the lake to the ocean in 1990/91 (Figure 14). The dam was designed to provide sufficient capacity to store five full years of precipitation, runoff and tailing discharge. Construction using a frozen core technique provided a structure built on and keyed into the permafrost, which would maintain its structural integrity for an indefinite period.

Between 1990 and 1992 considerable site specific research was carried out on the effects of lead and zinc on the marine organisms in Garrow Bay and also on the chemical and physical characteristics of Garrow Lake. The results of these scientific studies were used to determine effluent discharge limits for lead and zinc in the next Water License.

Since the existing Water License came into effect in 1994, discharge of Garrow Lake surface water has been resumed. The discharge method uses siphons to lift the water over the dam for discharge via Garrow Creek to the ocean. The mine has continued to meet the Water License Effluent Discharge Limits, without any incidents of exceedance of metal levels.

**Closure Approach**

Once tailing deposition is complete (after production ceases and the mill and other equipment is cleaned), all lines will be flushed to remove residual tailing solids. The flush water will be deposited into the bottom of Garrow Lake. The tailing lines within Garrow Lake will be disconnected and the anchors removed allowing the lines to float to surface. The lines along the land-based section will be cut into manageable sections and disposed into the LRD Quarry. The siphons and pipes at the Garrow Creek Dam will be removed and also disposed into the LRD Quarry.

### 5.2.2 Garrow Lake Stability and Chemistry

Since 1981, extensive sampling of Garrow Lake has been conducted under the Water License Surveillance Network Program (SNP). The results show that, with the exception of the tailing spills that occurred in 1985 and 1989, all of the tailing remains beneath the halocline. The overflow from Garrow Lake has been monitored during each discharge period and the metal concentrations have always been within the effluent limits established in the Water License.

The current Water License requires Polaris Operations to monitor the stratification of Garrow Lake and apply the results to a model that will predict the short and long-term stability of the Lake. AXYS Environmental Consulting Ltd. was retained in 1993 to conduct these studies and provide updates to the model as required. The model has been updated to include 1999 sampling results. The principal findings to date include the following:

- The basic vertical structure of the Lake has been maintained (i.e. low-salinity surface mixed layer, intermediate salinity halocline and hypersaline bottom layer);
- The halocline has thinned and been displaced upwards by introduction of tailing water and solids into the bottom layer;
- Mean annual dissolved zinc concentrations have decreased in the surface mixed layer since 1995;
- Zinc concentrations in the surface layer will remain nearly constant at about 0.3 mg/L for the remainder of mine operations (Water License effluent limit for zinc is 0.5mg/L);
- Mean concentrations of zinc in the surface layer are predicted to diminish once tailing deposition ceases with the closure of the mine.

Cominco is proposing to decommission the Garrow Lake dam by removing the centre portion of the dam after mine operations cease and the Lake water level has been restored to its original level (Section 5.2.3).

The present Lake level is approximately 2.5m above pre-dam level. In order to reach the pre-dam level, about 10 million cubic metres of water must be removed from the Lake.

Water is discharged from Garrow Lake each summer through three siphons. Over the last five years annual discharge volumes have averaged 2.7 million cubic metres with a maximum of 4.3 million cubic metres in 2000. Cominco installed two additional siphons in 2000 and additional siphons are scheduled for installation in 2001 in order to increase the annual discharge volumes such that the schedule for decommissioning of the dam can be achieved.

The increased discharge rate required to restore the elevation of Garrow Lake to its original elevation will increase the amount of metals discharged into Garrow Bay. This increase is temporary and will occur during the period of time that the lake is siphoned in 2000, 2001 and 2002.

DIAND proposed that the B.C. Environment Guidelines for Marine and Estuarine Aquatic Life be applied to the discharge. The four metals of concern were zinc, lead, copper and cadmium. As cadmium is not specifically set out in the BC guideline levels and as cadmium concentrations in the surface waters of Garrow Lake have remained below detection limits (<1 ug/L), it is not a concern. The Water License limit for discharge of zinc is 500 ug/L. The typical concentration of zinc in effluent, based on past sampling, is from 200 to 300 ug/L. The BC Average Guideline Value for zinc is 10 ug/L and the BC Maximum Guideline Value for zinc is 55 ug/L. To meet the guidelines, a dilution factor of between 6 to 50 times is required in Garrow Bay. Similar comparisons for lead and copper require less dilution to meet the BC guidelines. Based on the tides in Garrow Bay, the daily exchange of water in the bay is in excess of four times the total annual discharge volumes from Garrow Lake.

Cominco solicited advice regarding water quality in Garrow Bay from Dr. Peter Chapman of EVS Environment Consultants who is in agreement with the use of the B.C. Environment Guidelines. Based on the recommendations of Dr. Chapman, Cominco will:

- Ensure that discharge does not occur prior to melting of sea ice. This avoids the sensitive period when young aquatic organisms are released;
- Cease discharge in the fall when sea ice begins to form a solid cover. This avoids the period when most breeding occurs for aquatic fauna;
- Monitor the discharge concentrations of the metals in both the discharge water from Garrow Lake and the receiving environment (Garrow Bay).

Cominco complied with the recommendations listed above during the syphoning program in 2000. Due to the low detection levels required to comply with the BC guidelines, combined with the complexity of analyzing sea water, the lab results were unreliable. In 2001, extensive planning and consultation regarding sampling methods, equipment and analytical methods in the lab will be confirmed prior to commencement of the syphoning program.

Cominco commissioned AXYS Environmental Consulting Ltd. to assess the effect that Garrow Lake draw-down and partial removal of the dam might have on the zinc content of the siphon discharge and natural lake outflow. The AXYS model of zinc concentrations that was developed previously and that was modified on the basis of the last four years of actual observations was used to predict zinc concentrations. The feasibility of mixing the upper part of the halocline, the only source of water in Garrow Lake with zinc concentrations in excess of permit limits, was reviewed under different wave scenarios. The AXYS report (Volume 2, Supporting Documents) concluded that:

- The level of Garrow Lake can be safely lowered to pre-dam levels and the dam can be decommissioned without zinc concentrations exceeding Water License effluent discharge limits for the discharge and without affecting the stability of the halocline;
- Zinc concentrations in the surface layer will remain near the present levels of 0.3mg/L for the remainder of mine operations and will decrease gradually once disposal of tailing ceases when the mine is closed;

- There is a very low probability of wind caused mixing of even the top one metre of the halocline. However, even were the top two metres of the halocline to be mixed into the surface layer, zinc concentrations in the surface layer would still be below Water License effluent discharge limits;
- There is no possibility of wind induced “tilting” of the halocline sufficient to influence siphon or natural outflow zinc concentrations;
- The halocline is stable and will not be broken down by wind and wave action after the draw-down of the lake and decommissioning of the dam.

### 5.2.3 Frozen Core Dam

**Background**

Tailing from the mine operation has been deposited in Garrow Lake since mine startup in 1981. The Garrow Lake Dam was constructed during 1990 and 1991 to contain water within Garrow Lake such that water could be discharged from the lake in a controlled manner. EBA Engineering Consultants Ltd. (EBA) designed the dam and provided construction supervision.

The dam is located along Garrow Creek approximately 600 m downstream of the original outlet of Garrow Lake. The creek flows downstream from the dam toward the ocean approximately 600 m south of the dam.

The dam crest is approximately 250 m long with a maximum dam height of 8 m. A typical cross section through the dam is shown in Figure 14.

The dam core was constructed of crushed shale, placed in the winter to create a frozen core. It was mixed with water to create a very wet material such that it could be placed in saturated condition at an average moisture content of 41%.

The shell of the dam was constructed of blasted quarry shale. A saturated shell zone was placed adjacent to the core. This zone was constructed of a combination of blasted quarry shale and crushed shale. It was placed in a wet condition similar to the core material.

Rip rap was placed on the upstream face of the dam. The rip rap consists of blasted limestone placed in two layers. Over the years wave action will have deposited some sands and silts on the upstream face of the dam.

Temperatures within the dam core have been monitored monthly since April 1991. The average temperature at the centre of the dam core is approximately -12.7°C, while the top portion of the core warms to approximately -9°C by the end of the summer season.

### Closure Design

Cominco intends to draw down Garrow Lake to its original level and then to re-establish the original creek by decommissioning the dam. EBA examined two removal concepts to re-establish the creek bed. The first was total removal of the dam and the second was removal of enough material to ensure the long-term creek performance.

Total removal would require disturbance to the entire dam footprint area which would have to be reclaimed to minimize surface erosion and thaw subsidence. The total volume of the dam is approximately 49,000 $m^3$.

Partial removal would require removing the central portion of the dam to re-establish the original creek bed as shown in Figure 14. The cut slopes would be designed to provide a stable long-term condition. The dam core would be pulled further back from the final slopes to prevent warming and possibly sloughing of the ice rich dam core. The volume of material to be removed is 12,750 $m^3$. In addition, approximately 6,850 $m^3$ would have to be over-excavated and backfilled to pull back the core from the final slopes. The dam cut could be excavated using a thaw and strip operation in summer or a blasting operation in winter and the removed material would be disposed in the LRD Quarry. The styrofoam insulation in the dam crest would have to be removed in a manner that allows easy disposal in the LRD Quarry. The final creek-bed would be armoured with cobble sized material to provide a stable creek bed.

Partial removal is the preferred concept. This requires the least disturbance to the existing terrain. The EBA final design report can be found in Volume 2, Supporting Documents.

The slopes of the existing dam are relatively flat (4H:1V) and have performed exceptionally well over the past 10 years with no signs of surface erosion or slope movement. The gentle slopes of the removed section and existing dam will blend into the surrounding terrain.

In support of the partial removal concept, engineering analyses were carried out to ensure that the remaining embankment would be stable. Geothermal analyses were carried out to predict the long term thermal regime in the remaining embankment fill. Long term strength properties of the frozen core and foundation were estimated based on the results of the thermal analyses. Slope stability analyses of the embankment have been carried out. Details of these items can be found in the EBA report provided in Volume 2, Supporting Documents.

When the dam was constructed, a small berm was placed at the south end of Garrow Lake as a wave break for the reservoir between the original Garrow Lake and Garrow Lake Dam. The central portion of this berm may have to be removed to re-establish the creek bed. This work would be timed to avoid erosion or sediment mobilization during the summer discharge season.

# 5.3 Major Surface Structures

## 5.3.1 Process Barge

The process barge was constructed in Quebec in 1980. The barge is 31m wide, 122m long and 18m high above a 4.3m deep hull (Figure 15). The superstructure is a custom engineered frame building with ribbed, insulated sandwich panel exterior siding and roofing. The barge, outfitted with the process plant and power generators also includes the mine offices, warehouse and maintenance shops. In July 1981 the barge was towed to Polaris by ice breaking tugs. Prior to the arrival of the barge in August 1981, a berthing lagoon was excavated to a depth of about 4 m. The barge was floated into place onto a prepared gravel bed using a combination of tugs and cables attached to land based bollards. A berm was constructed across the entrance to the lagoon, the sea water was pumped out and the excavation backfilled. Details regarding barge construction and installation at the mine site are included in Volume 2, Supporting Documents.

Previous Closure Plans have considered only the option of removing the barge from the site by re-floating and towing to a southern location for disposal or re-fitting for another project. The feasibility of re-floating the barge had not been examined in any detail until recently, when it became clear that the concept of re-floating and towing south would present risks from environmental, operational and cost perspectives.

The Environmental Site Assessment that was conducted in 1999 and 2000 to assist in developing an updated decommissioning and reclamation plan concluded that the industrial activities conducted in the vicinity of the barge have resulted in significant impacts to the active layer surrounding the barge.

Two options for reclamation and disposal of the barge, including the risks associated with each option, have been reviewed:

- Option 1: Re-floating of the barge and towing to southern Canada for ultimate disposal;
- Option 2: Dismantling and/or demolition of the barge and disposal at the mine site.

**Option 1**

Option 1 is essentially a reverse of the barge towing and berthing of 1981. Preliminary assessments of seaworthiness have been positive, with no obvious defects that would prevent permitting for marine transport. Review of the procedures required to render the barge seaworthy and consideration of environmental and regulatory issues related to the cleaning of the barge and excavation of a lagoon to re-float the barge have identified several concerns associated with Option 1.

Re-establishing the correct weight and ballasting for the voyage is complicated by the extra concrete, equipment and service lines installed during operations. These items would have to be removed to provide sufficient freeboard for sailing and not all of the installations have been documented. Final adjustments could not be made until the barge was floating, which might result in delays. Significant delays could jeopardize the voyage.

The barge has been contaminated by processing activities including dust and internal spills. This contamination would have to be removed prior to the voyage. This would be accomplished by high pressure water washing. The wash water would be discharged through the tailing system to Garrow Lake. Other preparations required for the voyage have been identified by marine consultants that would need to be completed prior to sailing. These would include examination of the barge bottom, which could not be completed until the barge had been re-floated and in deep water.

The lagoon for floating the barge would be a similar size to that used in 1981. The removal of metal and oil contamination in the fill and ground water around and under the barge might necessitate some minor adjustments in size. The contaminated fill would be disposed in the underground mine. The best time to excavate the lagoon would be in the winter prior to the voyage. Provisions would have to be made to handle any spring runoff entering the excavation prior to flooding with seawater and this runoff would likely require disposal in Garrow Lake.

The removal of contaminated material beneath the barge would not be possible until the barge was moved. It would be very difficult to prevent mobilization of sediments and hydrocarbon and metal contamination by the seawater when it entered the lagoon. Discharge of these contaminants into the ocean would be in contravention of the Fisheries Act and the Arctic Waters Pollution Prevention Act.

If the barge voyage to southern Canada began at the optimum time, the third week in August, the ice conditions should allow easy sailing out through Lancaster Sound. The September weather in the Labrador Sea might be difficult with a higher frequency of storms, high winds and waves. However, if it were a “bad ice” year, the passage through to Lancaster Sound might also be difficult or impossible, resulting in delays at a minimum and cancellation or over wintering as the worst case.

**Option 2**

Option 2 requires dismantling/demolition of the barge superstructure and recovery of saleable equipment, followed by demolition of the barge hull. All demolition materials would be buried on site in the Little Red Dog Quarry. The volume of the quarry is sufficient to accommodate the barge, as well as materials from other demolition on site.

Option 2 fits into the same concept as the current Decommissioning and Reclamation Plan and, as a result, will require no special approvals other than those required for the Plan itself.

The contaminated fill can be dealt with in an environmentally sound manner, without concerns for release or mobilization of contaminants to the ocean. Following shut down of the mill site, provisions must be made for the management and treatment of potentially contaminated spring runoff; however, this is an issue common to both options being considered.

Option 2 is recommended as the preferable method to reclaim the barge. It provides one major advantage, every aspect of demolition and reclamation is under control. There is no dependency on unknowns such as floating the barge, potential for mobilizing contaminants, weather and ice.

**Barge Demolition Excavation**

As noted above, a 1999 assessment of rockfill quality in the area surrounding the barge identified contamination of the fill with petroleum hydrocarbons and lead and zinc (Section 5.8). The active layer within the area to be excavated to facilitate barge demolition is contaminated (upper 1-2 meters, depending on the contaminant and the location). Field investigations in 1999 and 2000 have also shown that, due to differential heating of the subsurface in the vicinity of the barge, a thicker active layer is present immediately adjacent to the barge that extends beneath the structure. The thickness of the rock fill beneath the barge is approximately 1.5m (Golder Associates, 1980).

The proposed remediation method for the contaminated rockfill surrounding and beneath the barge is excavation and disposal to the underground mine.

Free phase petroleum hydrocarbon product has not been found in the vicinity of the barge during the site investigation work conducted to date. Nonetheless, a contingency plan will be put into place for the management of free phase hydrocarbons. Depending on the seasonal timing of the contaminated rockfill excavation, groundwater and surface runoff may be present. These waters would have to be managed during the excavation and would likely require treatment prior to discharge.

### 5.3.2 Concentrate Storage Building

The Concentrate Storage Building is a metal-clad, steel frame structure. It is mounted on concrete footings and stub-walls and equipped with six interior conveyors. Decommissioning of this facility will commence with removal of all concentrate. This will be followed by dismantling of conveyors, electrical installations and any other services. The steel cladding will then be removed, and the structural elements dismantled. Concentrate accumulations on building materials will be removed prior to disposal of all of the materials from the demolition (6,000 cubic metres) into the LRD Quarry. Any soils with metal contamination will be disposed in the underground workings. The concrete footings and stub-walls will be broken to ground level and will be disposed into the LRD Quarry. The footprint formerly occupied by the building will then be backfilled and graded to a stable slope.

### 5.3.3 Cemented Rockfill (CRF) Plant

A new system of backfilling in the underground mine was implemented at Polaris in 1996. This system involved the use of cemented rockfill in place of the frozen fill that had traditionally been used. A plant was constructed on surface to produce a fill material consisting of a quarried limestone aggregate combined with a sufficient quantity of cement to produce a backfill material that will quickly consolidate when placed underground.

The plant primarily consists of a metal clad, steel frame building housing the screening plant and a steel framed, vinyl covered building which houses the processing equipment. The screening plant measures 15 meters wide, 12 meters long, and 10 meters high. The process building measures 16 meters wide, 45 meters long, and 13 meters high. Both buildings are placed on concrete foundations.

After the completion of backfill activities, the wall covers will be removed and the structural elements dismantled. The old fuel tanks will be drained, purged of vapours, cleaned and crushed to render them unusable prior to disposal to the LRD Quarry. Cement contaminated soils will be buried in the LRD Quarry. The process equipment will be removed for reuse or disposed in LRD Quarry. The concrete foundations and pedestals will be broken to ground level and covered with overburden. Ancillary water and electrical services will be disconnected and removed. All building materials and concrete from demolition (2,500 cubic metres) will be buried in the LRD Quarry.

### 5.3.4 Accommodation Complex

The Accommodation Complex is made up of eight modules each measuring 20 meters wide and 13 meters high. The overall length of the building is 280 meters. Four modules contain individual rooms. The remaining modules contain the boiler room and emergency power supply, the kitchen and cafeteria, pool and office facilities, and the gymnasium. The complex is supported one metre above grade on concrete pedestals extending into the permafrost. In addition, the boiler room and gymnasium modules have concrete floors.

The decommissioning of the accommodation complex will proceed as follows. The fuel tanks located in the emergency power module will be drained, purged of vapours and cleaned prior to dismantling and disposal (Section 5.3.6). Potentially hazardous materials such as engine coolants, refrigerants and swimming pool chemicals will be isolated and drummed for shipment off-site (Section 5.7).

The building will then be stripped of useful or saleable items prior to demolition. Following demolition of the structure, the foundations will be broken to ground level. All of the materials from the demolition (6,500 cubic metres) will be buried in the LRD Quarry. Finally, the area will be graded to a stable slope.

### 5.3.5 Tailing Thickener

The tailing thickener is located at the height of land to the west of the Garrow Lake tailing disposal area, approximately 4 km from the concentrator (Figure 9). The tailing thickener consists of a 40 metre diameter steel tank approximately five metres in height. It is fitted with motorised rakes which revolve within the tank at low speeds. The facility is enclosed within a metal-clad, steel frame structure, and includes pumps, piping and reagent tanks. The entire facility is mounted on a concrete foundation. A skid-mounted emergency power generator and an emergency tailing impoundment basin are located adjacent to the building.

Any tailing in the emergency impoundment basin will be reclaimed and transferred to the tailing thickener, for discharge into the Garrow Lake tailing impoundment area or will be sealed in the underground mine.

The tailing thickener and building will be cleaned, dismantled and removed. The base of the building and the tailing impoundment basin will be graded to a stable slope to prevent ponding of surface run-off. The associated tailing disposal pipelines will be flushed, dismantled and removed. The pipelines, tanks and building (2,500 cubic metres) will be buried in the LRD Quarry.

### 5.3.6 Fuel Storage and Handling Areas and Distribution Lines

The fuel tank farm is located to the south of the Concentrate Storage Building (Figure 9). It consists of two above-ground steel tanks, each with a capacity of 5.5 million litres and one small tank with a capacity of 100,000 litres. The two large tanks have been used to store P20 and P60 diesel fuel. The small tank was originally used to store gasoline, it now contains the remains of the Bent Horn crude oil used in a generator trial in the late 1980's. The tanks are located within a bermed area lined with an impermeable membrane.

The other main fuel storage tanks are in the barge bottom. These tanks have a capacity of 10.6 million litres. The fuel from the tank farm is transferred by pipeline to the barge tanks before being used in the diesel generators, the largest fuel user at the mine. The Cemented Rockfill Plant (CRF) also includes a newer 35,000 litre self-berming outdoor fuel tank used to supply the energy needs associated with the rock fill operation.

In addition there are a number of other small tanks at the site:

- Barge vehicle service tank; 22,730 litres;
- Accommodation building; 8,444 litres;
- Underground explosives plant: 15,000 litres;
- Thickener generator; 2,273 litres;
- Cat generator building; 34,095 litres;
- Fire hall; 8,444 litres;
- Foldaway vehicle storage; 2,273 litres;
- Barge day tank; 22,730 litres.

At closure, fuel remaining in the diesel tanks will be transferred to one of the main tanks in the tank farm, from where it will be removed from the site by oil tanker prior to the completion of site reclamation activities. Any sludge remaining in the tanks will be removed and burned. The tanks (750 cubic metres) will be purged of vapours prior to dismantling, cleaned and disposed into the LRD Quarry. The impermeable lining in the tank farm compound will be disposed in the underground workings. Soils containing petroleum hydrocarbon contamination will also be disposed underground (Section 5.8). The berms surrounding the tank farm area will be graded to prevent diversion or ponding of surface run-off. The fuel tank at the CRF plant is a double walled tank. It will be drained and sealed prior to being removed for re-use or disposal.

The pipelines associated with the fuel tanks will be drained, purged of vapours, cleaned by "pigging" and sectioned for disposal into the LRD Quarry. The pipeline right of ways and culverts under roadways will be graded and re-sloped to prevent ponding of melt water.

An additional installation to be decommissioned and removed is the Bent Horn fuel conditioning facility which is located adjacent to the barge. This facility consists of a small metal-clad, steel frame building. It was used to treat light crude oil received from the Bent Horn production facility on Cameron Island during the years 1987 - 1989. However it is presently used only as a day storage facility for a supplemental generator located nearby. This facility will be dismantled and the associated equipment will be removed for salvage, burial or disposal underground. The concrete foundation will be broken to ground level and the concrete buried in the LRD Quarry.

### 5.3.7 Bulk Chemical Storage Areas

The inventory of bulk chemicals currently stored on pallets to the west of the concentrate storage building will be reduced to the greatest extent possible prior to mine closure. Any chemical inventory remaining would be repackaged, if necessary, and shipped off-site for resale, disposal or return to the chemical supplier.

### 5.3.8 Concentrate Load-out Conveyors

Concentrate load-out support structures, conveyors and ancillary equipment will be removed and dismantled. Steel or equipment not required elsewhere will be cut into sections and disposed into the LRD Quarry. Contaminated soil around the load-out conveyors is discussed in Section 5.8. Any accumulation of concentrate on the equipment will be removed prior to disposal in the LRD Quarry.

### 5.3.9 Miscellaneous Outbuildings

Under the Plan, any buildings or equipment not specifically discussed above will be dismantled, removed from the site or disposed into the LRD Quarry. Examples include the firehall, equipment storage sheds and satellite receiving dishes (approximately 2,000 cubic metres). There are in excess of 100 ocean transport containers (Conexes) on shore that are in poor condition and not acceptable for shipping. These will be crushed and buried in the LRD Quarry. The Conexes currently used for storage of spare parts, that are in good condition, will be used to transport material back to southern Canada.

# 5.4 Support Infrastructure

## 5.4.1 Dock Site and Shoreline

The dock, located on the shore of Crozier Strait, consists of four main cells with a 92m docking face and a water depth of about 13m at the berth face. The four cells are constructed from steel sheet pilings backfilled with crushed rock. The rock fill was artificially frozen in place by circulating glycol through pipes embedded in the fill. The dock rises to about 5m above mean sea water level. The dock incorporates a conveyor system for the loading of concentrates onto vessels, including associated mechanical and electrical services.

The 1996 Closure Plan envisaged leaving the dock pilings and cells in place following closure of the mine. However, this Plan has been prepared on the assumption that all facilities and installations that comprise the Polaris Operations will ultimately be decommissioned, removed or reclaimed.

On behalf of Cominco, Westmar Consultants Inc. (Westmar) reviewed several options for decommissioning the dock:

- Option 1: Cutting off the sheet piles under water and re-instating a natural beach slope;
- Option 2: Encasing the dock in rock;
- Option 3: Leave the dock in place, as-is.

The Westmar report can be found in Volume 2, Supporting Documents.

Cominco has chosen Option 1 as the most acceptable. This option involves cutting off the sheet piles underwater below the low water level, excavating the material from the inside of the cells and removing the sheet piles with a crane. It provides the following advantages:

- Minimal impact on the seabed for both short and long term timeframes;
- Removes all above water improvements and provides adequate depths for small craft;
- Restores the beach to a more natural slope;
- Provides a smooth shoreline parallel to the original shoreline.

The dock will be required to remain in service during mine reclamation and will be one of the last structures to be decommissioned. Decommissioning will require removal of the shiploading tower, conveyorways, surface pipes and electrical utilities. Any soils containing concentrates will be removed prior to the shoreline reclamation work (Section 5.8).

In addition to the main dock, a temporary dock is situated to the south of the concentrate storage building. This dock consists simply of steel piles driven into the ground to prevent erosion of the shoreline. At a minimum, the steel pilings will be cut off at ground level.

### 5.4.2 Airstrip

The Polaris airstrip is a gravel strip measuring approximately 1200 metres in length and 30 metres in width. It is located immediately to the east of the Accommodation Complex.

The graded slopes associated with the airstrip were constructed to ensure long-term stability. No additional grading is expected to be required for reclamation purposes. The airstrip will therefore be left largely intact. The related equipment including the radio beacon, runway lights and signs will be removed and, prior to vacating the site, the airstrip will be formally closed. The airport regulatory authorities will be notified of these plans.

### 5.4.3 Tailing Lines

Two 250mm diameter plastic pipe lines, approximately 4 km in length, are installed from the process barge to the tailing thickener. Both lines are insulated and heat traced. One line is used to carry tailing from the concentrator to the thickener. The other line returns recycled water from the thickener to the process barge.

Both lines will be decommissioned and removed as part of the Closure Plan. The tailing line will be thoroughly flushed with clean water prior to dismantling to remove any residual tailing. The flush water will flow into the bottom of Garrow Lake. The recycled water line will not require flushing.

The lines will be dismantled and disposed in the LRD Quarry. The electric cables and controls along the tailing line will be removed for salvage or disposed in the LRD Quarry.

The tailing thickener has three discharge lines. One is approximately 100 m long and leads to the emergency tailing impoundment. The other two lines run along the surface to Garrow Lake. Prior to the point where they enter Garrow Lake, they are double walled, with a 150mm diameter line inside a 250mm diameter pipe. Both lines are heat traced and insulated through the full extent of the lines at the shoreline of Garrow Lake. The double walled lines extend underwater into the lake up to approximately 1,000 metres to the farthest discharge point. Once the lines reach 30 m depth, a combination of weights and floats hold the lines in place.

Following flushing of the tailing lines, the anchors will be disengaged and the lines allowed to float to surface. These sections will be removed and co-disposed along with the land based tailing lines, as previously discussed.

The pipeline right-of-way will be re-contoured as required, in order to restore natural drainage patterns and prevent ponding of surface run-off.

### 5.4.4 Freshwater Line and Pumphouse

In accordance with the Water License, fresh water for industrial and domestic use is supplied from Frustration Lake, located approximately 5 km north-east of the process barge. Water is pumped from the lake through a pumphouse located on a small rock jetty extending out from the shore. Water is distributed through five km of 200mm diameter insulated, heat traced fibreglass pipe. In addition a 200,000 litre heated storage tank is located immediately east of the north end of the airstrip.

The pumphouse at Frustration Lake will be dismantled and removed. The jetty extending into the lake will be left in place in order to prevent a disturbance of the aquatic environment. The water storage tank will be dismantled and removed, together with the associated electrical equipment. Its base will be graded to a stable slope. The associated water lines will be dismantled and disposed in the LRD Quarry.

The pipeline route will be re-contoured where required to prevent ponding of surface water and restore natural drainage routes.

### 5.4.5 Access Roads and Ramps

Approximately 40 km of roads exist at the site. The major roads being those from the plant site to Frustration Lake and to the tailing thickener and Garrow Lake. There are no stream crossings, except a small culvert crossing over the stream exiting Loon Lake.

The roads are generally constructed of pit-run material from the backfill quarries surfaced with crushed quarry material. Typical road widths are in the 6 m range.

All culverts will be removed to re-establish natural drainage patterns. Re-contouring will be carried out where graded slopes are expected to become unstable in the long-term.

### 5.4.6 Sewage System

Sewage from the accommodation building is collected by a vacuum system and flows by gravity through a pipeline to the 12,000 litre sewage holding tank located in a building at the northeast corner of the barge. The barge sewage and grey water is also collected in this holding tank. Grinder pumps macerate the sewage for discharge through a 180 m pipeline to the submerged ocean outfall close to the north dock cell.

The sewage pumps, storage tanks and pipelines will be removed and disposed into the LRD Quarry.

### 5.4.7 Heating (Glycol) Distribution Lines

Glycol is used in the heat exchanger system for the diesel generators and in the main heating system on the barge and the accommodation building. Ethylene glycol is used in the barge system and propylene glycol (a less toxic form) is used in the accommodation building.

The glycol will be drained, collected in drums and either incinerated on-site or shipped for disposal off-site (Section 5.7). The pipes and tanks associated with the heating systems will be flushed and disposed in the LRD Quarry.

### 5.4.8 Electrical and Communications Cables

All electrical and communications cables throughout the site will be removed. If any cables are worth recovering for sale they will be shipped south. It is likely that most cables will be cut into manageable lengths and disposed in the LRD Quarry.

## 5.5 Solid Waste Management Operations

There are currently three landfills at the mine site (Construction, Operational and Reclamation) and a fourth landfill (LRD Quarry) is proposed for closure. The Construction and Operational Landfills are located approximately one kilometre south of the accommodation building (Figure 16). The Construction Landfill is not active. The Reclamation Landfill is located approximately one kilometre northeast of the accommodation building in the area of surface subsidence (Figure 9). The LRD Quarry Landfill is proposed for closure and will not be active until that time.

Cominco commissioned Gartner Lee Limited (Gartner Lee) to prepare a closure plan to address the following issues for the Operational, Construction and LRD Quarry Landfills:

- Assess relocation options for the Construction Landfill;
- Geothermal assessment;
- Design of final cover and contours for the landfill.

A description of the landfill areas and the major findings of the landfill closure report are described in this section. The landfill closure report is provided in Volume 2, Supporting Documents.

### 5.5.1 Construction Landfill

The Construction Landfill is located on the shore of Cominco Bay and is approximately 200 m long and 40 m wide. This landfill was used for construction wastes during the mine construction and start-up period from 1979 to 1981. The landfill was closed in 1981/1982 and the surface area has since been used as an open storage area for old equipment. There are no records of the types of wastes disposed in the Construction Landfill. This landfill is close to the ocean and wave action could, under extreme storm conditions, cause erosion of the toe of the landfill.

Gartner Lee examined options for long term stabilization and closure for the Construction Landfill and concluded that the preferred option is the relocation of the materials to the Operational Landfill (Volume 2, Supporting Documents). The in-situ volume to be moved is estimated to be approximately 27,000 $m^3$.

A review of relocation options indicates that the preferred location is at the toe of the Operational Landfill. This location will allow closure of the landfills as one contiguous structure. Relocation of the landfill materials was initiated in 2000 as part of Cominco's progressive reclamation work and the relocation work is scheduled for completion prior to mine closure. The types of materials that are being exposed during the relocation work are being documented by Cominco.

### 5.5.2 Operational Landfill

The Operational Landfill was opened in 1981 just to the north of the Construction Landfill (Figure 16). This landfill is approximately 400 m long, 70 m wide and 10 m high. The wastes include empty dry chemical bags; empty drums; construction materials; used equipment and parts; wood scrap and municipal type solid waste. The municipal type solid waste, which consists largely of paper and kitchen food waste, is burned with waste oil to reduce problems with animal scavenging.

The burning takes place in a reinforced concrete "burn pit" that is located at the west end of the landfill and that is secured from scavenging by electric fencing. The burned residue is pushed over the end of the dump with the other wastes and covered with shale material from the New Quarry.

The Operational Landfill has been constructed in layers working from west to east, with each layer covered, graded and compacted prior to starting a new layer. In March 1999, Cominco installed five thermistors into the Operational Landfill to provide data on the thermal regime, in preparation for closure planning.

During the first year of monitoring, the thermistor results confirmed that the landfill remains frozen year round with an active layer of about one metre in the summer.

Gartner Lee studied a number of closure options, including cover design, geotechnical aspects, effect of global warming and final contouring of the landfill. The engineered cover design is described in detail in Volume 2, Supporting Documents. The cover will be constructed using locally available quarried shale rock and will be a minimum 1.8 metres thick to ensure that the landfilled materials remain frozen within the permafrost layer even for a conservative global warming projection.

The design of the landfill cover and surface contours incorporated the relocation of the Construction Landfill to the toe of the Operational Landfill. There is room within the existing containment berms for the Construction Landfill and also for additional landfill volumes until mine closure. The consolidated landfill area will be sloped to a 4H:1V slope to provide slope stability and minimize surface erosion. The design contours for the landfill are illustrated on Figure 17.

### 5.5.3 Reclamation Landfill

The Reclamation Landfill was initiated in 1997. This landfill is located in the subsidence area above the orebody (Figure 9). The main purpose of this landfill is to provide a location to bury obsolete heavy equipment and other material not destined for the Operational Landfill site.

Cominco maintains a written and photographic record of all items placed into the Reclamation Landfill. Decommissioned equipment to be placed into the landfill is cleaned of all oils, fuels, and fluids prior to disposal. The Reclamation Landfill has been used to clean up the old construction (Bechtel) laydown area. Items buried to date include dump truck boxes, sea-containers, tires, steel, wooden crates, conveyor pulleys, vehicles, rock bolts and others miscellaneous steel or wood items. Upon completion, this landfill will be covered and graded to the surrounding contours to promote surface runoff and to eliminate safety hazards.

The Reclamation Landfill does not require an engineered cover design to maintain frozen conditions as is required for the Operational Landfill. There are no contaminants within the landfill that can be released to the environment. Nonetheless, a minimum 1.5 metre thick cover of locally available soil/rock is planned.

### 5.5.4 LRD Quarry

Little Red Dog Quarry is proposed for the disposal of material from demolition of buildings and concrete foundations, as well as other items such as decommissioned pipelines and steel tanks. An estimated 100,000 cubic metres of demolition materials can be contained within the quarry. This would be to within 5m of the top of bench 4, where the quarry “daylights” to the slope of the hillside. Additional materials could also be contained within the quarry, if necessary. The actual volume of materials from demolition of buildings, fixed equipment and footings, and pipelines has been determined by a demolition consultant to be approximately 50,000 cubic metres. This does not include pipelines, Conexes, obsolete warehouse materials or other minor structures. The volume available in the LRD Quarry far exceeds the volume of materials to be contained.

The design of the quarry cover will be consistent with that developed for the Operational Landfill (Section 5.5.2 above). The cover will be graded to fit the surrounding contours, preventing ponding of water over the quarry. A schematic illustrating the LRD Quarry Landfill at closure is shown in Figure 12.

## 5.6 Disposition of Chemicals, Reagents, Fuel and Lubricants

The inventory of chemicals, reagents, fuel and lubricants at the Polaris mine site includes substances that are used for a variety of industrial purposes including:

- The mining operation maintains a supply of chemicals and reagents for mining, milling and associated processes such as laboratory analysis. The quantities of materials are sufficient to last from one summer sealift to the next. Milling process chemicals include: potassium amyl xanthate, methyl isobutyl carbinol, sodium cyanide, copper sulphate, and zinc sulphate. Other chemicals include: quicklime, calcium chloride, cement, explosives and flocculants;
- Explosives are used extensively in the mining operations. ANFO is manufactured at the site by mixing ammonium nitrate with diesel fuel. Purchased explosives are composed of nitroglycerin;
- Chemicals used for domestic purposes in the accommodations include: refrigerants, swimming pool chemicals, and cleaning fluids;
- Glycol is used in the heat exchanger system for the diesel generators and in the main heating system on the barge and in the accommodation building. Ethylene glycol is used in the barge systems and propylene glycol, a less toxic form of antifreeze/coolant, is used in the accommodations. Glycol is delivered in 205L drums and stored on pallets in well-marked locations on the pad below the diesel fuel tank farm;
- Freon is used in the refrigeration system to cool the underground mine during the summer months;
- Diesel fuel has been the main fuel used at the mine. Two types are used, P20 and P60. Both are arctic diesel, but P60 has a lower viscosity and is designed for lower temperatures. The P20 is used for power generation and P60 for mobile equipment on surface and underground;
- Gasoline usage has been minimal, restricted to that used for skidoos and all-terrain vehicles (ATVs). Since 1987, gasoline stored in 45-gallon drums has been transported by air from Resolute, as required;
- "Bent Horn" Crude Oil, remaining after a trial period to determine its use as a fuel source, is stored in the old gasoline tank within the bermed surface storage tank area;
- Jet B Fuel is stored in drums on pallets at the airstrip to refuel the medivac jet in case of emergency;
- Lubricating Oil, Grease and Solvents are stored in kegs or tubes on pallets in well-marked locations on the pad below and to the west of the oil tank farm.

The inventory of chemicals, reagents, fuels and lubricants will be carefully controlled during the final year of operation to ensure that a minimum volume remains to be managed after mine closure. Where possible, remaining inventory will be stored in original containers. Following mine closure, the remaining inventory of chemicals and reagents will be transported off-site and will be:

- Returned to the chemical supplier;
- Sold to another user of the product;
- Used at another Cominco facility;
- shipped to a licensed disposal facility.

The disposition of fuels and lubricants is further discussed in the next section.

## 5.7 Management of Hazardous Materials

The mining, milling and ancillary operations at the Polaris mine involves the use of materials classified as dangerous goods by the Federal *Transport of Dangerous Goods Act and Regulations (TDG)*. Hazardous wastes are defined as those contaminants regulated as dangerous goods under the TDG that are no longer used for their original purpose and are intended for recycling, treatment, disposal or storage. Cominco Ltd., as the waste generator, has responsibility for management of the hazardous waste until final disposal or treatment. Environment Canada has the overall responsibility for the management of hazardous waste, from Federal facilities and lands under the *Canadian Environmental Protection Act* (CEPA). Other Federal agencies with responsibility for specific hazardous wastes include:

- Natural Resources Canada has the authority to administer explosives under the *Explosives Act*. The *Mine Safety Act* deals with the permits for magazines and describes procedures for handling explosives;
- Atomic Energy Control Ltd. (AECL) administers the handling and disposal of radioactive materials in Canada.

The applicable legislation dealing with the management of hazardous wastes also includes the Federal *Northwest Territories Act, the Fisheries Act, the Transportation of Dangerous Goods Act and Regulations, the International Maritime Dangerous Goods Code, the National Fire Code, and Occupational Health and Safety Regulations.*

Under the authority of the *Environmental Protection Act*, the NWT department of Resources, Wildlife and Economic Development (RWED) has produced a series of documents for the management of specific hazardous wastes. These guidelines and the applicable legislation listed above will form the basis of the hazardous waste management procedures to be followed for the classification, handling, off-site transport and ultimate disposal of hazardous waste materials following closure of the Polaris Mine site.

### 5.7.1 Procedures for handling hazardous materials

Environmentally acceptable management procedures will be followed for the handling of each category of hazardous waste. Cominco Ltd. is a registered generator of hazardous waste (Government of Nunavut #100006) and will be responsible for the classification and labeling of hazardous wastes. For hazardous waste transportation off-site, Cominco Ltd. will complete waste manifests and ensure that the waste is transported by a registered hazardous waste carrier and received by a registered receiver. Cominco Ltd. will use trained workers for the management of hazardous waste including occupational health and safety and emergency spill response.

General requirements for storage containers for hazardous materials include the following:

- Original containers or containers manufactured for the purpose of storing hazardous waste should be used, where possible. The containers must be sound and sealable;
- The Transport Authority regulates container specifications. Standard containers include 16 gauge or equivalent metal or plastic 205 litre drums, as appropriate for the waste type;
- The containers must be sealed and clearly marked according to the requirements of WHMIS or the TDGR if transport is planned.

The following sections deal with the management of specific hazardous wastes and explosives.

**Petroleum Hydrocarbon Fuels**

The fuel inventory at the Polaris mine site will be carefully controlled during the late stages of mine operations and during mine reclamation to ensure a minimum volume remains for transport off-site near the completion of mine reclamation activities.

Decommissioning procedures for tanks removed from service, will follow the protocols outlined in the CCME document Environmental Code of Practice for Above Ground Storage Tank Systems Containing Petroleum Products (CCME-EPC-LST-71E, August 1994). For above ground storage tank systems that are to be permanently removed from service, the Code of Practice requires that petroleum products be removed and vapours purged from the storage tank, piping, dispensing and transfer equipment prior to physical removal of the tanks and associated piping. In addition, sufficient openings are to be cut in the storage tanks to render it unfit for future use. The storage tanks and pipelines are to be disposed in the LRD Quarry for burial.

**Waste Oil**

Waste oil is currently used as a fuel source for the burn pit located at the Operational Landfill. Burning of waste oil is expected to continue until decommissioning of the Operational Landfill following closure of the mine. Every effort will be made to reduce the inventory of waste oil prior to mine closure.

Waste oil remaining following the final closure of the burn pit and landfill will either be incinerated on-site or will be drummed, labeled with WHMIS data and TDGR classification, and shipped off-site.

**Waste Antifreeze**

Two types of antifreeze agent are used at the mine site. Ethylene glycol is used in buildings associated with mine and milling operations and propylene glycol is used in the accommodation building heating systems. Ethylene and propylene glycol are classified as hazardous on the basis of their toxicity. Antifreeze also contains corrosion and antifoaming inhibitors, while waste antifreeze may contain metals from pipes and engines. Proper handling and disposal of glycols is required to protect human health and the environment.

The inventory of propylene and ethylene glycol will be minimized to the greatest extent possible prior to mine closure. Waste antifreeze drained from the heating and cooling systems within the mine/milling operations and the buildings will be collected into sound steel or plastic 205 litre drums that are sealable. The containers will be clearly labeled with WHMIS data and TDGR classification and manifested as required for shipment off-site. Disposal options will be either through recycling or high temperature incineration.

**Waste Solvents**

Solvents such as acetone are used in small amounts at the on-site analytical laboratory. Larger quantities of solvents such as Varsol are used for industrial degreasing operations. Waste solvents are currently incinerated in the burn pit at the Operational Landfill. Every effort will be made to reduce the inventory of waste solvents prior to mine closure.

Waste solvents remaining following the final closure of the burn pit and landfill will either be incinerated on-site or will be drummed in their original containers, if possible, or sound steel drums with fitted lids. The drums of waste solvent will be labeled properly with WHMIS data and TDGR classification for shipment off-site and transfer for treatment or recycling.

**Waste Paint**

Paints and coatings classified as dangerous goods under the TDGR include alkyd paints and specialty coatings. Latex paints are not regulated under the TDGR. If the quantity of waste paints to be disposed is less than 5 litres, drying the paint and disposing to landfill is an option. Fully dried-out latex paints may be disposed into the landfill in any quantity.

If the quantity of alkyd paints and specialty coatings exceeds 5 litres, the materials will be bulked into 205 litre steel or plastic drums for shipment off-site. Disposal options include recycling or disposal at a registered facility.

**Freon (Chlorofluorocarbons)**

The refrigeration system used to cool the underground mine during the summer months contains freon. Freon is an ozone depleting substance and must be managed as a hazardous waste. Decommissioning of the refrigeration units will require removal of the freon prior to disposal to landfill. The freon will be transferred to canisters, labeled and transported off-site for recycling. Alternatively, the complete refrigeration units may be shipped off-site for removal and recycling of freon.

**Waste Batteries**

Waste batteries are currently bulked into metal or plastic 205 litre drums and labeled according to WHMIS and the TDGR for annual disposal off-site to an approved recycling facility or landfill. This practice will continue through the remaining mine operation and closure activities.

**Asbestos**

The original insulation used for the diesel generator exhaust pipes contained asbestos bearing materials. In 1993 the asbestos material was removed by specialists and the exhausts were re-insulated with ceramic fibre and fibreglass tape. The asbestos material was sealed in steel drums and buried in backfill in the mine. The removal and disposal project received approval from the Environmental Engineer in the Mine Safety Division of the Government of the Northwest Territories. The 1999 and 2000 ESA conducted by Gartner Lee Limited did not identify any other sources of friable asbestos on-site.

**PCBs**

The ESA conducted by Gartner Lee Limited in 1999/2000 verified that there are no PCB containing electrical transformers on-site.

There are 33 oil filled transformers on site, ranging from 4.5 to 21.5 gallon capacity. Twenty-six are in use on the tailing and fresh water line heat tracing and 7 are designated as spares and kept in a storage container. Under the Canadian Environmental Protection Act, PCB containing equipment has not been manufactured since July 1980. All of the transformer on-site were manufactured in 1980-1981. Efforts to identify the type oil from the nameplates and efforts to contact the manufacturers were unsuccessful and, therefore, confirmation testing of the transformer oil was conducted. Test results confirmed the absence of PCB's as reported in the 1999 and 2000 environmental site investigation reports that are provided in Volumes 3 and 4, respectively, of the Supporting Documents.

**Explosives**

The inventory of ammonium nitrate and explosives will be reduced to the greatest extent possible prior to mine closure. Purchased explosive residuals remaining after mine operations have ceased will be destroyed in accordance with applicable mine safety regulations.

## 5.8 Contaminated Soil Management

Environmental conditions at the Polaris mine site were investigated by Gartner Lee Limited during 1999 and 2000 in order to identify and assess the significance of potential environmental issues and to provide direction for future remedial planning. Reporting on the two phases of the environmental site assessment is provided in Volumes 3 and 4 of the Supporting Documents.

All environmental sampling was carried out in accordance with CCME protocols. The first phase of the assessment consisted of a review of available information relating to historic and current mine site operations and a detailed site inspection to identify the source areas and issues of potential environmental concern at the mine site. Fourteen areas of potential environmental concern for soil quality were identified at the mine site, as shown in Figure 18.

The second phase of assessment, conducted to determine the occurrence and approximate extent of contamination in the vicinity of the areas of potential environmental concern, found that soil quality in localized areas of the mine site contained elevated concentrations of metals, particularly lead and zinc from the mining operations, and petroleum hydrocarbons from the storage, transfer and dispensing of fuels.

Given the discrete nature of petroleum hydrocarbon sources at the mine site, the zones of contamination were readily identified and delineated. Sources of metal contamination at the lead and zinc mine are more varied and widespread, as described below.

Remediation of the metal and petroleum hydrocarbon contaminated soils will be conducted in conjunction with closure activities at the mine site. The overall objectives for the remediation of metal and petroleum contaminated soils following the permanent closure of the Polaris mine are:

- to comply with Federal and Territorial environmental regulations governing the management and remediation of contaminated sites;
- to mitigate, and/or prevent, release of contaminants into the environment;
- to return affected areas to an aesthetically acceptable condition, giving due consideration to practical factors including economics, climate, original land condition and future land use activities.

### 5.8.1 Human Health and Ecological Risk Assessment

Cominco recognizes that the Polaris mine site is a unique environment and that site-specific conditions are an important component of environmental issues.

The “barren and rugged” terrain around the mine area on Little Cornwallis Island precludes the regular use of the area by both wildlife and human receptors. In recognition of this, Cominco commissioned Cantox Environmental Inc. (1999/2000) to conduct a human health and ecological risk assessment that resulted in the development of site-specific soil quality remediation objectives.

The objectives of the risk assessment were to evaluate the residual metals identified at the site that may be of concern to human health and/or the environment and to use this information to derive site-specific soil quality remediation objectives (SQRO’s). A complete report, as prepared by Cantox, is provided in Volume 2, Supporting Documents.

The risk assessment work was done according to the permitted framework as governed by the Canadian Environmental Quality Guidelines (CCME, 1999). The CCME framework, outlined in the National Contaminated Sites soil protocol, provides the opportunity to move from generic soil guidelines to site-specific remediation objectives, which “allows the proponent to ensure that the assumptions used in the soil protocol apply to the site-specific conditions” (CCME, 1999).

The risk assessment used to develop the SQRO's utilized historical Inuit land use patterns on Little Cornwallis Island through a series of recent (2000) interviews in Resolute and Grise Fiord. The SQRO's were based on the most sensitive receptor spending time on-site, which in the case of lead and zinc were found to be Inuit children.

The surface soil concentrations that were determined to be safe for the most sensitive receptor (Inuit children) were 2,000 mg/kg for lead and 10,000 mg/kg for zinc.

### 5.8.2 Metal Contaminated Soils

Potential sources of metals to the environment at the Polaris mine site include: stockpiling or crushing of ore above-ground; storage, use and handling of metal-containing mill process chemicals; concentrate storage, handling, vehicle tracking or spills; tailing spills; windborne air dispersion of particulates; snow dumps; and mineralized rockfill.

The assessment of metal concentration in rockfill and soil at the mine site was determined on the basis of site-specific soil quality remediation objectives (SQRO's) developed using the risk assessment procedures described in the federal guidelines (CCME 1999). The SQRO's that have been recommended for remediation of soils within the barren-ground, active mine area are 10,000 ppm for zinc and 2,000 ppm, for lead as described in Secitobn 5.8.1.

**Waste Rock and Rockfill Areas**

As discussed in sections 4.2.1 and 5.1.4, waste rock from the original underground exploration decline (1973/4) and pre-production mine development in 1980/81was used for construction of the mine yard.

Rockfill material was also produced from the excavation of the lagoon used to provide access for the process barge. Once the barge was positioned and anchored, the excavated material was used to construct the dock and fill the area surrounding the barge. Additional sources of rockfill were provided by excavations for construction of ancillary services.

**Historic Surface Stockpiles**

Mineralized rock mined during the exploration and pre-production phase of mine development was stockpiled separately for metallurgical testwork and subsequent mill feed.

Although information provided by long-term Polaris mine personnel indicates that the ore stockpiles were removed for milling in 1984, the site investigations conducted in 1999 and 2000 found evidence of mineralized rock within these stockpiles. This material will either be processed through the mill or placed underground following mine closure.

**Process Barge / Shiploading Dock / Conveyor / Concentrate Storage Building**

Elevated concentrations of lead and zinc are present in surficial soils in the mine yard, milling and concentrate storage and handling areas. Sources of the metals in these areas include the storage, handling, spillage and tracking of concentrates as well as windborne air dispersion of particulates from the dryer emissions.

**Tailing Pipeline and Thickener Building Area**

Incidents of tailing spills along the pipeline corridor have been documented and in the vicinity of the thickener building. These areas were investigated and found to contain discrete areas of tailing residuals with associated elevated concentrations of metals.

**Surface Over Active Mining Area**

Sources of metals to the surface over the active mining area include: air emissions from ventilation raises; and, mineralized material from the drilling of the raise bores, the former outdoor crusher area and lead ore stockpiles.

This area will be targeted for remediation on the basis of the closure activities that will take place to regrade and re-contour the surface to restore this area of the mine site.

**Snowdumps**

The snow dumps represent areas of potential environmental concern due to the inclusion of metal containing particulates from the mining and milling areas of the site. Melting of the snow during the summer may result in elevated concentrations of metals in soils. Snowmelt has resulted in contamination of surficial soils beneath and surrounding the snow dumps.

Four main areas of the mine site are used to store snow from clearing activities. These are located west of the firehall (Firehall snow dump), near the foldaway buildings (Foldaway snowdump), south of Loon Lake (Loon Lake snow dump) and at the southern tip of the mine site peninsula (Main snowdump).

**Proposed Remedial Approach**

Areas of the mine site targeted for clean-up on the basis of elevated metal concentrations are shown on Figure 19. The volume of lead and zinc contaminated soil targeted for clean-up is estimated to be approximately 92,350 cubic metres.

The proposed remediation method for areas containing elevated concentrations of metals will involve excavation and disposal of the contaminated soil and rockfill to the underground mine as described in Section 5.8.4. The disposal area would be within the zone of continuous permafrost as shown in Figure 7. Excavated areas would be re-graded and, if necessary, filled with locally available materials.

### 5.8.3 Petroleum Hydrocarbon Contaminated Soils

Potential contamination from the storage, transfer, use and disposal of petroleum hydrocarbon source areas at the mine site include: the ventilation ports for the barge bottom and side fuel storage tanks; the vehicle fuelling tank; a day tank located on the west side of the barge; fuel pipelines and the oil tank farm; outdoor lube and hydraulic oil storage; above ground fuel storage tank installations at the foldaway buildings, the CRF plant, the tailing thickener building, the firehall, and the fire training area; a diesel tank located in the underground mine; and, a former oil bladder storage area located at the southeast end of the airstrip.

Subsurface investigations conducted at the Polaris mine site in July of 1999 and 2000 identified petroleum hydrocarbon contamination of soils/rockfill at concentrations that exceed the Yukon Territorial Contaminated Sites Regulations (CSR) standards for parkland land use (1,000 μg/g Light Extractable Petroleum Hydrocarbons or 1,000 μg/g Heavy Extractable Petroleum Hydrocarbons). CCME has introduced Canada Wide Standards (CWS) for petroleum hydrocarbons; however the standards have not yet been addressed by the Ministers of the Environment. These proposed standards are less stringent than the parkland standards stipulated by YTG for petroleum hydrocarbon. The Yukon CSR was adopted for application at Polaris. The petroleum products stored and dispensed at the Polaris mine site are diesel fuel, hydraulic and lube oils. A crude oil, known as Bent Horn crude, was used at the site for a period of two years (1987-89). A fuel conditioning system for heating the crude and removing the waxes by centrifuge was installed in a building to the west of the barge.

Extractable hydrocarbon analysis, a gross testing parameter that detects aliphatic and aromatic constituents in fuel, was used to quantify the petroleum hydrocarbon concentrations in soil samples. Light extractable petroleum hydrocarbons (LEPH), which quantify compounds in the C10-C19 carbon range, were used to determine the concentration of diesel fuel residuals in the soil samples. Lube/hydraulic oil and crude oil residuals were determined by analysis of heavy extractable petroleum hydrocarbons with a carbon range of C19-C32. Selected samples were also analyzed to determine concentrations of BTEX compounds (typical components of gasoline), volatile petroleum hydrocarbons (C6-10), and polycyclic aromatic hydrocarbons (PAHs; components of lube/hydraulic oils and crude oil).

Contaminant observations during test pit excavation and the results of chemical analysis indicate that petroleum hydrocarbon contamination is generally most concentrated in the saturated portion of the active layer. Analysis of soil samples collected from boreholes drilled in the vicinity of the process barge at depths below the maximum thickness of the active layer indicate that the presence of permafrost restricts the downward movement of contamination.

Concentrations of petroleum hydrocarbons in soil/rockfill that exceed the regulatory standards were identified in several areas of the mine site where petroleum hydrocarbons are stored and dispensed (Figure 20). These source areas are outlined below.

### *Process Barge Area*

Fuel storage and dispensing locations in the vicinity of the process barge include: fuel stored in the hull of the barge, a day tank adjacent to the west side of the barge, the vehicle fuelling tank at the northwest corner of the barge, the Bent Horn conditioning building, and a waste oil collection tank outside the maintenance bay on the north side of the barge. Seaworthiness testing of the barge as well as records of fuel inventories has shown that the tanks in the hull section of the barge do not leak fuel. However, observations recorded by mine site personnel indicate that small volumes of fuel have been spilled from the above ground vents during filling of the barge fuel storage tanks.

The highest concentrations of petroleum hydrocarbon residuals and, hence, the largest volume of contaminated soils is found at the bottom of the active layer just above the level of continuous permafrost, typically at 1 to 1.5 meters depth. The depth of the active layer in the vicinity of the barge is strongly influenced by the heat emitted from the barge and, therefore, the depth of the active layer in the vicinity of the barge will not be comparable to the depth of the active layer in other locations around the mine site.

The range of LEPH concentrations that exceeded the YTG CSR parkland land use standard (1,000 μg/g) in the soils collected from test pits and boreholes installed in the vicinity of the process barge is 2,350 to 17,000 μg/g. Only two samples contained HEPH concentrations that exceeded the standard for industrial land use. The elevated concentrations were approximately 20% higher than the YTG residential/parkland land use standard (2,000 μg/g).

The volume of petroleum contaminated soil requiring remediation within the process barge area is completely contained within the larger area of metal contaminated soils in the vicinity of the barge as described above.

### *The historic outdoor lube oil storage area*

Bladders of oil were stored during the construction phase of the mine site in an area southeast of the airstrip. Anecdotal information indicated that a spill incident had occurred in this area in 1980 or 1981. Petroleum hydrocarbon contamination was found to occur within the saturated interval of the active layer, generally from 0.4 to 0.6 metres below ground level to the depth of continuous permafrost at 0.8 to 1m. The levels of LEPH found in the soil samples averaged 5,600 μg/g compared with the YTG CSR residential/parkland land use standard of 1,000 μg/g. The depth of the active layer in this specific location is influenced by the physical characteristics of the soil and the orientation of the land and, therefore, the depth of the active layer may not be the same as at other specific areas on the mine site.

### *An above ground fuel storage tank installation at the foldaway buildings*

The subsurface investigation conducted in July 1999 identified an area of petroleum hydrocarbon contaminated soil adjacent to the aboveground diesel tank at the foldaway buildings. Hydrocarbon odors and staining as well as elevated concentrations of petroleum hydrocarbon concentrations were present from the ground surface to the top of the permafrost layer. The results of soils testing at a step-out location indicate that the diesel fuel contamination is highly localized.

***An above ground fuel storage tank installation at the tailing thickener building***

The environmental site assessment conducted in 1999 and 2000 did not identify hydrocarbon contamination at this location beyond superficial soil staining that will be excavated on a visual confirmation basis.

***Two former above ground fuel storage tank installations at the CRF plant***

Contaminant observations and the results of EPH analysis of soil samples collected at the CRF plant area showed that petroleum hydrocarbon contamination in excess of the Yukon CSR standards is present in the vicinity of two former above ground storage tank (AST) installations. The hydrocarbon contamination extends through the thickness of the active layer to the depth of continuous permafrost. The average concentration of LEPH found in the soil samples was 3,390 µg/g. Observations during test pit excavation suggest that the petroleum hydrocarbon contamination is localized.

***An above ground fuel storage tank installation at the firehall***

Diesel fuel contamination in soil at a location directly adjacent to the aboveground storage tank at the firehall was identified during the subsurface investigation conducted in July 1999. The highest levels of petroleum hydrocarbon odors and concentrations was found within the saturated zone overlying the continuous permafrost layer. The highest levels of LEPH found in the soil samples ranged from 7,100 to 11,200 µg/g.

***An aboveground fuel storage tank installation at the Accommodations Building***

Soil contamination was identified in the vicinity of the aboveground diesel fuel tank located at the rear (northeast corner) of the Accommodations Building.

**Proposed Remedial Approach**

Areas of the mine site targeted for clean-up on the basis of elevated hydrocarbon concentrations are shown on Figure 20. The volume of hydrocarbon contaminated soil targeted for clean-up is estimated to be approximately 36,700 cubic metres, which includes approximately 20,000 cubic metres in the vicinity of the barge which is included in the larger area of metal contamination.

The proposed remediation method for areas containing elevated concentrations of metals will involve excavation and disposal of the contaminated soil and rockfill to the underground mine as described in Section 5.8.4. The disposal area would be within the zone of continuous permafrost as shown in Figure 7. Excavated areas would be re-graded and, if necessary, filled with locally available materials.

## 5.8.4 Overview of Treatment Technologies for Petroleum-Contaminated Soil

Remedial technologies for the treatment of petroleum hydrocarbon contaminated soils can be applied both in-situ, where removal of soil from the ground is not required and ex-situ, where treatment occurs on excavated soils at either an on-site or off-site location. Soil remediation technologies fall into two general categories: technologies that destroy or treat the petroleum contaminants in the soil, and those designed to contain the movement of contaminants within the soil. Treatment technologies use the following processes to accomplish the cleanup goals:

- Biological treatment process use microorganisms and the enzymes they produce to degrade contaminants in the soil;
- Physical treatment processes change the physical form of the contaminants in order to remove them from the soil or encapsulate them to prevent leaching;
- Chemical treatment processes involve chemical reactions designed to alter or destroy contaminants in the soil;
- Thermal processes use energy to destroy or detoxify contaminants;
- The containment option involves land disposal in a manner designed to isolate the contaminants and prevent the migration of chemical constituents to the environment;
- Stabilization is often used in conjunction with containment to immobilize the contaminants by binding them within an insoluble matrix.

For the evaluation of petroleum-contaminated soil remediation at the Polaris mine site, only ex-situ remediation technologies were considered for the following reasons:

- the largest volume and areal extent of soil contamination with petroleum hydrocarbon residuals is located in the vicinity of the process barge. This structure is to be removed. Therefore, the contaminated rockfill around and beneath the barge will be accessible for excavation;
- The remaining areas of petroleum hydrocarbon contamination in subsurface soils are geographically distinct, and relatively small in terms of soil volumes and areal extent. These areas represent “hot spots” of contamination, given their limited extent;
- The zone of soil contamination is shallow (active layer only). The downward migration of petroleum hydrocarbons is restricted by the presence of permafrost.

**Evaluation of Options**

The applicability of the various technologies for remediation of petroleum-contaminated soils at the Polaris mine site was evaluated on the basis of the following factors:

- Applicability of the technology to site conditions
- Effectiveness
- Cost
- Treatment Time
- Regulatory / Community Acceptance

A brief description and evaluation of the various treatment technologies and disposal options for the management of petroleum hydrocarbon contaminated soils at the Polaris mine site is outlined in Table 5.1 and is discussed below.

### Biological Treatment

Bioremediation using land farming techniques is a well established soil treatment method for petroleum hydrocarbon contaminated soils. Either indigenous or introduced microbial populations via the enzymes they produce accomplish the degradation of aliphatic and aromatic compounds. Accordingly, the conditions under which remediation is conducted must be conducive for biological activity. The treatment conditions can be enhanced with the use of soil amendments, nutrients, moisture and water; however, the ambient temperature is critical for the activity of the microorganisms and is maximized between 10 and 45 degrees centigrade.

The extremely short summer season and cold climate in the high Arctic precludes this technology for use to treat petroleum hydrocarbon contaminated soils at Polaris mine. Other limitations include the high metal concentrations associated with the petroleum hydrocarbon contaminated soils. These concentrations would likely be toxic to the microbial population and would require specialized disposal procedures following treatment to contain the metals. These disposal procedures would consist of containing the soils in the underground mine workings within the continuous permafrost.

### Physical/Chemical Treatment Methods

Soil washing is the most common of the physical/chemical treatment methods for treating contaminated soils. Soil washing is designed on the principle that contaminant retention is directly related to particle size. This technology involves particle size separation using a combination of screening and hydrocyclone or gravity separation. The various size fractions are then washed with an appropriate flushing solution (water, surfactants, or solvents). The removal efficiency is highly dependent on the soil texture, and contaminants are most easily removed from coarse-grained soils. Fine grained fractions may require sequential treatments.

A major limitation of this technology is the production of a contaminated wastewater stream and sludge that requires treatment prior to discharge. Handling of additional waste streams would also likely require additional regulatory permits. The presence of heavy metals associated with the hydrocarbon-contaminated soil further exacerbates the washwater and sludge handling issues.

Soil washing requires extensive treatability testing to determine the optimal operational parameters. It is a complex remediation process that can only be carried out by highly skilled operators. The treatment hardware must be shipped to the remote site and would require in excess of one shipping season to complete.

**Table 5.1 Summary of Ex-Situ Petroleum-Contaminated Soils Treatment Technologies and Management Options**

**Table 5.1 Summary of Ex-Situ Petroleum-Contaminated Soils Treatment Technologies and Management Options**

| Technology | General Description | Advantages | Limitations | Regulatory / Community Acceptance |
|---|---|---|---|---|
| **Biological** | | | | |
| Landfarming | Placement of excavated soil in a lined treatment area. Volatilization and natural biodegradation of petroleum hydrocarbons is enhanced by tilling, aerating, and the addition of microorganisms, nutrients, air and other biological enhancements. A variation of this method is bio-mounding where the soil is placed in mounds rather than spread out over the lined treatment area, similar to a composting operation. | Relatively simple to design & construct; no residual products are generated by the process | Microbial activity is maximized between 10 & $45^0$ C. Extreme weather conditions as in the high Arctic would severely limit the practicality & effectiveness of this method. High concentrations of heavy metals are toxic to microbes. Cleanup requires years of time. Extensive monitoring and maintenance is required to ensure the effectiveness of cleanup | A well established soil treatment method that both regulators and community groups generally find acceptable. |
| Slurry Biodegradation | Petroleum- contaminated soils are excavated and treated in an aqueous or slurry solution within a bioreator vessel that provides the nutrients, microbes and other biological enhancements for biodegradation. | Effective in treating high concentrations of petroleum hydrocarbons Conditions are controlled | Complex treatment process for which treatability testing is necessary to determine process parameters. Heavy metals and chlorides may inhibit microbial activity requiring pre-treatment. Wastewater and sludges will require treatment before discharge/disposal. Cleanup may require several months. | unknown |
| **Physical / Chemical** | | | | |
| Soil Washing | Soil washing involves the use of chemical surfactants or solvent leaching agents combined with mechanical agitation to separate petroleum hydrocarbon components from the soil. The extraction fluid is then recycled and the contaminated wastewater requires treatment prior to discharge. | Produces a clean sand that can be used as backfill. Time required to remediate is typically less than 3 months. | Complex treatment system that requires extensive treatability testing and experienced operators. Treatment is less efficient in soils containing fine particulates and may require sequential washing steps to achieve cleanup. Trace amounts of solvent (if used) may remain in the cleaned soil. Process produces wastewater that requires treatment and produces a contaminated sludge. Air emission controls may also be required. Not cost-effective for relatively small volumes of contaminated soils. | The production of waste streams may require permitting to allow discharge. Community acceptance may be hindered by the production of a contaminated wastewater stream, given the proximity to the ocean. |
| **Thermal** | | | | |
| Thermal Desorption | A mobile rotary kiln system is used to heat the soil. Volatile and semi-volatile petroleum hydrocarbon components are volatilized and driven into an inert carrier gas stream. The contaminated gas stream required either treatment or incineration. | Mobile, transportable system that completely destroys petroleum contaminants. Well established operating parameters, does not require extensive treatability testing. System can process large quantities of soil, and will therefore require only short time for cleanup. | Diesel and heavy oils require a high temperature thermal desorber. Systems are very costly to construct and operate and are therefore typically used to treat chlorinated organic contaminated soils and seldom used for petroleum hydrocarbon. High metal concentrations will limit the disposal options for the treated soil, and will require greater emission controls during operation. Requires a large energy input to treat soils, especially for wet soils. | High temperature incinerators are typically opposed by community groups because they may be used to process other hazardous wastes such as organochlorines. |
| High Temperature Incineration | Contaminated soils would be transported to an off-site incineration facility at either Kirkland Lake in Alberta or Swan Hills in Alberta. Licensed treatment facility uses high temperature incineration to achieve thermal decomposition via thermal oxidation. | Complete destruction of the petroleum contaminants within the soil. | Transportation risk of contaminated soils. High metal concentrations will limit disposal options and possibly acceptability of waste to facility. Treatment costs are high. | High metal concentrations may limit acceptance by regulators of facility. |
| Vitrification | Electrodes or plasma torches are used to apply intense heat to the soil. The soil is melted and contaminants are volatilized, destroyed or encased in glass. Problems with control of the off-gases, high energy and capital costs, as well as permitting issues have prevented this technology from receiving widespread use. | Vitrification results in the complete destruction and permanent immobilization in glass of all contaminants. No residual wastes are produced, although the vitrified mass requires disposal. | Complex technology requiring high level of skill to operate safely. The high voltage and control of off-gases represent high health and safety risks for system operators. Wet soil take a longer time to remediate and therefore require higher energy costs. Field experience is limited. | Unknown |
| **Disposal** | | | | |
| On-Site Land Management | Excavated soils are disposed to a secure on-site location that ensures complete containment of the contaminated components of the soil materials. Hydrocarbon contaminated soils would be placed in the underground mine workings, within the zone of continuous permafrost. | The contaminated soils would be sealed underground in a permanently frozen state. Depth of placement underground eliminates risk to human health and the environment. Portal and other mine opening sealing procedures will further limit access to contaminated materials. | Acceptance by regulators | Unknown |
| Off-Site Land Disposal | Excavated soils are transported off-site for landfilling. A licenced facility, permitted to accept contaminated soils, is required for off-site disposal and/or land treatment. | Limit of liability associated with disposal to a licensed treatment and landfilling facility. | Transportation risk of contaminated soils. High metal concentrations may limit acceptability of waste to licensed facilities and as discussed for biotreatment methods, the high metal levels may be toxic to microbes necessary for degradation of petroleum contaminants. | High metal concentrations may limit acceptance by licensed facility and local regulators. |

Note: Estimated costs do not include engineering design, excavation, or transportation

Based on the foregoing discussion, this technology is considered too complex and would require too long a period for completion to be considered applicable for the treatment of petroleum hydrocarbon contaminated soils at a remote site.

**Thermal Treatment Methods**

Thermal desorption and vitrification are the two thermal methods that support mobile systems for the treatment of excavated soils on site. High temperature incineration would require the off-site transport of the contaminated soils to one of two licensed facilities in southern Canada in Alberta or Ontario.

A high temperature thermal desorption unit is required to destroy petroleum hydrocarbon compounds from soils contaminated with middle to high molecular weight oils such as diesel and hydraulic/lube oils. High temperature desorption is seldom used to treat petroleum hydrocarbon contaminated materials due to availability of cheaper, less sophisticated alternative technologies. These units are costly to construct and operate and hence are typically used to treat organochlorine contaminants such as PCBs.

The vitrification method, as described in Table 5.1, uses intense heat to melt the soil. Volatile contaminants are destroyed and recalcitrant compounds are immobilized in a glassy matrix. This method would provide a solution for the treatment of the high metal concentrations in the petroleum hydrocarbon contaminated soil. However, field experience with this method is limited due to the complexity of the technology and the very high level of skill required to operate the systems. In addition, the use of high voltage and problems with the control of off-gases represent high health and safety risks for system operators.

Limitations to both the potential on-site thermal destruction methods include the complex, costly technology that requires highly specialized equipment and skilled operators. In addition, both methods require a large amount of energy to heat the soil, especially if the soil is wet. In addition, the presence of high metal concentrations in the contaminated soil will limit the disposal options for the treated soil and would likely necessitate greater emission controls during operation. These factors would contribute to the cost of this treatment option.

In addition, off-site transport of contaminated soils to a licensed high temperature incineration facility would pose a risk to the environment during the loading and transport of the contaminated soil. The presence of high metal concentrations may also limit the acceptance of this material by the incinerator facility and the local regulators.

**Disposal Options**

Off-site transport of the petroleum hydrocarbon contaminated soils to a licensed landfill facility permitted to accept the material may also be considered an acceptable option by the regulators. As previously discussed, the off-site transport of contaminated soils should be evaluated on the basis of risk to the environment during transport. The presence of high metal concentrations will likely limit the options for disposal of the soil to an approved off-site location.

### 5.8.5 Preferred Remediation Option

This review of remedial technologies for the treatment of petroleum hydrocarbon contaminated soils at the Polaris mine site has shown that the high lead and zinc concentrations in the rock fill surrounding the process barge represent the major limitation to the use of several common treatment technologies. For example, metals cannot be destroyed by incineration technologies and would become concentrated in waste streams associated with separation technologies. In addition, the high metal concentrations may be toxic to microorganisms used in biological treatment systems apart from the obvious problem of local temperatures being too low for effective biological treatment.

Other major considerations for the applicability of remedial technologies include the severe climate, the remote access and time limitations for treatment of contaminated soils at the Polaris mine site.

These site specific limitations to the remedial technologies considered suggest that the preferred remediation option is to place the petroleum hydrocarbon and metal contaminated soil from the vicinity of the process barge and from other areas of the mine site in the underground mine within the zone of continuous permafrost.

It is proposed to place the petroleum hydrocarbon and metal contaminated soils in the underground mine. The contaminated soils will be placed within permafrost areas (Figure 7).

Gartner Lee Limited, on behalf of Cominco, solicited advice from BGC Engineering Inc. (BGC) regarding the implications on mine closure of the geothermal regime in the underground mine. BGC analysed a 2-dimensional geothermal model of the underground mine using appropriate air temperatures and rock properties. BGC advised that the existing thermal regime (as illustrated on Figure 7) is valid for closure planning and that the area of the mine proposed for placement of contaminated soils will remain frozen even under a conservative global warming scenario.

Based on the soil testing conducted to date, the maximum level of petroleum hydrocarbon contamination in the soils proposed for disposal in the mine workings is anticipated to be 1.7% light extractable petroleum hydrocarbon (LEPH). While free-phase petroleum hydrocarbons have not been encountered during testing, if such contamination is found during the excavation of contaminated soils, provision will be made to segregate the oil and either incinerate it on-site or place it into drums for shipment off-site. Free phase petroleum hydrocarbons would not be placed in the underground mine workings.

Placement of contaminated soil in the underground mine satisfies many of the criteria for the evaluation of the suitability of the remediation options, as reviewed below:

- Applicability of the technology to site conditions
  The underground mine option makes use of the presence of continuous permafrost to provide a secure location for the permanent storage of the petroleum hydrocarbon and metal contaminated soils. This solution takes advantage of the natural site conditions.

- Effectiveness of the technology
  The excavation of the soils contaminated with petroleum hydrocarbons and metals at concentrations that exceed the CCME Soil Quality Guidelines and the YTG CSR standards satisfies the objective of mitigating the identified contaminant source. Placing the contaminated soil in a secure location within the zone of continuous permafrost in the underground mine workings further satisfies the objective of preventing the release of contaminants to the environment. In the permafrost environment there are no water courses to allow migration of the metals or hydrocarbons.

- Cost of the technology
  The cost of the underground mine option is much lower than the estimated costs for all other treatment and disposal options considered.

- Time and other considerations
  The placement of soil in the underground mine could be scheduled to coincide with other reclamation and mining activities. Further, this option would allow the initiation of remediation activities prior to full scale closure of the mine as part of Cominco’s progressive reclamation work.

# 6. Northern Community Benefits

There are three potential forms of benefit to northern communities, including:

- disposal of assets;
- decommissioning contracts and employment;
- post-closure environmental monitoring and training.

At meetings with the communities of Grise Fiord and Resolute in October 2000, interest was expressed in purchasing or obtaining a number of assets such as small buildings, tools, office equipment, furniture, appliances, etc. which may be suitable for re-use in those communities. Cominco will be continuing to discuss these opportunities with community leaders and others.

While overall contracting strategy is still being developed, Cominco will require the services of one or more major contractors to carry out demolition, clean-up and reclamation of the mine site. It is anticipated that prime contractors will require a variety of subcontractors, suppliers and services. Northern contractors will be provided opportunities to bid on both the prime and sub contracts. While northern contractors with northern employees will be preferable, Cominco will require that all contracts entered into must be competitive as to price, quality and performance.

In order to ensure that northern communities receive maximum benefit from the closure and reclamation of the Polaris Mine, Cominco will discuss contracting opportunities with the Hamlet of Resolute and other communities in Nunavut to allow sufficient lead time for firms in these communities to prepare for this work. Cominco is committed to contributing to northern benefits throughout the closure, reclamation and follow-up monitoring associated with the Polaris Mine.

Cominco will be continuing to assess the environmental issues associated with the closure and reclamation of the Polaris Mine. As outlined earlier in this report, Cominco has completed an environmental site assessment to assist with the scoping of the environmental issues at the Polaris site. Cominco through its consultants, Gartner Lee Limited, ensured there was community involvement with the environmental site assessment by hiring local help for the field component of this study from the Hamlet of Resolute. Cominco will continue to ensure that opportunities are available for local contractors for all aspects of follow up environmental assessment and monitoring of the Polaris site.

# 7. Post Closure Site Management

After the mine operations cease, most Cominco personnel will leave the site within approximately 6 weeks. Cominco personnel will be used to properly shutdown equipment that will be salvaged or used during the decommissioning and reclamation work. They will also clean out process equipment and facilities. Concentrate stored onsite will be shipped out as soon as possible using Cominco personnel. Subsequent to these activities, contractors will do all work on the site related to decommissioning the facilities and conducting the reclamation activities under the supervision of a Cominco Project Manager. The nature of the decommissioning and reclamation work generally requires different skill sets from that of operating a mine. The most efficient manner to manage the decommissioning and reclamation work is with a work force having the appropriate construction trades and heavy equipment operating skills and experience. As there will be some underground activity and use of Cominco owned equipment during reclamation and closure, Cominco assumes that there will be some opportunities for previous Cominco personnel to work for the contractor at the site. The contractor will be responsible for selecting and hiring it's own work force.

Cominco will provide a project management team to oversee all activities and to maintain responsibility for the site. Cominco recognizes that it is responsible for the site until the land leases are returned to the Crown.

Work activity levels will vary depending on the time of year, but there will be a continuous presence on the island until all work on the site is completed in 2004. It is anticipated that contractors will continue to be housed onsite through until the completion of the project. Due to the high cost of maintaining a presence on the island, Cominco will expedite the project to minimize the time required to complete the decommissioning and reclamation work.

Once the decommissioning and reclamation work is completed, Cominco will not have a presence on the island other than during inspections as described in Section 7.1.

## 7.1 Post Closure Monitoring

Post closure monitoring of the site will be required to confirm that the remediation measures completed provide a site that is both physically and chemically stable. It is Cominco's intent to maintain the surface leases during this period.

Management of the site will progress through two distinct phases after the mine ceases production. The first phase is the two-year period during which the decommissioning and reclamation activities are undertaken. The second phase starts after decommissioning and reclamation work is complete and an on-going presence of personnel on the island ends. This phase is the post-reclamation monitoring phase, which is expected to last an additional five years.

### 7.1.1 Post Closure Monitoring – Phase I

After the mine ceases production, the decommissioning and reclamation of the site will begin immediately. The schedules forecast that this work will require two complete summer seasons to complete. This Phase is scheduled to last from mid 2002 until October 2004.

Monitoring at the site during Phase I will consist of:

a) Routine Monitoring

The Water License specifies the monitoring program that is required at the site until it expires on December 31, 2002. It is planned to have completed lowering Garrow Lake to its original lake level by late fall of 2002. Garrow Lake Dam will still be intact over the winter of 2002/2003 and through the summer of 2003. The lake will require siphoning in the fall of 2003 to remove precipitation and snow melt waters collected during the previous year to again return the lake to its original level prior to decommissioning the dam. It is proposed to continue the standard SNP monitoring program until the dam is decommissioned and for the following year (2004). Sampling during 2004 will monitor the first year that the lake has its natural outflow reinstated. The results from the SNP will be reviewed in conjunction with the model that has been developed for predicting stability of the lake stratification and discharge water quality (per the AXYS Environmental Consulting Ltd. report in Volume 2, Supporting Documents).

Monitoring the temperatures of the Operational Landfill will continue except when disrupted during placement of the engineered cover. Some or all of the monitoring sites may be damaged during this work. Once the cover has been completed, three monitoring holes will be maintained (or re-established) so that the thermal conditions of the engineered cap and the landfill can be monitored. Upon completion of placing the engineered cap on LRD Landfill, three similar monitoring holes will also be established to monitor the thermal regime of the LRD Landfill. At this time, monitoring will resume on a monthly basis until the end of Phase I monitoring.

b) Confirmatory Testing of Remediated Soils

As the removal and disposal of the metals and hydrocarbon contaminated soils progresses, confirmatory sampling will be done to document that the remedial objectives outlined in the Plan have been achieved.

c) Vegetation Sampling

As a follow up to the sampling program conducted in 1999 and 2000, re-sampling of vegetation will be conducted in the summer of 2004 and compared to the previous results.

### 7.1.2 Post Closure Monitoring – Phase II

Monitoring during Phase II will comprise of brief site inspections expected to last from 1 to 2 days each. Site inspections will be conducted in 2005, 2006, 2007, 2009 and 2011. The gradually decreasing frequency of testing is predicated on satisfactory inspection/monitoring results being obtained. If the results are not as predicted, additional, monitoring and/or remedial work will be undertaken.

The following inspections/monitoring of the site are proposed during this period:

a) Sampling of Garrow Lake.
AXYS Environmental Consulting Ltd. recommends that sampling of the Garrow Lake should focus on halocline stability. AXYS recommends that sampling continue until specific criteria are met. The criteria and rational are presented in their report 'Garrow Lake Dam – Effect of Removal on Lake Stability and Outflow Water Quality' (Volume 2, Supporting Documents). The sampling is recommended to be done in May or June for easy access to the lake (i.e. sample through the ice). The data collected will be reviewed using the Garrow Lake model. This will continue on an annual basis until their criteria are met and predictions confirmed. It is expected that their criteria will have been met by the end of Phase I. Cominco Ltd. proposes to sample the lake for a longer period of time to document the on-going stability of the lake. Cominco Ltd. proposes to sample the lake in 2005, 2006, 2008 and 2011. In addition, if water is discharging from the lake during the late July/early August inspections (discussed below), then samples of the lake water will also be taken in 2005, 2006, 2007, 2009 and 2011.

b) Temperature readings from the thermistor strings installed in LRD Quarry Landfill and the Operational Landfill will be collected. This will be done during each inspection of the site.

c) At each inspection, any surface water flowing from the site will be sampled for metals content. The creek from Loon Lake will be sampled near the location where it discharges into the Ocean.

d) At each inspection, visual observations of the site during July/August will be conducted to confirm stability of the physical features of the site, primarily related to erosion. A photographic record will be maintained. Specific areas to be observed include:
   - The slopes surrounding Garrow Lake and Garrow Creek;
   - The surface of LRD Quarry Landfill and the Operational Landfill;
   - Site roadways;
   - The decommissioned shoreline along the previous mill site including the decommissioned dock area;
   - The New Quarry area;
   - The surface areas over the underground mine workings.

e) At each inspection, visual observation of the mine subsidence area will confirm that there is no significant ground movement that would present a public safety hazard.

f) At each inspection, visual inspection of the mine entrances will confirm the integrity of the mine seals.

g) Vegetation sampling similar to the Phase I program will be conducted in 2011.

The results of sampling, monitoring and visual observations from each inspection will be reviewed and an annual report submitted to the DIAND related to land leases held and to the Nunavut Water Board related to any current water license.

During Phase II monitoring, if there are indications that conditions at the site are not behaving as expected, an assessment of the issues will be made in conjunction with the appropriate regulatory agencies. The assessment may require additional monitoring and/or studies than those proposed above. If it is determined that the environment or public safety is being significantly threatened then Cominco Ltd. would be prepared to take further action at the site.

In 2011, a review of all of the data and observations collected since mine closure will be conducted to confirm the chemical and physical stability of the site. An assessment of the on going, long term conditions at the site will be made based on this review. If the data demonstrates that the site is, and expected to remain stable for the long term, Cominco Ltd. will return the surface leases to the Crown and cease further involvement with the site.

## 7.2 Mine Records

Cominco recognizes the importance of maintaining records that are current as of the closure date. Records to be retained will include, but are not restricted to:

- mine plans and sections;
- surface plans including site layout and contour information;
- production records;
- geological information and plans;
- key engineering studies;
- environmental sampling records (pre and post closure);
- personnel records;
- survey information;
- design drawings of facilities;
- water licenses and land lease documents;
- landfill closure designs and documentation of landfill designs;
- environmental and archeological studies;
- closure plan documents;
- records of closure activities and associated detailed designs;
- photographic records of the site pre/post closure.

As indicated above, decommissioning and closure activities will be documented in detail and the records retained for future reference.

# 8. Glossary

## 8.1 Abbreviations

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|---|---|
| ABA | Acid Base Accounting |
| AECL | Atomic Energy Control Ltd. |
| ANFO | Ammonium Nitrate and Fuel Oil (a mixture used as blasting agent in many mines) |
| AST | Aboveground Storage Tank |
| BTEX | Benzene, Toluene, Ethylbenzene, and Xylenes |
| CCME | Canadian Council of Ministers of the Environment |
| CEPA | Canadian Environmental Protection Act |
| CRF | Cemented Rockfill |
| CSR | Contaminated Sites Regulation |
| CWS | Canadian Wide Standards |
| DIAND | Department of Indian Affairs and Northern Development |
| EPH | Extractable Petroleum Hydrocarbons |
| HEPH | Heavy Extractable Petroleum Hydrocarbons |
| LEPH | Light Extractable Petroleum Hydrocarbons |
| LCI | Little Cornwallis Island |
| LRD | Little Red Dog |
| MIBC | Methyl Isobutyl Carbinol |
| ML/ARD | Metal Leaching and/or Acid Rock Drainage |
| mg/kg | milligram per kilogram equivalent to parts per million |
| NWB | Nunavut Water Board |
| NWT | Northwest Territories |
| PAHs | Polycyclic Aromatic Hydrocarbons |
| PCBs | Polychlorinated Biphenyls |
| ppm | parts per million |
| RWED | Resources, Wildlife and Economic Development |
| SNP | Surveillance Network Program |
| TDGR | Transportation of Dangerous Goods Regulations |
| WCB | Workers Compensation Board |
| WHMIS | Workplace Hazardous Materials Information System |
| YTG | Yukon Territory Government |
| µg/g | micrograms per gram equivalent to parts per million |

## 8.2 Definitions

This glossary defines most of the technical terms used in this report, and are defined within the context of the Polaris Mine. It is recognized that some of the terms in the context of other mine sites may have broader definitions.

**A**

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| Acid Rock Drainage | Drainage that contains significant amounts of sulphate and heavy metals, such as iron, that in solution produce acidic conditions affecting vegetation and habitat. |
| Active Layer | The active layer, as used conventionally, is the top layer of ground above the permafrost table that thaws in summer and refreezes in winter. |
| Anoxic | Literally "without oxygen". An adjective describing a habitat devoid of oxygen. |
| Asbestos | Any of several minerals (as chrysotile) that readily separate into long flexible fibers, that have been implicated as causes of certain cancers, and that have been used especially formerly as fireproof insulating materials. |

**B**

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| Backfill | Waste material used to fill the void created by mining. The process of filling a cavity with soil, gravel, rock, or other material. |
| Ball Mill | A horizontal steel cylinder filled with steel balls into which crushed ore is fed. The ball mill is rotated, causing the balls to cascade and grind the ore into small particles in preparation for concentration. |
| Benches | The different levels in an open cut mine |
| Berthing Lagoon | A body of water separated from the sea by a barrier for securing a vessel. |
| Bituminous | Like or containing bitumen. Bitumen is a dark, naturally occurring solid or semisolid substance composed mainly of a mixture of hydrocarbons with little oxygen, nitrogen, or sulfur. |
| Bollard | A large solid post on a wharf or pier for securing mooring lines; the same when constructed on the deck of a ship. |
| Brackish | In a technical sense water that contains more than 0.5 and less than 30 grams per liter of total dissolved salts. In an ecological sense habitats characterized by a mixture of fresh- and saltwater (e.g. estuaries), a decrease in salinity in inland seas, or an increase in salinity in lakes. |

**C**

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| Calcite | A common, white mineral composed of calcium carbonate, and the |

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| | principal constituent of limestone. |
| Cofferdam | A large, temporary watertight enclosure from which the water is pumped to expose the bottom of a body of water. Used to permit construction (or placement of barge, in the case of Polaris) in ground which is usually submerged. |
| Concentrate | A fine, powdery product of the milling process containing a high percentage of valuable metal. |
| Concentrator | A milling plant that produces a concentrate of the valuable minerals or metals. Further treatment is required to recover the pure metal. |
| Cone Crusher | A machine which crushes ore between a gyrating cone or crushing head and an inverted truncated head known as a bowl. |
| Conexes | Transport containers. |
| Continuous Permafrost | Permafrost occurring everywhere beneath the exposed land surface throughout a geographic region. |
| Crusher | A machine for crushing rock or other materials. Among the various types of crushers are gyratory crusher, jaw crusher, and cone crusher. |
| Cryopeg | A cryopeg is unfrozen ground that is perpetually below $0^{o}C$. Freezing is prevented by freezing-point depression due to dissolved-solids content of the pore water. In this case (Polaris underground mine), a marine cryopeg, freezing point depression is a consequence of pore-fluid salinity. |
| Cryosol | Soil order (type) of the Canadian System of Soil Classification. This soil is common to high latitude tundra environments. The main identifying feature of this soil is a layer of permafrost within one meter of the soil surface. |

**D**

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| Decline | A sloping underground opening, usually driven at a grade of about 15% to 20%, for machine access from level to level or from surface to get to the ore and take the ore out; also called a ramp. |
| Deposit | Mineral deposit or ore deposit is used to designate a natural occurrence of a useful mineral, or an ore, in sufficient extent and degree of concentration to invite exploitation. |
| Disseminations | As in *disseminated ore*: ore carrying small particles of valuable minerals, spread through the gangue matter (i.e., rock surrounding a mineral or precious gem in its natural state). |
| Dolomite | The name of both a mineral and a rock type. As a mineral, dolomite is calcium magnesium carbonate(CaMg(CO3), has a hardness of 3.5 to 4, a |

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| | specific gravity of 2.9 and is commonly white colored. As a rock type, dolomite is a common constituent of sedimentary rocks. Dolomite is typically formed by the digenetic replacement of limestone by magnesium enriched brines. Dolomite's industrial uses include; agricultural lime, filler powder for use in paints and toothpaste, building stone, decorative aggregate, and as a source of magnesium metal. |
| Dolomitized Rocks | Rocks that have been through the process of dolomitization. Dolomitization is the process whereby limestone is wholly or partly converted to dolomite rock or dolomitic limestone by the replacement of the original calcium carbonate (calcite) by magnesium carbonate (mineral dolomite), usually through the action of magnesium-bearing water (seawater or percolating meteoric water). |
| Drift | A horizontal underground opening or passageway in a mine |
| Drum Filters | Mechanical device that uses a vacuum to remove water from the solids (i.e., concentrate) |
| **E** | |
| Effluent Discharge | Excess water from a mining and milling operation that is discharged to the receiving environment. |
| **F** | |
| Flocculent | A chemical substance or compound that promotes the combination, agglomeration, aggregation or coagulation of suspended particles in the water. |
| Flotation (Cells) | A common process in the concentration of minerals. When the various mineral particles have been ground sufficiently to allow separation from one to another and the gangue (i.e., rock surrounding a mineral or precious gem in its natural state) material, they are pumped in suspension to flotation cells. With the addition of certain chemicals and the passage of air through the suspension, the different mineral particles can be made to attach themselves selectively to the air bubbles to form a froth which is then skimmed from the remaining bulk of the suspension. |
| Free Phase | As referring to *free phase* petroleum hydrocarbon product: A petroleum hydrocarbon in the liquid ("free" or non-aqueous) phase. |
| Freeboard | The additional height of a structure above design high water level to prevent overflow. Also, at a given time, the vertical distance between the water level and the top of the structure (e.g., deck or gunwale of a boat). |
| Friable Bedrock | Bedrock which breaks apart or crumbles easily. |

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| Frost Mounding, Frost Stripping, Frost Wedge Polygons | Frost formations resulting from the disturbance to surficial soils caused by the repetitive freeze-thaw process. |
| Frozen Core Dam | A technology that uses frozen earthfill materials as the core of a water-retaining dam. In some cases, additional water is added to the earthfill core material before freezing  in order to increase the ice saturation content within the core. Ice saturation and low temperatures significantly reduces the permeability of these materials. This frozen, low permeability core is connected to permafrost underlying the dam, which aids in reduction of seepage underneath the dam. The dam is thermally designed such that the heat source from the retained water on the upstream side does not thaw the core for the required design life (e.g. 50 years). This technology is only appropriate for cold regions and areas of continuous permafrost. |

**G**

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| Galena | A bluish-gray to lead-gray mineral; a lead sulphide mineral, the most common ore mineral of lead. |
| Grinding | Means of reducing ore into very small particles by means of pressure or impact. Different types of grinders are used in the processing plant to obtain the desired dimension. At Polaris, grinding is carried out in a ball mill. |

**H**

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| Halocline | In the context of the Polaris mine, halocline is defined as the boundary between the bottom layer (monimolimnion) and surface layer (mixolimnion) in a meromictic lake (i.e., Garrow Lake) |
| Hanging Wall | The rock on the upper side of a vein or ore deposit |
| Host | A rock or mineral that is older than the other rocks or minerals introduced into it or formed within or adjacent to it. |
| Host Rock | A body of rock serving as a host for other rocks or mineral deposits In this case, the rock surrounding an ore deposit. |
| Hydrocarbon | Any of numerous organic compounds, such as benzene and methane, that contain only carbon and hydrogen. |
| Hydrocyclone | A liquid-solids separation device utilizing centrifugal force for settling. |
| Hypersaline | Referring to water with a salinity higher than that of natural seawater. Also, a term used to characterize waters with salinity greater than 40 ppt |

(parts per thousand), due to land-derived salts.

**I**

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| Isostatic Rebound | Uplift of the Earth's crust following the last glaciation, due to the disappearance of the large continental ice sheets. More specifically the adjustment of the lithosphere of the earth to maintain equilibrium among units of varying mass and density. Excess mass above is balanced by a deficit of density below, and vice versa. Weight added onto the earth's surface depresses the lithosphere slowly, and weight removed permits the lithosphere to rise slowly, but usually not to the same elevation it had before it was de-pressed. |

**J**

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| Jetty | The rock structure projecting out from the shore extending into Frustration Lake to locate the freshwater pump in deeper water. |

**L**

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| Limestone | A sedimentary rock consisting chiefly (more than 50% weight or by areal percentages under the microscope) of calcium carbonate, primarily in the form of the mineral calcite, and with or without magnesium carbonate; specif. a carbonate sedimentary rock containing more than 95% calcite and less than 5% dolomite. |
| Longhole Mining | A method of mining involving the drilling of up or down holes up to 30 m long into an ore body and then blasting a slice of rock which falls into an open space. The broken rock is extracted and the resulting open chamber is filled with supporting material. |

**M**

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| Marcasite | A common very light brownish-yellow or grayish, orthorhombic mineral. |
| Meromictic Lake | A lake in which some water remains partly or wholly unmixed with the main water mass at circulation periods. The process leading to a meromictic state is called Meromixts. The perennially stagnant deep layer of a meromictic lake is the Monimolimnion (‘bottom layer’). The part of the meromictic lake in which free circulation can occur is the Mixolimnion (‘surface layer’). The boundary between the monimolimnion and the mixolimnion is the chemocline (= halocline, in the context of the Polaris Mine). |
| Metallurgy | Process of extracting metals from their ores. |
| Micritic | Term used to refer to a rock containing calcite grains less than 4 microns in width; crystals appear closely-packed. |

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| Mill | 1) A plant in which ore is treated for the recovery of valuable metals, or the concentration of valuable minerals into a smaller volume for shipment to a smelter or refinery. 2) A piece of milling equipment consisting of a revolving drum, for the fine-grinding of ores as a preparation for treatment. |
| Mudstone | A fine-grained, dark gray sedimentary rock, formed from silt and clay and similar to shale but without laminations. |
| **N** | |
| Neutralization Potential | A general term for a sample's or a material's capability to neutralize acidity. |
| Nivation | Term referring to “snow patch erosion”, the development of shallow depressions at sites occupied by long lasting snow banks. The shallow depressions are caused by erosion of bedrock or surficial materials beneath and along the margin of snow patches by freeze-thaw processes (frost shattering and heave), meltwater action and snow creep. |
| **O** | |
| Open Pit | A mine that is entirely on surface. Also referred to as open-cut or open-cast mine. |
| Ordovician | The Ordovician Period is the interval of geological time from 495 to 443 million years ago. It is named after the Ordovices, an ancient British tribe in North Wales. |
| Ore | A mixture of ore minerals and gangue (i.e., rock surrounding a mineral or precious gem in its natural state) from which at least one of the metals can be extracted at a profit. |
| Orebody | A natural concentration of valuable material that can be extracted and sold at a profit. |
| Overburden | Surface waste materials covering a mineral deposit. |
| **P** | |
| Paleozoic | The Paleozoic Era is the interval of geological time from 545 to 248 million years ago. It includes the Cambrian, Ordovician, Silurian, Devonian, Carboniferous, and Permian periods. Paleozoic means "old life". |
| PCB’s | Polychlorinated biphenyl’s. A group of organic compounds. PCB’s are highly toxic to aquatic life. They persist in the environment for long periods of time, and they are bioaccumulants. |
| Permafrost | Ground (soil or rock) that remains at or below 0°C for at least two years. The definition is based upon time and temperature, without reference to the presence or absence of ice. |

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| Pigging | The process of cleaning pipelines with pigs. A pig is a generic term signifying any independent, self-contained device, tool or vehicle that moves through the inside of a pipeline for the purpose of cleaning, dimensioning, or inspecting. |
| Pile | A long, heavy timber or section of concrete or metal that is driven or jetted into the earth or bottom of a water body to serve as a structural support or protection. |
| Pillar | A block of solid ore or rock left in place to structurally support the roof or hanging wall in a mine. |
| Pit-Run Material | Natural gravelly material taken from excavation. Gravelly material which is not processed. |
| Portal | The surface entrance to a mine, tunnel or adit. |
| Process Water | Reclaimed tailings water with the solids removed and reused in the process. |

**R**

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| Raise | Steeply inclined rectangular or cylindrical opening used for ventilation or for conveying ore or backfill. |
| Raisebore Holes | Raise created by a raisebore drill, which drills near vertical holes by drilling a pilot hole from surface into an underground opening, then pulls up a 1.8 m diameter reamer head to enlarge the opening. |
| Rake | A rotating blade inside a thickener tank used to separate water and solids from a slurry. |
| Reamer | A tool used to enlarge, shape, smooth, or otherwise finish a hole. |
| Recalcitrant Compound | A compound that is being resistant to biodegradation or biotransformation. |
| Reclaim Water | Tailings water that has been reclaimed at the thickener and pumped back to the mill for reuse in the process. |
| Remedial/ Remediate/Remediation | Refers to any procedures or strategies used to address a hazardous waste site. For example, a Remedial Investigation determines what areas of a site need to be addressed (cleaned up or remediated), a proposed remedial action plan describes remedial actions (cleanup methods or corrective actions) that have been recommended for a specific site; remediation of a site could include removing contaminated soil. |
| Rip-Rap | A facing layer (protective cover) of stones placed to prevent erosion or the sloughing off of a structure or embankment. |
| Rotary Dryer | A horizontal steel tube rotated mechanically, through which the moist concentrate is conveyed, along with hot exhaust from the diesel generator, |

to reduce the moisture of the concentrate.

**S**

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| Shale | A fissile rock composed of layers of claylike, fine-grained sediments. |
| Sheet Pile | A pile with a generally slender, flat cross-section that is driven into the ground or bottom of a water body and meshed or interlocked with like members to form a wall or bulkhead. |
| Sink Hole | At the Polaris mine, a term used to describe a depression above the orebody created by subsidence caused by the early mining in the underground orebody. |
| Sludge | Mud-like residue (solids and some water). |
| Solifluction Lobes | Slow gravitational downslope movement of saturated non-frozen overburden across a frozen or otherwise impermeable substrate. |
| Sphalerite | A zinc sulphide mineral, the most common ore mineral of zinc. |
| Strata | Plural for stratum. Stratum: a tabular or sheet-like mass, or a single and distinct layer, of homogeneous or gradational sedimentary material of any thickness, visually separable from other layers above and below by a discrete change in character of the material deposited or by a sharp physical break in deposition, or by both; a sedimentary bed. |
| Stringer | A narrow vein or irregular filament of mineral traversing a rock mass. |
| Stub Walls | Short or partial walls. |
| Subsidence | The gradual sinking of the rock and soil layers into the underground mine. |
| Sulphide | A compound of sulphur and some other element (e.g., iron sulphide). |

**T**

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| Tailings | Material rejected from a mill after most of the recoverable valuable minerals have been extracted. |
| Tailings Line | Pipeline in which tailings are pumped or carried from one location to another. |
| Tank Farm | A group of tanks, as for the commercial storage of oil, sited together. |
| Thickener | A large, round tank used in milling operations to separate solids from liquids; clear fluid overflows from the tank and rock particles sink to the bottom. |

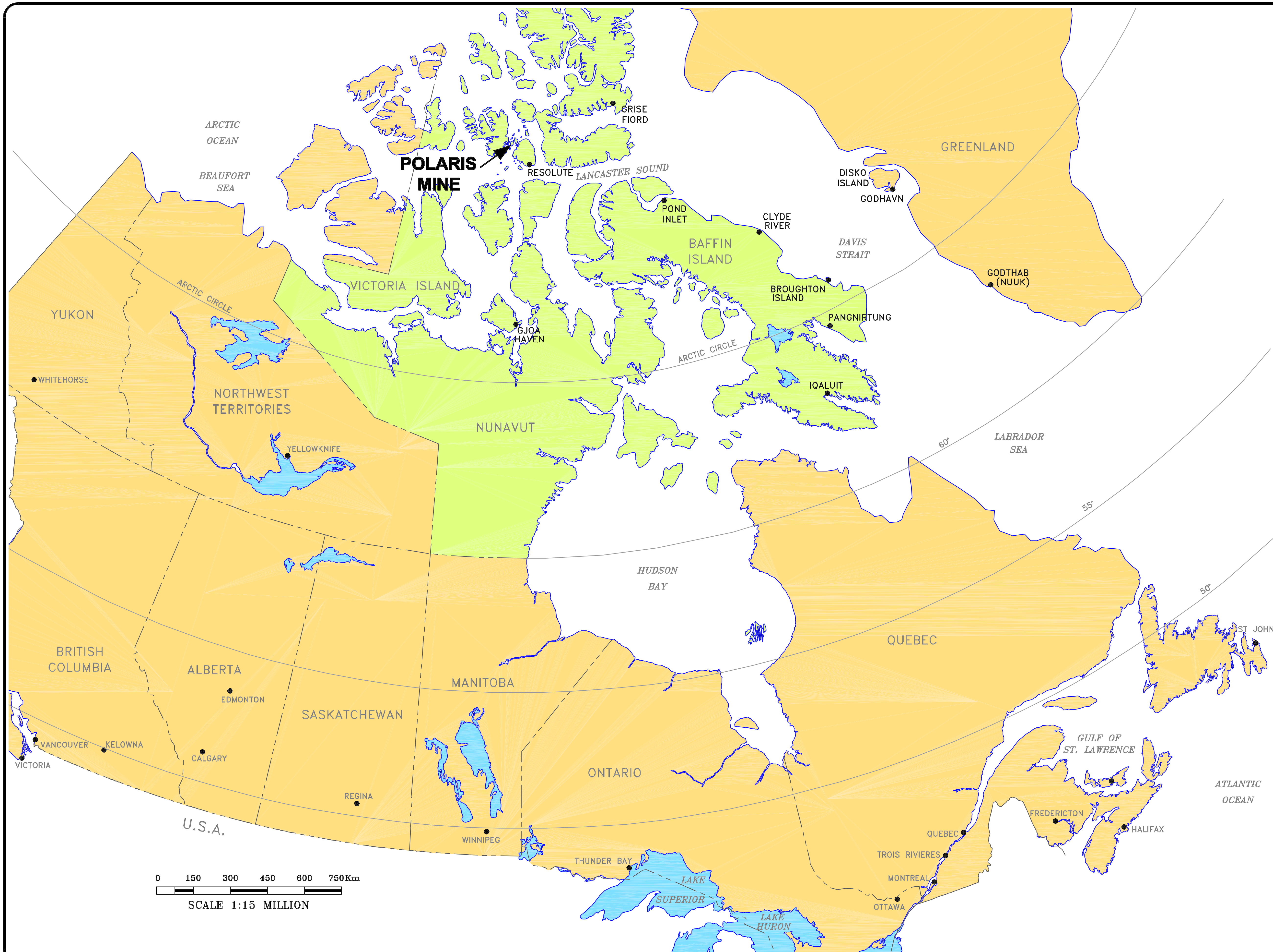
**U**

| | |
|---|---|
| Underground Methods | Refers to underground mining, which is the mining of ore that is below the |

| | |
|---|---|
| | surface and deep in the ground. To reach this ore the miners use tunnels and shafts. At Polaris this ore is accessed from a decline at surface. |
| Ungulates | A hoofed mammal which is usually adapted for running (e.g., caribou). |

**W**

| | |
|---|---|
| Waste Rock | The barren rock in a mine. |
| Wet Scrubber | Dust collectors used on the exhaust from the rotary dryer to reduce dust going to the atmosphere on discharge. |




LEGEND

NUNAVUT TERRITORY

**SOURCE OF DRAWING:**
GSC MAP D1880A (1996) CD DIGITAL MAP
PROJECTION:
LAMBERT CONIC CONFORMAL
NAD 27
UNITS METRES

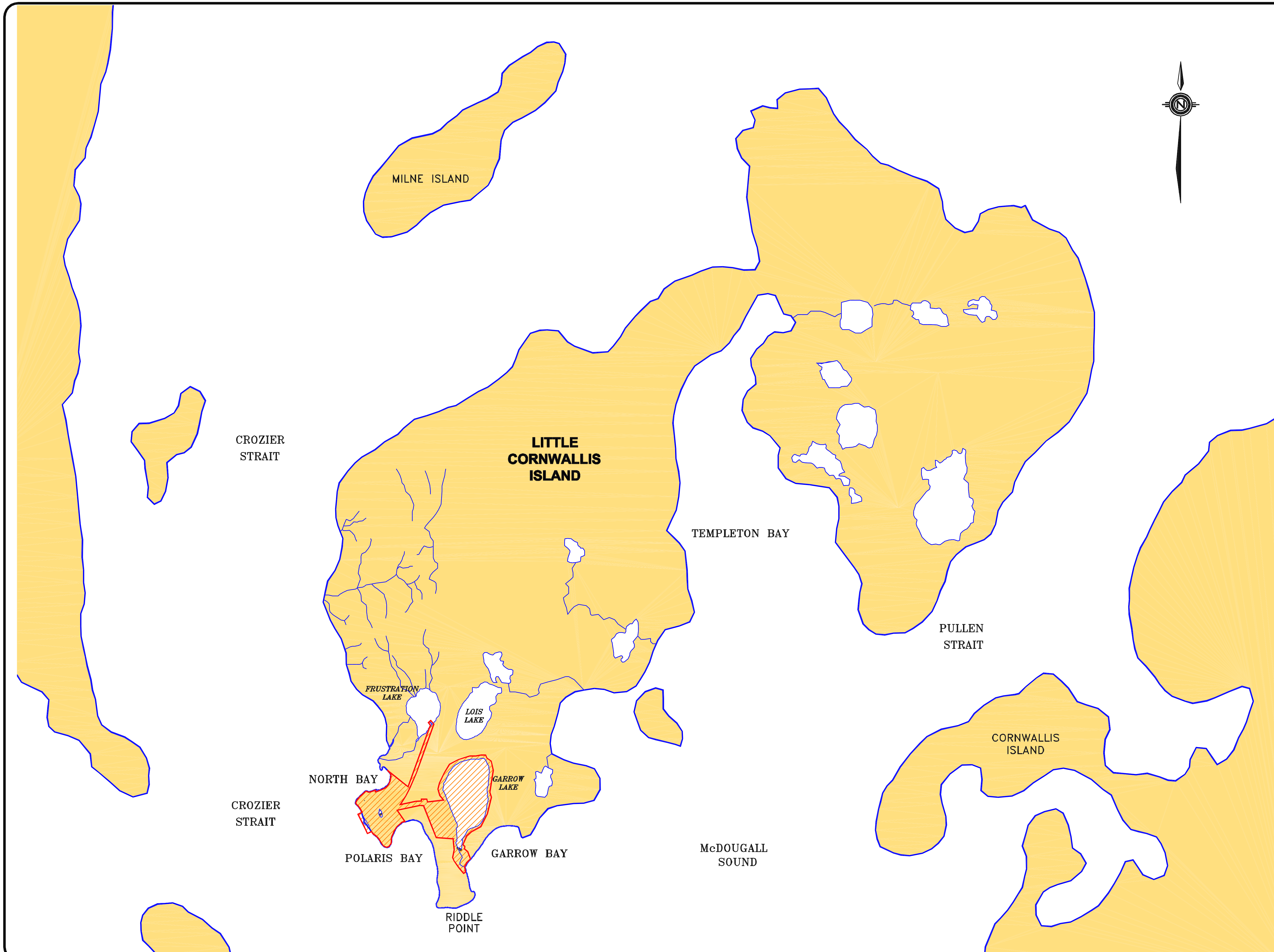
| DRAWING INFORMATION: | |
|---|---|
| DESIGNED BY: | AJK |
| REVIEWED BY: | AJK |
| DRAWN BY: | CPW |
| DATE ISSUED: | FEBRUARY 15, 2001 |
| PROJECT NUMBER: | 20-935 |
| FILE NAME: | 20935-F2-20.DWG |
| REVISION: | 0 |

Cominco
Cominco Ltd.
Polaris Mine
Decommissioning & Reclamation Plan

SITE LOCATION

Gartner Lee Limited

Figure No.
1




LEGEND

SHORE LINE

POLARIS MINE – LAND LEASE AREAS

Notes:

0 1.5 3.0 4.5 6.0 7.5 Km

SCALE 1:150,000

| DRAWING INFORMATION |
|---|
| DESIGNED BY: EG |
| REVIEWED BY: AJK |
| DRAWN BY: DL/CPW |
| DATE ISSUED: FEBRUARY 15, 2001 |
| PROJECT NUMBER: 20–935 |
| FILE NAME: 20935–F2–01.dwg |

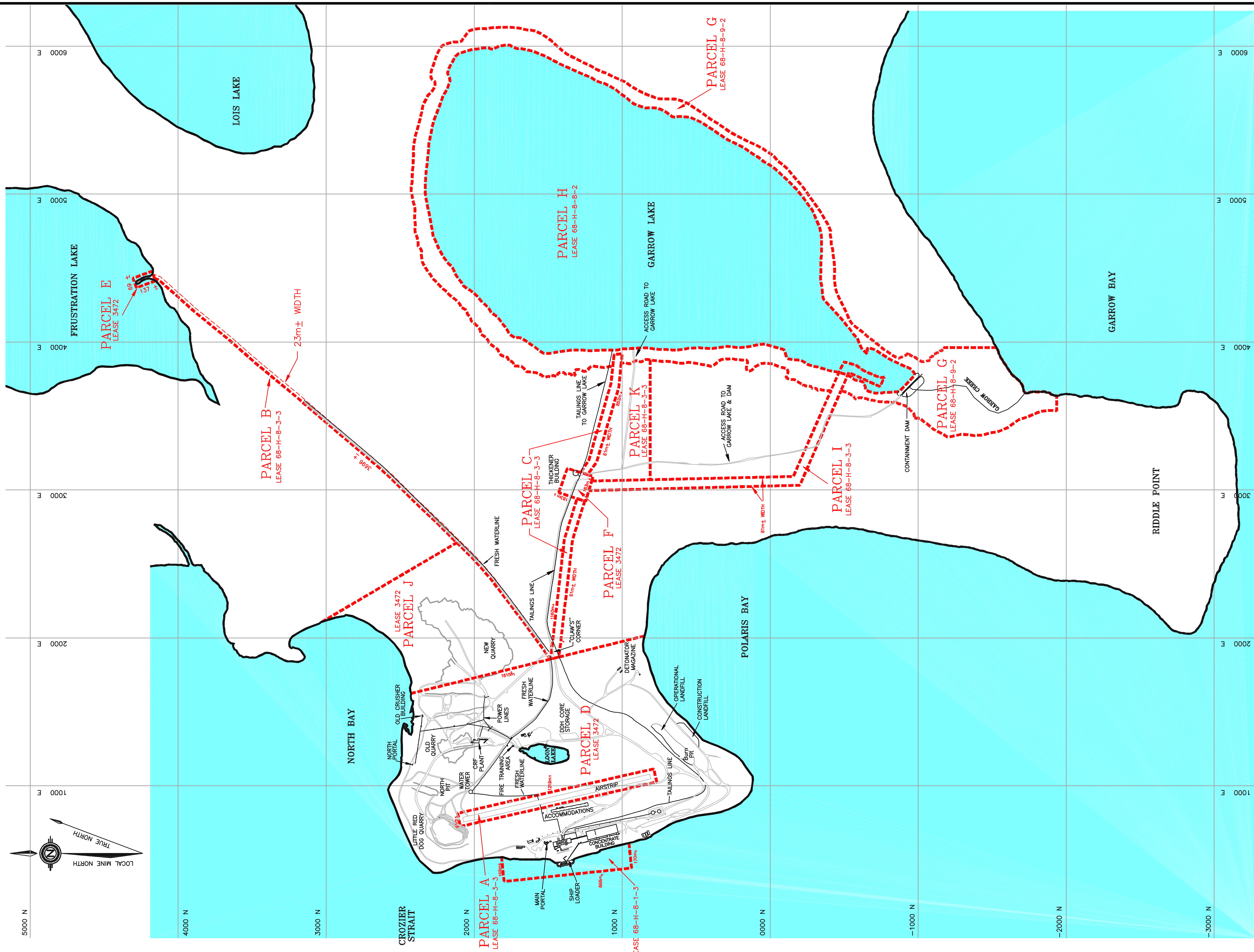
Cominco

Cominco Ltd.
Polaris Mine
Decommissioning & Reclamation Plan

LITTLE CORNWALLIS ISLAND
SHOWING LOCATION OF POLARIS MINE

Gartner Lee Limited

Figure No. 2




Base map provided by Cominco Resources

Scale 1:25,000
metres
0 200 1000

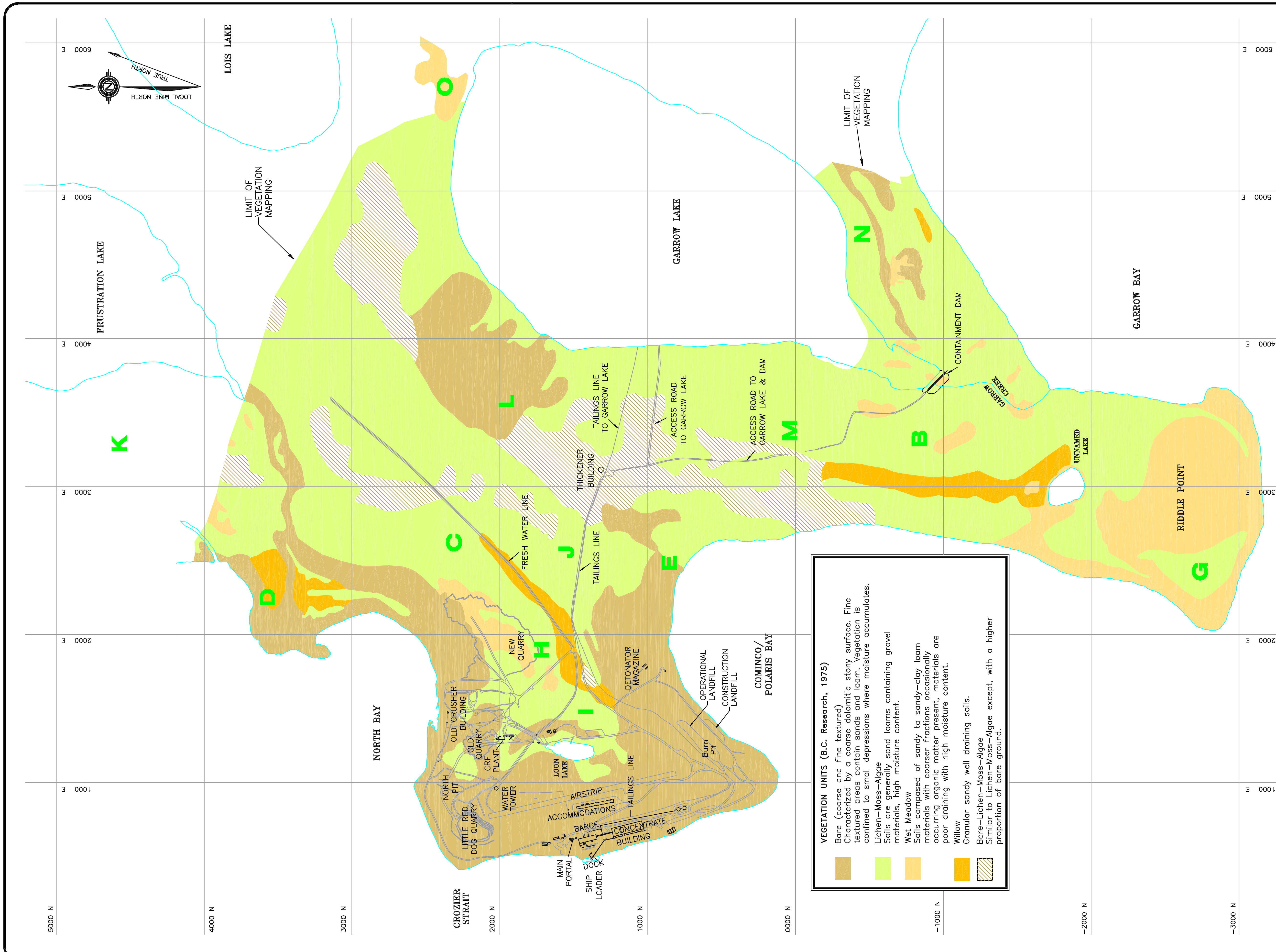
Date Issued: FEBRUARY 15, 2001
Drawn by: BB/CPW
GLL Project Number: 20-935
File Name: 20935-F2-09.dwg

Cominco Ltd.
Polaris Mine
Decommissioning & Reclamation Plan

Site Plan Showing Lease Areas and Legal Description

Gartner Lee

Figure No. 3




LEGEND

A VEGETATION SAMPLING LOCATION GLL JULY 2000

Scale 1:25,000

0 200 1000

metres

Date Issued: MARCH 21, 2001

Drawn by: BB/CPW

GLL Project Number: 20–935

File Name: 20935–F2–03.dwg

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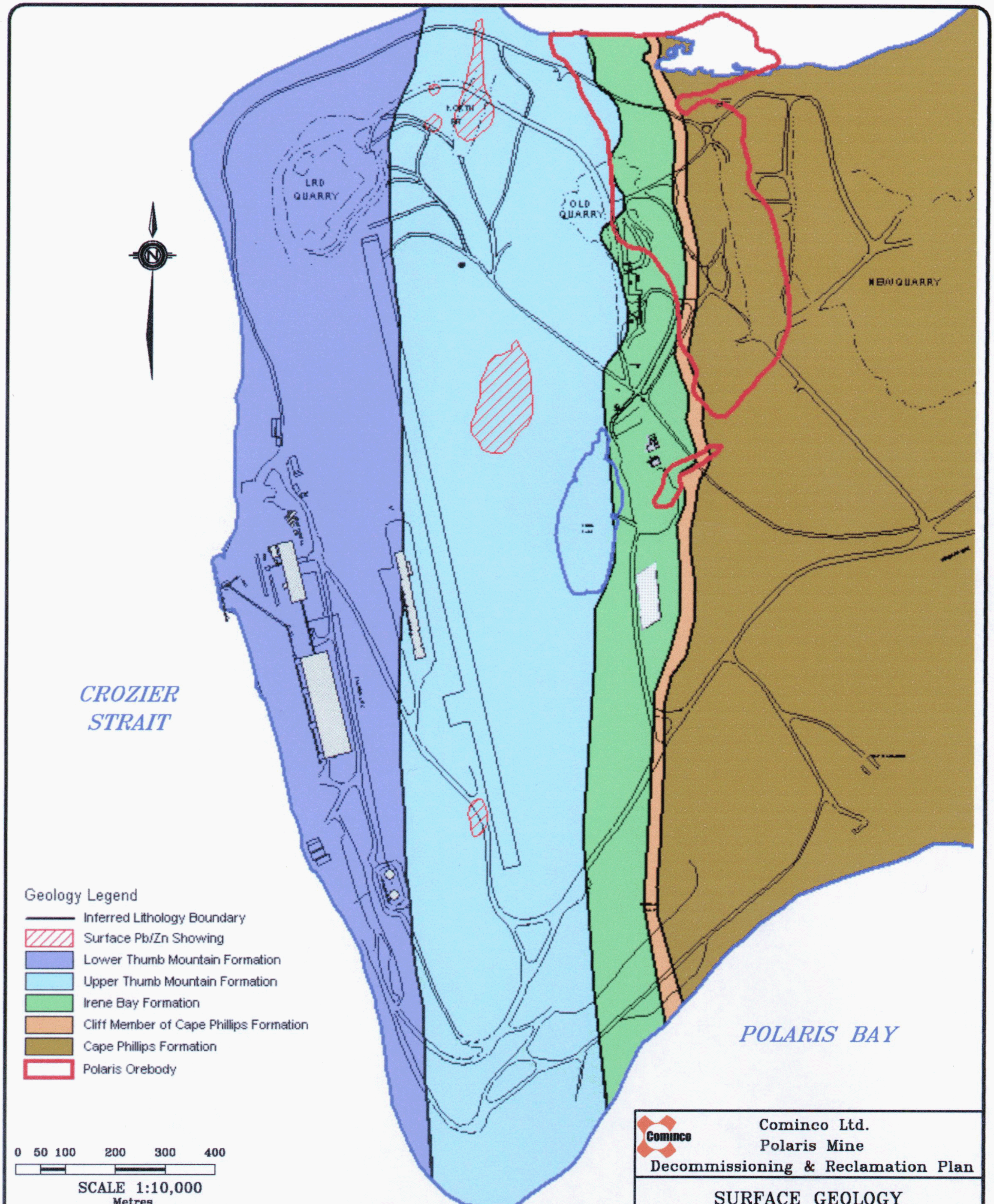
Cominco Ltd.
Polaris Mine
Decommissioning & Reclamation Plan

Site Plan Showing Major Vegetation Units, Soil Sampling Sites

Gartner Lee

Figure No. 4




Cominco

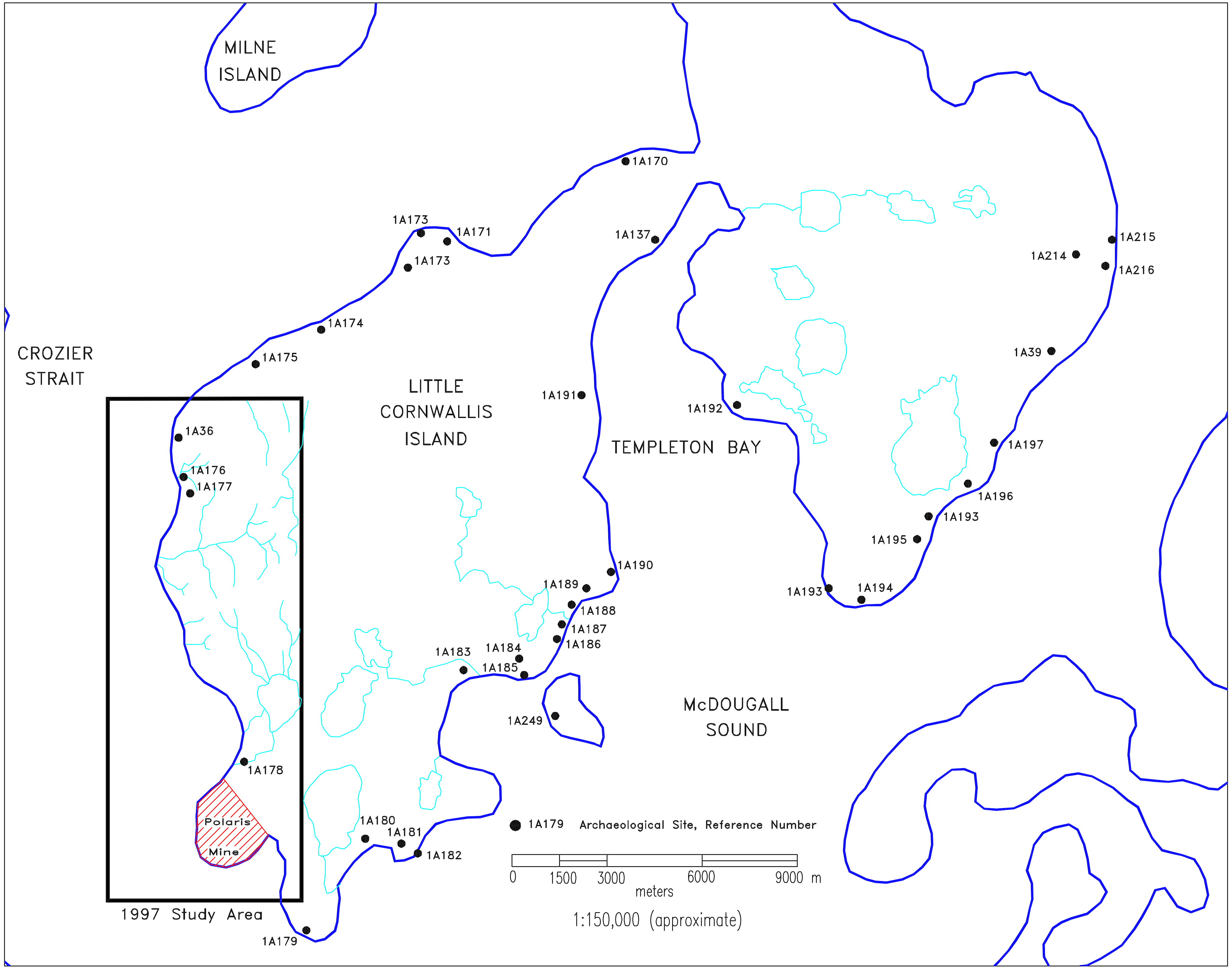
Cominco Ltd.
Polaris Mine
Decommissioning & Reclamation Plan

SURFACE GEOLOGY
POLARIS MINE AREA

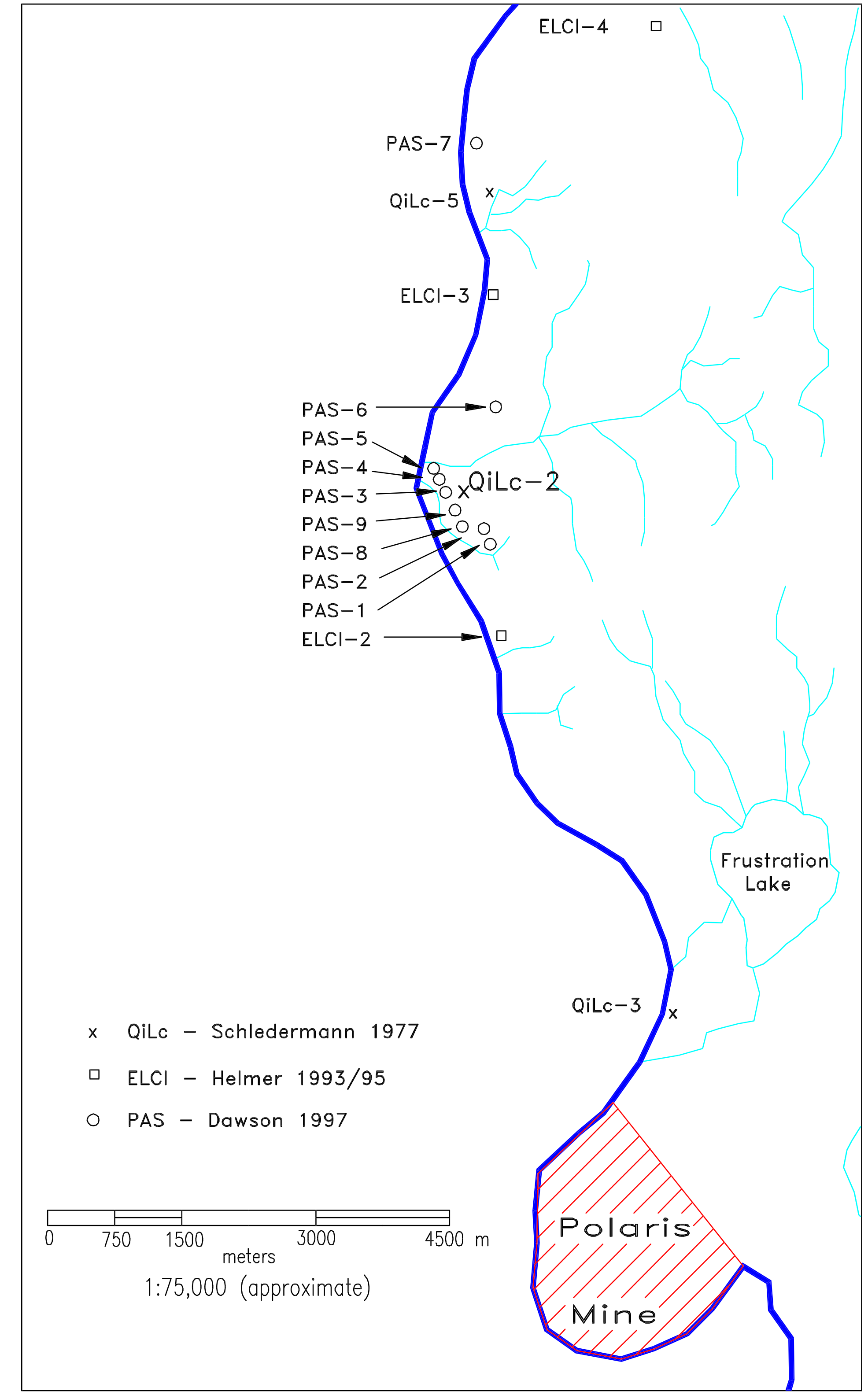
| | | | |
|---|---|---|---|
| SOURCE OF DRAWING: DRAWING PROVIDED BY VICTORIA YEHL OF COMINCO LTD. FEBRUARY, 2001 | | DATE ISSUED: | FEBRUARY 15, 2001 |
| | | PROJECT NUMBER: | 20–935 |
| | REVIEWED BY: COMINCO | FILE NAME: | 20935–F2–19.DWG |
| | DRAWN BY: CPW | REVISION: | 0 |

Gartner Lee Limited

Figure No. 5




1977 Study Map – Little Cornwallis Island Area




1997 Study Area – Archaeological Sites

LEGEND

General Polaris Mine Site

Note: 1977 Study Map based on Schledermann Report 1978 for Polar Gas Ltd.
1997 Study Area drawing based on Dawson 1997 Report for Cominco Ltd.

See scales on drawings

Scales

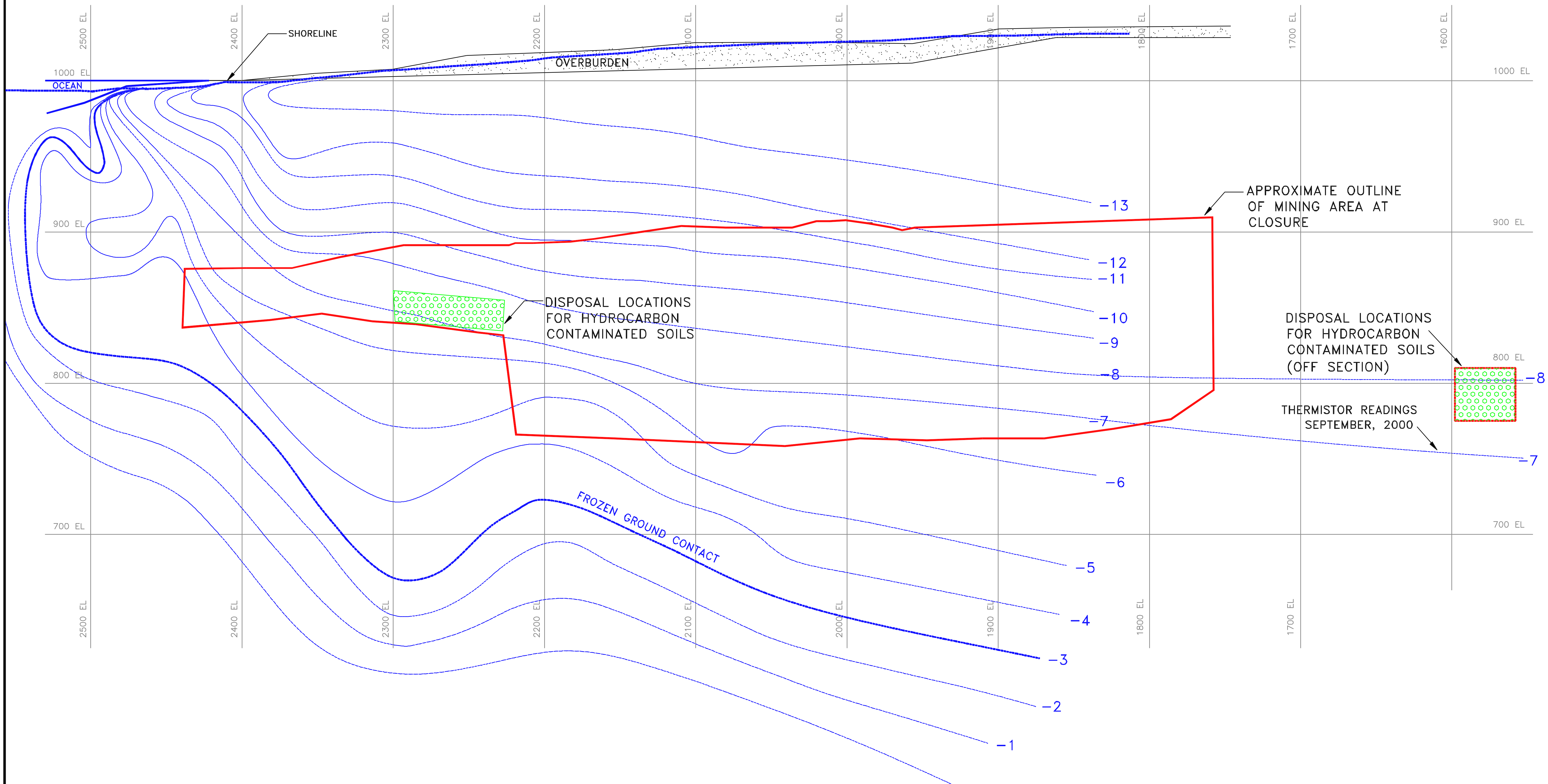
| | |
|---|---|
| Designed By: D.L. | Drawn By: D.L./CPW |
| Checked By: F.K.P./AJK | Approved By: AJK |
| Date Issued: FEBRUARY 15, 2001 | Project No. 20-935 |
| Site Name: POLARIS MINE | File Name: 20935-F2-04.DWG |

Cominco Ltd.
Polaris Mine
Decommissioning & Reclamation Plan

Polaris Mine Area
Archaeological Sites

Gartner Lee Limited

Drawing No.
6




LEGEND

SOURCE OF DRAWING:

COMINCO DRAWING LONG1425.DWG DATED JUNE 2000 BY TSF. SECT 1425 E

NOTE:

ISOTHERMS FROM COMINCO PAPER BY D. ANDRES, JUNE 1998; "THE EVOLUTION OF PILLAR MINING AT THE POLARIS MINE"

0 25 50 100 Metres

SCALE 1:2,500

Scales

| | |
|---|---|
| Designed By: COMINCO | Drawn By: COMINCO/CPW |
| Checked By: EG/AJK | Approved By: AJK/EG |
| Date Issued: MARCH 21, 2001 | Project No. 20-935 |
| Site Name: Polaris Mine | File Name: 20935-F2-14.DWG |

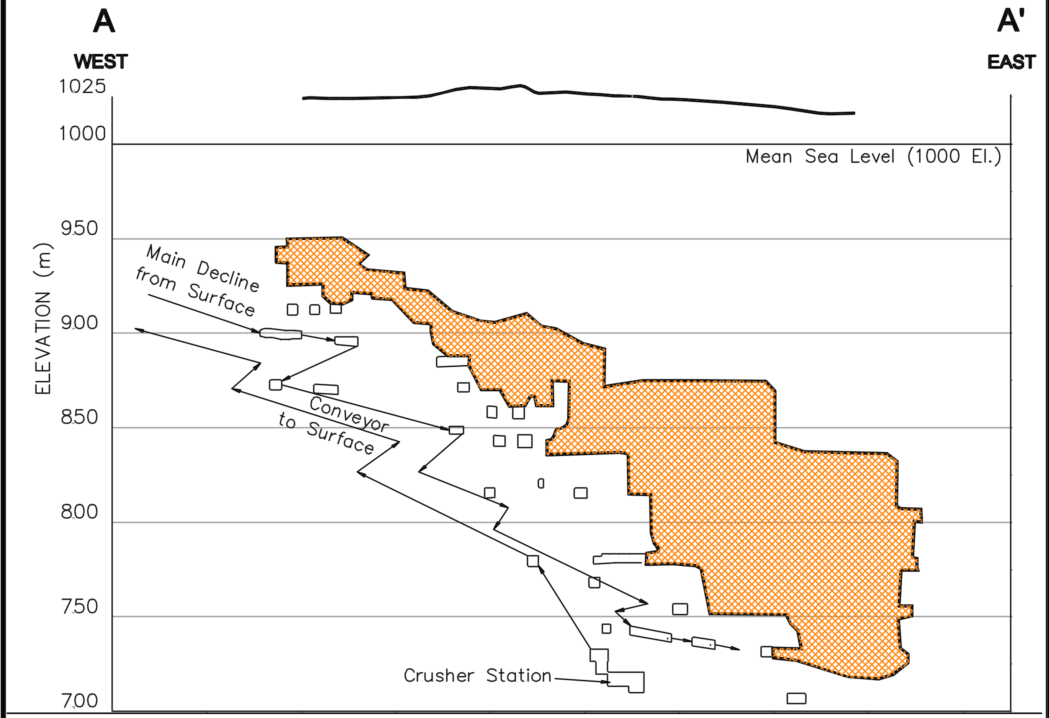
Cominco Ltd.
Polaris Mine
Decommissioning & Reclamation Plan

Location of Mining and Isotherms Composite Section of Mining Outline at Section 1425 E (Looking East)

Gartner Lee Limited

Drawing No. 7

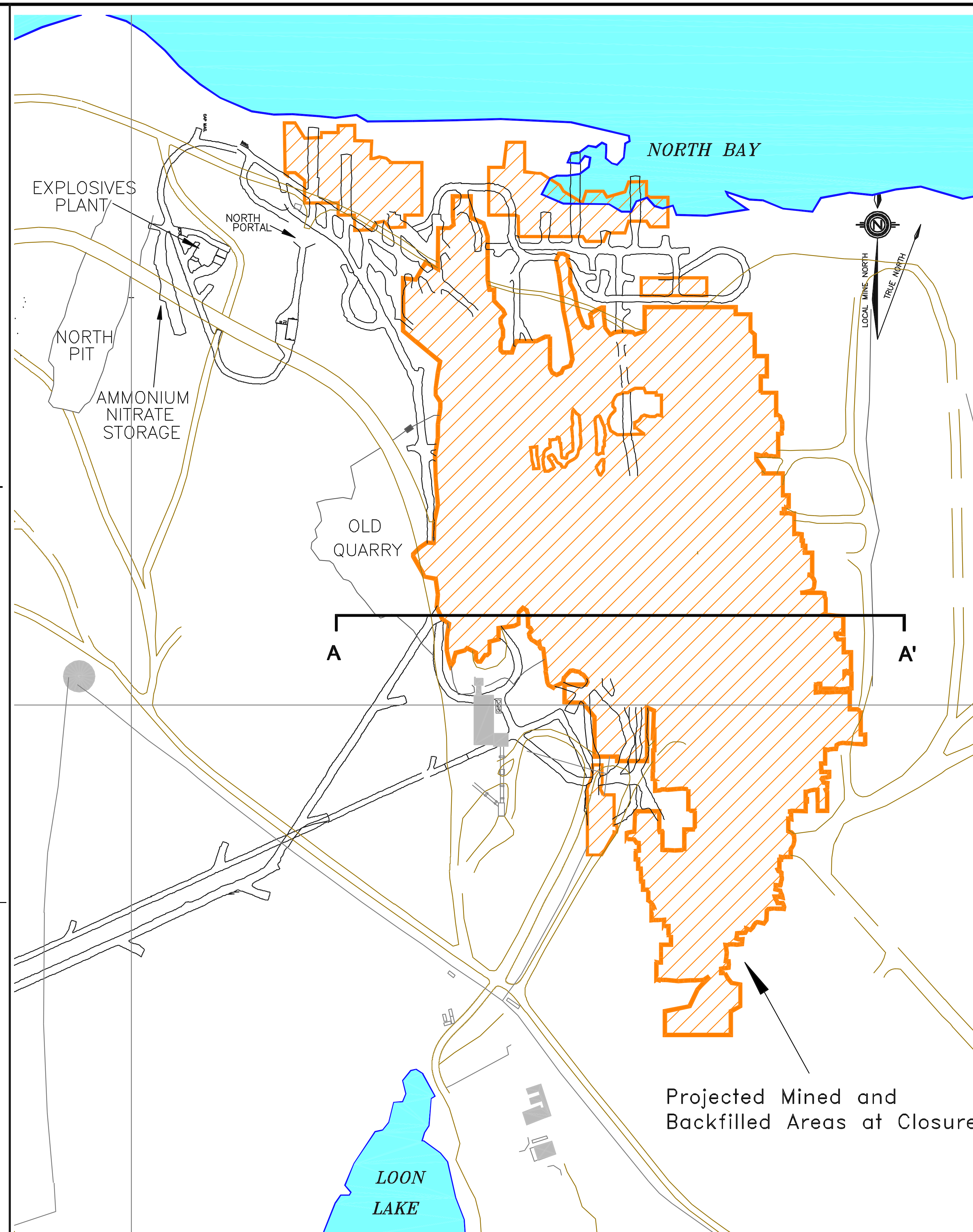
## SECTION A-A'

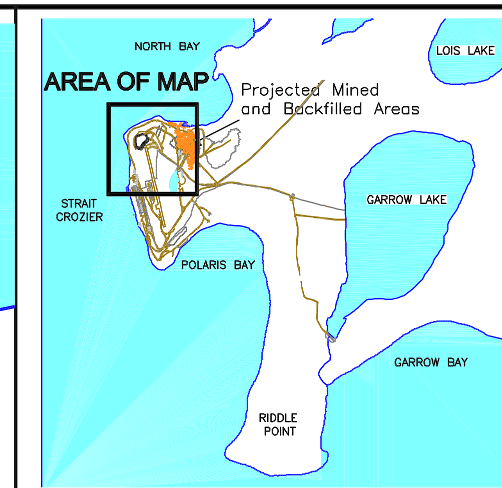



Mined Areas

Projected Mined and Backfilled Areas at Closure

0 100 200 Metres
SCALE 1:4000




KEY PLAN

LEGEND

- Backfilled Stopes
- Drifts (shown in black)
- Surface Buildings
- Surface Features

Note: Base map provided by Cominco Ltd.

0 100 200 Metres
SCALE 1:4000

| | |
|---|---|
| Designed By: AJK | Drawn By: FKP/CPW |
| Checked By: AJK | Approved By: AJK |
| Date Issued: MARCH 21, 2001 | Project No. 20-935 |
| Site Name: POLARIS | File Name: 20935-F2-02.DWG |

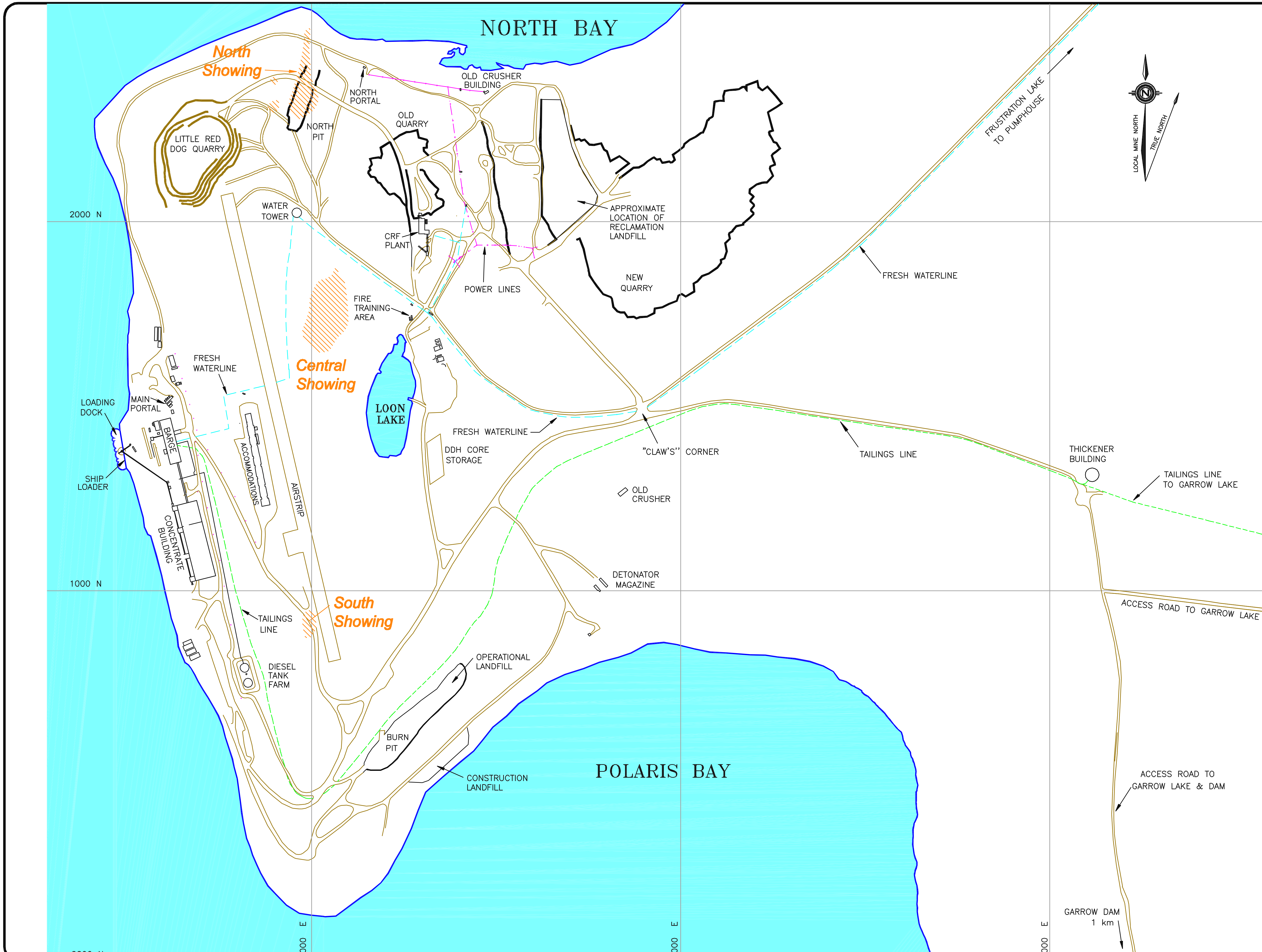
Cominco

Cominco Ltd.
Polaris Mine
Decommissioning & Reclamation Plan

Location of Underground Mine Workings

Gartner Lee

Drawing No.
8




LEGEND

- TAILINGS LINE
- POWER LINE
- WATER LINE
- ROADS

0 50 100 200 300 400 500 Metres

SCALE 1:10,000

| | |
|---|---|
| Designed By: DL | Drawn By: DL/CPW |
| Checked By: AJK | Approved By: AJK |
| Date Issued: MARCH 21, 2001 | Project No. 20-935 |
| Site Name: POLARIS | File Name: 20935-F2-10.DWG |

Cominco

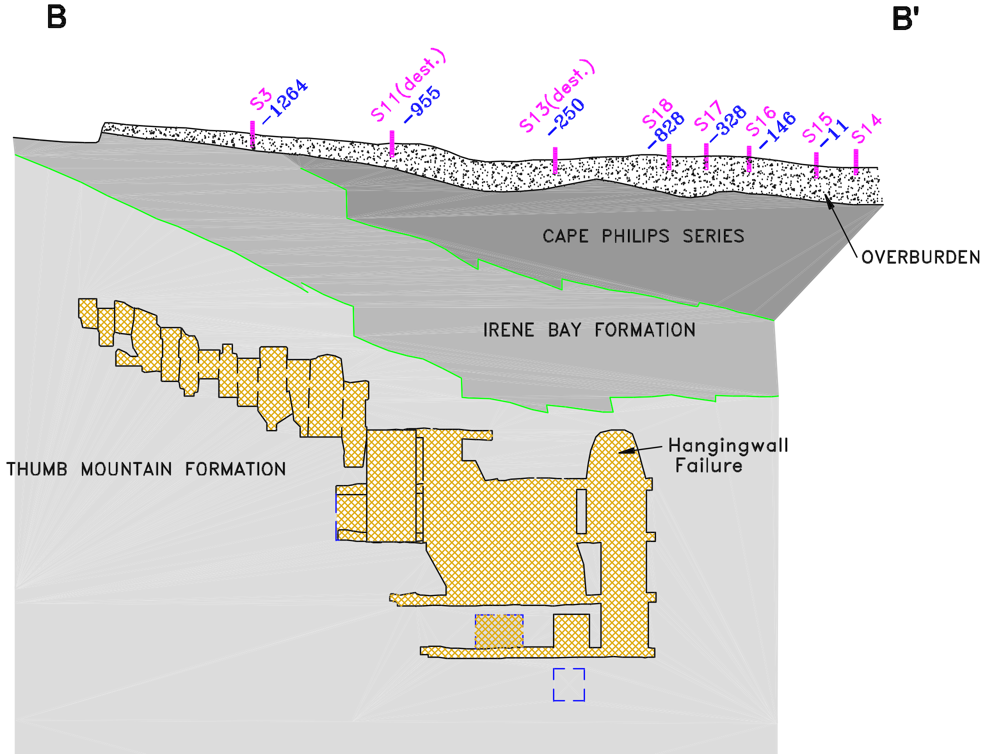
Cominco Ltd.
Polaris Mine
Decommissioning & Reclamation Plan

Surface Facility Locations

Gartner Lee

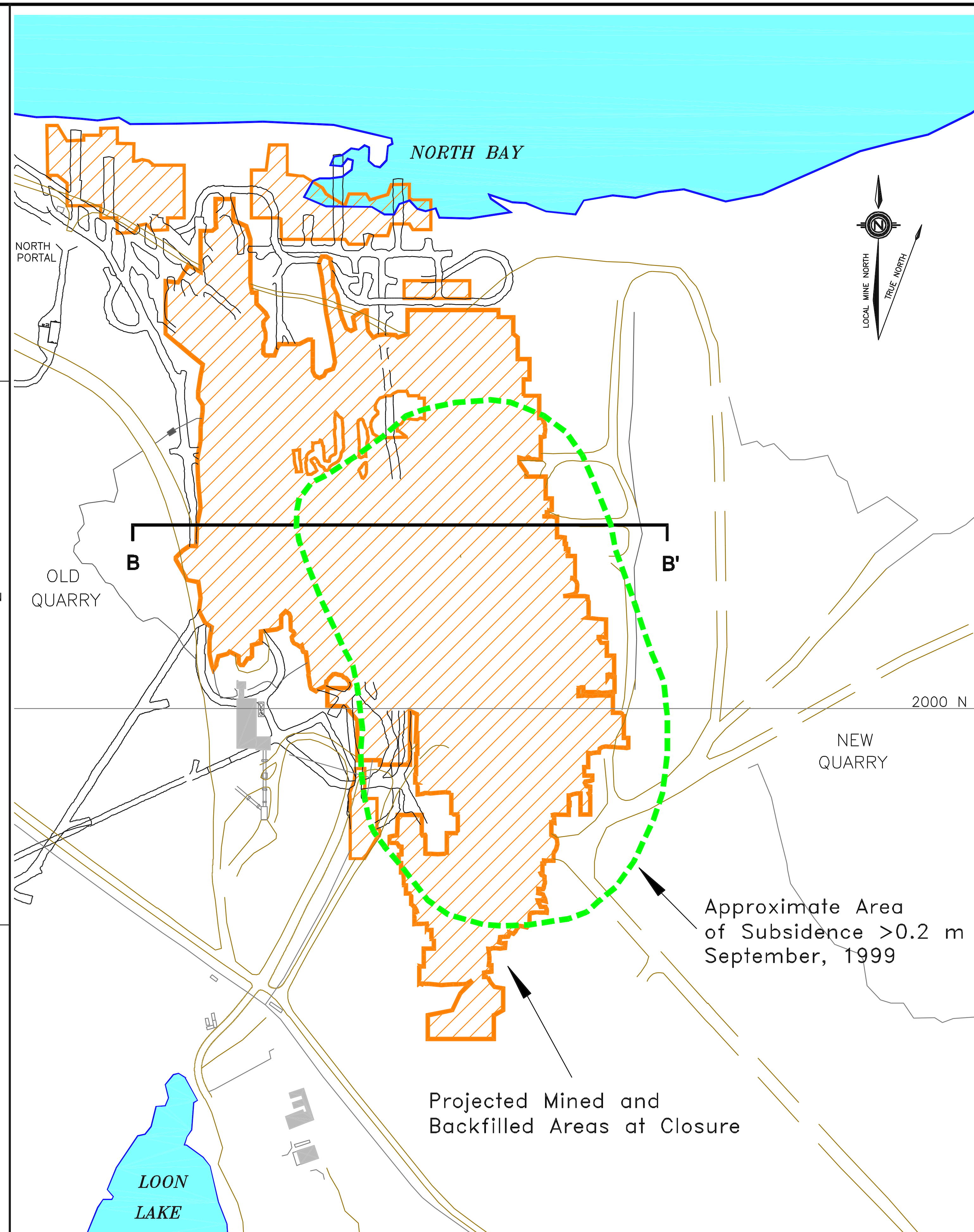
Drawing No.
9

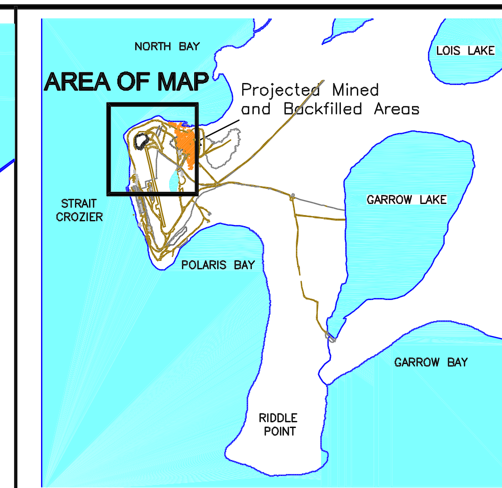
## 2150 NORTH SECTION




- Mined Areas
- Backfilled Areas
- S3 Subsidence Survey Stations
- -1264 Subsidence in mm

0 100 200 Metres
SCALE 1:4000




KEY PLAN

LEGEND

- Backfilled Stopes
- Drifts (shown in black)
- Surface Buildings
- Surface Features

Note: Base map provided by Cominco Ltd.

0 100 200 Metres
SCALE 1:4000

| | |
|---|---|
| Designed By: AJK | Drawn By: FKP/CPW |
| Checked By: AJK | Approved By: AJK |
| Date Issued: MARCH 21, 2001 | Project No. 20-935 |
| Site Name: POLARIS | File Name: 20935-F2-05.DWG |

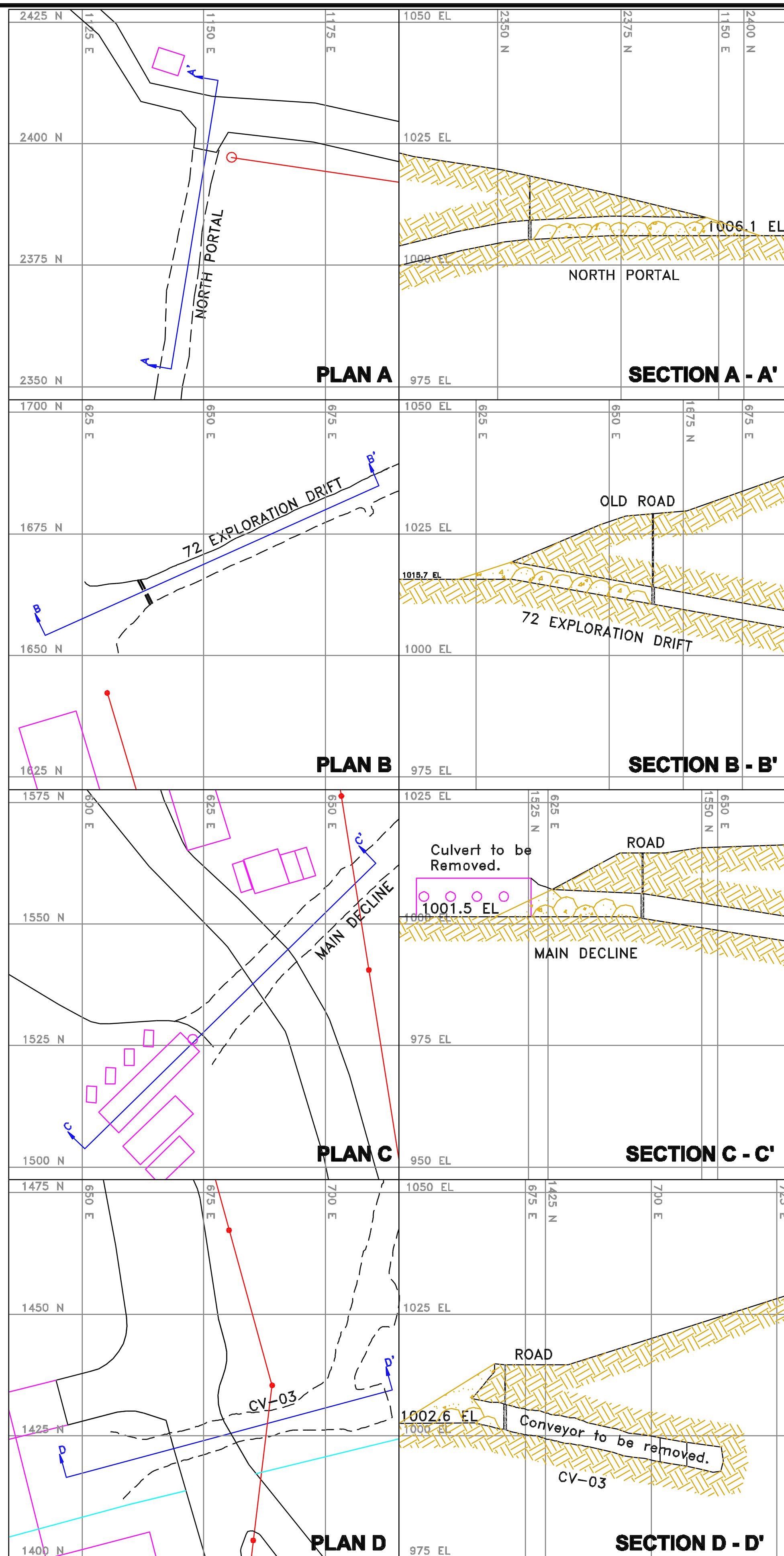
Cominco

Cominco Ltd.
Polaris Mine
Decommissioning & Reclamation Plan

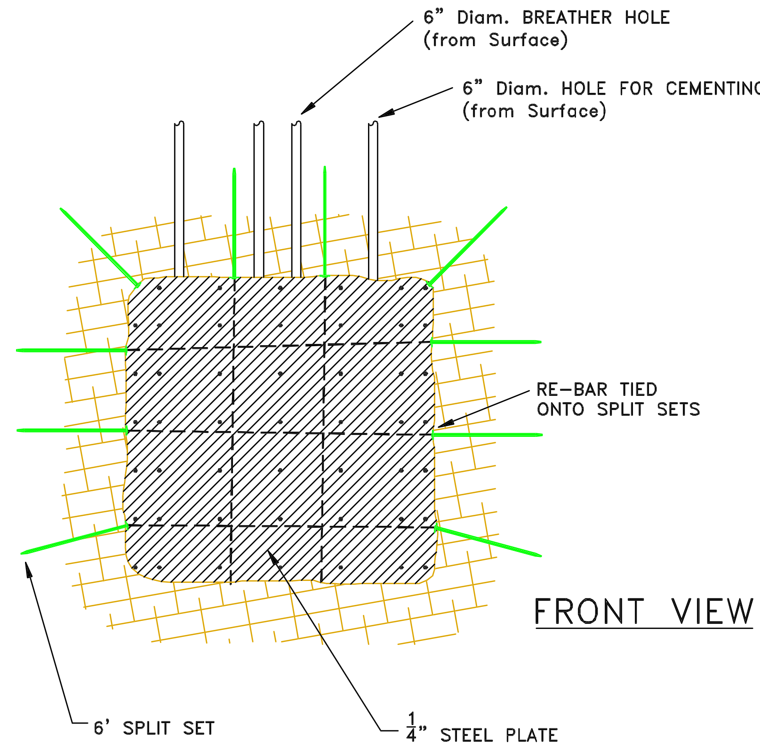
Mine Subsidence

Gartner Lee

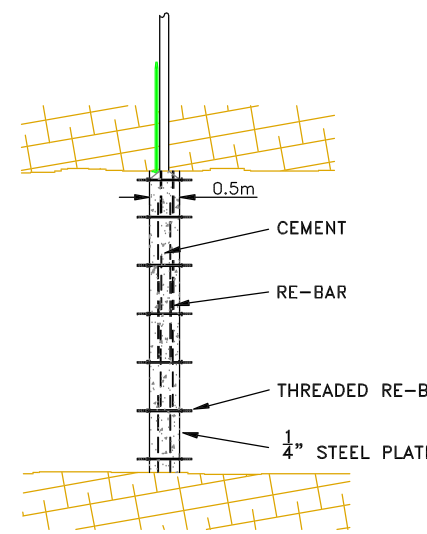
Drawing No. 10




## TYPICAL PORTAL PLUG




FRONT VIEW

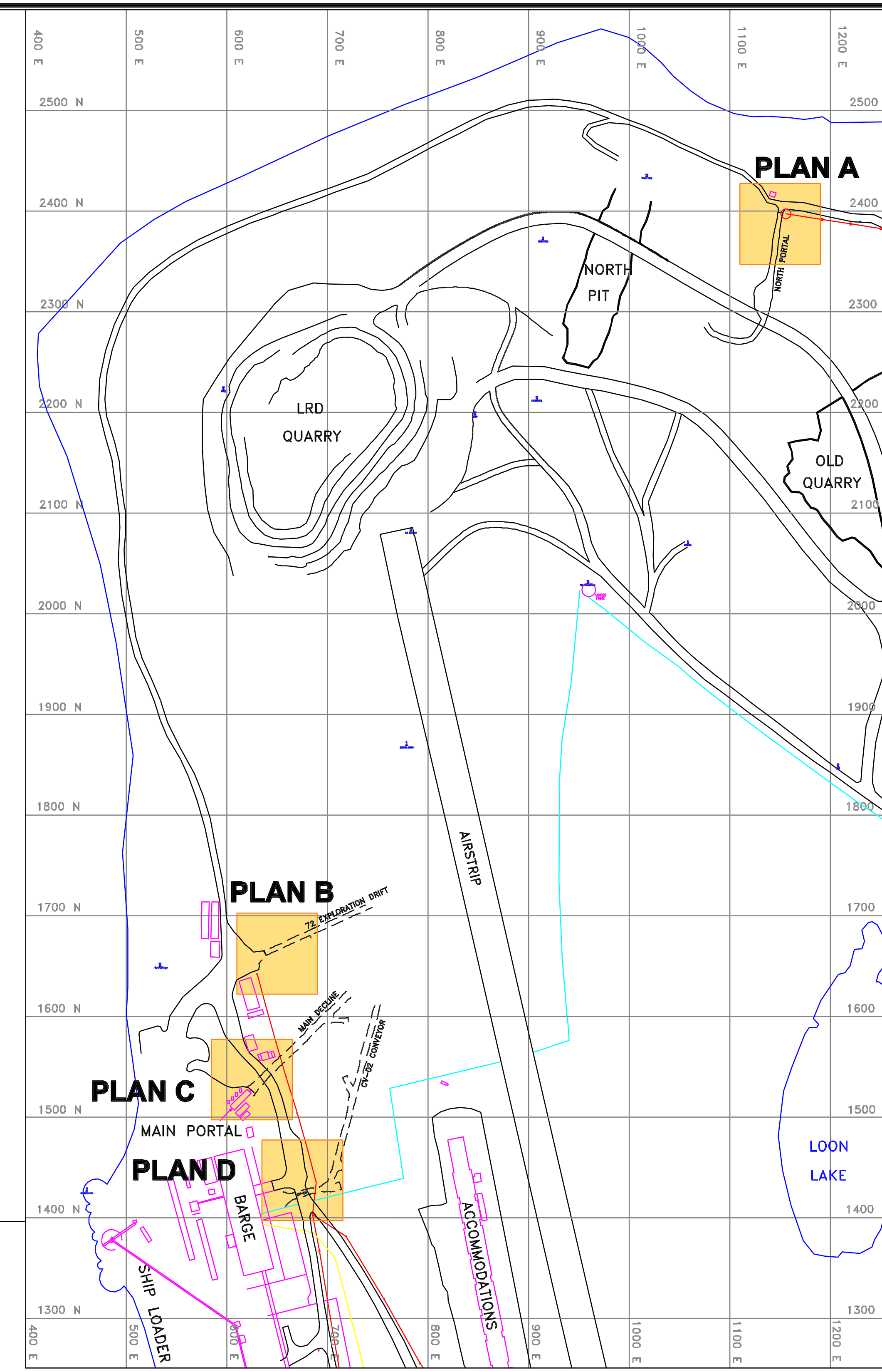



SIDE VIEW

Hydraulic Pressure = Depth x Density

North Portal = 4.1 x 2400 = 9,840 kg/sq.m = 14.0 PSI
72 Exploration Drift = 3.5 x 2400 = 8,400 kg/sq.m = 11.9 PSI
Main Decline = 5.1 x 2400 = 12,240 kg/sq.m = 17.4 PSI
CV-03 = 5.2 x 2400 = 12,480 kg/sq.m = 17.8 PSI

The combination of conventional concrete and reinforcing bars is commonly assummed to have a density of 2400 kg/cu.m




Cominco Ltd.
Polaris Mine
Decommissioning & Reclamation Plan

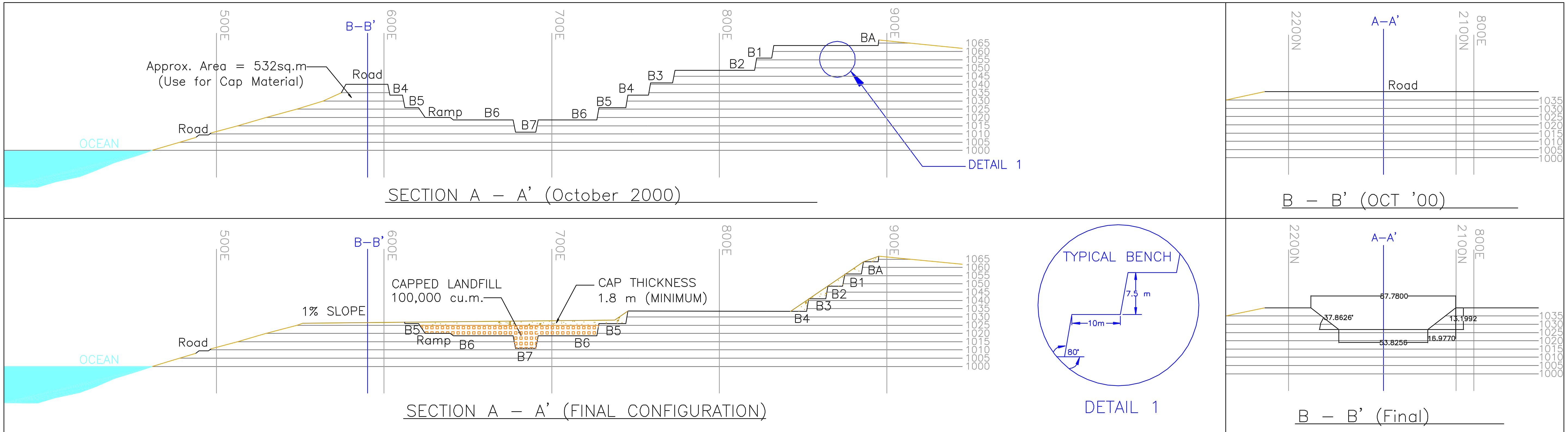
Mine Portal Closure

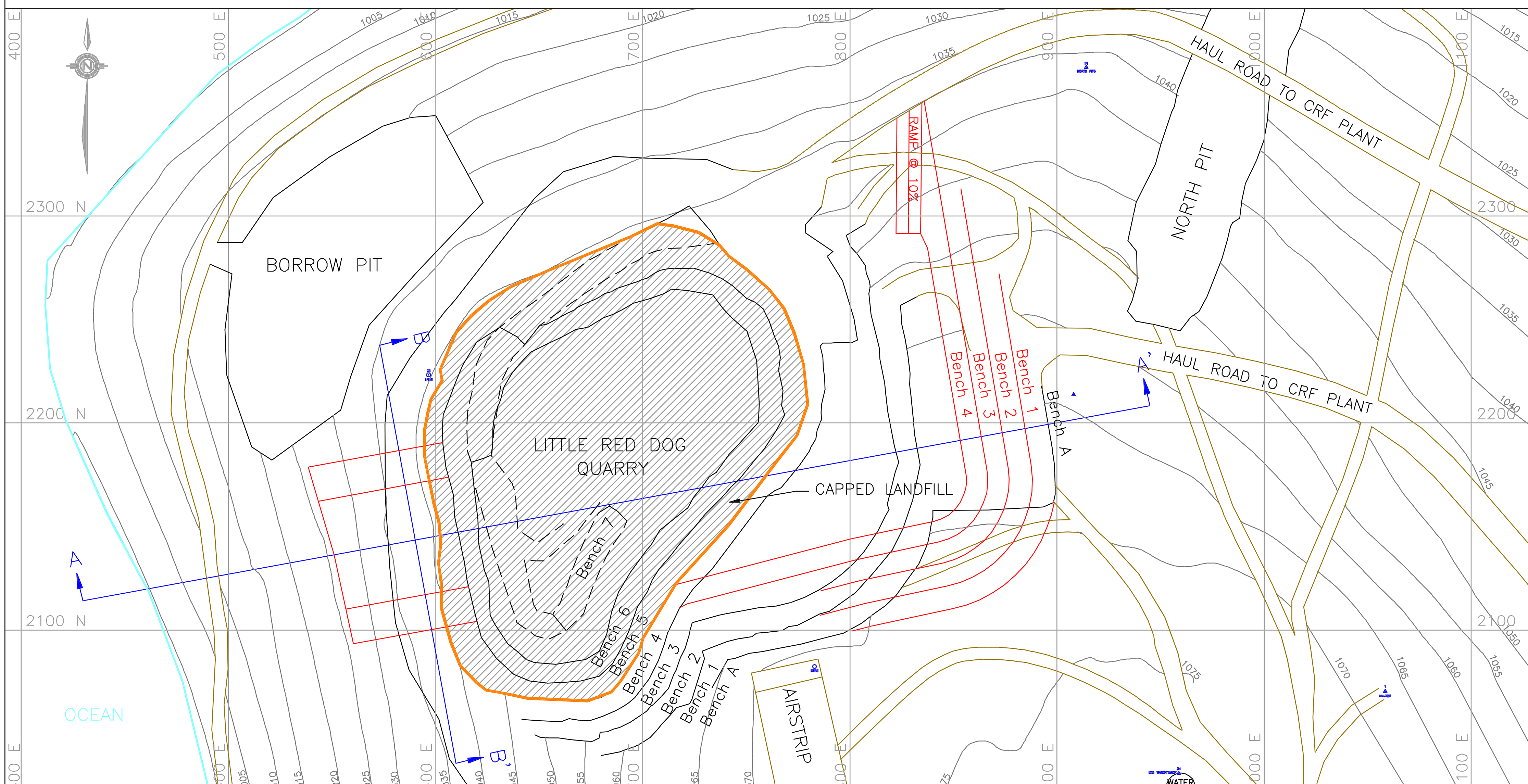
| | |
|---|---|
| Designed By: COMINCO | Drawn By: COMINCO/CPW |
| Checked By: AJK | Approved By: AJK |
| Date Issued: FEBRUARY 15, 2001 | Project No. 20-935 |
| Site Name: POLARIS | File Name: 20935-F2-13.DWG |

Note: Based on drawing by Cominco Ltd. Surface Portals Drawing dated Oct 2000

Gartner Lee

Drawing No. 11




PLANNED ULTIMATE QUARRY CONFIGURATION

## DRAINAGE CUT

Approx. Area = 532sq.m
Avg. Length = 70.8m
Approx. Volume = 37,666cu.m
Approx. Tonnage = 101,697 t

## VOLUMES

Bench 7 = 2,867 cu.m
Bench 6 = 114,039 cu.m
Debris = 100,000 cu.m
Cap = 37,708 cu.m (ESTIMATED)
VOLUME WILL VARY DEPENDING ON CAP THICKNESS
Cut = 37,666 cu.m

Note: Based on drawings by Cominco Ltd. LRD Reclamation Drawing dated Nov 6/00

0 25 50 100 Metres

SCALE 1:2,500

| | |
|---|---|
| Designed By: COMINCO | Drawn By: COMINCO/CPW |
| Checked By: AJK | Approved By: AJK |
| Date Issued: MARCH 21, 2001 | Project No.: 20–935 |
| Site Name: Polaris Mine | File Name: 20935–F2–08.DWG |

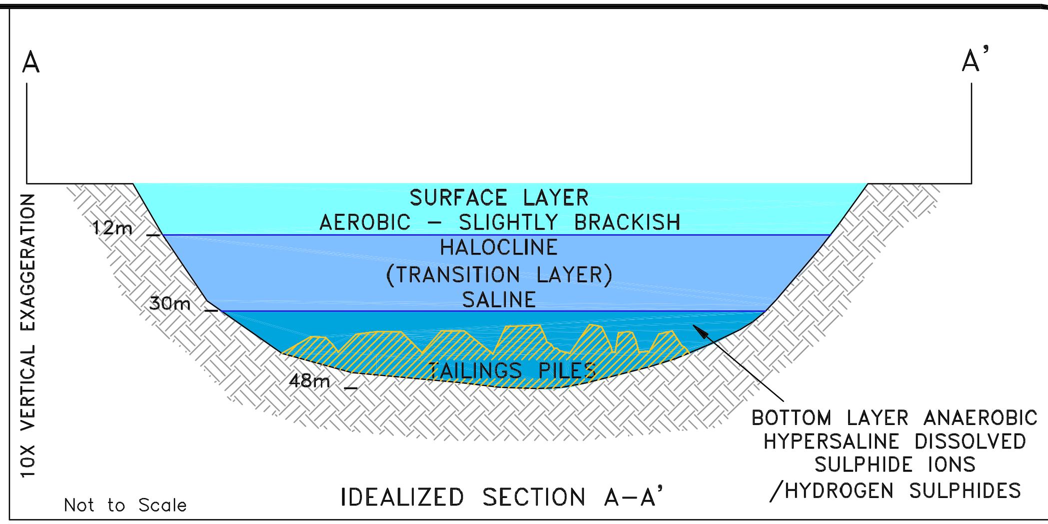
Cominco

Cominco Ltd.
Polaris Mine
Decommissioning & Reclamation Plan

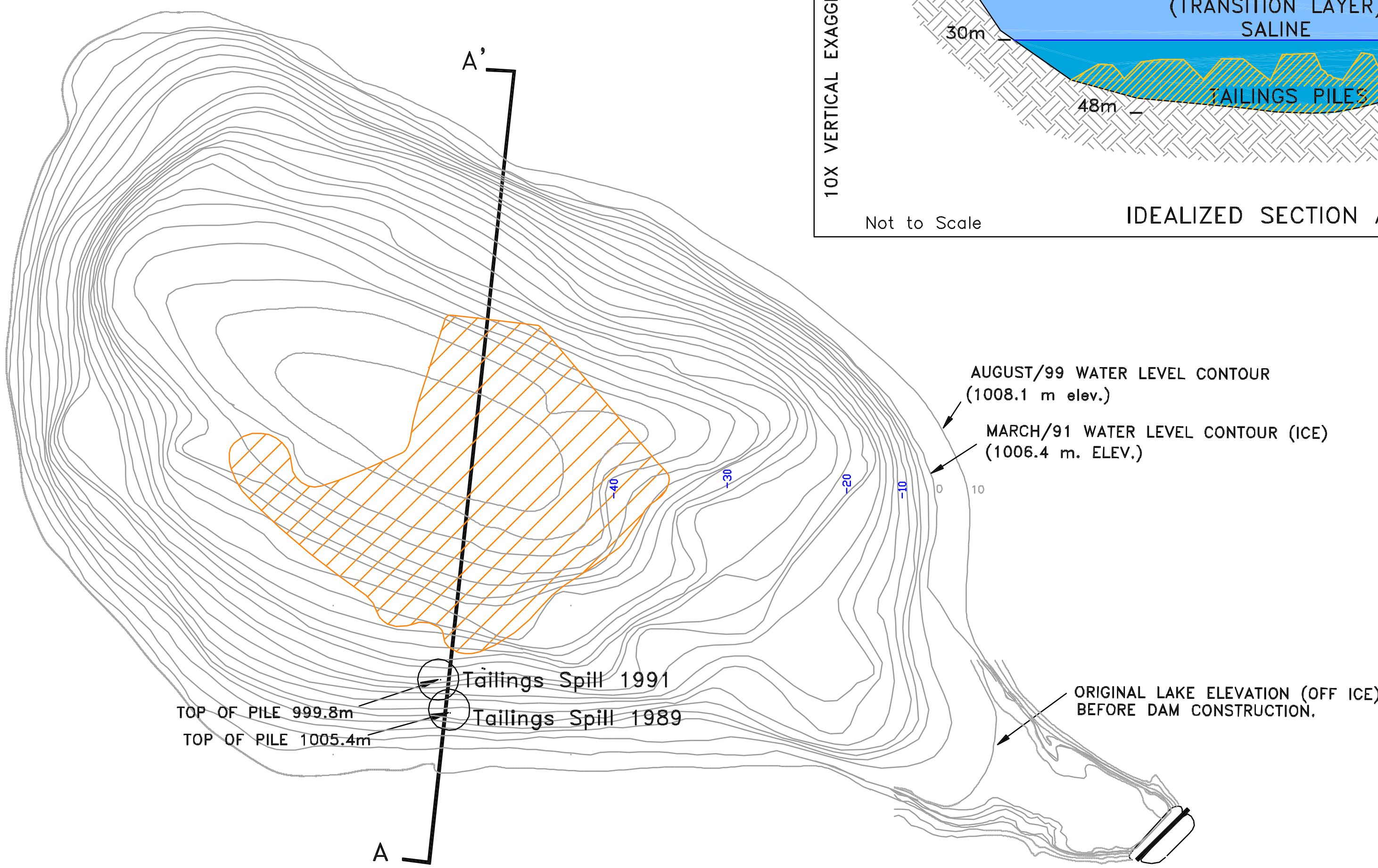
**Plan and Profile of Little Red Dog Quarry Reclamation Drawing**

Gartner Lee Limited

Drawing No. 12




IDEALIZED SECTION A–A'




Legend:

Approximate Tailings Discharge Location

Note: Based on drawings by Cominco Ltd.

Scale 1:20,000 (approximate)

0 200 400 800 1200 m

meters

Scales

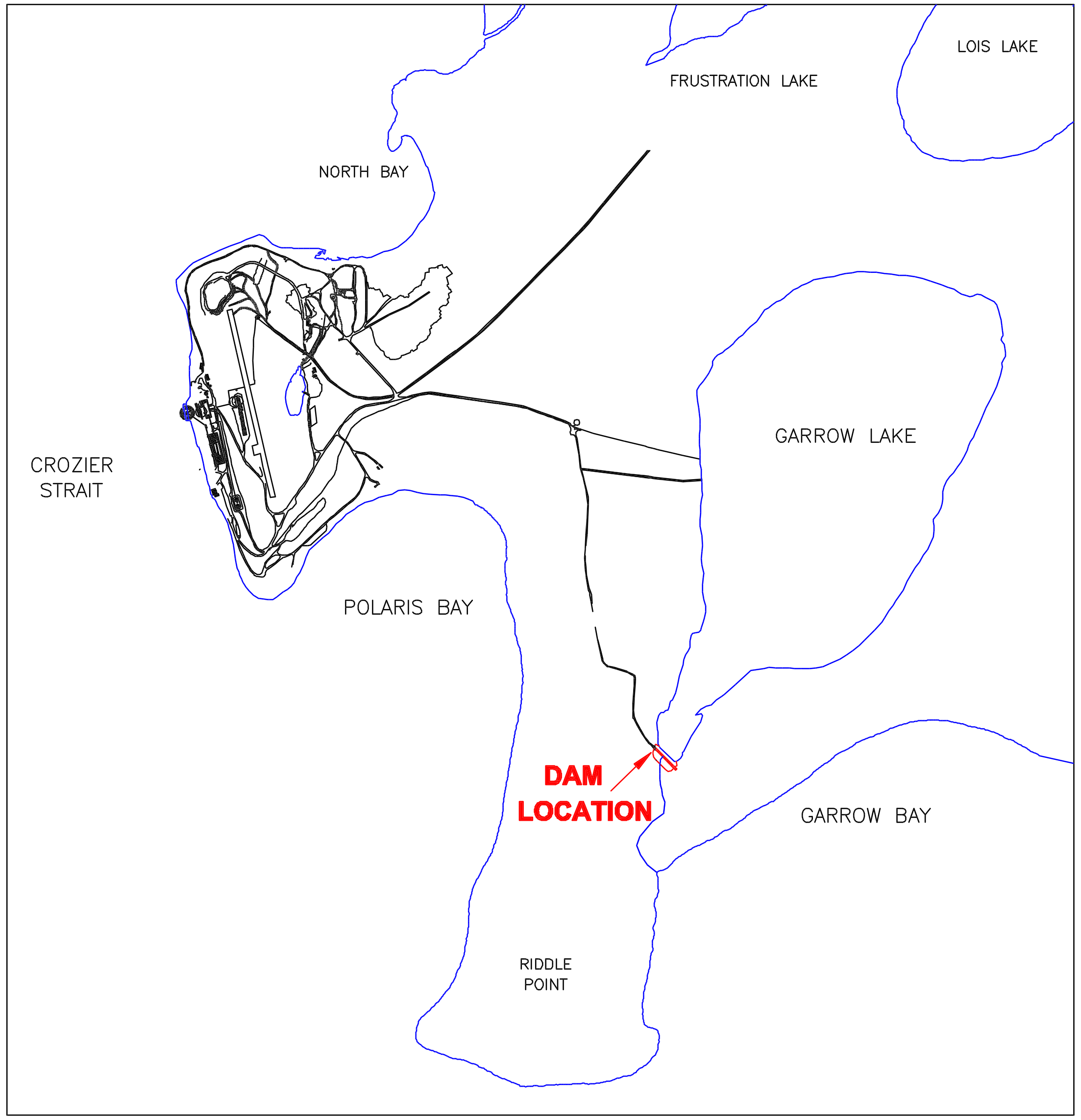
| | |
|---|---|
| Designed By: AJK | Drawn By: D.L./CPW |
| Checked By: AJK | Approved By: AJK |
| Date Issued: FEBRUARY 15, 2001 | Project No. 20–935 |
| Site Name: Polaris Mine | File Name: 20935–F2–06.DWG |

Cominco Ltd.
Polaris Mine
Decommissioning & Reclamation Plan

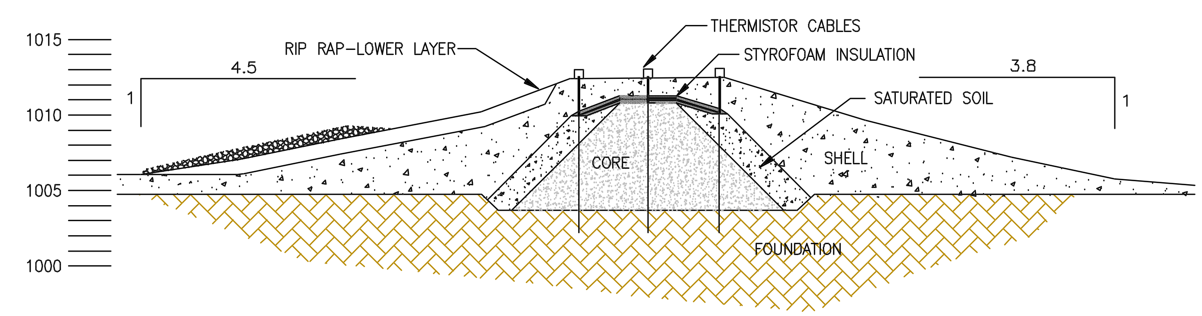
Garrow Lake
Tailings Discharge Locations
and Idealized Section

Gartner Lee Limited

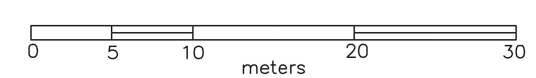
Drawing No.
13



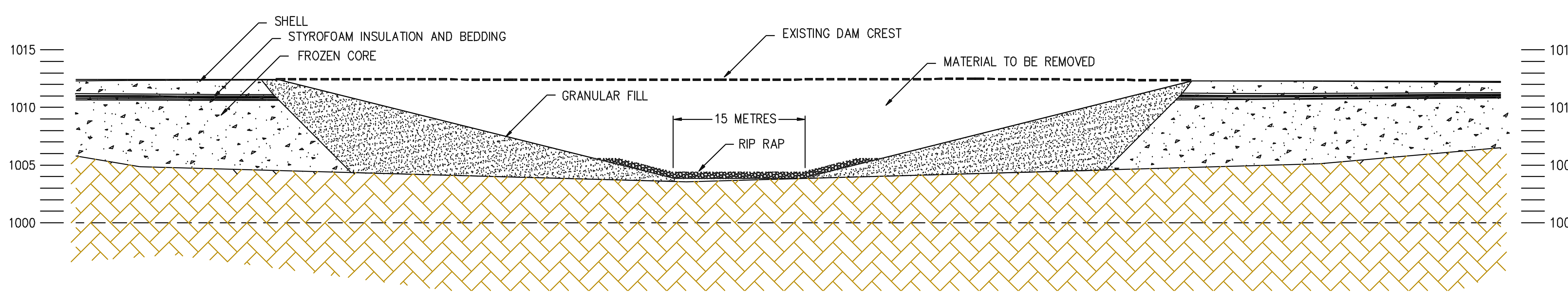

Key Plan
1:50,000 (approximately)



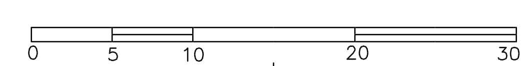

Dam Cross–section




1:500 (approximately)




Decommissioned Dam Longitudinal Section




1:500 (approximately)

Note: Based on drawings by EBA Engineering Ltd., September 2000

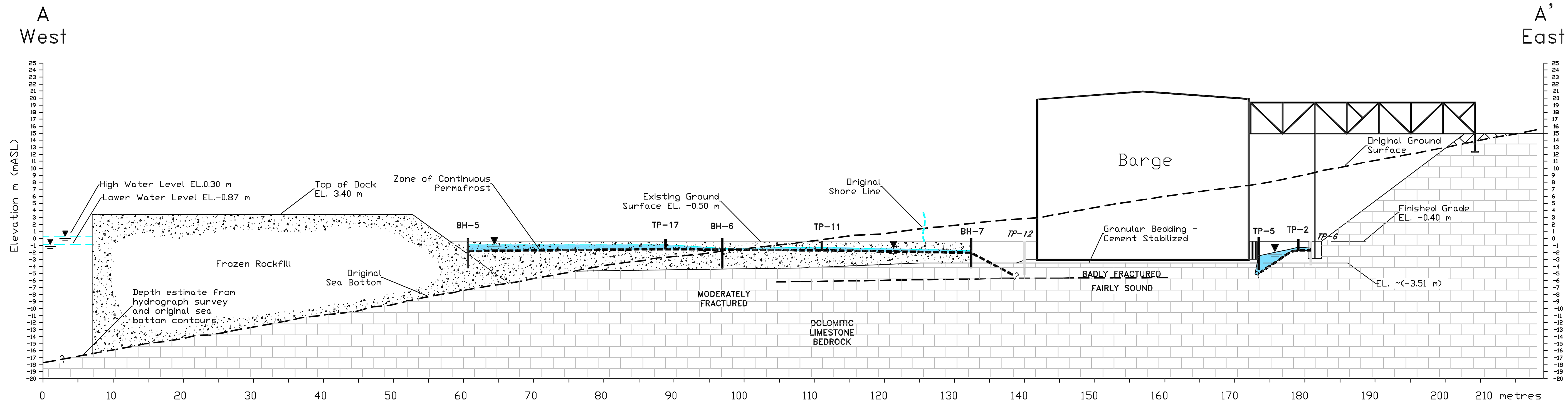
| | |
|---|---|
| Designed By: FKP | Drawn By: FKP/CPW |
| Checked By: AJK | Approved By: AJK |
| Date Issued: FEBRUARY 15, 2001 | Project No. 20–935 |
| Site Name: POLARIS | File Name: 20935–F2–07.DWG |

Cominco Ltd.
Polaris Mine
Decommissioning & Reclamation Plan

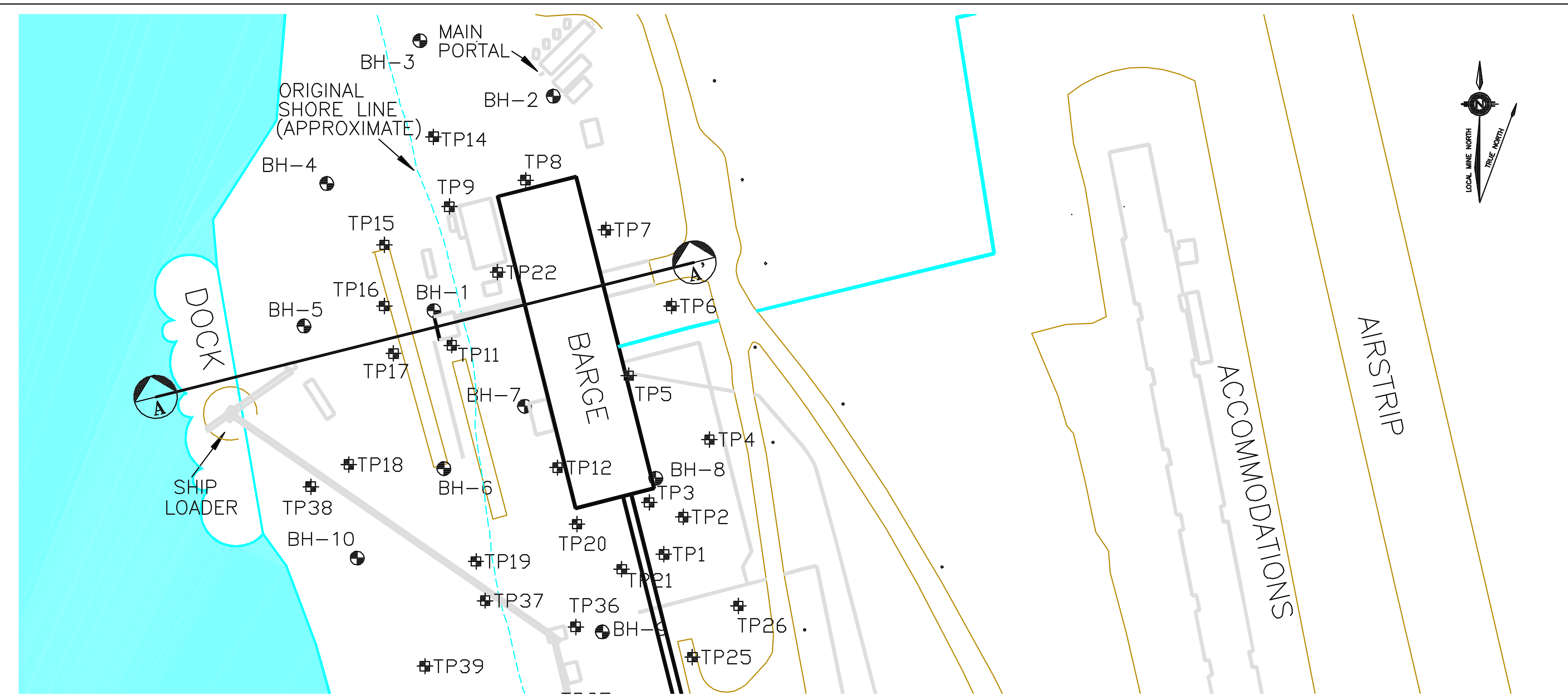
Garrow Dam
Decommissioning Design

Gartner Lee

Drawing No. 14




Scale 1:600 (approximate)




0 25 50 100 Metres

SCALE 1:2,500

NOTES:
1. Cross–section produced from drawing 110–C–116, Bechtel Canada Ltd., Cominco Ltd.
2. Water in test pits represents seasonal melt, measured July 11–16 1999.
3. Boreholes and test pits are projected along cross section line.
4. Elevations are in metres, mean above sea level (mASL).
5. Stratigraphic information adapted from Figure 8 Concentrator–Section, Golder 1980.

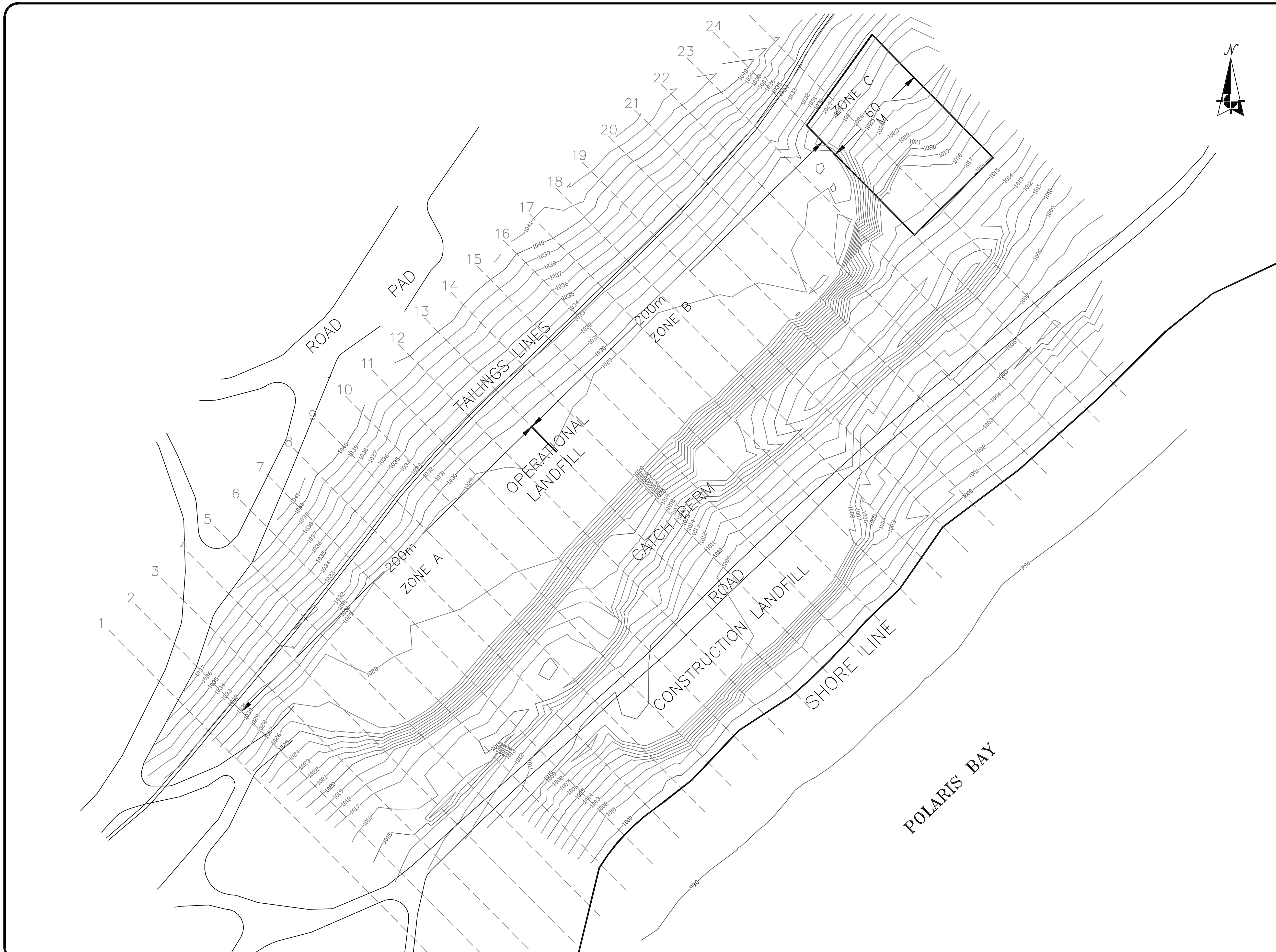
| | |
|---|---|
| Designed By: D.L./AJK | Drawn By: D.L./CPW |
| Checked By: AJK | Approved By: AJK |
| Date Issued: March 21, 2001 | Project No. 20–935 |
| Site Name: POLARIS MINE | File Name: 20935–F2–15.DWG |

Cominco
Cominco Ltd.
Polaris Mine
Decommissioning & Reclamation Plan

**Plan and Section of Barge and Dock**

Gartner Lee Limited

Drawing No. 15




LEGEND

CONTOUR, INDEX

CONTOUR, INTERMEDIATE

REFERENCE GRID LINE

SCALE 1:2000
metres

0 10 20 30 40 50 100

Contour interval one metre

| | |
|---|---|
| REVIEWED BY: | PJM, HC, AJK |
| DRAWN BY: | BB/CPW |
| DATE ISSUED: | MARCH 21, 2001 |
| PROJECT NUMBER: | 20-935 |
| FILE NAME: | 20935-F2-11.DWG |
| REVISION: | 0 |

Cominco

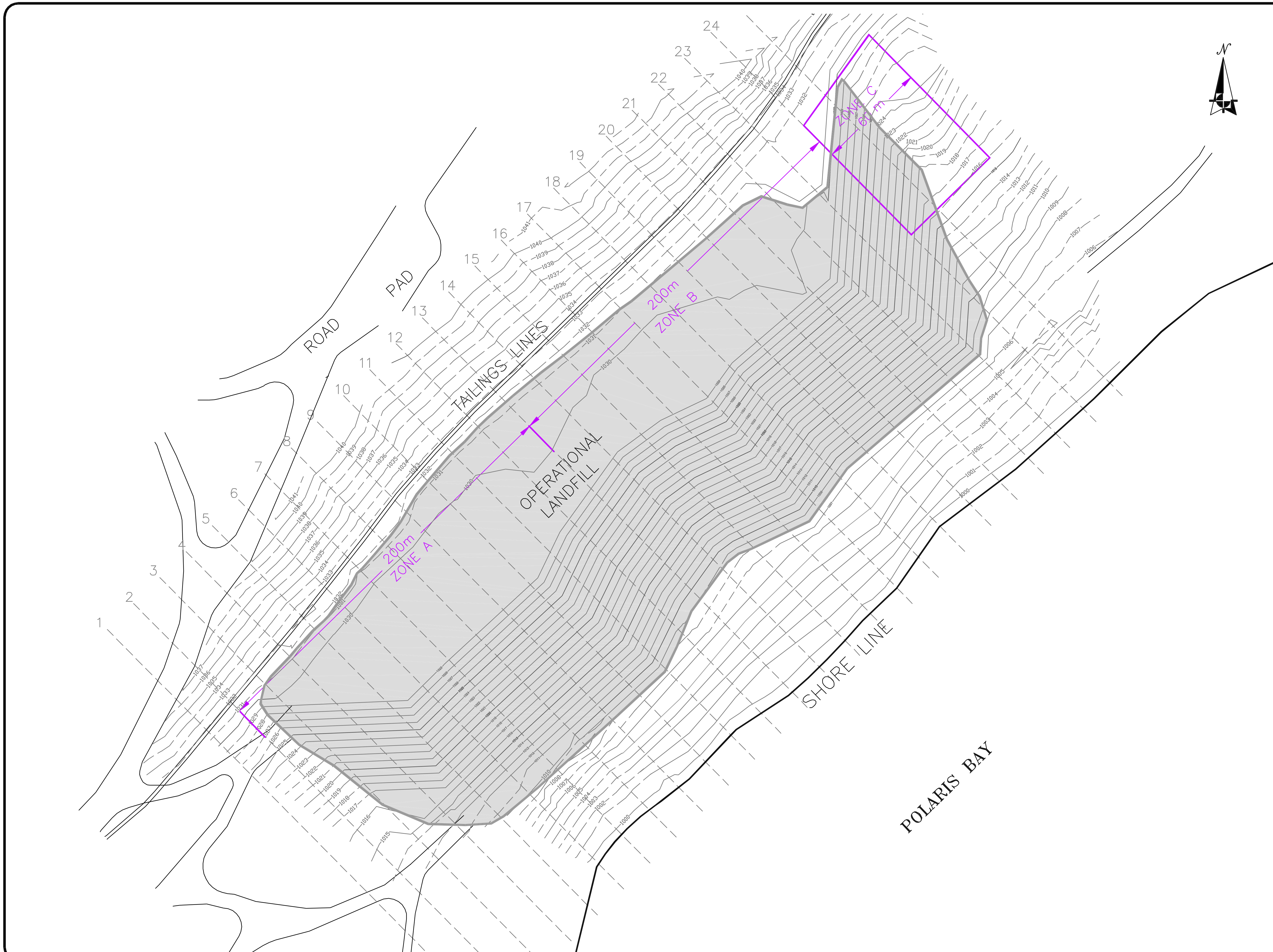
Cominco Ltd.
Polaris Mine

Decommissioning & Reclamation Plan

Operational and Construction Landfill Existing Contours

Gartner Lee Limited

Figure No. 16




LEGEND

CONTOUR, INDEX

CONTOUR, INTERMEDIATE

REFERENCE GRID LINE

AREAL EXTENT OF FINAL COVER
AREA=64409 sq.m.

SCALE 1:2000
metres

0 10 20 30 40 50 100

Contour interval one metre

| DRAWING INFORMATION |
|---|
| DESIGNED BY: |
| REVIEWED BY: PJM, HC |
| DRAWN BY: BB/CPW |
| DATE ISSUED: MARCH 21, 2001 |
| PROJECT NUMBER: 20–935 |
| FILE NAME: 20935–F2–12.DWG |
| REVISION: 1 |

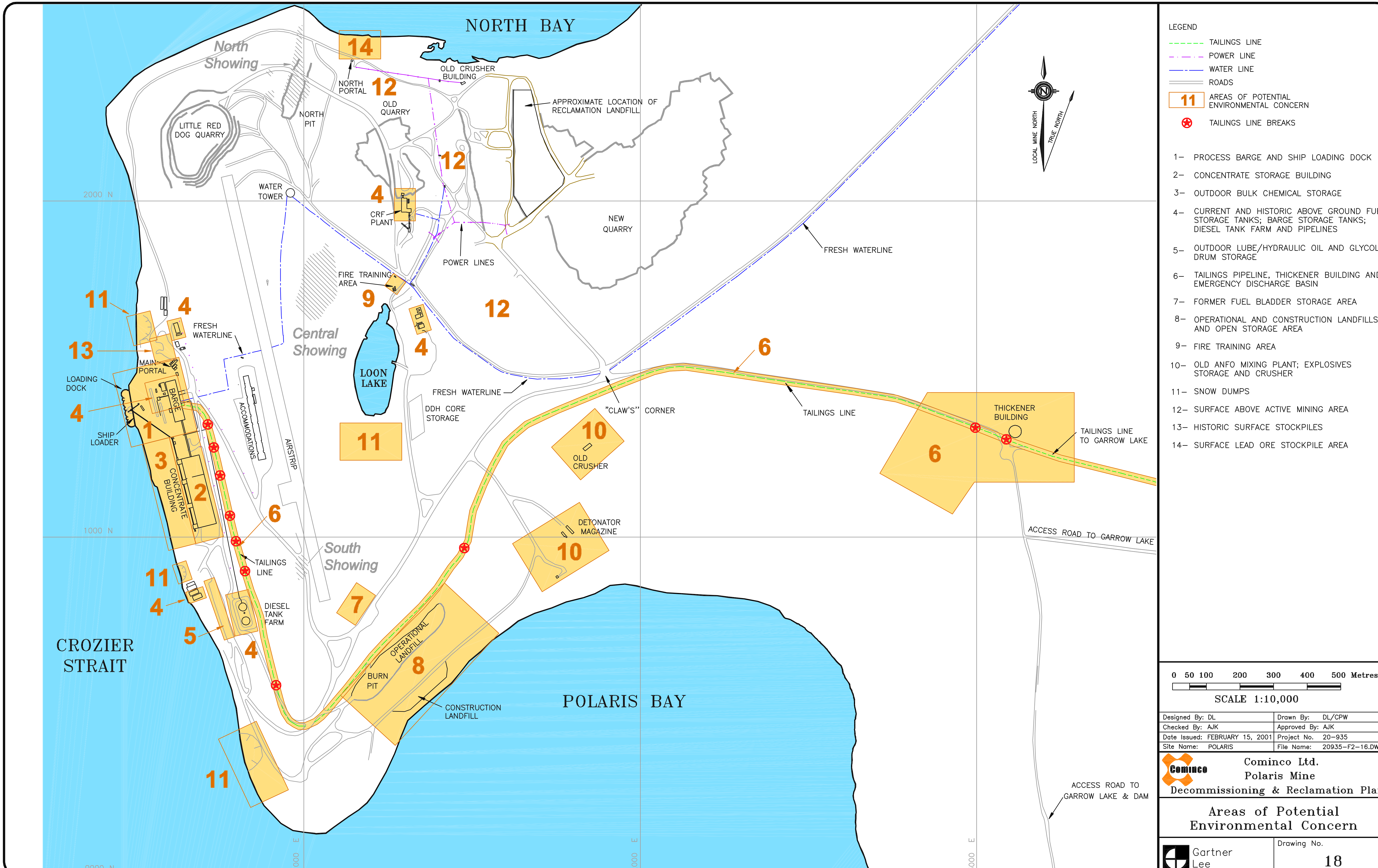
Cominco

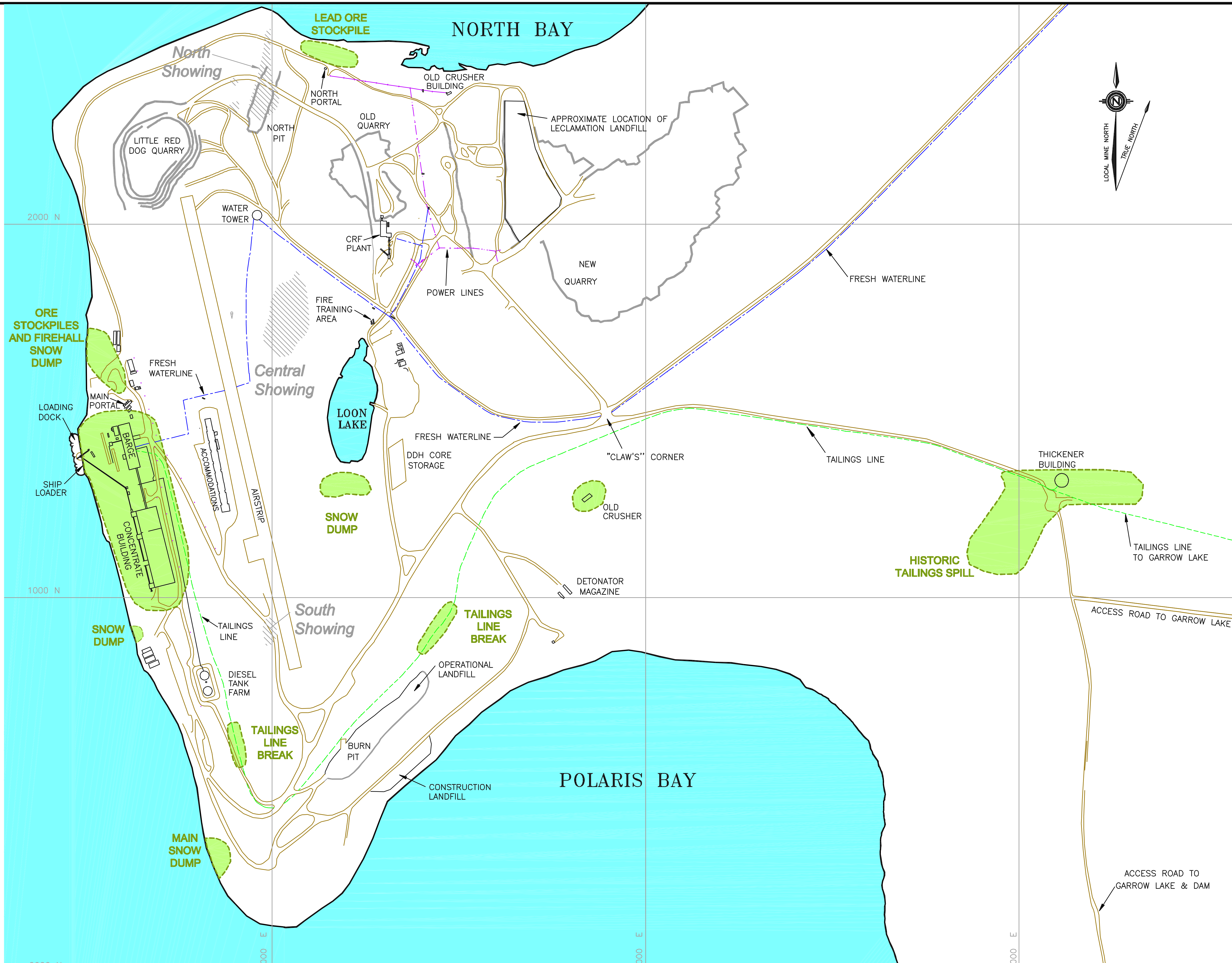
Cominco Ltd.
Polaris Mine
Decommissioning & Reclamation Plan

Operational and Construction
Landfill Proposed Final Contours

Gartner Lee Limited

Figure No.
17


NORTH BAY
POLARIS BAY
CROZIER STRAIT
North Showing
Central Showing
South Showing
LITTLE RED DOG QUARRY
NORTH PIT
NORTH PORTAL
OLD QUARRY
OLD CRUSHER BUILDING
APPROXIMATE LOCATION OF RECLAMATION LANDFILL
WATER TOWER
CRF PLANT
POWER LINES
NEW QUARRY
FRESH WATERLINE
FIRE TRAINING AREA
LOON LAKE
FRESH WATERLINE
MAIN PORTAL
LOADING DOCK
SHIP LOADER
BARGE
CONCENTRATE BUILDING
ACCOMMODATIONS
AIRSTRIP
DDH CORE STORAGE
"CLAW'S" CORNER
TAILINGS LINE
THICKENER BUILDING
TAILINGS LINE TO GARROW LAKE
OLD CRUSHER
DETONATOR MAGAZINE
ACCESS ROAD TO GARROW LAKE
TAILINGS LINE
DIESEL TANK FARM
OPERATIONAL LANDFILL
BURN PIT
CONSTRUCTION LANDFILL
ACCESS ROAD TO GARROW LAKE & DAM
LOCAL MINE NORTH
TRUE NORTH
2000 N
1000 N
0000 N
1000 E
2000 E
3000 E
14
12
12
4
4
9
12
4
11
13
4
1
3
2
6
11
4
5
4
7
8
10
10
6
6
11
LEGEND
TAILINGS LINE
POWER LINE
WATER LINE
ROADS
11 AREAS OF POTENTIAL ENVIRONMENTAL CONCERN
TAILINGS LINE BREAKS
1– PROCESS BARGE AND SHIP LOADING DOCK
2– CONCENTRATE STORAGE BUILDING
3– OUTDOOR BULK CHEMICAL STORAGE
4– CURRENT AND HISTORIC ABOVE GROUND FUEL STORAGE TANKS; BARGE STORAGE TANKS; DIESEL TANK FARM AND PIPELINES
5– OUTDOOR LUBE/HYDRAULIC OIL AND GLYCOL DRUM STORAGE
6– TAILINGS PIPELINE, THICKENER BUILDING AND EMERGENCY DISCHARGE BASIN
7– FORMER FUEL BLADDER STORAGE AREA
8– OPERATIONAL AND CONSTRUCTION LANDFILLS AND OPEN STORAGE AREA
9– FIRE TRAINING AREA
10– OLD ANFO MIXING PLANT; EXPLOSIVES STORAGE AND CRUSHER
11– SNOW DUMPS
12– SURFACE ABOVE ACTIVE MINING AREA
13– HISTORIC SURFACE STOCKPILES
14– SURFACE LEAD ORE STOCKPILE AREA
0 50 100 200 300 400 500 Metres
SCALE 1:10,000
Designed By: DL
Drawn By: DL/CPW
Checked By: AJK
Approved By: AJK
Date Issued: FEBRUARY 15, 2001
Project No. 20–935
Site Name: POLARIS
File Name: 20935–F2–16.DWG
Cominco
Cominco Ltd.
Polaris Mine
Decommissioning & Reclamation Plan
Areas of Potential Environmental Concern
Gartner Lee
Drawing No.
18




LEGEND

- TAILINGS LINE
- POWER LINE
- WATER LINE
- ROADS
- AREAS CONTAINING LEVELS OF LEAD AND ZINC THAT EXCEED THE FEDERAL RISK BASED REMEDIAL OBJECTIVES

0 50 100 200 300 400 500 Metres

SCALE 1:10,000

| | |
|---|---|
| Designed By: DL/EG | Drawn By: DL/CPW |
| Checked By: AJK | Approved By: AJK |
| Date Issued: FEBRUARY 15, 2001 | Project No. 20-935 |
| Site Name: POLARIS | File Name: 20935-F2-17.DWG |

Cominco

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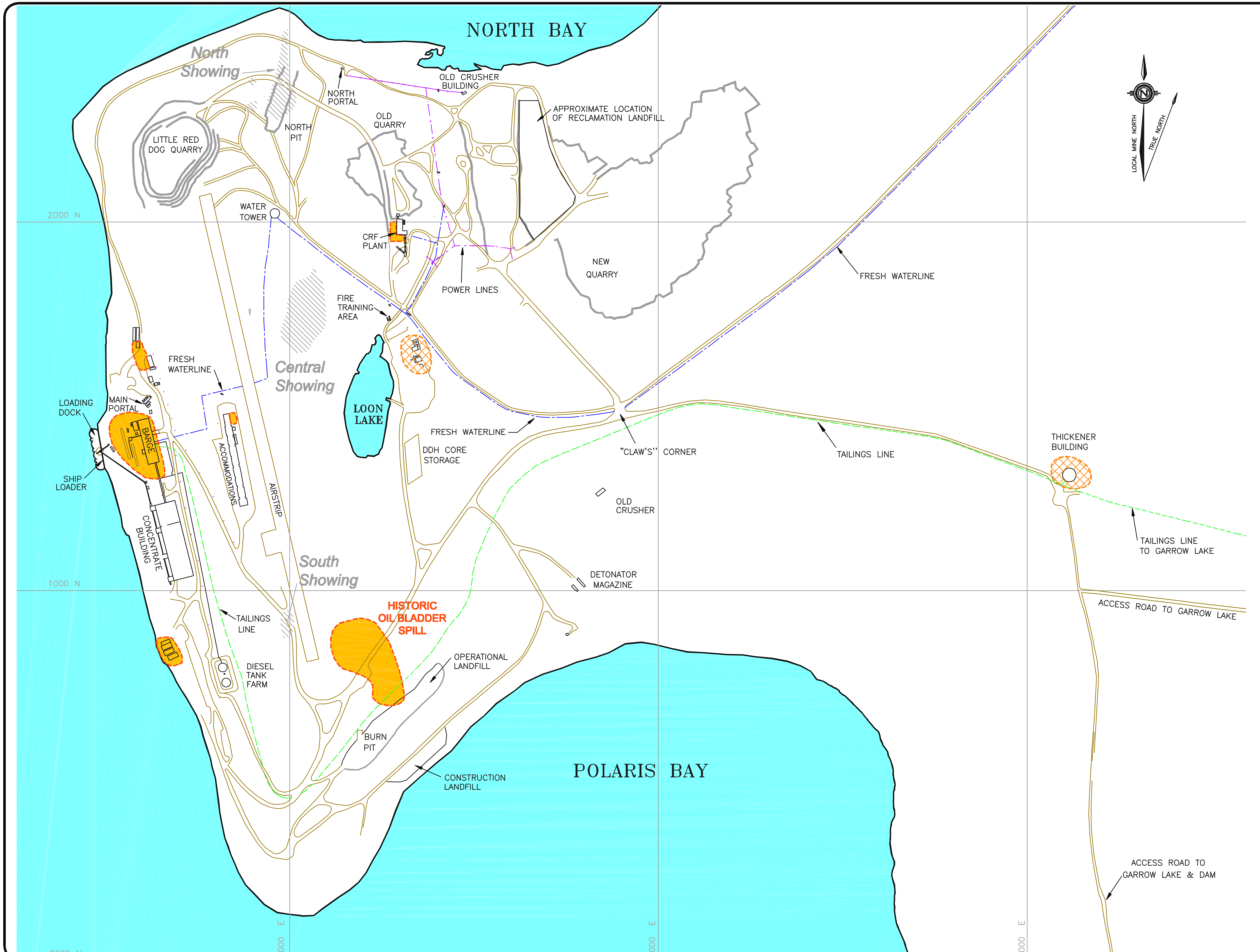
Polaris Mine
Decommissioning & Reclamation Plan

Targeted Areas for Remediation
Areas Containing Elevated
Levels of Lead & Zinc

Gartner Lee

Drawing No. 19




LEGEND

- TAILINGS LINE
- POWER LINE
- WATER LINE
- ROADS
- AREAS CONTAINING PETROLEUM HYDROCARBON RESIDUALS THAT EXCEED REGULATORY GUIDELINES/STANDARDS FOR PARK LAND USE
- SUSPECT LOCATION – SURFACE STAINING OBSERVED

0 50 100 200 300 400 500 Metres

SCALE 1:10,000

| | |
|---|---|
| Designed By: DL/EG | Drawn By: DL/CPW |
| Checked By: AJK | Approved By: AJK |
| Date Issued: FEBRUARY 15, 2001 | Project No. 20-935 |
| Site Name: POLARIS | File Name: 20935-F2-18.DWG |

Cominco

Cominco Ltd.
Polaris Mine
Decommissioning & Reclamation Plan

Targeted Areas for Remediation
Areas Containing
Petroleum Hydrocarbon Residuals

Gartner Lee

Drawing No. 20