EXHIBIT 13
EXAMINATION OF
DATE JAN. 24/08
Karoline Schumann
COURT REPORTER

#13

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY
200, 1121 Centre Street NW, Calgary, Alberta, Canada. T2E 7K6
Phone (403) 250-5185 Fax (403) 250-5330

PROJECT MEMORANDUM

To:	**Nunavut Water Board**	**Fax No.:**	**Via email**
Attention:	**Dionne Filiatrault, P. Eng., Acting Executive Director**	**CC:**	**D. Hohnstein L. Arenson J. Seto**
From:	**Holger Hartmaier, P.Eng. (Ext. 113)**	**Date:**	**January 8, 2008**
Subject:	**Review of Final Submissions for Hamlet of Cape Dorset Sewage Lagoon Type B Water Licence Application**		
No. of Pages (including this page): 22 Pages		**Project No:**	**0308-003-03-01**

1.0 INTRODUCTION

This memorandum was prepared by BGC Engineering Inc. (BGC) at the request of the Nunavut Water Board (NWB or Board) to review the final submissions for the Hamlet of Cape Dorset Sewage Lagoon Type B Water Licence Application.

A Technical Pre-Hearing/teleconference was held in Iqaluit on October 1, 2007 to address the following matters:

1. To set a timetable for the exchange of information.
2. To finalize the list of issues to be dealt with at the hearing.
3. To identify interested Parties.
4. To consider the desirability of amending an application for the purposes of clarification.
5. To finalize procedures to be followed in a hearing; and
6. To consider any other matters that may aid in the simplification and disposition of the application at the hearing.

The Parties agreed that the Board would set final dates for a Public Hearing and that the dates would permit a minimum of 30 days review time following submission of new information. As such, the Board has set a public hearing date of January 23 and 24, 2008.

This communication is intended for the use of the above named recipient. Any unauthorized use, copying, review or disclosure of the contents by other than the recipient is prohibited.

As a result of the Technical Pre-Hearing, the following list of issues to be dealt with at the Public Hearing was developed:

1. Seepage
2. As- built details
3. Operation and Maintenance
4. Ownership of the Lagoon
5. Geothermal Assessment
6. Stability Assessment
7. Identification of Geotechnical Engineer of Record
8. Discharge Criteria
9. Sludge Management
10. Use of current treatments (existing sewage lagoon) as a contingency measure
11. Abandonment and Reclamation
12. Monitoring

In addition to the above, BGC filed with the NWB on October 2, 2007, a summary of specific geotechnical items which required follow-up prior to the public hearing (See Appendix A).

The Board required that the above information be submitted no later than November 15, 2007. Final intervention statements concerning the above information must be submitted to the Board no later than 3:00 PM Mountain Time, January 8, 2008.

2.0 SCOPE OF WORK

BGC was requested by the NWB to review the following information posted on the NWB ftp site on November 13, 2007 by the Government of Nunavut Department of Community and Government Services (GNCGS), the proponent of the Cape Dorset Sewage Lagoon:

- The record (as-built) drawings of the construction.
- The Operation and Maintenance (O&M) Manual for the operation of the lagoon, prepared by Dillon Consulting Limited (Dillon), dated November 9, 2007.
- Memorandum Re: Additional Stability and Seepage Analysis for P-Lake Sewage Lagoon, Cape Dorset, NU, prepared by AMEC Earth and Environmental, a Division of AMEC Americas Limited (AMEC), dated November 15, 2007.
- Letter from GNCGS with table summarizing GNCGS's response to the list of specific geotechnical items requested by BGC, dated November 13, 2007.

This communication is intended for the use of the above named recipient. Any unauthorized use, copying, review or disclosure of the contents by other than the recipient is prohibited.

Upon receipt of this documentation, BGC noted that the as-built detail of the berm differed significantly from the design drawings, as well as the details used in the geothermal model. The main differences are the configuration of the GCL within the berm, the cut-off trench excavation and the cut-off trench backfill. These discrepancies, in addition to other technical issues raised by BGC in previous reviews resulted in a recommendation by BGC to conduct an independent geothermal analysis of the berm as part of this review. Board representatives (D. Hohnstein, December 19, 2007) agreed that this additional work would be worthwhile and should be included in BGC's budget.

The purpose of the independent analysis was to satisfy the following objectives:

- To support BGC's intervention statement; -specifically to back up any comments or critique of AMEC's geothermal modeling to-date.
- To provide the Board with an independent assessment and improve the level of confidence that the permafrost conditions in the as-built liner, berm, foundation and lagoon configuration will provide the necessary water retention of lagoon contents, such that waste water treatment objectives are met.
- To identify sensitive or critical parameters/issues that must be addressed either by additional investigations, monitoring, engineering or construction (remediation) on the part of the proponent.
- To provide technical guidance for drafting the terms and conditions of the water licence to address the above identified issues.

In summary, therefore, the overall scope of work for the technical support of the NWB for the January 23-24 Public Hearing included the following tasks:

- Task 1: Review of documentation received by NWB on November 15, 2007 and provide a final intervention statement no later than January 8, 2008.
- Task 2: Conduct an independent geothermal analysis of the lagoon based on the as-built drawing details to support this intervention and subsequent Board decisions.
- Task 3: Attend the Public Hearing in Cape Dorset on January 23-24, 2008.

This memorandum summarizes the comments on the documentation received by the NWB on November 15, 2007 as well as any preliminary comments on the results of the geothermal analysis review being undertaken concurrently on behalf of the Board.

3.0 INTERVENTION COMMENTS

This section summarizes BGC's comments on the final information package submitted by GNCGS to the Board by the November 15, 2007 deadline. Our review is limited primarily to the geotechnical and permafrost engineering related issues of the design, construction and operation of the sewage lagoon. Comments on sewage treatment and discharge criteria are being provided to the Board by others under separate cover.

This communication is intended for the use of the above named recipient. Any unauthorized use, copying, review or disclosure of the contents by other than the recipient is prohibited.

3.1 As-Built Drawings

3.1.1 Stamping of Drawings and Engineer of Record

The as-built drawing set submitted by GNCGS consisted of thirteen drawings, prepared by Dillon, as follows:

- Drawing 000- Cover Sheet, with location plan and drawing list.
- Drawing 100- Site Plan
- Drawing 101- Lagoon Containment Berms and Truck Turnaround Pad
- Drawing 102- Road Plan and Profile Station 0+300 to 0+360
- Drawing 103- Road Plan and Profile Station 0+360 to 0+700
- Drawing 104- Road Plan and Profile Station 0+700 to 0+932.55
- Drawing 105- Design Cross Sections Station 0+000 to 0+600
- Drawing 106- Design Cross Sections Station 0+625 to 0+933.75
- Drawing 107- Lagoon Road Plan and Profile Station 2+000 to 2+306.05
- Drawing 108- Lagoon Road Cross Sections Station 2+000 to 2+300
- Drawing 109- Berm Plans and Elevations
- Drawing 110- Earthworks & Sewage Discharge Details and Sections
- Drawing 111- Guardrail- Delineator- Gate Details and Sections
- Drawing 112- Lagoon Berm Sections and Details
- Drawing 113- Access Manhole Details

All drawings were stamped as "Record Drawing, dated November 12, 2007". All drawings were sealed with the professional engineering stamp of Mr. Gary Strong, P. Eng., of Dillon, registered in Nunavut/NWT, as well as the permit to practice stamp for Dillon Consulting Limited.

The record set of drawings fails to include a signature block for AMEC. It was noted that the original design drawings issued by Dillon in the December 21, 2006 design report, revision 5, marked "Issued for Construction" included a signature block "Reviewed by AMEC" on Drawing 111, which is the equivalent of Drawing 112 of the Record Drawings.

The Association of Consulting Engineers of Canada (ACEC) defines "Engineer of Record" as:

> "Engineer in charge of the Construction Documents and their interpretation".

The Association of Professional Engineers, Geologists and Geophysicists of the Northwest Territories (NAPEGG) requires stamps on all documents which:

a) Transfer technical information
b) Have technical impact on a third party, or
c) Have been specifically requested by a client or an authority having jurisdiction.

This communication is intended for the use of the above named recipient. Any unauthorized use, copying, review or disclosure of the contents by other than the recipient is prohibited.

NAPEGG further recommends that final drawings covering more than one discipline be stamped by the design engineer for each discipline and the approving engineer. For registered firms, the permit stamp must also appear.

Record drawings are essentially a revised set of final drawings that required input by or preparation under the direct supervision and control of an engineer and as such, must be stamped by each discipline engineer, as well as the approving engineer. In this case, a stamp from AMEC is required on all Record Drawings where geotechnical engineering was involved in their preparation. The available documentation presented for review indicates that AMEC representatives were present on site during construction. As a minimum, based on the documentation provided, the following Record Drawings should be stamped by AMEC as the engineer responsible (Engineer of Record) for the geotechnical discipline, in addition to the Dillon stamp as approving engineer that is already present:

- Drawing 101- shows location of test pits carried out for geotechnical investigations.
- Drawing 109- shows longitudinal geological sections along cut-off trench.
- Drawing 110- shows typical earthworks sections for the access road and berm.
- Drawing 112- shows lagoon berm sections.

Although the term "Engineer of Record" is not specifically used in the NAPEGG guidelines, it is clear that each discipline engineer stamping the drawings satisfies the ACEC definition.

Notwithstanding the above argument, the NWB, as "authority having jurisdiction" has the right to request these stamps on any drawings submitted for licensing purposes.

3.1.2 As-Built Details

The following comments, pertaining to the sewage lagoon itself were noted by BGC on the Record Drawings submitted by GNCGS:

3.1.2.1 General

In general, there was no identification shown on the drawings indicating where field changes were made from the construction drawings. Normally these would be highlighted in some way, such as a revision "bubble", as well as a brief note in the revisions section of the title block.

3.1.2.2 Drawing 100

In Record Drawing 100, major revisions were made with respect to the alignment of the access roads on both side of the lagoon between the East and West Berms compared to Design Drawing 100. Also, the configuration of the West Berm at the north abutment has been altered from the original design. Further clarification on this is requested from Dillon, as noted under the comments for Drawing 109.

This communication is intended for the use of the above named recipient. Any unauthorized use, copying, review or disclosure of the contents by other than the recipient is prohibited.

3.1.2.3 Drawing 109

Record Drawing 109 shows the berm plans and longitudinal sections along the cut-off trenches in the East and West Berms. The mapped depth of the active zone ranges up to 2 m (based on observations made between July 2-12, 2007). The base of the core trench was a minimum of 2 m below ground surface, up to 3 m below surface. In all cases it was excavated down into materials (bedrock, silt or clay) that were frozen at that time. Note that thaw could go deeper later in the season. Up to 1 m of unfrozen fill (mistakenly labelled "Rift Raft" on the Drawing) was used to level the ground surface under both berms. There are no details provided on the drawings as to what this material (Riprap?) actually comprised.

The drawings illustrate the distribution of materials within the cut-off trench. As noted in Appendix A (Item 23) "...the granite bedrock was weathered down to 100 mm, with oxidized stains. Below the weathered zone the granite was medium crystalline with some individual crystals larger than the groundmass, competent, with occasional closed fractures, and with no visible ice. It is considered by field observation that these fractures were likely induced by blasting."

As noted above in Drawing 100, the berm contours at the north abutment of the West Berm include a widened crest (from 4 m to about 25 m) for a turnaround area on the downstream side. On the upstream side, there are two significant gullies or ditches indicated by the contours and it is not clear what this represents. BGC requests that the proponent provide additional cross sections and longitudinal sections of this area to clarify as- built conditions. The concern is that there may be insufficient fill thickness in this area to ensure that the GCL tie-in to the cut-off trench remains frozen.

3.1.2.4 Drawing 110

Record Drawing 110 shows typical road sections. On July 30, 2007, GNCGS provided a revised ditch detail for the road which does not seem to be included in as-built details on this Drawing. The Hamlet of Cape Dorset noted a problem with seepage into the lagoon through the active zone with the as-constructed detail in the October 1, 2007 Technical Pre-Hearing. Dillon is requested to provide further clarification on how this issue is being resolved.

3.1.2.5 Drawing 112

Record Drawing 112 shows several modifications to the configuration of the GCL and cut-off trench. The upper half of the upstream side of the cut-off trench has been trimmed back to a 1:1 slope. The GCL was placed so that it slopes upstream at 1:1 from the crest to a point within the berm just above natural ground surface level, then is folded downstream at about 1:1 slope into the cut-off trench. This configuration is different from the original design where the liner was placed on top of the original ground surface under the berm, upstream of the cut-off trench. The concern with the as-built configuration is that the saturated zone upstream of the liner is closer to the cut-off trench.

This communication is intended for the use of the above named recipient. Any unauthorized use, copying, review or disclosure of the contents by other than the recipient is prohibited.

The drawings indicate that the material used to backfill the cut-off trench is a "Sand", the same material as used for the berm. At the October 1, 2007 technical pre-hearing, Hamlet representatives noted that water was observed to be seeping out of the downstream toe of the dam. Since the berm was constructed during the summer, on top of the thawed active zone, the berm foundation has not yet had a chance to freeze back. As a result, the water within the lagoon can seep under the berm, through the active zone, around the GCL through the sand backfill in the cut-off trench and through the thawed active zone under the downstream toe of the berm. As a result, the lagoon will not be useable until after the winter of 2007-08 at the earliest, when the foundation has had a chance to freeze back.

It is important to note that AMEC's original design recommendation (October 13, 2005) was to backfill the cut-off trench with "compacted clayey material or grouted". This requirement was never reflected in the previous construction drawings issued by Dillon to date, and has been raised as a design issue by BGC in previous reviews. The modification requires the lagoon to remain dormant over the first winter season so that the foundation can freeze back. This conflicts with the original intended commissioning of the lagoon in October. Thermistors are therefore required to validate the freeze back as a licence condition.

In the original Design Drawing 111, Detail 4 showed the liner embedment longitudinal section in the abutments. This Detail was absent from Record Drawing 112. The as-built liner embedment details for the abutment areas of the East and West Berms are therefore requested. The cut-off trench must extend sufficient distance into the abutment so that any "end-run" seepage through the active zone is prevented. It is not clear from the as-built information if the extent of the cut-off trench satisfies this criterion.

Also in Record Drawing 112, the crest detail of the emergency overflow weir section was changed. This change notice was transmitted to the contractor by Dillon on July 21, 2007. The as-built detail now shows the geo-web and the GCL in one layer, with no granular or other material between the two. Dillon initiated this modification to address a previous concern raised by BGC that water could seep under the GCL in the emergency spillway and potentially lift the liner. It is still not clear how the above modification prevents this problem from occurring.

3.2 Operation and Maintenance Manual

In Section 2.1.1, Dillon indicated that the lagoon was classified as a Very Low Consequence structure from a dam safety perspective. This consequence rating should be confirmed by the Hamlet of Cape Dorset, the facility owner and operator.

This communication is intended for the use of the above named recipient. Any unauthorized use, copying, review or disclosure of the contents by other than the recipient is prohibited.

The geothermal performance of the lagoon is dependent on the basic operation of the lagoon. Although waste water is theoretically held for a one year period, the critical aspect is the complete annual decantation of the contents prior to the start of winter. Additional wording is recommended in Section 3.4.1 Basic Operations to note that if operations change such that either constant lagoon water levels are maintained, or higher water levels are maintained over the winter period, then GNCGS shall be notified. In addition, BGC recommends that the Board include a condition in the water licence requiring prior approval by the Board for any change in waste water storage and decanting operations. This notification should trigger a geotechnical and geothermal review to assess the implications of year round water storage on permafrost conditions under the lagoon.

Section 3.4.6 describes geothermal monitoring, but does not provide the number, locations, depths or bead locations of the thermistors that are proposed. Further details should be provided as a licence condition.

Section 3.4.7 describes Geotechnical Reviews, but does not mention dam safety inspections. Inspections should be carried out more frequently than Dam Safety reviews. As a minimum, the lagoon should be subject to an annual inspection by a qualified geotechnical engineer. The O&M manual should also require operators to conduct a visual inspection of the berms whenever they are visiting the lagoon and record any observations in a log book that can be reviewed during the annual inspection. It is noted that weekly inspections of berms, dikes and drainage courses were recommended in Table 6 of the O&M manual. This is considered an adequate minimum frequency, similar to typical licence requirements for mining operations. It is recommended that these requirements be included as conditions in the water licence. The annual geotechnical inspection should be added under the "Yearly" frequency in Table 6.

Appendix C of the O&M Manual should include some forms to document the recommendations and follow up work required as a result of the annual geotechnical inspection.

3.3 Additional Stability and Seepage Analyses

The November 15, 2007 geotechnical report by AMEC includes some further stability and seepage analyses carried out as a result of discussions and recommendations by BGC at the October 1, 2007 Technical Pre-Hearing. AMEC previously submitted two geotechnical reports to Dillon dated October 13, 2005 and August 21, 2007, which were reviewed by BGC on behalf of the NWB after submission to the Board. The purpose of the current assessment was to re-assess the stability and seepage conditions based on the as-built berm details and in-situ subsurface conditions noted during construction.

This communication is intended for the use of the above named recipient. Any unauthorized use, copying, review or disclosure of the contents by other than the recipient is prohibited.

In the recommendations for further analyses prepared by BGC on October 2, 2007 the following analyses were requested:

1. Check stability of the upstream slope under rapid drawdown conditions based on maximum potential drawdown rate. Stability analysis should assess the stability of the thin unfrozen zone of the upstream shell predicted from the geothermal analysis as well as conservatively assuming that the entire shell upstream of the liner is thawed with a failure zone that incorporates the GCL liner as a potential lower strength element within the slope.
2. Conduct a seepage analysis for the case assuming there are undetected defects/holes in the liner, with seepage taking place through the active zone in the downstream shell. Assess potential for this seepage to affect slope stability and integrity of frozen conditions in the berm foundation.

At the time of formulating this request, the as-built details of the berm were not available. In reviewing the November 15, 2007 analyses, BGC noted some inconsistencies between the as-built information and the data used in the analyses, as noted in the comments summarized in the next few sections below.

AMEC also considered an additional scenario not listed in BGC's October 2, 2007 request. This scenario considered the long term stability of a downstream saturated slope assuming a berm with no frozen core and liner.

The water retention capability of the lagoon is one of the major issues to be resolved with respect to the water licensing of this facility.

3.3.1 Comments on Analytical Parameters and Subsoil Conditions

3.3.1.1 Depth of Active Zone

The soil profile observed during excavation of the cut-off trenches provided the most useful information on subsurface conditions in the berm foundations. The as-built data indicated that the cut-off was excavated down into frozen silt, clay or bedrock over the entire cut-off trench length.

The cut-off trench observations were summarized in a letter report from AMEC to Dillon, dated August 20, 2007. A longitudinal section summarizing this information was provided in Record Drawing 109.

This communication is intended for the use of the above named recipient. Any unauthorized use, copying, review or disclosure of the contents by other than the recipient is prohibited.

One of the key points is the active layer observations. The observations were carried out between July 2 to July 12, 2007. A 1 m thick working pad was placed over the natural ground surface, but depths were measured relative to the natural ground surface. Hard frozen soil was typically observed from about 1.5 m depth. This would suggest that the active layer (deepest in early October) is likely on the order of 2.0 to 2.5 m. AMEC should have commented on whether their geothermal model agreed with the active layer observations. In AMEC's August 21, 2007 geotechnical report that reviews the geothermal analysis, no mention is made of the assumed active layer thickness or of any calibration of the geothermal model to replicate these site conditions. Note that in bedrock areas, the depth of the active zone is typically much greater than in soils, say in the order of 3 to 4 metres deep.

3.3.1.2 Hydraulic Conductivity of Native Silt and Clay

AMEC assumed that the native silt and clay and frozen soil were impermeable material, having low values of hydraulic conductivity. This assumption may be true for the ice-saturated frozen material, below the active zone. However, for the active zone materials, which have been disturbed by freeze-thaw cycles this is not the case, nor has it been substantiated by site observations. Hamlet officials reported water seeping into the sides of the lagoon under the roadways and exiting the lagoon under the berm at the completion of construction in August, 2007. Therefore it is clear that the GCL by itself is not an effective water barrier. Freezing of the foundation and the berm will be necessary to form an effective barrier to seepage. This major design criterion must be confirmed with thermistor readings.

The major concern from a licensing perspective, is the water retention capability of the lagoon. Since the base of the lagoon is unlined, there is nothing preventing seepage losses (or gains) through the active zone along the sides and bottom of the lagoon. As noted above, it is also not clear from the record drawings if the cut-off trench extends far enough into each of the abutments to prevent end run seepage out of the lagoon through the active zone. The extent of the cut-off must also take into account global warming effects over the design life of the structure, which has not been included in the current geothermal analysis done by AMEC.

3.3.1.3 Modelling of As- Built Details

The modelled cross sections used in the seepage and stability analyses do not realistically represent the as-built configuration of the liner. The modelled case assumes a vertical liner in the centre of the berm, that ties into a core of frozen soil. The as-built detail indicates that the GCL is inclined at 45° from the horizontal within the upstream shell.

The active zone in the berm was assumed to be 2 to 3 m deep. This appears low considering that the berm is composed of granular material, which was placed during the summer in a relatively dry and drained state.

This communication is intended for the use of the above named recipient. Any unauthorized use, copying, review or disclosure of the contents by other than the recipient is prohibited.

From a seepage analysis perspective, the differences between the modelled and actual liner configuration are not considered significant. From a stability perspective however, it seems that having the GCL as a low shear strength element that is oriented at the as-built slope of 45° would have a greater effect in reducing the factor of safety of the upstream slope, than the vertical liner. With the modelled case, the slip circle lies essentially within the granular berm material of the upstream slope. If the failure path was modelled along the inclined low strength GCL, a lower factor of safety for the upstream slope is expected. It is recommended that the stability analyses for the 1 and 2 m head difference for the rapid drawdown case include this assessment to demonstrate the stability of the upstream slope based on the as-built detail. BGC recommends that AMEC validate the stability of the upstream slope with the revised liner configuration for all expected stability cases in agreement with Factors of Safety recommended by the Canadian Dam Association (CDA).

3.3.2 Conclusions Regarding Seepage and Stability

Based on field performance, the GCL on its own is not an effective seepage barrier. A GCL with overlapped sheets is an imperfect liner typically used for secondary containment. Freezing of the foundation is required to create an impermeable barrier to seepage under the berm. Within the berm itself, the upper 2-3 m is assumed to be within the seasonal active zone. In this area, the GCL has to act as the primary water retention barrier. It remains to be seen how effective this barrier is, since the lagoon has not yet been impounded.

In general, the seepage analyses have indicated that there are no significant adverse effects on stability. The downstream slope however has slightly less than the required factor of safety for the conservative case of full seepage, assuming no liner is present. The effectiveness of the liner under full lagoon conditions remains to be confirmed, especially for seepage through the active zone in the berm as noted above.

Several issues with respect to the observed seepage under the berm need to be addressed:

- Although the piping analysis carried out by AMEC indicated that there was an adequate factor of safety in terms of critical gradients, no information was presented regarding the filter criterion that was used in the design nor the as-built grain size curves for the trench backfill, foundation soils and berm material to show that particle migration is prevented.
- Did anyone observe if the seepage contained suspended material?
- Was the berm inspected for any signs of voids or settlement following the noted seepage event?

The above information should be provided in order to assess the need for any mitigative measures prior to filling the lagoon.

This communication is intended for the use of the above named recipient. Any unauthorized use, copying, review or disclosure of the contents by other than the recipient is prohibited.

The upstream slope stability should be re-checked with an inclined, low shear strength element, representative of as-built conditions. It is expected that lower factors of safety than presented in the current analysis will result.

AMEC has outlined potential mitigation strategies that could be implemented should factors of safety for the berm slopes not meet the required design criteria, including:

- Additional drainage provisions,
- Construction of support berms,
- Modified operational procedures.

Further details should be provided by AMEC regarding the event/trigger level when these contingency measures should be implemented. These details should be included in the O&M manual, as well as in water licence conditions.

3.4 Items from BGC October 2, 2007 Letter

Other items requested by BGC to be addressed by GNCGS in the October 2, 2007 letter were presented in table format in a letter dated November 13, 2007 to the NWB. Appendix A contains a copy of the response by GNCGS to these items in table format.

The following comments relate to those issues that are still considered outstanding. The items are referenced using the numbers in the table.

Item 5- Geothermal Assessment

GNCGS Response:
"A geothermal assessment completed as described by BGC cannot be completed without several years of thermistor data. The O&M Manual describes the proposed procedure to complete this assessment as part of the lagoon monitoring and first geotechnical safety review. This review will be carried out 3 years after commissioning. See also responses to Items 15 and 16. "

BGC Comments:
As part of this intervention, BGC has undertaken an independent geothermal analysis. Further details on this work is given in Section 4 below. BGC does not agree with the GNCGS response. The first geotechnical safety review should be done prior to impounding, after the initial set of thermistor readings monitoring the freeze back are available. It is therefore expected that the thermistor installation would be carried out as soon as possible to record temperatures over the winter of 2007-2008.

This communication is intended for the use of the above named recipient. Any unauthorized use, copying, review or disclosure of the contents by other than the recipient is prohibited.

Item 7- Identification of Geotechnical Engineer of Record

GNCGS Response:
"The term "Geotechnical Engineer of Record" is defined in a number of documents, and these definitions vary from document to document. Guidelines such as the Dam Safety Guidelines carry such a definition. However in our communication with the DSA, these guidelines have not been applied to a sewage lagoon in Canada."

"Therefore the use of that definition from that guideline is not applicable to this situation. The design process was completed through the retention of AMEC for geotechnical site investigation and reporting. The construction drawings were completed by Dillon with input from AMEC. On site observation was completed by both Dillon and AMEC at various times."

BGC Comments:
BGC's general response is given in Section 3.1.1 above. The above response by GNCGS does not address the issue of whether or not AMEC is accepting responsibility for the geotechnical discipline in terms of approving the design details shown on the construction drawings issued under Dillon's control, the design modifications carried out during construction and the as-built details shown on the record drawings. If AMEC was involved, as stated by GNCGS, then AMEC must stamp the drawings that include their input. The dam safety connotations raised by GNCGS are irrelevant. This issue is critical for licensing purposes due to the modifications that have occurred with respect to the water retention elements of the berm and the demonstrated need to have a frozen foundation and berm in order for this lagoon to hold water. The Board must have assurance that these modifications have the approval of AMEC as the responsible geotechnical engineer.

4.0 INDEPENDENT GEOTHERMAL ASSESSMENT

The water retention capability of the sewage lagoon is a key water licensing issue for this facility. The proponent has designed the berm with a GCL embedded in a cut-off trench excavated into the top of the permafrost. The lagoon basin is unlined. The integrity of the sewage lagoon strongly depends on the permafrost development within the berm and foundation. Retention of the waste water in the lagoon is critical so that minimum treatment objectives can be met.

This communication is intended for the use of the above named recipient. Any unauthorized use, copying, review or disclosure of the contents by other than the recipient is prohibited.

We anticipate that the required modelling will be completed in time for the public hearing. The ultimate use of this assessment will depend on the results. BGC will table any significant design issues at the public hearing, so that appropriate actions can be taken to address them.
The key question is to determine if the berm will behave as designed. Some initial conclusions based on the analytical assessment done to date, include:

- Assuming that the lagoon is filled after the first winter, the GCL liner is expected to freeze into the bedrock and seepage through the berm (mainly through the silt layer in the foundation) will not occur. Convection will only partially thaw the upstream side of the berm.
- A talik will not develop under the base of the lagoon.
- It may be difficult to thaw the water in the lagoon. When modelling the 0.45 m increments of filling, they freeze quite fast. The warm summer months might be too short to thaw the whole pond due to gravity driven natural convection. Even with high n-factors, the bottom of the pond stayed frozen which might cause new problems in terms of sewage management,
- Where the liner is embedded in bedrock, the active layer is much thicker than the depth of the core trench. If the bedrock is fractured, there may be a problem with seepage, unless there is sufficient cover provided to ensure permafrost aggradation. Additional modeling is still underway to assess this case. Confirmation that the GCL is keyed into permafrost should be carried out before filling the lagoon.
- It is critical to have thermistors installed in the berm to confirm that freeze-back has occurred within the foundation and the berm. Temperature data must be collected and reported in the annual inspection reports. BGC recommends that deep (20-25 m) thermistors be installed from the berm crest as a licence requirement.

5.0 CLOSURE

BGC Engineering Inc. (BGC) prepared this report for the account of Nunavut Water Board. The material in it reflects the judgment of BGC staff in light of the information available to BGC at the time of report preparation. Any use which a third party makes of this report, or any reliance on decisions to be based on it are the responsibility of such third parties. BGC accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

Dillon and AMEC are the Engineers of Record for this project and are wholly responsible for the design and performance of the noted project and its components. None of the review comments provided herein by BGC absolves Dillon and AMEC of that responsibility and again, BGC accepts no responsibility for any damages suffered by third parties based on the review comments provided herein.

This communication is intended for the use of the above named recipient. Any unauthorized use, copying, review or disclosure of the contents by other than the recipient is prohibited.

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. Authorization for any use and/or publication of this report or any data, statements, conclusions or abstracts from or regarding our reports and drawings, through any form of print or electronic media, including without limitation, posting or reproduction of same on any website, is reserved pending BGC's written approval. If this report is issued in an electronic format, an original paper copy is on file at BGC Engineering Inc. and that copy is the primary reference with precedence over any electronic copy of the document, or any extracts from our documents published by others.

We trust this information meets with your requirements. Please feel free to contact the undersigned at your convenience should you have any questions or require additional investigations.

Yours truly,
Per
BGC Engineering Inc.

Original signed and stamped by:

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

HHH/sf

Attachments: Appendix A- Letter from GNCGS to NWB dated November 13, 2007 with Table 1 summarizing response to Items from October 10, 2007 letter from NWB.

This communication is intended for the use of the above named recipient. Any unauthorized use, copying, review or disclosure of the contents by other than the recipient is prohibited.

APPENDIX A
NOVEMBER 13, 2007 LETTER FROM GNCGS

This communication is intended for the use of the above named recipient. Any unauthorized use, copying, review or disclosure of the contents by other than the recipient is prohibited.

ᓄᓇᓕᖕᓂ ᑲᕙᒪᒃᑯᓐᓂᓪᓗ ᐱᔨᑦᓯᕋᖅᑎᒃᑯᑦ
Nunalingni Kavamatkunillu Pivikhaqautikkut
Department of Community and Government Services
Ministère des Services communautaires et gouvernementaux

Nunavut

Phyllis Beaulieu
Manager of Licensing
Nunavut Water Board
P.O. Box 119
Gjoa Haven, NU X0B 1J0

Nov.13, 2007.

Sub: Pre-hearing Meeting/Teleconference for the Hamlet of Cape Dorset Type B Water License Amendment Application

Dear Ms. Phyllis,

The GN is submitting on behalf of the applicant a response to the items raised in your letter dated October 10, 2007, file reference No.3BM-CAP0207. We have tabulated our responses to specifically address the issues raised in your letter. Each item from your letter and the appended memo to you letter from BGC is addressed in the table below and the attachments. The attachments include the following:

- The record drawings of the construction
- The O&M Manual for the operation of the lagoon
- AMEC report on Seepage and stability analysis.

The table identifies the items that are addressed by the attachments. Otherwise the table itself provides the response to the issues.

Table 1- Cape Dorset Sewage Lagoon
Items from the October 10, 2007 letter from the NWB.

Item	Description	Response
1	Seepage	No seepage occurs through the frozen core or non-damaged liner. However, a seepage analysis is under way for the scenario with a damaged liner (hole in the liner). The hole is positioned near the active layer base. Results of the analysis will be provided to NWB on November 15, 2007.
2	As-built	Record Drawings of the construction based on information provided by the contractor, observations by Dillon and construction records provided by AMEC are attached.
3	Operation and Maintenance	O&M Manual submission is attached.
4	Ownership of the Lagoon	The Hamlet of Cape Dorset is the facility owner and operator.

Nunavut

ᓄᓇᓕᖕᓂ ᑲᕙᒪᒃᑯᓐᓂ ᐱᔨᑦᓯᖅᑎᒃᑯᑦ
Nunalingni Kavamatkunillu Pivikhaqautikkut
Department of Community and Government Services
Ministère des Services communautaires et gouvernementaux

Item	Description	Response
5	Geothermal Assessment	A geothermal assessment completed as described by BGC can not be completed without several years of thermister data. The O&M Manual describes the proposed procedure to complete this assessment as part of the lagoon monitoring and first geotechnical safety review. This review will be carried out 3 years after commissioning. See also response to 15 and 16.
6	Stability Assessment	Results of the analysis will be provided to NWB on November 15, 2007.
7	Identification of Geotechnical Engineer of Record	The term "Geotechnical Engineer of Record" is defined in a number of documents, and these definitions vary from document to document. Guidelines such as the Dam Safety Guidelines carry such a definition. However in our communication with the DSA, these guidelines have not been applied to a sewage lagoon in Canada. Therefore the use of that definition from that guideline is not applicable to this situation. The design process was completed through the retention of AMEC for geotechnical site investigation and reporting. The construction drawings were completed by Dillon with input from AMEC. On site observation was completed by both Dillon and AMEC are various times.
8	**Discharge Criteria**	The discharge criteria set in other communities in Nunavut have used the NWT Water Board "Blue Book". It is also understood that the new Municipal Waste Water Effluent Canada Wide Strategy will come into effect shortly. It is expected that the Criteria based on the MWWE will be TSS 45 mg/l BOD 45 mg/l. Disinfection will be completed on a risk assessment basis. The design of the lagoon is based on achieving the 45/45 value at the discharge of the lagoon pipe.
9	Sludge Management	Sludge volume will be monitored as part of O&M. The sludge will stay in the lagoon for the first 20 years. Fifteen (15) years after commissioning a sludge facility will be planned to address sludge accumulation once it's a concern. See section 3.4.5 of the O&M manual as well for information on monitoring.

ᓄᓇᕗᑦ
Nunavut

ᓄᓇᓕᖕᓂ ᑲᕙᒪᒃᑯᓐᓂᓪᓗ ᐱᕕᒃᓴᖃᖅᑎᒃᑯᑦ
Nunalingni Kavamatkunillu Pivikhaqautikkut
Department of Community and Government Services
Ministère des Services communautaires et gouvernementaux

Item	Description	Response
10	Use of current treatments system as a contingency measure	One cell will remain as contingency measure. Cell #1 of the old lagoon system. See section 3.4.3 of the O&M manual as well.
11	Abandonment and Reclamation	It is understood that the current licence will be extended for 2 years for the existing facilities. Decommissioning of the old system will occur after 1 year of the operation of the new system. As soon as the new lagoon is under operation, then the old one will no longer be used, except as noted for emergency contingency response. GN will develop an A&R plan over the next two years. **(Within the terms of the extended licence)** to cover the remediation and rehabilitation of the existing system.
12	Monitoring	The monitoring program is outlined in the O&M manual. See sections 3.4.4, 3.4.5 and 3.4.6 of the manual for details.
13	Confirmation of who is the geotechnical engineer of record for the design and construction of the sewage lagoon	See response to question 7.
14	As-built construction drawings, including design criteria, inspection records during construction, materials used, quality assurance protocols and quality control documentation	See attached record. Inspection records during cut-off trench construction are provided in AMEC's report "Cut-off Trench excavation. Sewage lagoon Berms Construction Monitoring, cape Dorset, NU."

ᓄᓇᓕᖕᓂ ᑲᕙᒪᒃᑯᓂᖕᓗ ᐱᕕᔅᓯᖃᖅᑎᒃᑯᑦ
Nunalingni Kavamatkunillu Pivikhaqautikkut
Department of Community and Government Services
Ministère des Services communautaires et gouvernementaux

Item	Description	Response
15	Installation of thermistors to monitor freeze-back of foundation and confirm geothermal modeling predictions. Details to include location, depth, bead locations (depths), method of monitoring (data logger or manual reading), frequency of readings, who will carry out the readings. Thermistors should go below the depth of zero annual temperature change in at least one of the locations that is representative of general site conditions so that the regional geothermal gradient can be determined. Geotechnical logs of the holes drilled for each thermistor should be provided	Based on Dam Safety Guidelines and AMEC's recommendations, monitoring boreholes should be advanced to confirm freeze-back of berm body and foundation. The monitoring program also allows for determination of temperature regime in the berm during operation. One or two monitoring boreholes can be drilled around the site (away from the berm) to confirm initial permafrost temperature used for the geothermal modeling. No need is required in determination of the regional geothermal gradient or initial ground temperatures. It is a known fact that the geothermal gradient for typical permafrost conditions is in a range 0.01 °C/m to 0.02 °C/m. However, if the geothermal gradient is even as high **as 0.06 °C/m, it will result in** insignificant impact to estimated berm temperature regime because influence of extremely cold climate is considerably greater than influence of the high geothermal gradient. Similarly, changing the initial ground temperature will alter the freeze-back estimates only for initial year after construction. Subsequence years will show very little difference from that already modeled.
16	Calibration of the geothermal analysis to the thermistor temperature measurements and site data.	Monitoring of permafrost temperature around the site does not allow for calibration of the geothermal model used for prediction of the berm temperature regime. Such monitoring would help in calibration of boundary conditions for undisturbed surface conditions (natural snow cover and undisturbed vegetation). The boundary conditions over the berm and impoundment area will differ considerably from boundary conditions of the undisturbed surface and for this reason cannot be calibrated with the use of temperature data obtained around the site. However, temperature data obtained from the monitoring boreholes along the berm can be used for calibration of boundary conditions over the berm area.
17	Confirm that the lagoon water temperatures used in the geothermal analysis are conservative with respect to operational water temperatures	This is confirmed.
18	O&M manual to include thermistor monitoring protocol and lagoon operation (annual discharge) required to maintain a frozen geothermal regime in the base of the lagoon. Changes in operations with respect to operating pond levels should trigger a review of the need to reassess geothermal model to check that frozen conditions are maintained	See O&M Manual section 3.4.6 and 3.4.7
19	Confirm rate of drawdown of lagoon during annual discharge	Draw down will occur over a 2 week period.

Item	Description	Response
20	Check stability of upstream slope under rapid drawdown conditions based on maximum potential drawdown rate. Stability analysis should assess stability of the thin unfrozen zone of the upstream shell predicted from the geothermal analysis as well as conservatively assuming that the entire shell upstream of the liner is thawed, with a failure zone that incorporates the GCL liner as a potential low strength element within the slope	See response to item 6.
21	Conduct a seepage analysis for the case assuming there are undetected defects/holes in the liner, with seepage taking place through the active zone in the downstream shell. Assess potential for this seepage to affect slope stability and integrity of frozen conditions in the berm and foundation	See response to item 1.
22	What was the protocol/criteria used in the field to establish the base of the cut-off trench?	The base of the trench should be at least 2 m below the existing ground surface and located in frozen ice poor soil or frozen competent bedrock (see longitudinal trench profiles in design drawings
23	For the areas where rock was encountered, what was the condition of the rock at the base of the core trench? (i.e. tight, fractured with open fractures, ice filled fractures, etc.).	Based on field notes of AMEC field engineer, the granite bedrock was weathered down to 100 mm with oxidization stains. Below the weathered zone the granite was medium crystalline with some individual crystals larger than the groundmass, competent, with occasional closed fractures, and with no visible ice. It is considered by field observation that these fractures were likely induced by blasting
24	Was any stripping done of the foundation under the upstream and downstream shells	The stripping was done within the drainage outfall section (see drawing "lagoon Berm Sections and Details")
25	Provide an as-built longitudinal section of the cutoff trench showing original ground surface, depth of any stripping and final depth of cutoff trench, top of rock and top of permafrost. Add any other information from previous investigations (air track holes)	See record drawings.
26	Were any seepage tests done in the base of the trench	No
27	Was any leakage testing done at the completion of the berm	No
28	Confirmation of material type used to backfill the cutoff trench	See record drawings
29	Provide operational protocols with respect to the potential for freezing of the discharge pipe	See O&M Manual section 3.4.2

ᓄᓇᕗᑦ
Nunavut

ᓄᓇᓕᓐᓂ ᑲᕙᒪᒃᑯᓐᓂᓗ ᐱᕕᒃᓴᖃᐅᑎᒃᑯᑦ
Nunalingni Kavamatkunillu Pivikhaqautikkut
Department of Community and Government Services
Ministère des Services communautaires et gouvernementaux

Item	Description	Response
30	Ditch liner detail provided by applicant does not prevent seepage from entering the lagoon since it does not go below the active zone. Seepage inflow was noted at site through the recently completed berm.	The berm and cut-off trench were, as mentioned in the BGC memo, recently completed and for this reason were in an unfrozen state. Thus, the reported seepage, noted in the 2007 fall, was likely through the still unfrozen active layer and the unfrozen cut-off trench beneath the berm. This will be monitored. If the ditch seepage is present at an unacceptable rate, remediation action will be undertaken. Of note is the constructed containment is approximately 4,000 m^3 greater than the design requirements. Also in the first years of operation, the lagoon has 38,000 m^3 of spare hydraulic capacity because the hydraulic retention is **designed for a 20 year life. Should there be** seepage through the ditch in the first several years of operation it will not aversely impact the operation of the lagoon.

Please review this information, and should there be any outstanding issues, please contact the undersigned immediately.

Thanks,

Bhabesh Roy, M.A.Sc., P.Eng.
Municipal Planning Engineer
Community & Government Services
Baffin Region,Government of Nunavut
P.O.Box 379,Pond Inlet, X0A 0S0
Ph-867 899 7314
Fax-867 899 7328

Copy: Shawn Maley, ADM, GN-CGS
John Dawe, Director, Capital planning, GN-CGS
Timoon Toonoo, Regional Director, Baffin Region, GN-CGS
Johnathan Palluq, Asstt. Regional Director, Baffin Region, GN-CGS
Patricio Fuentes, Regional Projects Manager, Baffin Region, GN-CGS
Tom McDonald, Projects Officer, Baffin Region, GN-CGS