



**BGC ENGINEERING INC.**  
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**MEMORANDUM**

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<b>To:</b>	<b>Breakwater Resources Ltd.</b>	<b>Fax No.:</b>	<b>Via email</b>
<b>Attention:</b>	<b>Bob Carreau</b>	<b>CC:</b>	
<b>From:</b>	<b>Geoff Claypool</b>	<b>Date:</b>	<b>May 31, 2008</b>
<b>Subject:</b>	<b>Proposed 2008-2012 Geotechnical Monitoring Schedule</b>		
<b>No. of Pages (including this page):</b>	<b>5 plus Table 1</b>	<b>Project No:</b>	<b>0255-017-04</b>

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Dear Bob,

As per your request, BGC Engineering Inc. (BGC) has undertaken a review of the geotechnical monitoring requirements for the Nanisivik Mine site. This memorandum provides the following:

- General commentary on the monitoring program in place since 1988;
- A description of the monitoring program developed in 2004 to assess the effectiveness of the (then) planned closure and reclamation activities;
- A brief review of the results of the monitoring program, and their significance with respect to performance of the reclamation measures, as well as assumptions and analyses undertaken during the development of the reclamation plan; and,
- A proposed schedule for the remainder of the Closure Monitoring Period.

Geotechnical instrumentation was first installed at Nanisivik in 1988 to monitor permafrost behaviour at the site for the purpose of designing engineered covers required at the eventual closure of the mine. The information collected over the next 16 years, provided by approximately 70 units and several hundred temperature nodes, was used to determine site specific conditions and validate modelling presented in the Closure Cover Design Report (BGC 2004)<sup>1</sup>.

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<sup>1</sup> BGC Engineering Inc. 2004. Engineering Design of Surface Reclamation Covers. Submitted to CanZinco Ltd. February 2004.

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Subsequently, as per the Nanisivik Mine Reclamation and Closure Monitoring Plan (GLL 2004)<sup>2</sup>, the various surface reclamation covers constructed around the Nanisivik Mine site were instrumented, both pre- and post-construction, to assess the effectiveness of the reclamation measures and to validate the results of various analyses undertaken while developing the reclamation plan. A conceptual geotechnical monitoring plan (developed by BGC) was included in GLL (2004) outlining the geotechnical monitoring schedule during the Reclamation and Closure periods. The majority of the instrumentation was installed in 2005 and the monitoring plan was implemented in 2006, although monitoring of previously installed instruments continued throughout the entire period.

Monitoring has been conducted as per the schedule included in GLL (2004). Most instruments have been monitored on a bi-weekly basis between May and October with additional quarterly readings obtained typically in April and December. The monitoring data is reviewed on an ongoing basis by BGC and an assessment of the monitoring data, and its significance with respect to the performance of the reclamation measures, is included in the Annual Geotechnical Inspection report submitted annually to Breakwater. This Annual Geotechnical Inspection report is subsequently submitted by Breakwater to the Nunavut Water Board as a component of their Annual Environmental report.

Based on the monitoring data collected since the covers were completed in 2005, the data supports the following main conclusions:

- The surface reclamation covers are performing as anticipated. The geothermal monitoring data collected to-date indicates that the covers are generally achieving their design objectives by confining the active layer within the cover and maintaining the underlying materials in a perennially frozen state. The monitoring data indicates that performance of the covers continues to improve with time, despite the warmer than average climate conditions experienced by the site since the covers were constructed.
- Freeze-back of the Surface Cell and Test Cell taliks is occurring as expected. The monitoring data collected to-date indicates that cooling of the subsurface profile is continuing. In the Surface Cell, the upper 10 to 20 m of the subsurface profile in the most areas of the Surface Cell is frozen back. In the Test Cell, the freeze-back is also occurring, with at least the upper 8 to 10 m of the subsurface profile frozen in the centre of the talik. The monitoring data collected to date validates the results of the talik freeze-back modelling undertaken during the development of the WTDA reclamation plan.
- The freeze-back of the Surface Cell talik has resulted in elevated pore pressures in the centre of the talik. This was expected and validates the assumptions made regarding talik pore pressures in the Surface Cell during the development of the reclamation plan.

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<sup>2</sup> Gartner Lee Limited. 2004. Nanisivik Mine Reclamation and Closure Monitoring Plan. Prepared for CanZinco Ltd. February 2004.

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The increasing pore pressures are not considered to negatively impact the stability of the West Twin Dike due to the continued downward advancement of the freezing front and the confinement of the pore pressures within the centre of the talik, away from the dike.

- The freeze-back of the Test Cell talik has resulted in only minor increases in pore pressures within the Test Cell talik. The piezometric data from the Test Cell suggests hydrogeologic connection exists between the Test Cell talik and the Reservoir. This validates the assumptions made during the development of the contaminant loading model component of the WTDA reclamation plan.
- The West Twin Dike and its foundation remain in a perennially frozen state and no indications of instability have been observed.
- The waste rock used to backfill the open pits has frozen back. Additionally, the covers constructed over the waste rock backfill have confined active layer thaw to within the cover materials maintaining the underlying materials in a perennially frozen state.
- The monitoring data collected at the Nanisivik Landfill confirms the perennially frozen state of the materials contained within the landfill. Also, the cover constructed over the landfill materials has been effective in confining the active layer thaw to within the cover materials.

Given the results of the monitoring program and the performance of the reclamation measures observed to-date, a proposed geotechnical monitoring schedule for the Closure Period is provided in Table 1.

The proposed monitoring schedule provided in Table 1 is summarized by the following points:

- The Closure Period is subdivided into two smaller time periods; 2008 through 2010 and 2011 through 2012. Different monitoring frequencies are proposed for each of these periods.
- For the 2008-2010 portion of the Closure Period, the following will apply:
  - Thermistors will be monitored on a quarterly basis, at a minimum.
    - Additional data will be collected from thermistors providing information from the active layer. These thermistors will be monitored on a bi-weekly basis between June and September.
  - Vibrating wire piezometers will be monitored on a quarterly basis, with additional readings collected on a bi-weekly basis between June and September.
  - Frost gauges will be monitored on a bi-weekly basis between June and September.
  - Thermocouples will be monitored on a quarterly basis.
  - Samples will be collected from the groundwater monitoring wells installed in the Surface Cell and Test Cell taliks once per year, during the summer months. The samples will be subsequently forwarded to an accredited laboratory and tested for pH, conductivity and total metals (zinc, lead and cadmium).

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- For the 2010-2012 portion of the Closure Period, the following will apply:
  - Thermistors will be monitored on a quarterly basis.
  - Vibrating wire piezometers will be monitored on a quarterly basis.
  - Frost gauges will be monitored once per year in late August when the active layer is the deepest.
  - Thermocouples will be monitored on a quarterly basis.
  - Samples will be collected from the groundwater monitoring wells installed in the Surface Cell and Test Cell taliks once per year, during the summer months.

Monitoring data will continue to be forwarded to BGC immediately after collection for review and assessment. Additionally, an annual inspection by a qualified geotechnical engineer will be conducted throughout the Closure Period. The inspection observations and the monitoring data will be included in the Annual Geotechnical Monitoring report, along with an assessment of the significance of the data with respect to the reclamation measures.

It should be noted that the monitoring schedule proposed herein is based on the expectation that the reclamation measures will continue their current trend of positive and improving performance. In the unlikely event that performance is observed to be not as expected, the monitoring schedule may be altered accordingly.

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BGC Engineering Inc. (BGC) prepared this memorandum for the account of Breakwater Resources Ltd. (Breakwater). 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.

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.

This memorandum presents a proposed monitoring schedule for the geotechnical instrumentation installed at Nanisivik Mine, NU. We trust the information provided herein meets your requirements and expectations. Should you have any questions or comments regarding the information provided herein, please contact the undersigned at your convenience.

Respectfully submitted,  
**BGC Engineering Inc.**  
Per:



Geoff Claypool, B.Sc., P.Eng.  
Geological Engineer

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**Table 1 - Geotechnical Monitoring Requirements 2008-2012**

Summary of Instrument Readings Requirements				
Instrument Information			Closure Period (2008-2012)	
Instrument Label	Instrument Type	Location	Recommended 2008 - 2010 Monitoring Frequency	Recommended 2011 - 2012 Monitoring Frequency
<b>West Twin Dike</b>				
TC12	Thermocouple	Dike Face	Quarterly	Quarterly
TC13A	Thermocouple	Dike Face	Quarterly	Quarterly
TC31	Thermocouple	Dike Face	Quarterly	Quarterly
TC32	Thermocouple	Dike Face	Quarterly	Quarterly
TC33	Thermocouple	Dike Face	Quarterly	Quarterly
BGC03-33	Thermistor	Dike Crest	Quarterly	Quarterly
BGC03-34	Thermistor	Dike Crest	Quarterly	Quarterly
BGC05-09	Thermistor	Dike Crest	Quarterly/ Bi-weekly June 1 - Sept 15	Quarterly
BGC05-15	Thermistor	Dike Crest	Quarterly/ Bi-weekly June 1 - Sept 15	Quarterly
BGC05-17	VW Piezo.	Dike Crest	Quarterly/ Bi-weekly June 1 - Sept 15	Quarterly
<b>Surface Cell</b>				
BGC02-03	Thermistor	Surface Cell	No longer functioning, discontinue monitoring.	
BGC03-07	Thermistor	Surface Cell	Quarterly	Quarterly
BGC03-09	Thermistor	Surface Cell	Quarterly	Quarterly
BGC03-10	Thermistor	Surface Cell	Quarterly	Quarterly
BGC03-11	Thermistor	Surface Cell	Quarterly/ Bi-weekly June 1 - Sept 15	Quarterly
BGC03-12	Vibrating Wire Piezometer	Surface Cell	Quarterly	Quarterly
BGC03-14	Vibrating Wire Piezometer	Surface Cell	Quarterly	Quarterly
BGC03-15	Thermistor	Surface Cell	Quarterly	Quarterly
BGC03-20	Thermistor	Surface Cell	Quarterly/ Bi-weekly June 1 - Sept 15	Quarterly
BGC03-21	Thermistor	Surface Cell	Quarterly	Quarterly
BGC03-32	Vibrating Wire Piezometer	Surface Cell	Quarterly/ Bi-weekly June 1 - Sept 15	Quarterly
BGC03-35	Vibrating Wire Piezometer	Surface Cell	Quarterly/ Bi-weekly June 1 - Sept 15	Quarterly
BGC03-36	Thermocouple	Surface Cell	Quarterly	Quarterly
BGC03-37	Thermistor	Surface Cell	Quarterly/ Bi-weekly June 1 - Sept 15	Quarterly
BGC05-05	Thermistor	Surface Cell	Quarterly	Quarterly
BGC05-06	VW Piezo.	Surface Cell	Quarterly/ Bi-weekly June 1 - Sept 15	Quarterly
BGC05-07	VW Piezo.	Surface Cell	Quarterly/ Bi-weekly June 1 - Sept 15	Quarterly
BGC05-08	Contingency	Surface Cell	-	-

**Table 1 - Geotechnical Monitoring Requirements 2008-2012**

Summary of Instrument Readings Requirements				
Instrument Information			New Closure Period (2008-2012)	
Instrument Label	Instrument Type	Location	Recommended 2008 - 2010 Monitoring Frequency	Recommended 2011 - 2012 Monitoring Frequency
<b>Surface Cell</b>				
BGC05-10	VW Piezo.	Surface Cell	Quarterly/ Bi-weekly June 1 - Sept 15	Quarterly
BGC05-11	Monitoring Well	Surface Cell	Once per summer.	Once per summer.
BGC05-12	Monitoring Well	Surface Cell	Once per summer.	Once per summer.
BGC05-13	VW Piezo.	Surface Cell	Quarterly/ Bi-weekly June 1 - Sept 15	Quarterly
BGC05-14	Contingency	Surface Cell	-	-
BGC05-16	Contingency	Surface Cell	-	-
FG-1	Frost Gauge	Surface Cell	Bi-weekly (June 1 - Sept 15)	Once per summer in late August.
FG-2	Frost Gauge	Surface Cell	Bi-weekly (June 1 - Sept 15)	Once per summer in late August.
FG-3	Frost Gauge	Surface Cell	Bi-weekly (June 1 - Sept 15)	Once per summer in late August.
FG-4	Frost Gauge	Surface Cell	Bi-weekly (June 1 - Sept 15)	Once per summer in late August.
FG-5	Frost Gauge	Surface Cell	Bi-weekly (June 1 - Sept 15)	Once per summer in late August.
FG-6	Frost Gauge	Surface Cell	Bi-weekly (June 1 - Sept 15)	Once per summer in late August.

## Notes:

Quarterly readings to be taken during December, Late April, Early July, Late August.  
Frost Gauges to be read weekly between June 1 and Sept. 15.

**Table 1 - Geotechnical Monitoring Requirements 2008-2012**

Summary of Instrument Readings Requirements				
Instrument Label	Instrument Type	Location	Recommended 2008 - 2010 Monitoring Frequency	Recommended 2011 - 2012 Monitoring Frequency
<b>Toe of West Twin Dike</b>				
BGC03-18	Thermocouple	Toe of West Twin Dike	Quarterly	Quarterly
BGC03-19	Thermistor	Toe of West Twin Dike	Quarterly/ Bi-weekly June 1 - Sept 15	Quarterly
BGC05-26	Thermistor	Toe of West Twin Dike	Quarterly/ Bi-weekly June 1 - Sept 15	Quarterly
<b>Test Cell</b>				
BGC05-04	Thermistor	Test Cell	Quarterly/ Bi-weekly June 1 - Sept 15	Quarterly
BGC05-18	VW Piezo.	Test Cell	Quarterly/ Bi-weekly June 1 - Sept 15	Quarterly
BGC05-19	Thermistor	Test Cell	Quarterly/ Bi-weekly June 1 - Sept 15	Quarterly
BGC05-20	VW Piezo.	Test Cell	Quarterly/ Bi-weekly June 1 - Sept 15	Quarterly
BGC05-21	Monitoring Well	Test Cell	Once per summer.	Once per summer.
BGC05-22	VW Piezo.	Test Cell	Quarterly/ Bi-weekly June 1 - Sept 15	Quarterly
BGC05-23	Monitoring Well	Test Cell	Once per summer.	Once per summer.
BGC05-24	VW Piezo.	Test Cell	Quarterly/ Bi-weekly June 1 - Sept 15	Quarterly
BGC05-25	Contingency	Test Cell	-	-
FG-7	Frost Gauge	Test Cell	Bi-weekly (June 1 - Sept 15)	Once per summer in late August.
FG-8	Frost Gauge	Test Cell	Bi-weekly (June 1 - Sept 15)	Once per summer in late August.
<b>Test Cell Dike</b>				
BGC02-09	Thermistor	Test Cell Dike	Quarterly	Quarterly
BGC03-22	Thermistor	Test Cell Dike	Quarterly	Quarterly
BGC05-29	Thermistor	Test Cell Dike	Quarterly/ Bi-weekly June 1 - Sept 15	Quarterly
<b>Toe of Test Cell Dike</b>				
BGC05-27	Thermistor	Toe of Test Cell Dike	Quarterly/ Bi-weekly June 1 - Sept 15	Quarterly
BGC05-28	VW Piezo.	Toe of Test Cell Dike	Quarterly/ Bi-weekly June 1 - Sept 15	Quarterly
FG-9	Frost Gauge	Toe of Test Cell Dike	Bi-weekly (June 1 - Sept 15)	Once per summer in late August.
FG-10	Frost Gauge	Toe of Test Cell Dike	Bi-weekly (June 1 - Sept 15)	Once per summer in late August.

**Table 1 - Geotechnical Monitoring Requirements 2008-2012**

Summary of Instrument Readings Requirements				
Instrument Label	Instrument Type	Location	Recommended 2008 - 2010 Monitoring Frequency	Recommended 2011 - 2012 Monitoring Frequency
<b>Oceanview Pit</b>				
BGC05-01	Thermistor	Oceanview Pit	Quarterly/ Bi-weekly June 1 - Sept 15	Quarterly
FG-16	Frost Gauge	Oceanview Pit	Bi-weekly (June 1 - Sept 15)	Once per summer in late August.
<b>East Open Pit</b>				
BGC05-02	Thermistor	East Open Pit	Quarterly/ Bi-weekly June 1 - Sept 15	Quarterly
BGC05-03	Thermistor	East Open Pit	Quarterly/ Bi-weekly June 1 - Sept 15	Quarterly
FG-13	Frost Gauge	East Open Pit	Bi-weekly (June 1 - Sept 15)	Once per summer in late August.
FG-14	Frost Gauge	East Open Pit	Bi-weekly (June 1 - Sept 15)	Once per summer in late August.
<b>Landfill</b>				
BGC05-30	Thermistor	Landfill	Quarterly/ Bi-weekly June 1 - Sept 15	Quarterly
FG-11	Frost Gauge	Landfill	Bi-weekly (June 1 - Sept 15)	Once per summer in late August.
<b>Area 14</b>				
TC7	Thermocouple	Area 14	Quarterly	Quarterly
FG-15	Frost Gauge	Area 14	Bi-weekly (June 1 - Sept 15)	Once per summer in late August.
<b>Upper Dump Pond</b>				
FG-17	Frost Gauge	Upper Dump Pond	Bi-weekly (June 1 - Sept 15)	Once per summer in late August.

**Notes:**

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