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July 27, 2004

Indian and Northern Affairs Canada
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P.O. Box 100
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Attention: Mr. Spencer Dewar, Land Administrator Specialist

Re: NWB1POL0311- Polaris Decommissioning and Reclamation Plan- Submission on Landfill Cover Cap Design for Little Red Dog Quarry

Dear Sir:

As requested in your e-mail of July 16, 2004, I have reviewed the submissions prepared by Teck Cominco Limited (TCL), for the Landfill Cover Cap Design for the Little Red Dog (LRD) Quarry. The submission is composed of three parts:

- Covering letter by TCL summarizing the cover cap design, construction and monitoring, dated June 14, 2004.
- Specifications and drawings for the landfill cover prepared by Gartner Lee Limited (GLL), dated May 7, 2004.
- Design memorandum by BGC Engineering Inc, dated March 30, 2004, describing the geothermal analysis to determine the required cover thickness required to keep the underlying wastes in a frozen state.

It was agreed with INAC that my review would be limited to the first two parts of the submission to avoid any potential conflict of interest concerns. The BGC report was however read to gain an understanding of the design basis for the cover, so that a comparison could be made with the specifications and drawings prepared by GLL.

Design Basis- Thermal Analysis

The thermal analysis was conducted to predict the active layer thickness for the proposed blasted limestone cover for the LRD Quarry. The proposed material specification is as follows:

- Well graded material.
- Maximum particle size = 300 mm
- < 10% fines (material passing the #200 sieve, or finer than 0.08 mm).
- Compacted with a minimum of four passes of a D8 dozer or equivalent for each 600 mm lift.

BGC estimated the thermal and physical properties of the blasted limestone using data obtained from the literature. The estimated values were comparable to the properties obtained previously for similar materials that were used to construct the Garrow Lake Dam.

In addition, BGC used updated thermistor data from the Operational Landfill to revise the thermal properties of the fractured shale and shale bedrock units to provide a better correlation between the predicted and measured ground thermal regime in the Operational Landfill. The model stratigraphy used comprised 1.1 m of shale gravel and 0.5 m of fractured shale overlying shale bedrock.

Following calibration of the geothermal computer model, the model stratigraphy was modified to include the blasted limestone cover. The 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.

The ground thermal regime was predicted under three scenarios:

- Current climatic conditions (base case).
- Climate warming of 2.9^{o} C/100 years (best estimate case).
- Climate warming of 5.0^{o} C/100 years (high estimate case).

The predicted active layer thickness (assuming thin snow cover) with the blasted limestone cover was as follows, for each scenario:

- Current condition- 1.11 m.
- Climate warming 2.9^{o} C/100 years- 1.35 m.
- Climate warming 5.0^{o} C/100 years- 1.53 m.

The predicted active layer depth using blasted limestone was about 15-20% less than for a cover comprising compacted shale gravel. BGC recommended that a factor of safety of 1.3 to 1.5 may be appropriate for the best estimate climate warming case. Therefore the blasted limestone cover should have a thickness of 1.8 to 2.0 m.

Cover Specifications and Drawings

The specifications and drawings for the LRD cover were prepared by GLL. The cover detail shows a thickness of 1.8 m of Type A material that is placed on top of compacted waste that has been graded to a uniform 2% slope.

Note that this section is not in agreement with the stratigraphy modeled in the BGC thermal analysis for the blasted limestone cover. Major differences include:

- The blasted limestone cover is being placed directly on a significant thickness of waste material.
- The waste material consists of a mixture of demolition debris and a variety of soils that are contaminated with metals. The physical and thermal properties of these waste materials are expected to be significantly different than those assumed for the 1.1 m of shale gravel used in the analyses.
- In most cases, the depth to bedrock in the LRD Quarry, from the surface of the cover exceeds the 3.1 m used in the model.
- The bedrock at LRD Quarry is limestone, not shale.
- The lower portion of the waste was in a saturated state when it was placed. Therefore the moisture content of the fill used in the model (10%) is not representative of the actual moisture content conditions in the LRD Quarry.

The above noted discrepancies could affect the predicted active layer thickness and hence the required cover thickness. It is recommended that the thermal analysis be reviewed by GLL to assess these factors. The thermal model must be run again with the actual conditions that GLL intend to construct.

GLL have selected a cover thickness of 1.8 m. This exceeds the 1.1 m of cover used in the model. The model results showed that the active zone ranged from 1.11 m to 1.53 m, meaning that in the model, the active zone has penetrated the underlying shale gravel, which has different thermal properties than the blasted limestone. The modeled cover thickness should be increased to 1.8 m to reflect the proposed conditions and the predicted active zone re-assessed under the three climate warming scenarios.

I agree with the requirements to grade and proof roll the surface of the waste prior to placing the cover. With respect to the quality control and testing, it was noted during the June 2004 INAC site inspection that the Operational Landfill cover contained zones that did not meet the gradation specifications. There are no provisions in these specifications to address what must be done if the cover material does not meet the required gradation. The specifications omit details regarding placing fill, which contains snow and ice and ensuring that no fill is placed on top of snow or ice. It may be assumed, however that the cover will be constructed over a time period when this is not an issue.

TCL should be requested to provide the ASTM (or equivalent) standard for the plate load tests being recommended as a means of checking compaction of the cover in the specifications. It is not clear how the specified force and plate displacement relates to the in-situ density of the material. Similar concerns were raised previously by BGC with respect to the Operational Landfill cover. Surface rutting of the Operational Landfill shale cover as well as the final limestone cover was subsequently noted on various site visits, indicating that this quality control procedure is ineffective.

Monitoring

TCL have indicated that once the cap construction is complete, they will be installing five thermistors into the pipes that extend upward through the landfill wastes and the final cover. Several of the sensors will be within the cover cap, so that performance of the cap can be monitored. TCL have indicated that the depth of the thermistors will extend beyond the depth where seasonal temperature fluctuations occur. I would recommend that the thermistors be placed to the bottom of the quarry so that the entire thickness of the waste can be monitored and regulators can be assured that it is entirely frozen.

Closure

We trust that this meets with your requirements at this time. If you have any questions or require additional information, please do not hesitate to contact me.

Yours truly,
BGC Engineering Inc.
per:

Holger Hartmaier, M.Eng., P.Eng.
Senior Geotechnical Engineer

HHH/sf