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Nunavut Water Board
P.O. Box 119
Gjoa Haven, NU
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Attention: Mr. Joe Murdock, Technical Advisor

Re: Cape Dorset Sewage Lagoon- Response to Dillon Letter of July 14, 2006

Dear Sir:

As requested, BGC Engineering Inc. (BGC) has prepared this letter response to the comments provided by Dillon Consulting Limited (DCL) in their letter to the Nunavut Water Board (Board) dated July 14, 2006. The DCL letter addressed comments provided by BGC (June 2, 2006) to the Board concerning DCL's application for a water licence for the new sewage lagoon at Cape Dorset.

Based on BGC's review of the July 14, 2006 letter from DCL, the individual comments may be grouped under several broad issues of concern, as detailed below. In order to move this project forward in a timely manner, BGC recommends that the Board convene a technical hearing some time in the near future so that all concerned parties can meet to resolve these issues.

It is important to note that the Government of Nunavut has tendered and awarded the contract for the construction of the sewage lagoon prior to receiving Board approval. The contractor, Kudlik Construction, is now on-site constructing the access road to the new sewage lagoon, and is awaiting approval to proceed with construction.

The main issues of concern that need to be resolved before addressing individual technical details are:

1. Responsibility for geotechnical design.
2. Requirements for submission of technical documents for water licence approval.
3. Design recommendations regarding water retention.
4. Construction supervision and execution.

1.0 RESPONSIBILITY FOR GEOTECHNICAL DESIGN

Included as Appendix 3 with the July 14, 2006 response by DCL is a section by AMEC Earth and Environmental (AMEC) dated July 17, 2006 responding to the NWB review. It is apparent from this response that:

- AMEC's original scope of work as defined by DCL included site investigations, geothermal analysis, development of design requirements for lagoon wall stability, discussions on borrow source materials and recommendations for site grading and drainage.
- AMEC was not given the opportunity to review the design drawings and is not aware of how their recommendations were incorporated by DCL into the drawings and specifications.
- Given the design issues raised by BGC in this review, AMEC agrees that some additional work could be carried out as extra work prior to proceeding to construction.

As a first step, DCL should state if AMEC is the geotechnical engineer of record responsible for the design of the lagoon structures. If so, AMEC should review the scope of work and determine if there are additional requirements to address all the design issues. AMEC should then be given the opportunity to review the DCL design report, specifications and drawings to ensure that their design recommendations have been incorporated. As noted previously by BGC, there are some significant variations between the AMEC recommendations and the tendered drawings and specifications.

The NWB must be assured that all members of the proponent's design team have reviewed, vetted and approved the documentation being submitted for water licence approval.

2.0 REQUIREMENTS FOR SUBMISSION OF DOCUMENTS TO THE NUNAVUT WATER BOARD

This issue is raised in response to the inconsistencies noted between the design report, technical specifications and drawings that were submitted by DCL for the licence application.

This is an issue that requires some policy direction from the regulators and will depend to a large degree on the type of project being proposed and the level of ongoing communication between proponent and the regulators. As a starting point, for discussion, it is appropriate to review the mandate and powers of the Board.

The Nunavut Waters and Nunavut Surface Rights Tribunal Act (Act) clarifies the mandate of the Board and creates legal certainty over the scope of their powers and responsibilities. The role of the Board is to regulate fresh-water resources and water use in Nunavut. In the "Summary" section of the Act, the powers of the Board are described:

> "The Nunavut Water Board has powers similar to those of the Northwest Territories Water Board under the Northwest Territories Waters Act. The Board's primary function is to license uses of water and deposits of waste. The Board is required, in the exercise of that licensing power, to consider any detrimental effects of a potential use of waters or a deposit of waste on other water users and is to hold, where appropriate, public hearings."
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> "The Nunavut Water Board is required to cooperate with the Nunavut Planning Commission to develop land use plans that affect water, and with the Nunavut Impact Review Board to assess environmental and socio-economic impacts of water related project proposals."

Section 48 of the Act describes the requirements for applications in relation to licences:

> "Requirements: 48. (1) An application in relation to a licence shall contain the information and be in the form required by the rules or by-laws of the Board, and be accompanied by the fees required by the regulations."
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> "Information and studies to be provided to Board: 48 (2) An application, except in relation to a cancellation, shall be accompanied by the information and studies concerning the use of waters or the deposit of waste that are required for the Board to evaluate the qualitative and quantitative effects of the use or the deposit on waters."
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> "Guidelines for Applicant: 48 (3) On filing of an application, the Board may provide guidelines to the applicant respecting the information to be provided by the applicant in respect of any matter that the Board considers relevant, including the following:
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> a) The description of the use of waters, deposit of waste or appurtenant undertaking, as the case may be;
> b) The qualitative and quantitative effects of the use of waters or the deposit of waste on the drainage basin where the use is to be undertaken or the deposit is to be made, and the anticipated impact of the use or deposit on other users;
> c) The measures the applicant proposes to take to avoid or mitigate any adverse impact of the use of waters or the deposit of waste;
> d) The measures the applicant proposes to take to compensate persons, including the designated Inuit organization, who are adversely affected by the use of waters or the deposit of waste;
> e) The program the applicant proposes to undertake to monitor the impact of the use of waters or the deposit of waste;

f) The interests in and rights to lands and waters that the applicant has obtained or seeks to obtain; and
g) The options available for the use of waters or the deposit of waste."

Section 57 of the Act covers the conditions for issuance of a water licence:

"Conditions for issuance of licence: 57. The Board may not issue a licence unless the applicant satisfies the Board that

a) Any waste produced by the appurtenant undertaking will be treated and disposed of in a manner that is appropriate for the maintenance of the water quality standards and effluent standards that are prescribed by the regulations or, in the absence of such regulations, that the Board considers acceptable; and
b) The financial responsibility of the applicant taking into account the applicant's past performance, is adequate for
    i. The completion of the appurtenant undertaking,
    ii. Such measures as may be required in mitigation of any adverse impact, and
    iii. The satisfactory maintenance and restoration of the site in the event of any future closing or abandonment of that undertaking."

With respect to conditions of water licences, the powers of the Board are provided in Section 70 of the Act:

"Powers of Board: 70 (1) Subject to this Act and the regulations, the Board may include in a licence any conditions that it considers appropriate, including conditions relating to

a) The manner in which waters may be used;
b) The quantity, concentration and types of waste that may be deposited and the manner of depositing waste;
c) The studies to be undertaken, works to be constructed, plans, including contingency plans, to be submitted, and monitoring programs to be undertaken; and
d) Any future closing or abandonment of the appurtenant undertaking."

Section 74 of the Act covers conditions relating to design of works:

> "Conditions relating to design of works: 74. A licence shall include conditions that are at least as stringent as any standards prescribed by the regulations for the design, construction, operation and maintenance of works used in relation to appurtenant undertakings.

Notwithstanding the existing guidelines and policies of the Board, BGC believes that it is in the applicant's best interest to initiate communication with the regulators regarding any project as soon as possible so that the application requirements and time lines can be determined. Regulators are allowed a certain time period to conduct reviews and it is therefore incumbent on the applicant to ensure that the submitted documentation is as complete as possible. The timing of submissions to regulators must also be coordinated with the overall project schedule to meet the milestone dates for engineering design of the various components, tendering and award of contract and construction. This is especially critical in the north, where the available construction time window may be very short.

The generic requirements for a license submittal are excerpted above from the Act. It is the applicant's responsibility to determine when sufficient information has been gathered to support a water license application. As noted above, the Board can provide guidelines to the applicant regarding the types of information to be provided on a project specific basis. The Board's responsibility however, is strictly to approve the application for a water licence. The Board may request additional information or reject the application. The responsibilities and liabilities related to the design itself and ultimate performance of the structure lies with the Licence holder. The Board has the power to revoke the water licence if the terms and conditions of the licence are not being met.

The prime requirement from the Board's perspective is that the documents submitted for water licence approval reflect accurately what will be built. As such, it is the responsibility of the applicant to ensure that the Board receive the complete documentation trail through the engineering design, tendering, award, construction and operation phases. This will ensure that there are no "surprises" for both applicant and regulator that would delay approval. Deficiencies in terms of information provided or additional studies required can be identified at an early stage, minimizing delays or need for re-design and revisions. Open communication between the applicant and regulators will provide feedback to give the regulators a better assessment of when the available information is sufficient for licencing approval. In general, BGC recommends that the level of documentation required for water licence approval should be equivalent to a final design level of detail. The Board should receive hardcopy versions of all documentation to be kept on file for record purposes. These record copies should bear the professional seal of the responsible engineer, licensed to practice in Nunavut.

Once the licence is granted, the Board may impose conditions for subsequent studies and documentation. This may include submission of the "Issued for Tender" and "Issued for Construction" specifications and drawings to the Board for review to ensure compliance with the

terms and conditions of the water licence. The tender and construction drawings must be consistent with the final design documents submitted for water licence approval, but will include more detail for construction purposes. A further condition of the licence may be the provision of "as-built" drawings and specifications once the project has been completed.

From a design perspective, the following is a general checklist of the geotechnical information that BGC believes should be provided in support of a water licence application for a sewage lagoon in northern Canada:

- Design requirements, design criteria, design parameters, design standards.
- Options assessment and cost assumptions to justify choice of selected alternative.
- Siting data for options considered- airphotos, bedrock and overburden geology, topography, physiography, climate, permafrost conditions, hydrogeology, hydrology, slope stability and potential geohazards.
- Site reconnaissance- structure alignment, height, length, side slopes, principal dimensions, general arrangement, site geological plan, bedrock exposure mapping, borrow materials sources, ground truthing of airphoto interpretation, including assessment of potential geohazards.
- Subsurface investigations to assess depth of overburden, overburden stratigraphy, bedrock elevation, extent of frost shattered bedrock zone, presence/absence of ground ice, depth of active zone, ground temperatures (thermistors), hydraulic conductivity of active zone in overburden and bedrock. Sampling of foundation materials and construction materials. Plan and section views showing proposed layout and foundation stratigraphy.
- Laboratory testing to determine index properties of foundation and construction materials, including thaw stability, as well as compaction characteristics of fine grained materials and durability of riprap and rockfill.
- For detention type lagoon- design data to support selection of liner or main water retention element(s), including seepage analysis and design cross-section of water retention berm(s) to show adequate cutoff of seepage both through and under the embankment. The depth of cutoff must extend into ground that will remain impervious ($<1x10^{-6}$ cm/s) even if thawed.
- Predictions of seepage volumes and associated contaminant loadings compared with regulatory limits.
- Stability analysis of lagoon embankments and side slopes for end-of construction, normal and extreme operating, and extreme flood conditions.
- Description of construction methodology, including foundation preparation, establishing depth of cutoff, QA/QC requirements.
- Instrumentation and monitoring requirements.

The level of information required for each item will depend on the site location and local conditions. The applicant should ensure that all the relevant data is collected to support the proposed design on a site specific basis, rather than using assumptions. In some cases it may

be appropriate to use conservative assumptions in the design if significant variability exists in the data available.

3.0 DESIGN RECOMMENDATIONS REGARDING WATER RETENTION

BGC has major concerns with the design of the water retention elements of the lagoon berm.

Section 3.5 of the DCL Final Design Report (January 2006) indicates that the proposed sewage lagoon will be an annual retention lagoon. Environment Canada and INAC no longer consider exfiltration lagoons acceptable or adequate for effective sewage treatment. As such, DCL's design must ensure that the lagoon does not leak.

To ensure retention of the sewage, the lagoon berms must be constructed using fine-grained, low permeability materials and/or an impervious liner.

To create an impermeable containment, the designers must demonstrate that all potential seepage paths have been cut off. The major seepage paths include:

- Seepage through the berm.
- Seepage under the berm through overburden.
- Seepage under the berm through bedrock, particularly through the frost shattered zone.
- Seepage around the berm at the abutments through the active zone in overburden and bedrock.

None of these seepage paths are adequately addressed in the design, drawings and specifications submitted by DCL to the Board for review.

Before discussing the seepage control aspects of the design, it must also be noted that the design proposed by DCL relies, in part, on permafrost aggradation within the berm to provide a seepage barrier, particularly within the foundation, under the berm. The geothermal design carried out by AMEC was based on an option that involves using a liner on the upstream slope of the berm. The liner configuration that was modelled in the geothermal analysis is, however, not what is being proposed in the DCL tender documents, and as a result the thermal conditions within the berm and foundation will be different.

If permafrost is to be relied on to form a water retaining element within the berm and foundation, the design must include:

- Provisions for instrumentation and monitoring of temperatures within the dam and foundation to confirm that permafrost is present and that the required temperatures are achieved to ensure containment.
- A contingency plan for dealing with seepage/loss of retention.
- A capability for cooling or freezing the soil and re-establishing frozen conditions within the dam and foundations should temperatures rise.

Dams that rely on frozen conditions for water retention require installation of thermistors within the berm and foundation with regular monitoring of temperatures and interpretation by personnel with the appropriate technical qualifications. According to Section 1.7 of the Design Report, the proposed facility is supposed to be designed to be simple so it can be operated by local forces. As such, the instrumentation, monitoring and backup mitigative measures that would be required in support of a frozen dam concept would not satisfy the design parameters given by DCL in Section 1.7 of the Design Report. Therefore, with the present design, there can be no reliance made on frozen conditions being present within the berm or its foundation to provide a seepage barrier. The local forces at Cape Dorset also have no capability of mitigating warming in the berm, if it were to occur.

Failures of frozen core dams are due to thermal erosion of the frozen materials due to seepage. Therefore the primary design requirement for this structure should be that impervious materials are used in the berm and that adequate foundation preparation and cutoff measures be implemented to prevent seepage under and around the berm.

With respect to seepage through the berm, Section 5.6 of the DCL design report states that the berm will be constructed of "fine-grained, (low permeability material)", in addition to the GCL liner. This differs from the Tender Drawings (Drawing 111), which shows the berm to be constructed of "Type II Granular Material". No grain size gradation is provided in the specifications for this material, although the Drawing refers to the specifications for details. Unless information is provided to the contrary, it is assumed that the material shown in the tender drawings will not satisfy the requirement as a "low permeability" material. If a seepage path were to develop through the GCL, the hydraulic conductivity of the granular berm material would be too high to prevent thermal erosion in the downstream portion of the berm. This would lead to uncontrolled release of contaminants from the lagoon into the downstream environment.

A Geocomposite Clay Liner (GCL) is proposed as a seepage barrier within the lagoon berm. Since the berm material proposed in the tender drawings is not considered to be sufficiently impervious, the GCL becomes the prime seepage barrier through the berm. There are several concerns regarding the proposed configuration of the GCL:

- As proposed, the GCL will be installed vertically, along the centreline of the berm, down into the foundation.
- In this configuration, it will be difficult to ensure that the overlaps are sealed and it will be difficult to compact the berm material around the liner. As such, there is a concern that the liner integrity will be compromised and retention of sewage will be at risk.
- The AMEC design shows the GCL placed along the upstream slope of the berm, then wrapping under the upstream slope of the berm along the foundation and tying in to a core trench. This is the preferred and conventional method of installation and will provide greater assurance that the overlaps are sealed by the weight of the overlying berm materials, reducing the risk for loss of liner integrity.
- The main reason DCL provides for proposing the vertical liner configuration is that it requires less liner and the contractor says it is practical. None of these reasons address the design requirement to have an impermeable berm that will retain sewage.

Based on the limited field investigations carried out by AMEC, the proposed lagoon site is "...fully covered with shattered granite, 8-15 cm in size". Despite this information, the AMEC drawings show approximately 2 m of overburden over bedrock on the dike cross-sections in their report. The cutoff trench under the berm is shown going into the overburden unit only and does not extend into the bedrock. The DCL tender drawings (Drawing 111) do not specify what the foundation materials consist of, using the term "existing ground" and not differentiating between bedrock and overburden. These inconsistencies indicate that the underseepage issue is not being fully addressed in the design and contract documents. Assuming there is no overburden in the berm foundation, then seepage through the frost shattered bedrock will be the prime concern. The hydraulic conductivity of the frost shattered bedrock zone was not determined by AMEC, but may be assumed to be large enough to allow complete loss of containment. The depth of the frost shattered bedrock needs to be determined so that the depth of the cutoff trench and final liner configuration can be designed. Clear statements must be made regarding the design intent with respect to the frost shattered bedrock.

The presence of an extensive zone of frost shattered bedrock across the berm footprint negates the design assumption, based on geothermal modelling, that the downstream portion of the dam foundation will be become frozen and thereby provide containment to the lagoon. If seepage through the frost shattered bedrock is not addressed, the hydraulic conductivity of the fractured bedrock is so large, that once a seepage path is established under the berm, there will be no way that thermal effects alone will arrest the seepage.

The seepage cutoff must also extend far enough into the abutment areas, beyond the point where the crest of the berm meets the natural ground slope. The seasonal active zone, as well as the frost shattered bedrock zone, provide a potential seepage path around the structure if located below lagoon water level. The seepage cutoff must extend to the point where these

potential subsurface seepage zones are above lagoon water level. Low points in the surrounding topography should also be checked for potential seepage paths in the active zone, even though the ground surface is above lagoon water level. These cutoff details should be shown on the drawings and described in the specifications.

The design report, specifications and drawings as submitted by DCL must be revised to remove the internal inconsistencies and demonstrate that retention of the wastes in the lagoon is assured. The key aspects of this recommendation are:

- Construct berm using fine-grained, low permeability materials.
- Install the GCL liner in the upstream slope configuration, as modelled by AMEC.
- Ensure adequate foundation preparation to remove frost shattered bedrock and extend the core trench into impervious bedrock.
- Ensure cutoff extends into abutments a sufficient distance to prevent end-run seepage through the active zone and frost shattered bedrock.
- Place compacted impervious material in core trench to seal liner against impervious bedrock and form a cutoff.

If the designers wish to incorporate a frozen dam design element for water retention, then the design parameters must be changed and provisions must be included for instrumentation, monitoring, and contingencies for dealing with preventing seepage and mitigating increasing ground temperatures. These provisions must be supported by the staff and resources of the licence holder who is responsible for operations and maintenance, for the life of the structure.

Other design issues raised by BGC's review may be subsequently discussed and resolved once the basic water retention elements are determined.

4.0 CONSTRUCTION SUPERVISION AND EXECUTION

A qualified earthwork inspector, preferably from AMEC, acting in their capacity as geotechnical design engineer, should be present on site throughout construction. This individual will be responsible to the Owner for ensuring that the lagoon is constructed according to the design requirements. With respect to the major concerns outlined above, the following major tasks should be carried out:

- Use on-site contractor's equipment to excavate test pits within the berm footprint to assess the depth of the frost shattered bedrock zone and determine the depth and lateral extent of the cutoff trench. Modify designs accordingly with DCL.
- Open up borrow materials area to allow materials to thaw and drain. Confirm quality and quantity of fine-grained impervious materials by visual inspection, grain size analysis and field hydraulic conductivity measurements.
- Supervise foundation stripping and preparation and cutoff trench excavation.
- Supervise compaction of berm materials and GCL liner installation.

The inspector would also be responsible for preparing "as-built" construction drawings and records that must be submitted to the Board for record purposes.

5.0 CLOSURE

We trust this information meets with your requirements at this time. Should you have any questions or require additional information, please do not hesitate to contact the undersigned, at your convenience.

Yours truly,
BGC Engineering Inc.
per:

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