Bruce J. Donald
Reclamation Manager

June 14, 2004

Department of Indian Affairs and Northern Development
Box 100
Iqaluit, NU X0A 0H0
Attention: Carl McLean, Manager, Land Administration

Nunavut Water Board
Box 119
Gjoa Haven, NU X0B 0H0
Attention: Phyllis Beaulieu, Licensing Administrator

Dear Carl and Phyllis;

Re: Polaris Decommissioning and Reclamation Plan – Submission of Landfill Cover Cap Design for Little Red Dog Quarry

Attached please find two copies of the Little Red Dog Quarry Landfill ("LRDQL") cover cap design drawings and specifications. I have also attached two copies of a geothermal review of the LRDQL cap design by Bruce Geotechnical Inc. as the LRDQL cap is constructed with limestone/dolomite rather than the shale from the New Quarry.

The design for this cap is much simpler than the Operational Landfill due to the fact that we are capping a landfill located in a pit so there is only the top surface that needs to be covered. The both the sides and bottom of the landfill are within the pit walls of the Little Red Dog Limestone Quarry. As the cap has a relatively flat slope, erosion of the cap is not a concern. Once construction of the cap is complete, we will be installing thermistors that have several sensors within the cover cap layer so that the performance of the cap can be monitored. The thermistors will extend far enough into the landfill to ensure that temperatures are monitored beyond the depth where seasonal temperature fluctuations occur.

If you have any question please contact me at any time. I will be traveling to a number of our sites for much of the next two months so email is the best method of contacting me in a timely manner.

Yours truly,

Bruce Donald

Attachments: 2 Sets each of LRDQL cover Cap Design Drawings & Specifications (GLL), and Polaris LRD Landfill Cover Technical Memorandum (BGC)

Cc: Bob Hutchinson (Teck Cominco)
John Less (Cascade Management)
Joe Dahoy (Teck Cominco)

Teck Cominco Limited / Environment and Corporate Affairs
Bag 2000/Kimberley, British Columbia, Canada V1A 3E1 · Tel: 250-427-8405 · Fax: 250-427-8451 · Email: bruce.donald@teckcominco.com

Gartner Lee Limited

memorandum

to: Mr. Bruce Donald, Teck Cominco
from: Paul Manley
date: May 7, 2004
ref: 40080
re: **Polaris Project – Little Red Dog Quarry Specifications for Landfill Final Cover**

I. General

1. The final cover for the Little Red Dog Quarry shall be a minimum of 1.8 m thick above the waste, as shown on Drawings 40080-1D-1 and 40080-1D-2.
2. The final cover should be comprised of Type A material, which may consist of limestone or limestone-dolomite. The rip rap berm above the final cover shall consist of Type B material. Refer to Section II for the type A and B material specifications.
3. The top of the waste surface shown on Drawing 40080-1D-2 has been estimated. The location of the final cover shall be adjusted in the field to suit the top of the waste (the final cover may have to be raised or lowered depending on the top of the waste). The slope of the top of the final cover shall have a minimum slope of 2% to the northwest.
4. Prior to placement of the final cover, the surface of the waste material shall be graded to a uniform 2% slope. The surface shall be proof rolled to identify any areas which exhibit noticeably higher deformation. These areas should be sub-excavated, backfilled with soil, and rolled until a surface with uniform deformation under heavy equipment passage is observed. Cover material can then be placed.
5. In order to verify the thickness of cover material placed, a survey of the top of the waste surface shall be completed prior to placement of any final cover material, after completion of each lift of cover material, and after completion of construction of the final cover. Survey points should be completed at a maximum grid spacing of 25 m.
6. Five pipes for the future installation of thermistors have been installed within the quarry as shown on Drawing 40080-1D-1. These pipes shall be extended upwards through the final cover and shall be fitted with a cap plate flush with the final surface. Final cover material shall be carefully placed around these pipe to avoid damaging or bending the pipes. The thermistor strings shall not be installed until the final cover has been constructed and accepted by the Owner.

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www.gartnerlee.com

II. Material Specifications

1. The final cover for the Little Red Dog Quarry Landfill shall consist of a single monolithic layer of material as defined in Schedule 1, and shall be placed in lifts as specified in Section III.

Table 1. Schedule 1 – Material Specifications for Little Red Dog Quarry Cover

Item	Material Type	Grain Size Distribution
Final Cover	Type A: Limestone or limestone-dolomite	Well-graded sand, gravel and cobbles Maximum particle size 300 mm Maximum 10% passing US sieve #200
Rip Rap	Type B: Limestone	Well-graded cobble and boulder sized angular particles Maximum particle size 450 mm Minimum particle size 75 mm

III. Placement and Compaction

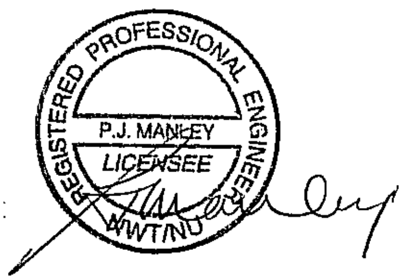
1. Type A material shall be placed, spread and compacted three lifts of equal thickness to achieve the specified minimum thickness of 1.8 m.
2. Placement of the final cover material (Type A) shall be completed such that void spaces are not created. Where void spaces are created (e.g. collection of large particles placed together), they should be removed by breaking of the large particles, regrading, excavating or other means necessary before compacting.
3. After spreading, each lift shall be compacted with a minimum of 4 passes of the equipment (Caterpillar D8 or equivalent). The area compacted shall be 100% of each lift. Each successive pass of the compaction equipment shall be completed perpendicular to the previous pass. Alternative means of compaction by 30 tons haul trucks is permissible provided that uniform coverage is achieved, subject to approval by the Engineer.
4. Placement of successive lifts may not commence in any area until adequate compaction is completed on the lower lift in that area.

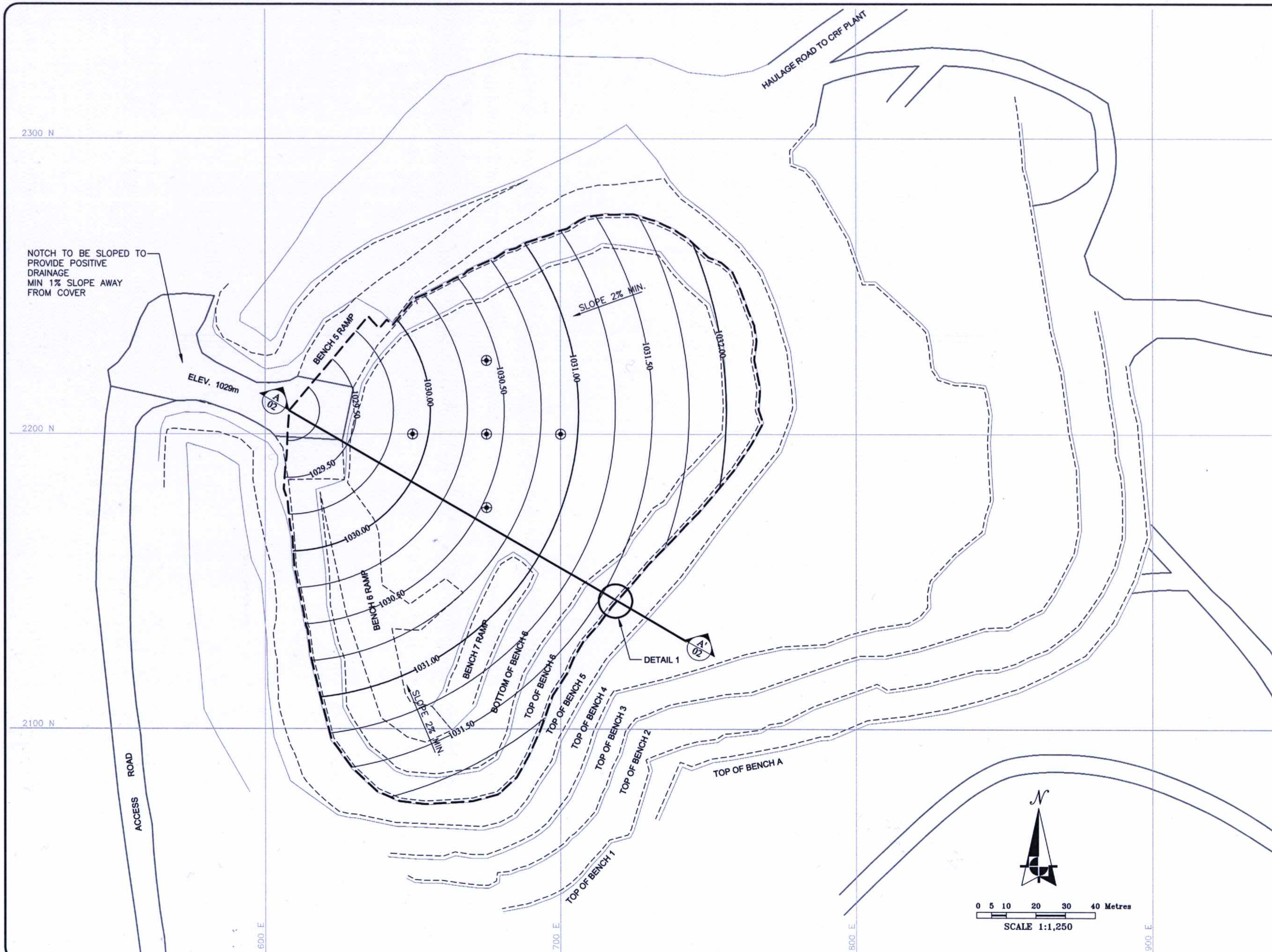
IV. Quality Control and Testing

1. Prior to placement of any Type A cover material, a grain size analysis shall be completed on 3 three representative samples of the material to ensure compliance with the material specifications. Additional tests should be completed at a frequency of one per 10,000 cubic metres of material placed.

2. The surveys prior and after placement of final cover shall include sufficient points (elevation shots and horizontal control) to ensure the minimum cover thickness is achieved for the Little Red Dog Quarry Landfill cover. The survey points should have an elevation accuracy of +/- 0.05 m. The total cover thickness at each point shall be calculated by subtracting the original elevation (after regrading the waste) from the final elevation. If the total thickness of the cover is calculated to be less than 1.80 m, then additional Type A material shall be placed on the cover to meet the required 1.80 m thickness. The placement of the additional material shall extend to the nearest point that meets the required thickness. New elevation shots are required until the minimum 1.80 m cover thickness is met at all survey locations. The survey results are to be approved by the Owner before installation of the thermistor strings.

3. Plate load tests should be completed on each lift to verify that adequate compaction has been achieved. The plate load tests should be completed at a frequency of one test for every 5,000 square metres. A minimum 25 mm thick, round steel plate with an area of 0.0929 square metres (1 square foot) (diameter of plate = 0.344 m) shall be placed on the surface of the compacted cover material. The edge of the plate should be flat not rounded. Prior to starting the test, the surface of the test location (over an area with a diameter of 0.6 m) shall be groomed smooth using the steel plate. The plate will be plced in the centre of the groomed area. A force of 13.3 kN (3,000 lbs) shall be applied in a uniform manner to the plate in a manner that the load reaches the soil as a static load, without impact, fluctuation or eccentricity. The load shall be applied for a period of 5 minutes. The plate shall be removed without disturbing the soil around the edge of the plate. The displacement of the soil shall be measured at four equidistant locations along the edge of the test area to the nearest 1 mm. All four displacement measurements at each test location should be recorded as well as the average displacement. The average displacement shall not exceed 10.0 mm for any test. For each test location, the following information shall be recorded: date, time, material type, lift number, location (co-ordinates or shown on a plan drawing), applied load, the four displacement measurements, the average displacement, pass/fail compaction requirement. If a plate load test fails, the area between passing plate load tests should be recompacted and retested until the compaction standard is achieved. All test results are to be forwarded to the Owner for review and approval after each lift is tested and before subsequent lifts are placed.





LEGEND:

- ROAD
- TOP OF BENCH
- TOE OF BENCH
- EDGE OF COVER
- TOP OF COVER MAJOR CONTOUR 1.0m
- EXISTING PIPES FOR FUTURE INSTALLATION OF THERMISTORS UPON COMPLETION OF COVER

REGISTERED PROFESSIONAL ENGINEER
P.J. MANLEY
LICENSEE
NWT/NU
4/10/04

NOTES:

REFER TO DRAWING 40080-1D-02REV1 FOR SECTION A-A' AND DETAIL

DRAWING TO BE READ IN CONJUNCTION WITH THE SPECIFICATION

SOURCE OF DRAWING:

-BASE PLAN SUPPLIED BY TECK COMINCO
-SURVEY BY SNC LAVALIN, APRIL 2004

COORDINATES ARE LOCAL MINE GRID
ELEVATIONS ARE CHART DATUM + 1000m

DRAWING INFORMATION:

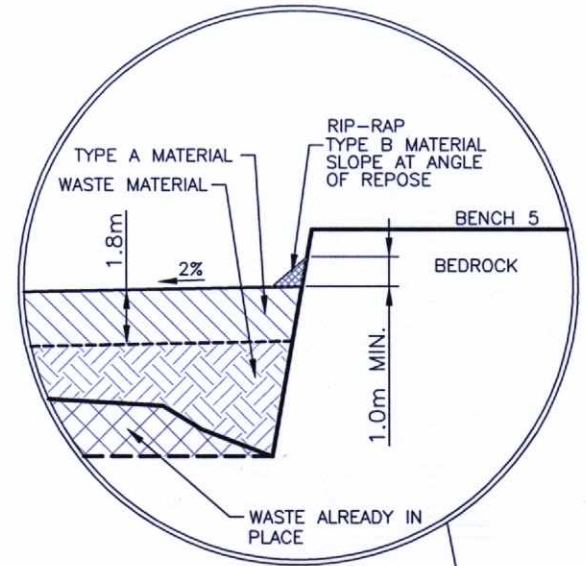
DESIGNED BY:	AK/HC
REVIEWED BY:	PM
DRAWN BY:	CCL/CPW
DATE ISSUED:	MAY, 2004
PROJECT NUMBER:	40-080
FILE NAME:	40080-1D-01REV1.DWG
REVISION:	1

LITTLE RED DOG QUARRY LANDFILL
POLARIS MINE
TECK COMINCO

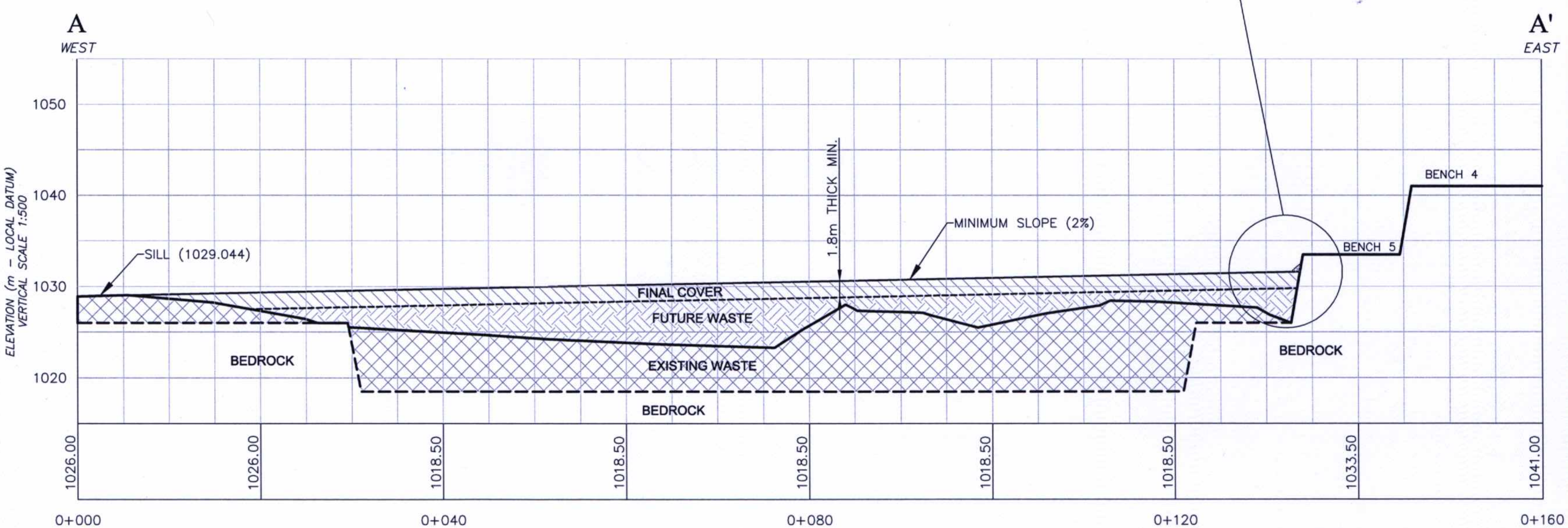
PROPOSED FINAL LANDFILL COVER

Gartner Lee

Drawing No.
40080-1D-01-REV1



DETAIL 1
1:250



SECTION A-A'
H: 1:500

LEGEND:

- EXISTING QUARRY SURFACE
- BEDROCK
- FUTURE TOP OF WASTE
- FINAL COVER - TYPE A MATERIAL LIMESTONE OR LIMESTONE-DOLOMITE GRAIN SIZE MAX. 300mm SAND, GRAVEL AND COBBLES
- RIP-RAP - TYPE B MATERIAL GRAIN SIZE 75-450mm LIMESTONE COBBLES AND BOULDERS
- FUTURE WASTE DEMOLITION DEBRIS
- WASTE MATERIAL ALREADY IN PLACE

REGISTERED PROFESSIONAL ENGINEERS
P.J. MANLEY
LICENSEE
NWT/NU
4/10/04

NOTES:

REFER TO DRAWING 40080-1D-01REV1 FOR LOCATION OF SECTION AND DETAIL

DRAWING TO BE READ IN CONJUNCTION WITH SPECIFICATION

SOURCES OF DRAWING:

-BASE PLAN SUPPLIED BY TECK COMINCO
-SURVEY BY SNC LAVALIN, APRIL 2004

COORDINATES ARE LOCAL MINE GRID
ELEVATIONS ARE CHART DATUM + 1000m

DRAWING INFORMATION:	
DESIGNED BY:	AK/HC
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REVISION:	1

LITTLE RED DOG QUARRY LANDFILL
POLARIS MINE
TECK COMINCO

SECTION A-A' AND DETAIL

Gartner Lee

Drawing No. 40080-1D-02-REV1

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Suite 500 - 1045 Howe Street, Vancouver, British Columbia, Canada. V6Z 2A9
Phone (604) 684-5900 Fax (604) 684-5909

BGC Project Memorandum

To:	**Gartner Lee Ltd.**	**Fax No.:**	**Sent via email**
Attention:	**Alistair Kent**	**CC:**	**B. Donald, Cominco**
From:	**Michael Porter (Ext. 123)**	**Date:**	**March 30, 2004**
Subject:	**Polaris LRD Landfill Cover**		
No. of Pages (including this page): 7 Pages		**Project No:**	**0168-006-08**

Mr. Kent:

Introduction

BGC Engineering Inc. (BGC) was retained by Gartner Lee Limited (GLL) and Cominco Ltd. to conduct geothermal analysis for the Little Red Dog (LRD) landfill, located at the Polaris Mine, Nunavut. The objective of the analysis was to determine the required cover thickness to keep the underlying waste materials in a frozen state. Cover material is expected to comprise blasted limestone available from a nearby quarry. The propose scope of work was outlined in a BGC proposal dated March 19, 2004.

Background

BGC previously conducted geothermal analyses for closure design of the operating landfill at the Polaris Mine (BGC 2000; BGC 2001). The landfill cover material was expected to comprise a compacted gravel derived from shale. One-dimensional geothermal analyses were conducted to calibrate the geothermal properties of in-situ materials and assumed climate conditions based on available thermistor data for the operating landfill. Active layer thicknesses were predicted for a shale gravel cover material under a range of potential climate warming scenarios. Model predictions were as follows:

Table 1: Active Layer Thickness in a Shale Gravel Cover (BGC 2001)

Scenario	Current Condition	Climate Warming Best Estimate	Climate Warming High Estimate
	No warming	2.9°C/100 years	5.0°C/100 years
Active Layer for Thin Snow Cover	1.36 m	1.67 m	1.80 m

A description of assumptions used in the analyses can be found in our previous reports.

Proposed Cover Material for LRD Landfill

It is proposed to use a blasted limestone as cover material for the LRD landfill. The approximate material specification is as follows:

- Well graded material
- Max particle size = 300 mm
- < 10% fines content
- Compacted with a minimum of 4 passes of a D8 dozer or equivalent for each 600 mm lift

The main anticipated differences between a shale gravel (considered in previous analyses) and a coarse blasted limestone are that the limestone is expected to have a greater porosity, lower moisture content, and lower unfrozen water content. Because air has a lower thermal conductivity than mineral solids, the increase in porosity is expected to result in a lower thermal conductivity, and therefore a reduction in the active layer thickness. On the other hand, a reduction in moisture content will mean that less latent heat is available to retard the freezing and thawing processes. This will tend to increase the active layer thickness.

On the basis of literature review, empirical correlation using methods reported by Kersten (1949), Johansen (1975), and Smith and Tice (1988), and through model calibration, the following physical and thermal properties for the limestone cover material were estimated:

Table 2: Summary of Estimated Physical and Thermal Properties.

Unit Description	Thermal Conductivity (W/m°C)		A	B	Moisture Content (%)	Dry Density (g/cm^3)
	Thawed	Frozen				
Blasted Limestone[1]	1.4	1.2	0.02	-0.40	5	1.8
Shale Gravel[2]	2.46	2.89	0.05	-0.40	10	1.8
Fractured Shale[3]	2.2	2.8	0.05	-0.40	10	2.1
Shale Bedrock[4]	2.3	2.9	0.05	-0.30	10	2.1

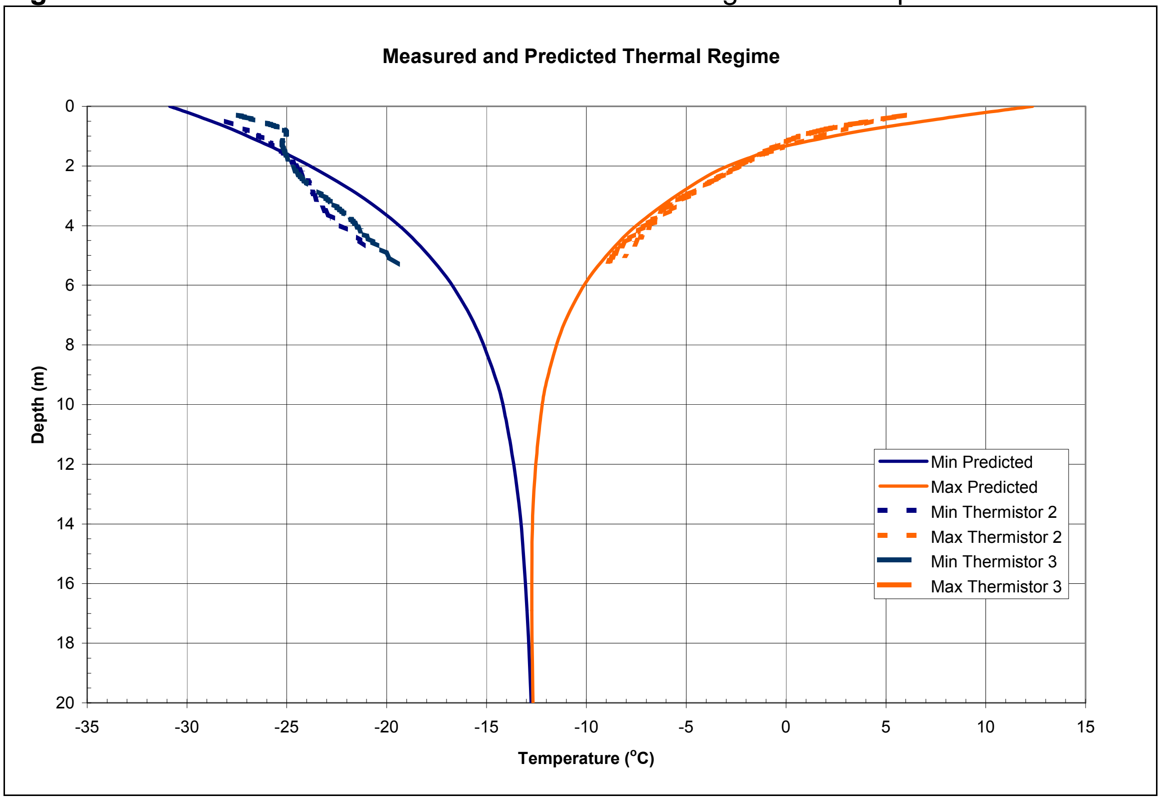
1 based on Johansen's (1975) method for coarse, crushed material with 5% moisture content and 31% porosity
2 based on empirical methods and BGC model calibration (BGC 2000; BGC 2001)
3 based on Johansen's (1975) method for coarse, crushed material with 10% moisture content and 23% porosity
4 based on Johansen's (1975) method for coarse, crushed material with 10% moisture content and 21% porosity

For reference, EBA (1988) estimated the dry density, thawed and frozen thermal conductivity for a granular shell on the Garrow Lake Dam at 1.8 g/cm^3, 1.23 W/m°C, and 1.0 W/m°C, respectively. Shell materials had a design gradation ranging from about 2 mm to 300 mm, and their properties are comparable with estimates for the coarse limestone cover materials.

Model Calibration

Cominco provided BGC with updated thermistor data for the operational landfill at the Polaris Mine. These indicated that previous estimates of thermal conductivity for the Fractured Shale and Shale units were too low. Revised thermal properties for these materials are presented in Table 2, and provide a better correlation between the predicted and measured ground thermal regime in the operational landfill (Figure 1). The model stratigraphy used for calibration comprised 1.1 m of Shale Gravel and 0.5 m of Fractured Shale overlying Shale Bedrock. Climate and other assumptions were the same as those used in BGC's previous analyses.

Figure 1: Predicted and Measured Ground Thermal Regime in the Operational Landfill



As shown in Figure 1, the updated thermal properties accurately predict the maximum ground temperatures, as measured by Thermistor String 2 and 3. The model appears to slightly under predict the minimum ground temperatures below 2 m depth, but is sufficiently accurate for the purpose of estimating active layer thickness, which is the main objective of this scope of work.

Predicted Active Layer Thickness Beneath a Limestone Cover

Following calibration, the model stratigraphy was revised within the THERM1 geothermal modelling software to include a blasted limestone cover.[1] Model stratigraphy comprised 1.5 m of Blasted Limestone, 1.1 m of Shale Gravel, and 0.5 m of Fractured Shale, overlying Shale Bedrock.

Assuming a "thin snow cover" (BGC 2001), three scenarios were evaluated: current conditions (the base case); climate warming of 2.9°C/100 years; and, warming of 5.0°C/100 years. Minimum and maximum predicted ground temperatures, and the thickness of the active layer were recorded. The predicted ground thermal regime for each scenario is illustrated in Figure 2. The predicted active layer thickness for each scenario is provided in Table 3.

[1] THERM1 is a commercially available, alternating direction explicit finite difference program that solves one-dimensional heat transfer problems involving freezing and thawing.

Figure 2: Predicted Ground Thermal Regime Beneath a 1.5 m Thick Limestone Cover

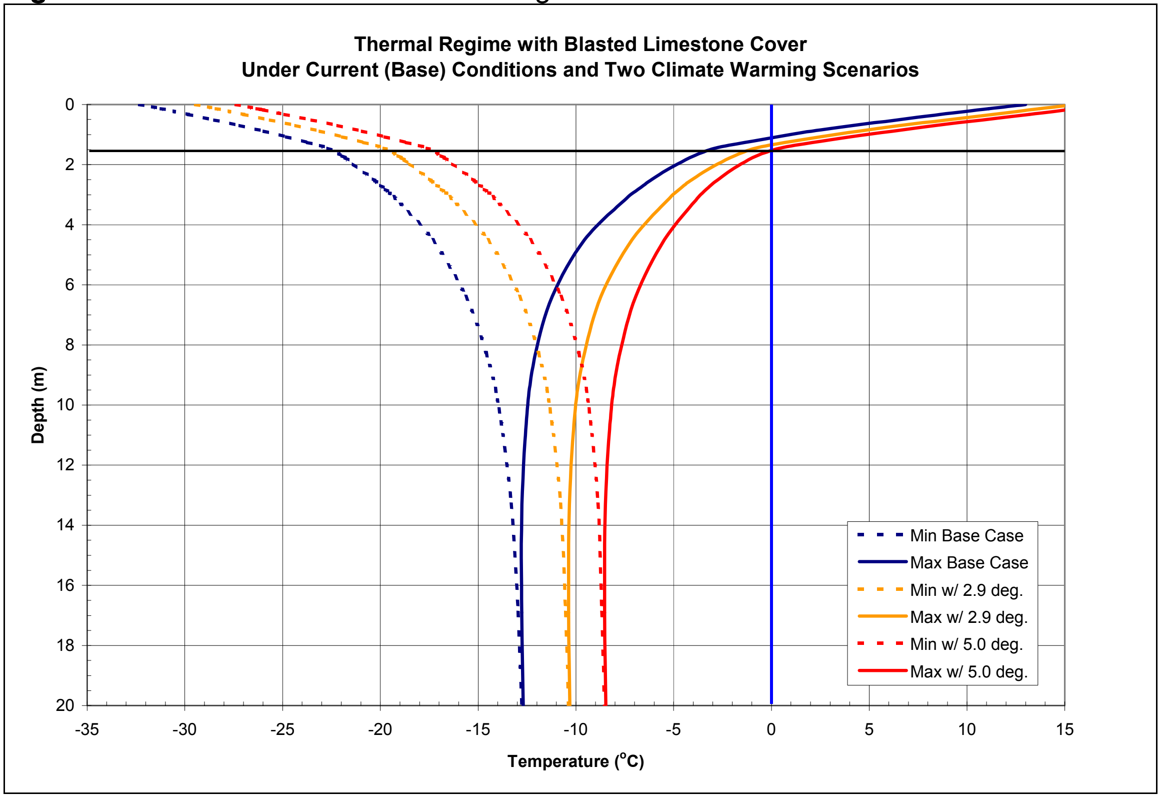


Table 3: Predicted Active Layer Thickness in a Blasted Limestone Cover

Scenario	Current Condition	Climate Warming Best Estimate	Climate Warming High Estimate
	No warming	2.9°C/100 years	5.0°C/100 years
Active Layer for Thin Snow Cover	1.11 m	1.35 m	1.53 m

Discussion

Coarse, blasted limestone with a relatively low moisture content and high air content is expected to exhibit a low thermal conductivity in comparison with compacted shale gravel. While a reduction in moisture content tends to increase active layer thickness, the low thermal conductivity appears to override this tendency in the scenario evaluated for the LRD landfill cover. The predicted active layer thickness is about 15 to 20% less for a blasted limestone cover than for a cover comprising compacted shale gravel.

Caution is required in extending these numerical predictions to field conditions. The equations on which the numerical formulation is based deal with heat conduction. As saturation levels fall, void ratios rise, and particularly as void spaces become larger, heat exchange is increasingly governed by convection rather than conduction. The design approach typically taken is to adjust the thermal conductivities and continue using heat conduction equations. There is evidence, however, that this approach has a long way to go to effectively simulate the behaviour of coarse soils and engineered fills.

For example, it is well known that active layer depths in coarse scree and talus, as well as in eskers, kames and elevated beach ridges are greater than the foregoing results would infer. On the other hand, very coarse, dry granular fills exhibit behaviour that suggests colder than expected operative temperatures. Under this scenario it is postulated that high porosity facilitates convective cooling during the winter when cold near-surface air densities become unstable and settle downward through the soil, thus imparting steady convective cooling (Goering and Kumar, 1996; Saboundjian and Goering, 2002). During the summer, the near-surface air is warmer than at depth, which is a stable condition that does not promote convection. These issues are much less prevalent for materials such as compacted shale gravel, as was used as cover material for the main operational landfill.

Until such time as the foregoing conduction-convection uncertainties are resolved, we recommend a conservative approach to cover design regardless of the numerical results we report above. Conservatism can be incorporated by applying an appropriate factor of safety to the predicted active layer thickness as part of the cover design evaluation.

The factor of safety chosen should reflect the uncertainty in the modelling, the consequences of the active layer depth predictions being exceeded, and the ability to monitor cover performance. Given the relatively low consequence should the active layer seasonally extend a few centimetres beneath the cover, and the provisions to install thermistors to monitor cover performance, a relatively small factor of safety of 1.3 to 1.5 may be appropriate. If these factors of safety are applied to the best-case climate-warming scenario, it results in a recommended blasted limestone cover thickness of 1.8 m to 2.0 m. If conditions conducive to moss growth at the surface of the cover can be incorporated in the design, it may be acceptable to use an even lower factor of safety. These details have not been considered thus far, but further work can be undertaken, if requested.

Closure

This memorandum was prepared by BGC Engineering Inc. (BGC) for the account of Gartner Lee Ltd. and Cominco Ltd. The material in it reflects the judgement of BGC staff in light of the information available to BGC at the time of memorandum preparation. Any use which a Third Party makes of this memorandum, or any reliance on decisions to be based on it are the responsibility of such Third Parties. BGC Engineering Inc. accepts no responsibility for damages, if any, suffered by any Third Party as a result of decisions made or actions based on this memorandum.

As a mutual protection to our client, the public, and ourselves, all reports and drawings are submitted for the confidential information of our client for a specific project, and authorization for use and / or publication of data, statements, conclusions, or abstracts from or regarding our reports and drawings is reserved pending our written approval.

We trust the information provided meets your current requirements. Please do not hesitate to contact us if you have any questions or comments, or if we may be of further assistance.

Sincerely,

BGC Engineering Inc.
Per:

Michael Porter, M.Eng., P.Eng.
Geological / Geotechnical Engineer

Dr. K. Wayne Savigny, P.Eng., P.Geol.
Vice President and Senior Engineer

References:

BGC Engineering Inc. 2001. Polaris Landfill Closure Report. Memorandum submitted to Gartner Lee Ltd., dated January 10, 2001.

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