BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

NYRSTAR

NANISIVIK MINE, NUNAVUT

2016 ANNUAL GEOTECHNICAL INSPECTION

FINAL

PROJECT NO.:	0255027	DISTRIBUTION:	
DATE:	March 7, 2017	NYRSTAR:	2 copies
DOCUMENT NO.:		BGC CALGARY:	2 copies
		BGC VANCOUVER:	e-copy

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY
Suite 200 - 1121 Centre St. NW
Calgary, AB Canada T2E 7K6
Telephone (403) 250-5185
Fax (403) 250-5330

March 7, 2017
Project No.: 0255027

Mr. Johan Skoglund
Group Environment Manager, Americas
Nyrstar
Tessinerplatz 7
8002 Zurich, Switzerland

Dear Johan,

Re: 2016 Annual Geotechnical Inspection, Nanisivik Mine, Nunavut

Please find attached our above captioned report on the 2016 Annual Geotechnical Inspection undertaken at Nanisivik Mine. If there are any questions or comments regarding this report, please contact the undersigned at your convenience.

Yours sincerely,

BGC ENGINEERING INC.
per:

Geoff Claypool, M.Eng., P.Eng.
Senior Geological Engineer

EXECUTIVE SUMMARY

The Annual Geotechnical Inspection was undertaken at the Nanisivik Mine site in 2016. The program involved the following:

- Completion of a site inspection by a professional geotechnical engineer. The site inspection included visual observations of all reclamation measures undertaken at the Nanisivik Mine site since 2004.
- Download of air temperature monitoring equipment and the re-installation of water level monitoring equipment in the Reservoir.
- Collection of geotechnical monitoring data from various instruments located around the mine site. The data was collected generally in line with the frequency outlined in the Water License.
- Review of the geotechnical monitoring data to assess the performance of various reclamation measures with respect to the original design intent.

The following paragraphs provide a summary of the significant observations, conclusions and recommendations based on the results of the 2016 Geotechnical Inspection Program undertaken at the Nanisivik Mine site.

Embankments

The West Twin Dyke was physically stable with no signs of erosion or seepage. The breaches in the remnant dykes at the East Adit Treatment Facility continue to permit natural drainage of the area with only limited ponding in the Retention Pond. The size of this ponding is gradually decreasing with time as the low spots in the pond area backfill with natural sediment transported from upslope areas.

Hydraulic Structures

The West Twin Dyke Spillway continues to effectively drain water from the Surface Cell cover into the Reservoir and is generally functioning as intended. Additional erosion of the left bank was noted in 2016, likely in response to elevated flows during freshet in combination with ice and snow blockage within the spillway channel. Due to the nature of the flows causing the erosion, it is likely that this erosion will continue without additional enhancement of the left bank armour. If not addressed, this may lead to decline in the effectiveness of the spillway over time.

As observed during previous inspections, a small head pond developed on the Surface Cell cover at the spillway inlet. The presence of the head pond is not considered to negatively impact the overall cover performance; hence the elimination of the head pond is not considered necessary.

The seepage at the West Twin Outlet Wall seems to have slowed in recent years, as the water level upstream of the wall has been maintained more consistently at or above the invert of the outlet wall.

The stability of the perimeter slopes of the upstream polishing pond was not observed to degrade further in 2016. Based on the water quality measurements collected since the East Twin Lake

access road was breached in 2008, the seepage losses from the polishing pond do not appear to be affecting the overall performance of the West Twin Area reclamation measures. The seepage losses should continue to be monitored and additional seepage control measures could be considered pending observations.

Some erosion at the East Twin Diversion Dyke was noted during the inspection. The erosion was likely due to elevated flows during freshet in combination with snow blockage in the channel. The extent of the erosion appeared to be similar to what was observed in 2014 and 2015. At the time of the inspection, the dyke stability did not appear compromised. However, it is recommended that additional re-sloping and armouring of select areas of the channel be undertaken to enhance long term performance. As has been observed during inspections over the past few years, seepage was observed at the toe of the East Twin Diversion Dyke upstream of the convergence of flow from West Twin. This seepage did not appear to have increased in 2016, but should continue to be monitored in future inspections.

Thermal Covers

The thermal covers performed adequately in 2016, maintaining the active layer thaw within the cover profile through much if not all of the summer thaw season. Only minor occurrences of erosion, cracking and thermokarsting/settlement were observed, which were not seen to negatively impact the thermal performance nor the water quality in the surrounding areas. Many of these features have been noted previously and have been observed to be physically stable for the past several years. Continued improvement has also been observed in the quality of the surface water runoff from the Surface Cell cover system. This is an indication of the beneficial impacts related to improved geothermal performance of the cover system. Additionally, the water quality observed at the final discharge point for the West Twin Disposal Area has also been observed to remain well below the discharge criteria.

It is anticipated that, over time, the ice saturation will continue to progress within the base of the cover materials. As this occurs, the geothermal performance of the covers will continue to improve, further confining the active layer thaw within the cover. No maintenance is required for the thermal covers at this time; however, visual monitoring is recommended to check for additional surface deformation.

Talik Freeze-back

Freeze-back of the talik in the Surface Cell and Test Cell appears to be proceeding at anticipated rates despite warming of the upper portion of the geothermal profile being observed in many instruments in 2016. Most piezometers within the Surface Cell have frozen back due to continued downward migration of the freezing front. Where the piezometers remain in thawed tailings, the pore pressures continue to increase. The increasing pore pressures are related to continued freeze-back of the tailings. The pore pressures are lowest near the dyke and highest in the centre of the talik. The piezometers in the Test Cell talik have shown pore pressures increasing at a greater rate than in the past. This may be due to constraining of the hydraulic connection between the Test Cell talik and Reservoir due to downward migration of the freezing front.

Mine Openings, Crown Pillars and Raises

The covers constructed over the mine openings generally appear to be physically stable. Cracking at the East Open Pit crown pillar does not appear to have progressed since 2011. No maintenance is recommended, but continued visual inspection is warranted.

Shale and Armour Borrow Areas

In general, the shale and armour borrow areas appear to be physically stable and are not causing any significant ponding to occur. No maintenance was recommended at any of the borrow areas.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF APPENDICES

LIST OF DRAWINGS

LIMITATIONS

BGC Engineering Inc. (BGC) prepared this document for the account of Nyrstar. The material in it reflects the judgment of BGC staff in light of the information available to BGC at the time of document preparation. Any use which a third party makes of this document or any reliance on decisions to be based on it is 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 document.

As a mutual protection to our client, the public, and ourselves, all documents and drawings are submitted for the confidential information of our client for a specific project. Authorization for any use and/or publication of this document or any data, statements, conclusions or abstracts from or regarding our documents 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. A record copy of this document is on file at BGC. That copy takes precedence over any other copy or reproduction of this document.

1.0 INTRODUCTION

Nanisivik Mine is currently owned by Nyrstar, who obtained the property through its purchase of Breakwater Resources Ltd. (Breakwater) in 2011. Nanisivik Mine is located on the Borden Peninsula on northern Baffin Island, just south of Strathcona Sound, as shown on Drawing 01.

Mining operations at Nanisivik ceased in September 2002. Site operations in 2016 were conducted under Nunavut Water Board License 1AR-NAN1419 (the License), effective from December 23, 2014, through December 22, 2019, that entitles CanZinco (the Licensee and a subsidiary of Breakwater Resources Ltd.) to use water and dispose of waste associated with the closure and reclamation activities and post-closure monitoring at the Nanisivik Mine. Part I, Item 6 of the License states the following:

> *"The Licensee shall undertake a geotechnical inspection, to be carried out annually by a Geotechnical Engineer, during the months of July, August or September and provide a report as set out in Part I, Item 7. The inspection shall be conducted in accordance with the Canadian Dam Safety Guidelines (2007) where applicable and be consistent with the previous Annual Geotechnical Inspection reports submitted by BGC Engineering Inc. for the project, and shall taking into account all major earthworks and any changes to the project."*

Additionally, the Nunavut Water Board's Letter of Approval for the Mine Reclamation Plan (NWB 2004) states the following:

> *"In addition to the requirements outlined in Part H, item 6, of the previous License (NWB1NAN0208), the Licensee shall include inspection of all portals, audits, mine openings, ventilation shafts associated with the mine and an examination of the area around the Industrial Complex ice lens."*

Also, the approved Nanisivik Mine Reclamation and Closure Monitoring Plan (Gartner Lee Ltd. (GLL) 2004a) states that the annual geotechnical inspection will include "all earth structures, water diversions, rock slopes and soil covers by a professional engineer." As per the Monitoring Plan, "the engineers report will include a professional review and assessment of all thermal monitoring information and flow information relevant to a physical stability assessment."

In fulfillment of these regulatory requirements, Mr. Johan Skoglund, Group Manager Environment, for Nyrstar, requested that BGC Engineering Inc. (BGC), conduct an inspection visit. The current report provides a summary of the conditions observed and any resulting recommendations and maintenance issues. The report also provides a comprehensive review of geotechnical monitoring data collected on site in 2016. Table 1-1 provides a list of the structures that were included within the inspection.

Table 1-1. Summary of inspection items.

Facility Type	Inspection Item
Embankments and Containment Structures	West Twin Dyke
	Test Cell Dyke
	East Twin Creek Diversion Dyke
	East Adit Treatment Facility
	Day Tank Farm Area
	Main Tank Farm Spill Containment Berm
	West Twin Outlet Channel
Thermal Covers	Surface Cell
	Test Cell
	Toe of Test Cell Dyke
	Toe of West Twin Dyke
	Landfill
	West Open Pit
	East Open Pit
	Oceanview Open Pit
	Area 14
	Upper Dump Pond
	Industrial Complex
Mine Openings, Crown Pillars and Raises	00/01 Portals and crown pillar
	17 N Portal
	Oceanview Portal
	K-Baseline Portal
	Area 14 Portal
	9S Portal
	Former Portal to Mill Foundation
	Lower Adit
	Shale Hill Raise
	Oceanview East and West Raises
	Area 14 Raise
Shale and Armour Borrow Areas	Mt. Fuji Shale Borrow Area
	West Twin Shale Borrow Area
	East Twin Shale Borrow Area
	Area 14 Shale Borrow Area

Facility Type	Inspection Item
	Townsite Shale Borrow Area
	Shale Hill Shale Borrow Area
	Twin Lakes Delta Armour Borrow Area
	Kuhulu Lake Road Borrow Area
	09S/17N Armour Borrow Area
	Chris Creek Armour Borrow Area
Other	Concentrate Storage Shed

All pre-1998 site investigation work, geotechnical design and construction monitoring of the West Twin and East Adit containment structures was carried out by Terratech, a division of SNC Inc. and Mr. Frank Tordon, P.Eng. Initial design work relating to the East Twin diversion dyke and channel and the dump containment ponds was provided by Kilborn Engineering Ltd. Golder Associates Ltd. (Golder) prepared the annual inspection reports for the waste containment dykes in 1998 and 1999, while BGC has provided the annual inspection reports since 2000.

2.0 MINE RECLAMATION ACTIVITIES

The Final Closure and Reclamation Plan (FCRP) was submitted to the Nunavut Water Board for review and approval in March 2004. The review process included a technical meeting in Yellowknife in May 2004 and a public hearing in Arctic Bay in June 2004. The Board conveyed its approval of the plan in a letter to Breakwater dated July 6, 2004.

The reclamation of the mine site began in August 2004, with the bulk of reclamation completed between 2004 and 2008. Since 2004, the following reclamation activities related to the geotechnical inspection have been completed:

- Permafrost aggradation or “thermal” covers were constructed over tailings in the Surface Cell, Test Cell, toe of the Test Cell Dyke, toe of the West Twin Dyke, and at the Upper Dump Pond.
- Thermal covers were constructed over waste rock in the West Open Pit, East Open Pit, Oceanview Pit, and Area 14 Waste rock pile.
- A thermal cover was constructed over the Nanisivik Landfill.
- A thermal cover was constructed over the Industrial Complex Foundation, which had been backfilled with metals contaminated soil.
- Portal plugs and thermal covers were constructed at the Lower Adit, 09 South, Oceanview, K-Baseline, 17 North, 88 North, 00 and 01 Portals.
- A fill pillar was constructed beneath the 00/01 crown/rib pillar.
- The West Twin Dyke Spillway was constructed to convey water from the Surface Cell to the Reservoir.
- The West Twin Outlet Channel was constructed to control the water level in the Reservoir.
- Additional armour was applied to the face of the East Twin Creek Diversion Berm.
- The East Adit Treatment Facility was decommissioned by breaching each of the dykes.
- The Day Tank Farm was decommissioned by removing the tanks, liner and berms.
- The Lower Dump Pond was decommissioned by removing the berms, tailings and the liner and transporting them to the underground mine workings.
- The Concentrate Storage Shed was dismantled and a surficial cover was constructed over the concrete floor slab.
- The road separating the Polishing Pond and the Reservoir was breached, and the culverts and stop log control structure were removed.
- The Main Tank Farm was demolished and hydrocarbon impacted soils from beneath the tank farm were excavated and removed.

Most of these reclamation measures are summarized in the project completion report (BGC 2009b) and documented in detail in various as-built reports referred to throughout this document. Reclamation of the Nanisivik Mine site is essentially complete. Post closure monitoring of the site is on-going and has been conducted in many areas of the site since 2006.

3.0 CLIMATE REVIEW

Climatic data was collected at the Nanisivik Airport by Environment Canada from 1976 to 2010, which is located approximately 10 km south of the West Twin Disposal Area (WTDA) and approximately 250 m higher in elevation. The recorded climate data were previously analyzed in Golder (1998) to provide a basis for deriving the existing climate parameters such as precipitation, air temperatures and lake evaporation at the project site. The following list is a summary of the main climatic parameters based on the data available in 1998:

- Mean annual air temperature (MAAT) was estimated to be -15.2°C
- Mean annual precipitation total was estimated to be 240 mm
- Twenty-four-hour Probable Maximum Precipitation (PMP) value was estimated to range from 140 to 210 mm
- Mean annual lake evaporation value, as measured at the Nanisivik site, was approximately 200 mm.

Climate monitoring was discontinued at the Nanisivik Airport in January 2011. Currently, the nearest available climate monitoring station is located at Arctic Bay, approximately 30 km from Nanisivik. Data collected from Arctic Bay since 2011 is provided on Drawing 02. The summer of 2016 was an above average in terms of average air temperatures. The MAAT recorded at the Arctic Bay weather station in 2016 was approximately -11.7°C. This is approximately 2.4°C warmer than 2015, and 2.2°C warmer than the 2014 MAAT. Additionally, the average summer air temperatures (July and August) in 2016 were approximately 2.0°C warmer than those recorded in 2015. The Air Thaw Index calculated for 2016 was approximately 581 degree Celsius days (°C•d). This value is significantly higher than 2015 (424°C•d), and higher than the average of the previous five years of 477°C•d.

Due to the approximately 630 m difference in elevation and the proximity to the coast line, the climate data sets from Arctic Bay and the historical data collected from the Nanisivik airport station are not directly comparable. In order to put the climate data collected from Arctic Bay since 2011 in historical context, a correction factor is required. Based on the overlap of data sets while monitoring data was collected from both sites in 2010 and 2011, and the air temperature data collected sporadically on site since 2013, a correction factor of -2°C has been estimated (Nanisivik 2°C cooler than Arctic Bay). This correction factor was applied to the climate data collected from Arctic Bay between 2011 and 2016, as shown on Drawing 02. The results suggest that 2013, 2014, and 2015 were the coldest years in terms of both MAAT and ATI since reclamation of the site was initiated in 2004 with MAAT and ATI averages of -15.8°C and 207°C•d, respectively. At -13.7°C, the 2016 corrected MAAT is warmer than the 1977-2013 average of -14.3°C, but equivalent to the average MAAT since 2004.

Precipitation measurements were unavailable from both Nanisivik and the Arctic Bay weather station in 2016, but based anecdotal information from site staff, precipitation in July and August 2016 was typical for the region.

4.0 MINE DESCRIPTION

Mining was conducted at Nanisivik Mine between 1976 and 2002. During that time, mining was conducted at four small open pits (West Open Pit, East Open Pit, East Trench, and Oceanview Open Pit) and underground (Main Lens, Area 14, Oceanview, and K-Baseline). The locations of each mining area are illustrated on Drawing 01. The ore was processed at the mill and the tailings were transported to the WTDA, located at West Twin Lake.

The WTDA is comprised of an upper, solids retention pond, named the Surface Cell, and a lower, water retention pond, called the Reservoir, as shown on Drawing 03. The Surface Cell and Reservoir are separated by the West Twin Dyke, a frozen-core, rockfill dyke. Prior to construction of the West Twin Dyke, tailings were deposited throughout the original West Twin Lake. After construction of the dyke, tailings were primarily deposited into the Surface Cell. Excess water was then siphoned or pumped from the Surface Cell into the Reservoir from where it was reclaimed for use in the mill. The Reservoir was subsequently further separated by constructing the Test Cell Dyke, creating additional tailings disposal capacity in what was known as the Test Cell.

The Reservoir and a final polishing pond were separated by a rockfill causeway and stop log structure. Water from the polishing pond was then discharged to Twin Lakes Creek at the decant structure located at the outlet from the pond. The decant structure was replaced in 2005 by the West Twin Outlet Channel. In September 2008, the stop log structure was removed and the rockfill causeway was breached allowing the Reservoir and Polishing Pond to behave as a flow-through hydraulic system.

5.0 REVIEW OF 2015 MAINTENANCE RECOMMENDATIONS

The 2015 Annual Geotechnical Inspection Report (BGC 2016) outlined a number of maintenance recommendations. These recommendations, and their status, as observed during the 2016 inspection, are provided in Table 5-1.

Table 5-1. Summary and status of previous (2015) recommendations.

Inspection Item	Recommended Action Items (2015)	2016 Comments/Actions
West Twin Dyke Spillway	Review additional enhancements to armouring along left bank of spillway. The area should continue to be visually monitored for any signs of erosion or permafrost degradation induced deformation of the side slopes.	Additional erosion of left bank and bed materials has occurred since the 2015 inspection, likely during freshet. It is recommended that the base of the spillway be graded with a pass of a dozer. It is also recommended that additional armouring of the left bank be considered to address erosion of the left bank of the spillway.
West Twin Outlet Channel	Monitor the water elevation in the Reservoir. Consider seepage control measures such as backfilling the remnant polishing pond upstream of the wall.	Seepage at the West Twin Outlet wall appears to have slowed, as the water level upstream of the wall has been maintained more consistently. The stability of the perimeter slopes of the upstream polishing pond did not noticeably degrade since the 2015 inspection. Annual visual review of the outlet wall slope stability is recommended.
East Twin Creek Diversion Channel	Additional armouring of left bank should be considered to enhance long term performance of channel. Seepage at toe of dyke should continue to be monitored.	No additional erosion has occurred along the left bank, but it should be re-sloped and additional amour rock should be applied to enhance long term stability. The seepage previously noted at the toe of the slope at this location was observed to exhibit a similar flow rate compared to previous years.
Surface Cell Tailings Cover	Continue to monitor thermokarst areas for additional deformation.	No additional thermokarst features were noted in 2016. Pre-existing thermokarst features do not appear to have progressed in 2016. Some cracking was observed in the southwest and northeast quadrants of the cover system. The cause of this cracking is uncertain but is likely related to thermal effects either within the cover or related to the freezeback

Inspection Item	Recommended Action Items (2015)	2016 Comments/Actions
		of the underlying tailings. The areas where the cracking was observed should be monitored for additional cracking in adjacent areas.
East Open Pit/ East Trench Waste Rock Cover	Continue to visually monitor cracking in EOP crown pillar and minor surficial erosion of EOP and East Trench covers.	No noticeable progression of crown pillar cracking in 2016. Minor rill erosion was noted on the EOP and East Trench Covers. Continue to visually monitor crown pillar for progression of cracking and surface of cover for erosion.
Oceanview Pit Waste Rock Cover	Continue to visually monitor surficial erosion along backslope.	Minor rill erosion associated with natural groundwater springs was noted on the Oceanview Pit Cover in 2016. Continue to monitor for progression of erosion.
00/01 Portals and crown pillars	Continue to visually monitor cracking in WOP crown pillars.	No noticeable progression of crown pillar cracking in 2016. Continue to monitor for progression of cracking. Monitoring could include installation and survey of monitoring pins in the crown pillar to provide additional means of assessment, if desired. Given the observations of the monitoring program to date, this level of physical monitoring is not considered necessary at this time.
Instrumentation/Monitoring	Re-install water level logger in Reservoir during 2016 inspection. Re-install the frost gauges prior to the 2016 monitoring season to permit additional readings to be collected in 2016.	Water level loggers were successfully installed in 2016 in the Reservoir and polishing pond. The loggers were not recovered by site staff prior to the onset of winter conditions. Recovery of the data from the loggers should be attempted early in 2017 and new loggers should be installed in the same locations in 2017. The frost gauges were installed early in the 2016 monitoring season and monitored throughout the year.

Any recommendations identified in previous inspections that have yet to be addressed, or have only been partially addressed, have been carried forward as recommendations for 2016. More information regarding the 2016 recommendations is provided in Section 6.0.

6.0 2016 INSPECTION CONDITIONS

Mr. Geoff Claypool, P.Eng., conducted the geotechnical site inspection between July 29 and August 1, 2016. Each of the elements from Table 1-1 was inspected on foot. Pertinent observations concerning the physical condition of each element were recorded by photograph. Select photos are provided in Appendix I. The following sections review the results of the geotechnical inspection and geotechnical instrumentation monitoring program at the various site facilities.

6.1. Embankments and Containment Structures

Several embankments and containment structures were constructed at Nanisivik Mine throughout its history for various purposes. These include the following:

- West Twin Dyke
- Test Cell Dyke
- East Adit Treatment Pond Dyke
- East Adit Retention Pond Dyke
- Day Tank Farm Spill Containment Berm
- Main Tank Farm Spill Containment Berm.

The following sections provide a summary of the inspection conditions at each of the structures mentioned above. It should be noted that since the West Twin Dyke and Test Cell Dyke have been incorporated into the Surface Cell and Test Cell tailings covers, respectively, the inspection conditions for these structures are reviewed in Section 6.4 (Thermal Covers).

6.1.1. East Adit Treatment Facility Dykes

Construction Details

The East Adit Treatment Facility was located approximately 3 km east of the mill, downslope from the East Adit area, as shown on Drawing 01. The facility was comprised of a Treatment Pond and a Retention Pond, both of which employed earthen dykes to retain surface water flow. Water that flows through this area is runoff water from the surrounding drainage basin, where the water quality is affected and/or impacted by natural mineralized soil and rock.

Both dykes are shale rockfill structures mixed with a combination of one or more of the following: regional talus, glacial till, marine clay and/or bentonitic clay. The Treatment Pond Dyke is approximately 5 m above the surrounding ground surface. The Retention Pond Dyke is approximately 3 m above the surrounding ground surface.

Commitments were made in the 2004 Reclamation and Closure Plan (CanZinco 2004) to restore natural drainage by breaching/removing any man made diversions or catchments. As such, both dykes were breached in late 2006. The breaches are approximately 5 m wide at the base and are sloped back to the remnant crest of the dykes at an angle of approximately 3(H):1(V).

Inspection Conditions

Select photos from the inspection are provided in Appendix I. The main observations made during the inspection are summarized by the following:

- Both the breach of the East Adit Retention Pond and the breach of the East Adit Treatment Pond promote drainage of the former pond areas as intended.
- As observed during previous inspections, a small remnant pond was observed in the East Adit Retention Pond area which has been present since breaching. The ponding has been reduced in aerial extent over time due to continued natural backfilling of the area by sediments, mostly weathered shale, being transported and deposited in this area from upslope.
- Some channelization of remnant sediments was observed in the bottom of the East Adit Treatment Pond.

As expected, natural sedimentation has steadily been reducing the aerial extent of remnant ponding in the East Adit Retention Pond. As such, additional remedial actions at the East Adit Treatment Facility are not considered necessary.

6.1.2. Day Tank Farm Spill Containment Berm

Construction Details

The Day Tank Farm Spill Containment Berm was located just uphill from the Industrial Complex, as shown on Drawing 01. The berm provided contingency storage for fuels in the event that the day tanks leak or spill. The berm was approximately 4 m high at its highest point, and had a crest width of approximately 2 m.

CanZinco (2004) details the reclamation plan for the facility which involves the following:

- The liner is to be removed and disposed of underground according to the Waste Disposal Plan.
- Hydrocarbon contaminated soils are to be relocated to the underground mine, in accordance with the Underground Waste Disposal Plan.
- The areas which are disturbed during reclamation are to be backfilled and/or contoured to their surroundings.

In 2007, the day tank farm was decommissioned. According to site staff, the tanks, liner and berm were removed and transported to the underground mine workings. Site staff also indicated that some hydrocarbon contaminated soil was excavated and was also transported to the underground mine workings.

Inspection Conditions

The main observation made during the inspection was that the area where the day tank farm used to be was well drained and no ponding of surface water and no erosion of surface materials was observed.

No additional maintenance was recommended for this area, in terms of geotechnical requirements. As documented in SRK (2009), all geo-environmental considerations at the Day Tank farm area have been addressed.

6.1.3. Main Tank Farm Spill Containment Berm

Construction Details

The Main Tank Farm Spill Containment Berm was located adjacent to the loading dock at Strathcona Sound, just west of the concentrate storage building (Drawing 01). The purpose of the berm was to provide contingency storage for fuels should the fuel storage tanks leak or spill.

The berm was approximately 5 m high at its highest point and has a crest width of 1-3 m. The side slopes of the berm are approximately 1.5H:1V to 2H:1V.

Decommissioning of the Main Tank farm was initiated in 2010, with the removal of the tanks and removal of the containment berms completed in 2011. Remediation of the hydrocarbon impacted soils from beneath the Main Tank farm was completed under the direction of SRK, the mine's geo-environmental consultant. As of 2016, remediation of the tank farm area is considered complete and the site is now in possession of Department of National Defense who are constructing a new tank farm facility in the footprint of the former mine tank farm.

Inspection Conditions

Given that the remediation of the tank farm is complete and the site is now in possession of DND and an active construction area, no inspection of the former main tank farm area was undertaken by BGC. No future inspections of this area are considered necessary at this time.

6.2. Water Conveyance Structures

Several water conveyance structures were constructed at Nanisivik Mine, both prior to, and during the reclamation process. These include the following structures:

- West Twin Dyke Spillway
- West Twin Outlet Channel
- East Twin Creek Diversion Berm and Channel.

The following sections provide a summary of the inspection conditions at each of the structures mentioned above.

6.2.1. West Twin Dyke Spillway

Construction Details

The West Twin Dyke Spillway is located at the south end of the Surface Cell, as shown on Drawing 03. The spillway conveys water from the Surface Cell to the Reservoir. The physical details of the spillway are summarized by the following:

- The spillway is approximately 550 m long.
- The bottom of the spillway is approximately 6 m wide.

- The grade of the spillway bottom varies from 0% at the inlet to 7% near the middle of the spillway and 2% at the outlet.
- The bottom of the spillway is founded on rock from the inlet to 100 m down gradient of the access ramp. The remainder of the spillway bottom is comprised of rockfill.
- The side slopes of the spillway vary from near vertical in rock to approximately 3(H):1(V) in soil side slopes.
- Side slopes composed of poor quality rock or soil are armoured with riprap.

Inspection Conditions

Select photos from the inspection are provided in Appendix I (Photos 5 through 8). The main observations are summarized by the following:

- A small pond was observed at the spillway inlet on the Surface Cell cover. The maximum depth of the pond was estimated to be between 20 and 30 cm. The pond was slightly larger than what has been observed in previous years.
- Surface flow seemed to travel further down the spillway than previous years before going subsurface into the rockfill, suggesting that the subgrade is sanding-up/freezing-back.
- Erosion of the left bank materials due to freshet flows breaching the ice-plug at the spillway entrance has been observed in previous years (Photo 6). During the spring of 2014, Mr. Claude Lavallee was on-site when the ice-plug breach occurred. The observations collected during this time provide further insight into the erosive event that occurs annually. Based on his observations collected during the event, the flow following the breaching of the ice-plug becomes focused along the left bank at an elevated level 1 to 2 m above the base of the spillway. Draining of the water that backs up on the Surface Cell cover occurred quickly, over a period of less than four hours. Some erosion of the bank armour materials occurred before the flow re-entering the spillway towards the outlet, depositing eroded material in the base of the spillway (Photo 8).
- Some armour material from the left bank was also observed to have raveled into the bottom of the spillway in response to the freshet erosion, restricting the width of the base of the spillway by about a third over a 10 m length of the spillway.

While the spillway currently remains effective in directing and confining flow from the Surface Cell to the Reservoir, it is recommended that additional armouring of the left bank be considered to address these types of flow events in the future. Re-grading the base of the spillway to ensure the full design width is available for flow should be completed at the same time. Until these issues are addressed, it is recommended that the spillway channel continue to be inspected annually for stability of the side slopes and erosion of the side slopes and channel bottom.

6.2.2. West Twin Lake Outlet Channel

Construction Details

The West Twin Lake Outlet Channel is located in the northeast corner of the WTDA, as shown on Drawing 03. The channel conveys water from the Reservoir into Twin Lakes Creek. The channel replaces the former decant station located in the same area. The main design feature of the channel is a steel-reinforced, concrete wall which provides water retention and elevation control for the water level in the Reservoir. The physical details of the channel are summarized by the following:

- The concrete wall is approximately 17 m long and 0.3 m thick.
- The central portion of the wall where the flow occurs is 7 m wide and has an invert elevation of approximately 370.2 m.
- The wall contains sloping side walls (4(H):1(V)) and the elevation of the top of the side walls is approximately 370.8 m.
- The concrete wall is founded into the underlying bedrock via a steel-reinforced, concrete footing.
- The channel is armoured to approximately 370.8 m elevation, upstream and downstream of the wall.
- A plunge pool is located downstream of the wall to provide energy dissipation during flooding events.

In 2007, a geosynthetic clay liner (GCL) was installed upstream of the concrete wall, as suggested in the 2006 inspection report. This was completed in response to observations of declining water levels upstream of the wall during periods of low inflows. The declining water levels were inferred to suggest seepage losses through the foundation of the wall. As such, the GCL approach was suggested as a way to limit the potential for these seepage losses.

In September 2008, the culverts in the East Twin access road that had previously impeded the flow from the Reservoir to the Polishing Pond were removed and the Reservoir is now considered to be a fully flow-through hydraulic system at the normal water level. Due to the limited depth of the breach, the former East Twin access road restricts flow into the former polishing pond area at lower water levels.

Inspection Conditions

Select photos from the inspection are provided in Appendix I (Photos 9 through 12). The main observations are summarized by the following:

- During the inspection, the water level upstream of the wall was noted to be just above (+1 cm) the elevation of the wall invert.
- The seepage at the West Twin Outlet Wall seems to have slowed in recent years, as the water level upstream of the wall has been maintained more consistently at or above the invert of the outlet wall.

- Slumping and settlement of the perimeter slopes of the upstream polishing pond have been noted in recent years, but no further degradation was observed in 2016. This previous degradation is related to the deepening of the polishing pond (and associated water depths) during reclamation of this area.

Water level loggers were installed in both the Reservoir and the polishing pond during the inspection trip. The loggers were not recovered by site staff before the onset of winter conditions and will remain on site over the winter. The loggers may be damaged as a result. The loggers should be recovered and returned to BGC as early as possible in 2017 to download the data. It is recommended that the loggers be re-installed during the 2017 inspection trip. The observed seepage losses and stability issues along the edge of the remnant polishing pond are thought to be related to the excavation of sediments from the polishing pond during site reclamation activities in 2005. Excavation of these sediments created a deeper pocket of water upstream of the wall, measured to be between 3 and 4 m in the deepest parts of the pond. This provided a heat source which likely resulted in thawing of the ground beneath the pond and the associated water retention concrete wall.

Based on the water quality measurements collected since the East Twin Access Road was breached in 2008, the seepage losses through the foundation of the wall do not appear to be influencing the overall performance of the West Twin Area reclamation measures. As suggested by the water level data discussed previously, the impact of seepage losses on the main water level in the Reservoir is minimized by the various breaches creating flow restrictions between the Reservoir and the remnant Polishing Pond. However, the breaches only act to slow the lowering of the water level and, therefore, should not be considered a permanent solution in mitigating seepage losses from the West Twin Area. In light of continuing seepage losses and increasing slope instability noted along the perimeter of the remnant polishing pond, it is recommended that measures to address these concerns be considered. This may involve backfilling of the Polishing Pond immediately upstream of the wall. This backfilling would be intended to provide the following benefits with respect to seepage control and stability:

- Enhance stability of slopes along the perimeter of the pond by buttressing these slopes.
- Lengthen the seepage pathway to reduce impacts of seepage losses on water levels upstream of the wall.
- Promote freeze-back of the foundation beneath the pond which could result in a corresponding reduction in seepage losses. Complete freeze-back of the foundation may be difficult to achieve depending on, among many variables, ground conditions and seepage gradients.

Detailed design drawings and specifications such as fill materials/volumes and surface grades and water management plans will need to be developed prior to implementation of any mitigation plan. Given the difficulty in obtaining detailed information regarding ground and geothermal conditions as a basis for design, the mitigation of the polishing pond may require an adaptive design approach with associated contingency measures should observed performance not meet design intent.

6.2.3. East Twin Creek Diversion Dyke and Channel

Construction Details

The East Twin Creek Diversion Dyke is located along Twin Lakes Creek between East Twin Lake and the West Twin Outlet Channel, as shown on Drawing 03. The diversion dyke and channel deflect flow from East Twin Lake away from its previous drainage course, which drained directly into West Twin Lake (the Reservoir). The flow from the diversion channel combines with the flow from the Reservoir downstream of the West Twin Outlet Channel.

The diversion dyke is approximately 2 m above the adjacent ground level and is comprised of sand, gravel and cobbles derived from the nearby Twin Lakes sand and gravel deposit. A portion of the dyke was re-graded during reclamation construction to be less susceptible to erosion. Additionally, the re-graded portion of the dyke was armoured with riprap to prevent future erosion from occurring.

Inspection Conditions

Select photos from the inspection are provided in Appendix I (Photos 13 through 16). During the inspection, the area where erosion of the left bank of the channel was observed during previous inspections was reviewed. No significant changes have been observed for at least two years, as the erosion was found to be in similar condition compared to 2015. The observed erosion at this location may be the result of a similar scenario as the erosion due to freshet in the West Twin Dyke Spillway. It appears that the flow in East Twin Creek was elevated near the crest of the diversion dyke by snow blockage and concentrated flow resulted in erosion of the berm as it re-entered the main channel of East Twin Creek. It is recommended that the noted area should be re-sloped and additional amour rock should be applied to the entire face of the dyke to enhance long term stability of this area.

It should be noted that a seepage discharge spring was observed at the toe of the left bank of the dyke, as it has been during the inspections undertaken since 2012. The seepage water is likely originating in the polishing pond and is also likely related to excavation of polishing pond sediments during site reclamation. The seepage flow was observed to be clear and free of sediment and not observed to have increased compared to recent years. No mitigation efforts to address the observed seepage are recommended at this time, but the discharge point should continue to be visually monitored.

6.3. Thermal Covers

The following sections provide information regarding each of the thermal covers constructed at site. Each section provides details regarding the construction of each cover, a summary of the observations made during the 2016 inspection and reviews the monitoring data collected from each area in 2016. A table documenting the instrumentation monitoring undertaken in 2016 is provided in Appendix II. No additional attempts to collect data are planned prior to July 2017, in-line with the monitoring schedule defined within the current Water License.

An additional note on the interpretation of the geothermal monitoring data; for the purposes of interpretations made in this report, the following assumptions were made:

- In the active layer, ground conditions are considered “thawed” when ground temperatures of 0°C and warmer are observed.
- In the taliks, ground conditions are considered “thawed” when ground temperatures of warmer than -0.5°C are observed. This temperature adjustment accounts for freezing point depression effects which have been noted in the tailings talik at the site.

6.3.1. Surface Cell Tailings Cover

Construction Details

A thermal cover was constructed over the tailings in the Surface Cell in 2004 and 2005. The thermal cover consists of a 1 m thick layer (minimum thickness) of granular shale overlain by a 0.25 m thick layer (minimum thickness) of armour material comprised of sand, gravel and cobbles. It should be noted that, due to surface grade considerations, significantly increased shale thicknesses (greater than 2 m thick) were applied to approximately 30% of the Surface Cell. Additionally, due to practical construction considerations related to the grain size distribution of the armour materials, the armour layer thickness regularly exceeded 0.25 m. The shale was sourced from the Mt. Fuji and Area 14 borrow areas (Drawing 01). The armour material was sourced from the Twin Lakes Delta deposit (Drawing 01). The Surface Cell tailings cover is drained by a series of swales which convey surface water to the spillway inlet located at the south end of the Surface Cell. The spillway transfers water draining off of the Surface Cell into the Reservoir. It should be noted that surface flow is not regularly observed on the Surface Cell and that the majority of the water flow occurs sub-surface due to the coarse nature of the cover materials.

Inspection Conditions

Select photos from the inspection are provided in Appendix I (Photos 17 through 20). The main observations are summarized by the following:

- The head pond at the entrance to the spillway at the south end of the cover was observed to be similar in size compared to previous years.
- As has been observed in previous inspections, some minor thermokarst features were noted along the south shoreline, along the east edge of the main drainage swale and just north of the E/W trench. These localized thermokarsts are not considered to be negatively impacting the overall performance of the cover system. Additionally, the same thermokarst features have been observed in past inspections and do not appear to be changing with time, suggesting they are physically stable.
- No erosion of the cover materials was noted, but some minor settlement deformation in the bottom of the main drainage swale was observed closer to the spillway entrance.
  Some cracking was noted in the northeast and southwest quadrants of the cover system (Drawing 05). The cause of this cracking is uncertain but is likely related to thermal effects within the cover materials or continued freezeback of the underlying tailings.

No maintenance is recommended for the Surface Cell cover system, though the surface of the cover should continue to be visually inspected for additional deformation and cracking.

Monitoring Data

The Surface Cell is instrumented with 10 thermistors, seven vibrating wire piezometers, six frost gauges and two monitoring wells. The location of each of these instruments is provided on Drawing 05. Select plots providing the results of the monitoring are provided, for interpretation purposes, on Drawings 06 through 10.

The instrumentation has two main purposes; monitor the depth of the active layer thaw in the cover and monitor the ground temperatures and pore pressures in the talik during freeze-back. Monitoring wells originally installed in the Surface Cell and Test Cell taliks to monitor pore water quality during freeze-back are no longer functional and are no longer monitored in accordance with the approved geotechnical and geothermal monitoring program.

Drawing 06 provides data from thermistors installed throughout the Surface Cell talik. The graphs illustrate the following:

- The tailings profile continues to cool over time. The rate of cooling observed in 2016 appears to be similar to what has been observed in previous years.
- The upper 20 to 22 m of the ground profile appears to be frozen, as illustrated by data recorded from Thermistors BGC03-09, BGC03-10 and BGC05-05.
- The rate of downward progression of the -0.5°C isotherm has slowed compared to previous years, as illustrated by data from Thermistors BGC03-09, 03-10 and 05-05.

Drawing 07 illustrates the downward progression of the freezing front over time in the Surface Cell. The depth of the -0.5°C isotherm from various thermistors is plotted against the distance from the crest of the West Twin Dyke. The data suggests the -0.5°C isotherm has migrated between 7 and 18 m downwards since the cover system was completed in 2005. The data also illustrates how the thickness of frozen ground increases with proximity to the West Twin Dyke.

Drawing 07 also illustrates that the freeze-back of the Surface Cell talik is generally proceeding quicker than anticipated, compared to the results of the geothermal analysis documented in BGC (2004a). This is illustrated by comparing the observed depth of the -0.2°C isotherm with the freeze-back envelope predicted by the original geothermal modeling. The -0.2°C isotherm was used for this comparison as it was the freezing point depression assumed during the original geothermal modelling completed as part of the talik freeze-back assessment (BGC 2004a).

Drawing 08 provides data collected from the piezometers installed in the Surface Cell talik. The graphs indicate that all of the piezometers in the Surface Cell talik have frozen back in response to continued downward migration of the freezing front in the tailings. These piezometers were installed at depths ranging from 15 to 24 m bgs.

Drawing 09 illustrates the relationship between piezometer tip depth and the freeze-back temperature of the piezometers in the Surface Cell cover system. The freeze-back of the piezometer tips occurred at temperatures ranging from -0.5°C to -1.3°C, and the freeze-back temperatures appear to decrease with depth. For the purposes of this assessment, freeze-back of the piezometer tip is taken to be the time at which a significant drop or increase in erratic nature of the recorded pore pressure is observed. The deeper the piezometer tip, the lower the temperature before freeze-back occurred. This relationship is likely related to the increasing metals concentration in the remnant talik as it becomes smaller and cryo-concentration of solute in the pore water occurs. The freezing point of the water becomes lower with a higher solute concentration.

Drawing 10 shows the data collected from select Surface Cell frost gauges. The data suggests that active layer thaw remained within the cover material at frost gauges one, three, and six in 2016. However, frost gauge three suggests approximately 0.1 m of thaw into the tailings.

The results of water quality testing undertaken on samples collected at the inlet of the West Twin Dyke Spillway are provided on Drawing 11. As can be seen, the total zinc concentration in the water draining off the Surface Cell was low (less than 0.01 mg/L) in the sample collected in 2016. However, since only one sample was taken in early August, that sample may not represent the peak solute concentrations, as water quality decreases with increased depth of thawing. Similar results have been observed since 2010. Additionally, reductions in the total sulphate concentrations have also been observed since 2010. The water quality monitoring data suggests that the improved geothermal performance of the Surface Cell cover system observed since 2007 has had beneficial effects on the quality of the surface water runoff.

6.3.2. West Twin Dyke

Construction Details

The West Twin Dyke is a frozen core, upstream constructed, earth fill dyke that separates the Surface Cell and the Reservoir (Drawing 03). The dyke is constructed of frozen, compacted shale and founded on frozen, settled tailings. The dyke is approximately 14 m high and the downstream face slopes at an angle of approximately 15°. The downstream face of the dyke was surfaced with a 0.25 m thick layer (minimum thickness) of sand, gravel and cobbles sourced from the Twin Lakes Delta.

Inspection Conditions

Select photos from the inspection are provided in Appendix I (Photos 21 and 22). The main observations made during the inspection are summarized by the following:

- No settlement or cracking of the crest was noted
- The downstream face of the dyke shows no indications of erosion or settlement
- No seepage was noted on the face of the dyke or at the toe of the dyke.

In general, the dyke appeared to be in a satisfactory condition and no maintenance is recommended.

Monitoring Data

The West Twin Dyke is instrumented with five thermocouple cables installed within the dyke, as well as four thermistors and one vibrating wire piezometer installed from the crest of the dyke.

The location of each of these instruments is provided on Drawings 05 and 12. Select plots providing the results of the monitoring, for interpretation purposes, are provided on Drawing 13.

Drawing 13 provides data from Thermistor BGC03-34, which provides a geothermal monitoring profile from 5 m below the crest of the dyke to approximately 14 m bgs. An adjacent thermistor, BGC03-33, extends from 15 to 24 m bgs, but this instrument was not functioning in 2016. The data indicates the following:

Drawing 13 provides data from additional thermistors installed from the crest of the dyke, as well as one vibrating wire piezometer installed within a thawed zone at depth. The data indicates the following:

- The profile immediately upstream of the dyke is frozen (cooler than -0.5°C) to at least 23 m bgs (approximately 5 m below base of dyke).
- The geothermal profile from approximately 3 to 13 m bgs has warmed in 2016, but continues to cool below 13 m depth.
- At piezometer 05-17, the pore pressures within the small thawed zone at approximately 24.5 m bgs (approximately 6.5 m below the base of the dyke) are approximately 13 m artesian and have decreased slightly since 2015. The elevated pore pressures observed at depth remain well below the trigger levels established in BGC (2009c) and are not considered to negatively impact the stability of the West Twin Dyke.
- The piezometer tip temperature at piezometer 05-17 is approximately -1.6°C, but does not yet appear to be frozen.

6.3.3. Test Cell Area

Construction Details

The Test Cell area consists of the Test Cell, former Test Cell Dyke and Toe of Test Cell Dyke. A thermal cover was constructed over the Test Cell area in 2004 and 2005. The thermal cover consists of a 1 m thick layer (minimum thickness) of granular shale overlain by a 0.25 m thick layer (minimum thickness) of armour material comprised of sand, gravel and cobbles. It should be noted that, due to surface grade considerations, significantly increased shale thicknesses (greater than 2 m) were applied to approximately 20% of the Test Cell. Additionally, due to practical construction considerations related to the grain size distribution of the armour materials, the armour layer thickness regularly exceeded 0.25 m. The shale was sourced from the Mt. Fuji, East Twin and Area 14 borrow areas (Drawing 01). The armour material was sourced from the Twin Lakes Delta deposit (Drawing 01). The Test Cell tailings cover is drained by a main swale which conveys surface water directly into the Reservoir.

The Test Cell Dyke is an earth fill dyke that separates the Test Cell and the Reservoir (Drawing 03). The dyke is constructed of frozen, compacted shale and founded on frozen, settled tailings. The dyke was approximately 4 m high. During reclamation, the top 2 m of shale material in the dyke was removed and placed in the Test Cell as cover material. The remnant dyke was surfaced with a layer of armour material, approximately 0.25 m thick. As such, the dyke is now essentially integrated into the Test Cell cover.

A thermal cover was constructed over the tailings at the toe of the Test Cell Dyke in 2005. The thermal cover consists of a 1 m thick (minimal thickness) layer of granular shale overlain by a 0.25 m thick layer (minimal thickness) of armour material comprised of sand, gravel and cobbles. It should be noted that, due to surface grade considerations, shale fill thickness in excess of the 1 m minimum thickness was applied to the tailings beach at the toe of Test Cell Dyke, especially immediately adjacent to the remnant Test Cell dyke. The shale was sourced from the Mt. Fuji and Area 14 borrow areas (Drawing 01). The armour material was sourced from the Twin Lakes Delta deposit (Drawing 01). The riprap was sourced from the dolostone outcrop at the south end of the West Twin Dyke.

Inspection Conditions

Select photos from the inspection of the Test Cell and Test Cell Dyke are provided in Appendix I (Photos 23 through 28). The main observations are summarized by the following:

- No erosion or ponding was observed.
- Similar to previous inspection observations, the north-south arm of the Test Cell dyke and the Test Cell cover just inside of the dyke remains undulating, suggesting some amount of thaw settlement of the cover materials has occurred. The undulating nature of the cover in this area has not noticeably changed in the last several years and the cover is overbuilt in this area due to grade requirements. The undulating nature is not considered to negatively impact the cover performance and, as such, this area is not of concern.

Select photos from the inspection of the cover along the toe of the Test Cell Dyke are provided in Appendix I (Photos 29 through 32). The main observations are summarized by the following:

- No erosion of the cover was observed
- No disturbance due to ice plucking of the riprap was observed.

In general, the tailings cover in the Test Cell area appears to be in satisfactory condition. As such, no maintenance is recommended.

Monitoring Data

The Test Cell area is instrumented with seven thermistors, five vibrating wire piezometers and four frost gauges. As previously noted in the Surface Cell monitoring review, the monitoring wells installed in the Test Cell talik are no longer functioning and are no longer monitored in accordance with the approved monitoring program. The location of each of these instruments is provided on Drawing 12. Select plots providing the results of the monitoring are provided on Drawings 14 through 17.

Drawings 14 through 15 provide geothermal and piezometric monitoring data collected from the Test Cell in 2016. The data indicates the following:

- The active layer thaw was generally confined within the cover materials throughout 2016.
- The subsurface profile between 1.5 and 15 m depth in the Test Cell at the base of the West Twin Dyke (BGC05-04) is colder than -0.5ºC and is presumed to be frozen. The geothermal profile continues to cool with time.

- As suggested by Thermistor BGC05-29, the subsurface profile just inside the former location of the Test Cell dyke is frozen (colder than -0.5°C) to approximately 24 m bgs.
- The data collected from Thermistor BGC05-19, indicates cooling of the geothermal profile near the centre of the Test Cell talik continues.
- Thermistor 05-19 also suggests that the centre of the Test Cell talik has frozen back to approximately 14 m bgs, an approximately 1 m downward migration of the freezing front since 2014.
- The pore water pressures and pore water temperatures measured at piezometer 05-22 have decreased by approximately 2 m and 0.5 ˚C, respectively since 2015.
- The monitoring data from Piezometer BGC05-20 shows a slight pore pressure decrease in 2016 after a small increase in 2015. The pore water temperature measured at the piezometer tip has remained static over the past three years at -0.4˚C, but is not yet frozen. The temperature of the unfrozen pore water is generally between -0.4˚C and -0.6˚C and is relatively stable. Minimal cooling of the recorded pore water temperature has been observed since installation in 2005.

Select plots providing the results of the monitoring of the Test Cell Dyke are provided on Drawing 16. The monitoring data indicates the following:

- Data from thermistor BGC03-22 suggests that the dyke and foundation beneath the dyke was frozen to approximately 22 m bgs. The geothermal profile appears to have warmed slightly between 7 and 27 m depth in 2016, but remains relatively unchanged at 27 m depth.
- The vibrating wire piezometer (BC05-24) installed approximately 20 m bgs beneath the dyke has frozen back as indicated by the tip temperature below -5°C and the corresponding variability in pore pressures. The recorded pore pressure is considered to be localized and associated with the freeze-back of the piezometer tip and is not considered to be representative of pore water pressures throughout the Test Cell talik.

Select plots providing the results of the monitoring of the tailings cover at the toe of the Test Cell Dyke are provided on Drawing 17. The graphs indicate the following:

- The subsurface profile at the toe of the Test Cell Dyke (BGC05-27) between 3 and 22 m bgs is colder than -0.5˚C and is presumed to be frozen. The geothermal profile continues to cool with time. The monitoring data demonstrates that the upper 22 m of the subsurface profile is frozen, despite being along a shoreline which was periodically submerged in water during operations of the tailings disposal area. The fact that permafrost exists at this location, to the extent it does, is considered beneficial to the overall Test Cell talik freeze-back. This is because it exceeds expectations and assumptions made in the contaminant loading model (CanZinco 2004) which assumed a completely thawed tailings profile adjacent to the water.
- The monitoring data from Piezometer BGC05-28 indicates a piezometric elevation of about 370.3 m asl. This is consistent with the elevation of the water level in the Reservoir, and suggests hydraulic connectivity between the tailings at depth and the reservoir. However, the pore water temperature at the piezometer tip has cooled to - 1.2 °C in 2016, and is likely to become frozen in the next couple years.

6.3.4. Toe of West Twin Dyke Tailings Cover

Construction Details

A thermal cover was constructed over the tailings at the toe of the West Twin Dyke in 2005. The thermal cover consists of a 1 m thick layer (minimum thickness) of granular shale overlain by a 0.25 m thick layer (minimum thickness) of armour material comprised of sand, gravel and cobbles. The shale was sourced from the Mt. Fuji and Area 14 borrow areas (Drawing 01). The armour material was sourced from the Twin Lakes Delta deposit (Drawing 01). The riprap was sourced from the dolostone outcrop at the south end of the West Twin Dyke.

Inspection Conditions

Select photos from the inspection are provided in Appendix I (Photos 33 and 34). The main observations are summarized by the following:

- No erosion of the cover was observed.
- As observed during previous inspections, some minor thermokarst features were observed, but was not seen to be negatively impacting the overall performance of the cover system. No visual changes in the appearance of these thermokarst features have been noted in recent years, suggesting the area is generally physically stable.
- No erosion or ice plucking of the riprap along the shoreline was observed.

No additional maintenance items were recommended.

Monitoring Data

The tailings cover at the toe of the West Twin Dyke is instrumented with two thermistors. The location of each of these instruments is provided on Drawing 12. Select plots providing the results of the monitoring are provided on Drawing 18. The graphs indicate the following:

- As illustrated by the data collected from Thermistor BGC05-26, the subsurface profile below 5 m has warmed in 2016, but remains colder than -5˚C and is presumed to be frozen to at least 24 m bgs, the depth of the bottom of the instrument. The bottom 15 m of the instrument is measuring ground temperatures in the bedrock, demonstrating the frozen nature of the bedrock near the base of the West Twin Dyke.
- As illustrated by the data collected from Thermistor BGC03-19, the subsurface profile below 3 m has also warmed in 2016 but remains colder than -3˚C and is presumed to be frozen to at least 11 m bgs, the depth of the bottom of the instrument.

West Twin Disposal Area Water Quality

As required in the Water License used for site operations in 2016, water quality sampling and testing were undertaken at the West Twin Outlet Channel throughout the open water period in 2016. This channel is considered the final discharge point for water from the WTDA before entering the environment in Twin Lakes Creek. Only two samples were collected and forwarded to a laboratory in 2016. Water samples were tested for pH, conductivity, Total Suspended Solids (TSS), sulphate, total metal concentrations, and ammonia (NH_3). The total zinc, total lead, total cadmium and sulphate concentrations observed at the West Twin Outlet Channel in 2016 are illustrated on Drawing 19. The total zinc, lead and cadmium concentrations observed in the 2016 samples met discharge criteria, as they have since the covers were completed in 2005. Since surface water quality is expected to be poorest when thawing is at its annual maximum (typically early fall), and the last water sample was taken in early August, it should not be assumed that the samples represent the annual maximum metal concentrations. The low and declining metals and sulphate concentrations suggest that the thermal covers and the water cover in the Reservoir are effective in limiting metal loading to the water in the Reservoir.

It should be noted that the TSS values obtained from the samples collected throughout 2016 were similar to what was observed in the five years prior. The last five years have all been well below discharge criteria and at the lowest end of the historical range. These TSS values indicate an improvement over values recorded prior to breaching of the East Twin access road. Hence, the results suggest that excessive amounts of solids are not being carried in the outflow from the WTDA.

Stantec (2017) should be referenced for a detailed review of the results of the water quality monitoring program undertaken in 2016.

6.3.5. Landfill Cover

Construction Details

A thermal cover was constructed over the Nanisivik Landfill in 2005. The thermal cover consists of a 2 m thick layer (minimum thickness) of granular shale overlain by a 0.25 m thick layer (minimum thickness) of armour material comprised of sand, gravel and cobbles. The shale was sourced from the Townsite Shale borrow area. The armour material was sourced from the Twin Lakes Delta deposit. The face of the landfill is sloped at approximately 3(H):1(V).

It should be noted that the thermal cover constructed at the Landfill was built over an existing surficial shale cover that was continuously placed and maintained during operations as part of the on-going landfill operating procedures (for pest control and protection against wind transport). No attempts were made during construction of the thermal cover in 2005 to verify the existing cover thickness and thereby, reduce the fill requirements. Therefore, it can be assumed that the thermal cover is thicker than just the material placed in 2005.

Inspection Conditions

Select photos from the inspection are provided in Appendix I (Photos 35 and 36). The main observations are summarized by the following:

- No erosion of the cover was observed, either on the upper flatter portion of the cover or on the sloping face of the Landfill.
- No seepage was observed at the toe of cover during the time of the inspection.
- Some exposed shale was observed on the lower portion of the west face. This is due to an insufficient amount of armour material available for covering and is not related to erosion. Previous attempts undertaken to spread the armour over the exposed shale were determined to be impractical from a construction standpoint. Considering the observed

stability of the area since construction, additional maintenance is not considered necessary.

- Some minor cracking and thermokarst features were observed along the upslope water deflection berm. This has resulted in a minor amount of surface water running along the west edge of the cover system. This is not considered to be negatively affecting the performance of the adjacent landfill cover system and no maintenance is considered necessary at this time.
- No areas of settlement or thermokarst features were observed on the surface of the landfill cover system.

No maintenance items were recommended.

Monitoring Data

The Landfill cover is instrumented with one thermistor and one frost gauge. The location of each of these instruments is provided on Drawing 20. Select plots providing the results of the monitoring are provided on Drawing 21. The graphs indicate the following:

- The landfill debris underlying the cover remained frozen throughout the year.
- The geothermal profile within the underlying landfill debris warmed slightly during 2016, but remained frozen throughout the year.
- The active layer thaw did not penetrate into the underlying waste material throughout 2016.
- The geothermal performance of the landfill cover in 2016 was observed to be similar compared to previous years. The maximum temperature recorded at the thermistor node located at 2.3 m bgs, near the cover/landfill debris interface, was approximately - 2.5°C. However, since mid-August was the last reading of the year, a small amount of additional warming would be reasonably expected late in the summer.

6.3.6. West Open Pit

Construction Details

A thermal cover was constructed over the West Open Pit in 2006. The thermal cover consists of a 2 m thick layer (minimum thickness) of granular shale overlain by a 0.35 m thick layer (minimum thickness) of armour material comprised of sand, gravel and cobbles. The shale was sourced from the Townsite Shale borrow area. The armour material was sourced from the local borrow source located along the road between the 09S portal and the 17 North Portal. The face of the West Open Pit cover is sloped at a maximum angle of approximately 3(H):1(V).

Inspection Conditions

Select photos from the inspection are provided in Appendix I (Photos 37 through 40). The main observations are summarized by the following:

- No erosion of the armour surface was noted
- No areas of settlement or thermokarst features were observed
- No seepage water was observed at the toe of the cover.

Based on the observations noted above, the West Open Pit waste rock cover are considered to be physically stable. As such, no maintenance is recommended.

Monitoring Data

The West Open Pit cover is instrumented with one thermistor (BGC08-01). The purpose of the thermistor is to monitor the freeze-back of the underlying backfill materials as well as the active layer thaw within the cover materials. The location of this instrument is provided on Drawing 22. The results of the monitoring undertaken in 2016 are provided on Drawing 23. The graphs indicate the following:

- The waste rock used to backfill the open pit has frozen back.
- The active layer thaw was confined within the cover materials throughout 2016, but had a slight decrease in performance (thicker active layer) compared to 2015.
- The geothermal profile within the waste rock warmed slightly in 2016 due to warmer air temperatures, but remains frozen.

6.3.7. East Open Pit

Construction Details

A thermal cover was constructed over the East Open Pit in 2005. The thermal cover consists of a 2 m thick layer (minimum thickness) of granular shale overlain by a 0.35 m thick layer (minimum thickness) of armour material comprised of sand, gravel and cobbles. The shale was sourced from the Shale Hill borrow area. The armour material was sourced from the local borrow source located along the road between the K-Baseline Portal and Kuhulu Lake. The face of the East Open Pit cover is sloped at a maximum angle of approximately 3(H):1(V). A remnant highwall exists along the south edge of the pit area. The remnant highwall ranges from 1 to 5 m high and is sloped back at an angle of approximately 60°. A bench exists between a portion of the remnant highwall and the main portion of the cover system.

Inspection Conditions

Select photos from the inspection are provided in Appendix I (Photos 41 through 44). The main observations are summarized by the following:

- Some surface (rill) erosion was noted on the surface of the cover. The erosion has advanced a nominal amount since the 2015 inspection, as illustrated by Photo 43.
- Some minor cracking was noted on the surface of the cover. This cracking is thought to be related to thermal expansion and contraction of the cover materials and settlement of the underlying backfill materials.
- No areas of settlement or thermokarst features were observed on the surface of the cover.

The minor erosion noted on the surface of the cover was anticipated. The armour material at this location contains a fine grained fraction that was expected to wash away with time leaving behind the coarse grained fraction, a process known as self-armouring. As such, the armour thickness at this location, and many others where alternative armour materials were used, was increased to 0.35 m. The coarse grained fraction of the armour material is expected to limit the amount of erosion that can occur, without negatively impacting the geothermal performance of the cover.

The cracking in the crown pillar at the East Open Pit was not observed to have progressed since 2015. As previously noted, the cracking coincides with the mined out rib pillar and the area of the 39 Portal. As in previous years, no opening to the underground was observed during the inspection. As such, the cracking was not seen to be of immediate concern especially given the lack of progression over the past several years. Accordingly, no maintenance was recommended, but the crown pillar should continue to be visually monitored for additional deformation.

Monitoring Data

The East Open Pit Waste Rock cover is instrumented with two thermistors and two frost gauges. The location of each of these instruments is provided on Drawing 24. Select plots providing the results of the monitoring are provided on Drawing 25. The graphs indicate the following:

- Data from Thermistor BGC05-02, installed in the area with a thin layer of waste rock backfill (approximately 3 m thick), indicates the waste rock has frozen back. Although the upper 15 m bgs has warmed in 2016 due to air temperatures, the portion below 15 m bgs continues to cool.
- Data from Thermistor BGC05-03, installed in the area with a thicker layer of waste rock backfill (approximately 9 m thick), indicates the waste rock, and hydrocarbon contaminated soil buried at depth, has frozen back. The geothermal profile remains similar to last year.
- The active layer monitoring data from Thermistor BGC05-03 and BGC05-02 indicates that the active layer was confined within the cover materials throughout 2016. An increase to the active layer thickness was observed in 2016, but thawing remained confined to the cover material, with an approximately 1.4 m active layer thickness.

6.3.8. East Trench Waste Rock Cover

Construction Details

A thermal cover was constructed over the East Trench in 2005. The thermal cover consists of a 2 m thick layer (minimum thickness) of granular shale overlain by a 0.35 m thick layer (minimum thickness) of armour material comprised of sand, gravel and cobbles. The shale was sourced from the Shale Hill shale borrow area. The armour material was sourced from the local borrow source located along the road between the K-Baseline Portal and Kuhulu Lake. The face of the East Trench cover is sloped at an angle ranging between 4(H):1(V) and 6(H):1(V).

Inspection Conditions

Select photos from the inspection are provided in Appendix I (Photos 45 through 46). The main observations are summarized by the following:

- As noted in previous inspections, minor surface erosion was observed near the upslope edge of the cover where seepage water periodically discharges from natural rock outcrops onto the surface of the cover. No progression of this erosion was noted in 2016.
- No seepage was observed at the toe of the cover.

In general, the East Trench cover appears to be physically stable. As such, no maintenance was recommended.

6.3.9. Oceanview Open Pit Waste Rock Cover

Construction Details

A thermal cover was constructed over the Oceanview Open Pit in 2005. The thermal cover consists of a 2 m thick layer (minimum thickness) of granular shale overlain by a 0.35 m thick layer (minimum thickness) of armour material comprised of sand, gravel and cobbles. The shale was sourced from the Shale Hill borrow area (Drawing 01). The armour material was sourced from the Chris Creek “A” borrow area (Drawing 01). The face of the Oceanview Open Pit cover is sloped at a maximum angle of approximately 3(H):1(V). The surface of the cover in the bottom of the pit slopes to the north at a grade of approximately 3%.

Inspection Conditions

Select photos from the inspection are provided in Appendix I (Photos 47 through 50). The main observations are summarized by the following:

- No ponded water was observed on the surface of the cover.
- The upslope water deflection berm appeared to be effective in directing surface water away from the cover. This was inferred from visual observations indicating surface water flow along the upslope edge of the berm.
- Minor surface erosion was noted along the backslope at the south end of the cover, as has been noted during previous inspections. The erosion appears to be slowly progressing, based on visual observations, but is not expected to impact the overall performance of the cover system. Self armouring of the erosion areas is occurring as the coarser particles within the armour layer are exposed and concentrated at surface, as anticipated.
- Some seepage was observed at the toe of the cover.
- Some acid rock drainage staining was observed on the east edge of the cover. The stained area appeared to originate upslope of the extent of the cover and appeared to cover a similar extent to what has been observed in previous inspections.
- A minor sinkhole was observed in the middle of the cover surface, but did not appear to have grown since the 2015 inspection.

In general, the Oceanview Open Pit cover appears to be in satisfactory condition. As such, no maintenance was recommended. The surficial erosion should continue to be visually monitored for additional progression.

As discussed previously, minor erosion of the surface of the cover was anticipated. Similar to the East Open Pit cover, the armour material at this location contains a fine grained fraction that was expected to wash away with time. As such, the armour thickness was increased to 0.35 m. The coarse grained fraction of the armour material, which can be observed in Photo 48, is expected to limit the amount of erosion that can occur, without negatively affecting the geothermal performance of the cover.

Monitoring Data

The Oceanview Pit Waste Rock cover is instrumented with one thermistor and one frost gauge. The location of each of these instruments is provided on Drawing 26. Select plots providing the results of the monitoring are provided on Drawing 27. The graphs indicate the following:

- The active layer was confined within the cover materials throughout 2015.
- The waste rock underlying the cover has frozen back and remained completely frozen throughout 2016.
- Thermistor BGC05-01 shows that bedrock at depth continues to cool at a similar rate to recent years.
- Based on the thermistor data collected from BGC05-01, the geothermal performance of the cover in 2016 was slightly improved to the performance observed since 2010, despite the warmer air temperatures. The maximum active layer thaw depth indicated by Thermistor BGC05-01 was estimated to be approximately 1 m bgs, which is approximately 1.3 m above the base of the cover.

6.3.10. Area 14 Waste Rock Cover

Construction Details

Area 14 is a satellite ore body situated on a west-facing slope, approximately 1 km to the east of East Twin Lake (Drawing 01). A waste rock pile was created outside the portal during mining operations. In 1988, the waste rock pile was flattened and a thermal cover was constructed over the top of the waste rock pile, but the face was left exposed.

In 2005, the thermal cover at the Area 14 waste rock pile was completed by constructing a cover over the exposed face and armouring the entire surface of the cover. The thermal cover consists of a 2 m thick layer (minimum thickness) of granular shale overlain by a 0.35 m thick layer (minimum thickness) of armour material comprised of sand, gravel and cobbles. All shale was sourced from the Area 14 shale borrow area (Drawing 01). All armouring material was sourced from the hill side immediately north of the Area 14 portal.

Inspection Conditions

Select photos from the inspection are provided in Appendix I (Photos 51 and 52). The main observations are summarized by the following:

- No erosion of the cover materials was observed
- No areas of settlement or thermokarst features were observed on the surface of the cover
- No seepage was noted at the toe of the cover.

In general, the Area 14 waste rock cover appears to be in a physically stable condition. As such, no maintenance was recommended.

Monitoring Data

The Area 14 Waste Rock cover is instrumented with one thermocouple and one frost gauge; locations for each of these instruments are provided on Drawing 28. No thermocouple data was collected in 2016. Frost gauge FG 15 indicates that the active layer was approximately 1.2 m thick, which is 1.2 m above the base of the cover, as shown on Drawing 29.

6.3.11. Upper Dump Pond Tailings Cover

Construction Details

The upper dump pond was an emergency tailings storage containment cell located between the water tank and the West Twin Disposal Area, as shown on Drawing 01. A thermal cover was constructed over the tailings in the Upper Dump Pond in 2005. The thermal cover consists of a 2 m thick (minimal thickness) layer of granular shale overlain by a 0.25 m thick layer (minimal thickness) of armour material comprised of sand, gravel and cobbles. The shale was sourced from the Townsite shale borrow area (Drawing 01). The armour material was sourced from the Twin Lakes Delta deposit (Drawing 01).

Inspection Conditions

Select photos from the inspection are provided in Appendix I (Photos 53 and 54). The main observations from the inspection are summarized by the following:

- No erosion of the surface of the cover was observed
- No seepage was noted at the toe of the cover
- No areas of settlement or thermokarst features were observed on the surface of the cover.

In general, the Upper Dump Pond tailings cover appears to be in a physically stable state. As such, no maintenance was recommended.

Monitoring Data

The Upper Dump Pond tailings cover is instrumented with one frost gauge. The location of this instrument is provided on Drawing 30. Frost gauge FG 17 indicates that the active layer was approximately 1.5 m thick, which is 0.8 m above the base of the cover, shown on Drawing 31.

6.3.12. Industrial Complex Foundation Cover

Construction Details

The Industrial Complex is located approximately 1 km north of the town site (Drawing 01). The Industrial Complex housed the concentrator, DMS circuit, power plant, maintenance shops, warehouse, administration and technical offices and associated facilities. The facility was built on bedrock and a reinforced concrete foundation.

The Industrial Complex was dismantled between 2005 and 2006 and the remnant foundation was backfilled with metals contaminated soils. In 2008, a thermal cover was constructed over the backfilled foundation. The thermal cover consists of a 2 m thick layer (minimum thickness) of granular shale overlain by a 0.35 m thick layer (minimum thickness) of armour material. The shale was sourced from the Mill Area deposit and the armour materials were locally sourced. The sloping face of the cover is approximately 3(H):1(V).

Inspection Conditions

Select photos from the inspection are provided in Appendix I (Photos 55 through 57). The main observations made during the inspection are summarized by the following:

- No erosion of the surface of the cover was observed
- No settlement or thermokarst features were observed on the surface of the cover
- No seepage was observed at the toe of the cover.

In general, the Industrial Complex cover appears to be physically stable. As such, no maintenance is recommended.

Monitoring Data

The Industrial Complex Foundation cover is instrumented with one thermistor. The location of this instrument is provided on Drawing 32. Select plots providing the results of the monitoring are provided on Drawing 33. The graph indicates the following:

- The metals contaminated soils used to backfill the foundation footprint have frozen back.
- The active layer thaw (approximately 1.9 m) was confined within the cover materials throughout 2016 and the cover performance appears similar to 2015.
- The geothermal profile beneath the cover has warmed slightly since 2015 but remains similar to 2014.

6.4. Mine Openings

6.4.1. 00/01 Portals and Crown Pillar

Construction Details

00 Portal

The 00 Portal is located at the edge of the West Open Pit at the western end of the mine, as illustrated on Drawing 01. The 00 Portal was the principal access at the western extremity of the mine. The portal measured approximately 5 by 5 m in cross section. The brow immediately above the portal was approximately 4 to 5 m high.

In 2005, the portal was backfilled with waste rock. The backfill was placed approximately to within 1 m of the top of the portal and into the portal approximately 5 m from the entrance. The backfill extended outside the portal face and was sloped at an angle of approximately 3(H):1(V) and graded into the overall backfill of the West Open Pit. A thermal cover was subsequently constructed over the waste rock as part of the West Open Pit thermal cover.

01 Portal

The 01 Portal was located at the western end of the mine, as shown on Drawing 01. The 01 Portal housed the main ventilation fans during mining operations which were mounted in a plate steel bulkhead. The portal opening was approximately 22 m wide and 4 m high. The brow immediately above the portal was approximately 4 to 5 m high.

In 2005, the portal was backfilled with waste rock. The backfill was placed approximately to within 1 m of the top of the portal and into the portal up to the face of the bulkhead. The backfill extended outside the portal face and was sloped at an angle of approximately 3(H):1(V) and graded into the overall backfill of the West Open Pit. A thermal cover was subsequently constructed over the waste rock as part of the West Open Pit thermal cover.

00/01 Crown Pillar

A stope connecting the 00 and 01 portals was located approximately 5 m behind the West Open Pit highwall. A portion of the rock between the 00 and 01 portals, known as the 00/01 rib pillar, was removed during later stages of mine development as part of the pillar recovery program. After the recovery of a portion of the rib pillar, a crack developed in the crown pillar above the area that had been mined. In 2005, a fill pillar was constructed beneath the cracked portion of the crown pillar to provide additional support and prevent development of an opening into the mine workings if the pillar were to collapse. The pillar was constructed out of waste rock and was constructed approximately to within 1 m of the top of the opening.

Inspection Conditions

The area of the West Open Pit cover where the portals had existed was inspected in July 2015. The observations are summarized by the following:

- No indications of surface deformation were observed
- No indications of seepage from the mine workings were observed.

No maintenance of the portal plugs or the cover over the portal plugs was recommended.

The crown pillar was also inspected from surface. The observations are summarized by the following:

- Similar to previous inspection observations, a small crack (1-3 cm wide) was observed in the crown pillar area. Based on visual observations, the size of the crack has not changed relative to previous years, and no additional cracking has occurred.
- No visually distinguishable deformation was observed in the crown pillar.
- Overall, no significant changes have been observed in the West Open Pit crown pillar since the fill pillar was constructed in 2005.

In general, the portal plugs constructed for the 00 and 01 portals and the 00/01 crown pillar appear to be in satisfactory condition. It is recommended that the crown pillar area continue to be visually monitored to check for further propagation of the cracking.

6.4.2. 17 North Portal

Construction Details

The 17 North Portal was a culverted portal giving access to the Main Ore Zone. The location of the portal is illustrated on Drawing 01. The 17 North Decline was approximately 5 m by 5 m in cross section and the culvert was half round with a diameter of 5 m and a length of 28 m. The culvert was supported by a 0.25 m thick by 2 m high concrete wall on either side and it extended 5 m inside the dolostone bedrock of the drift.

In 2005, the culvert was removed and the portal was backfilled with granular shale derived from the Shale Hill borrow area. The backfill was placed to within 1 m of the top of the portal and extended into the portal for approximately 4 m. The backfill extended outside the portal face and was sloped at an angle ranging between 4(H):1(V) and 7H:1V and graded into the surrounding topography. A 0.35 m thick layer of armour material, derived from the Kuhulu Lake borrow area, was then applied to the surface of the shale backfill.

Inspection Conditions

Select photos from the inspection are provided in Appendix I (Photos 58 and 59). The main observations are summarized by the following:

- No erosion of the surface of the cover was observed
- No seepage was observed at the toe of the cover.

In general, the 17 North Portal cover appears to be physically stable and in satisfactory condition. As such, no maintenance was recommended.

6.4.3. Oceanview Portal

Construction Details

The Oceanview Portal was a bare rock entrance into the north side of the Oceanview underground workings. The location of the portal is illustrated on Drawing 01. The Oceanview decline had a cross section of approximately 5 by 5 m. The brow of the portal was approximately 5 m in height.

Prior to 2004, the portal had been backfilled with waste rock and covered over with locally derived overburden materials. In 2005, a thermal cover was constructed over the existing portal plug. The cover consisted of a 2.0 m thick layer (minimum thickness) of granular shale overlain by a 0.35 m thick layer of armour material consisting of sand, gravel and cobbles. The shale was derived from the Shale Hill borrow area. The armour material was derived from the Chris Creek “A” deposit. The thermal cover was extended to the east and north of the portal entrance in an old ore stockpile area. Additionally, a water deflection berm was constructed upslope of the cover extension to prevent concentrated surface water from flowing over the cover area.

Inspection Conditions

Select photos from the inspection are provided in Appendix I (Photos 60 and 61). The main observations from the inspection are summarized by the following:

- A small area of surficial settlement was observed near the southwest corner of the portal cover. The settlement area appears to have stabilized as it has not changed significantly since it was first observed in 2006.
- Some minor cracking was noted along the east edge of the portal cover, as has been noticed in previous inspections.The condition of the cracking does not appear to have changed in several years.
- No seepage was observed at the toe of the cover.
- The surface water deflection berm appeared to be effective in diverting water around the cover extension.

In general, the Oceanview Portal cover appears to be physically stable. As such, no maintenance was recommended.

6.4.4. K-Baseline Portal

Construction Details

The K-Baseline portal was a culverted entry used to access the K-Baseline ore body. The location of the portal is illustrated on Drawing 01. The K-Baseline decline was approximately 5 m by 5 m in cross section and the culvert was half round with a diameter of 5 m and a length of 28 m. The culvert was supported by two concrete pony walls, 1 m wide by 2.4 m high, on both sides. The concrete pony walls extended 3 m inside the dolostone bedrock of the drift.

In 2004, the culvert was removed and the portal was backfilled with waste rock. In 2005, a thermal cover was constructed over the waste rock portal plug. The cover consisted of a 2.0 m thick layer (minimum thickness) of granular shale overlain by a 0.35 m thick layer of armour material consisting of sand, gravel and cobbles. The shale was derived from the Shale Hill borrow area. The armour material was derived from the Chris Creek "A" deposit. An additional thermal cover was constructed over the area below the road immediately outside the portal where mineralized soils and additional waste rock were located. A surficial cover of shale was also constructed adjacent to the thermal cover to improve drainage conditions.

Inspection Conditions

Select photos from the inspection are provided in Appendix I (Photos 62 and 63). The main observations are summarized by the following:

- No erosion of the cover was observed
- No seepage was noted at the toe of the cover
- No areas of significant settlement were observed in the cover
- Some minor cracking was noted on the surface of the cover, likely related to thermal expansion and contraction of the cover materials.

In general, the K-Baseline portal appears to be physically stable. As such, no maintenance is recommended.

6.4.5. Area 14 Portal

Construction Details

The Area 14 Portal was a bare rock portal that provided access to the Area 14 underground workings. The location of the portal is illustrated on Drawing 01. Mining ceased in this area around 1987 and the portal was backfilled with waste. The waste was covered and contoured with shale in 1987 and 1988.

In 2005, locally derived armour material was stockpiled adjacent to the portal cover for construction of the final armour layer. In late 2006, the stockpiled armour materials were spread over the portal area.

Inspection Conditions

Select photos from the inspection are provided in Appendix I (Photo 64). The main observations are summarized by the following:

- No erosion of the cover was observed
- No seepage was noted at the toe of the cover.

In general, the Area 14 Portal cover appears to be physically stable. As such, no maintenance is recommended.

6.4.6. 09 South Portal

Construction Details

The 09 South Portal is located at the western end of the mine, as shown on Drawing 01. The 09 South Portal is a culverted entry giving access to the Main Ore Zone. The 09 South drift is approximately 5 m by 5 m in cross section. The culvert is round with a diameter of 5 m and a length of 28 m. The bottom of the culvert is filled with rockfill to provide a smooth floor. The culvert extends approximately 13 m inside the shale bedrock of 09 south drift, leaving 15 m exposed on surface, a portion of which is covered with talus from the slope above.

The 09 South Portal remained open until the fall of 2008 to provide access to the underground workings during the underground waste disposal program. Once the underground waste disposal program was complete in September 2008, work on permanent closure of the 09 South Portal began.

In 2008, the culvert was removed and the portal was backfilled with granular shale derived from the Mill Area deposit. The backfill was placed to within 0.5 m of the top of the portal and extended into the portal for approximately 5 m. The backfill extended outside the portal face and was sloped at an angle of approximately 4(H):1(V) and graded into the surrounding topography. A 0.25 m (minimum thickness) layer of locally derived armour material was then applied to the surface of the shale backfill.

Inspection Conditions

Select photos from the inspection are provided in Appendix I (Photos 65 and 66). The main observations are summarized by the following:

- No erosion of the cover was observed.
- No seepage was noted at the toe of the cover.
- Some minor cracking and deformation of the cover was noted, in a similar condition as was observed in 2012 to 2015 inspections. The area appears to have stabilized since the cracking was first noted in 2009.
- Some shale from rock outcrops upslope was deposited on the surface of the portal cover.

In general, the 09 South Portal cover appears to be physically stable. As such, no maintenance is recommended.

6.4.7. Lower Adit

Construction Details

The Lower Adit is located at the western end of the mine near the Industrial Complex, as illustrated on Drawing 01. The Lower Adit provided the main access into the underground crusher and fine ore bin, as well as secondary access to the Main Ore Zone.

The Lower Adit Portal remained open until the fall of 2008 to provide ventilation to the underground workings during the underground waste disposal program. Once the underground waste disposal program was complete in September 2008, work on permanent closure of the Lower Adit Portal began.

In 2008, the portal was backfilled with granular shale derived from the Mill Area deposit. The backfill was placed to within 0.5 m of the top of the portal and extended into the portal for approximately 5 m. The backfill extended outside the portal face and was sloped at an angle of approximately 4(H):1(V) and graded into the surrounding topography. A 0.25 m (minimum thickness) layer of locally derived armour material was then applied to the surface of the shale backfill.

Inspection Conditions

A photo from the inspection is provided in Appendix I (Photo 67). The main observations are summarized by the following:

- No erosion of the cover was observed
- No seepage was noted at the toe of the cover
- No cracking or deformation of the cover was noted.

In general, the Lower Adit portal plug appears to be physically stable. As such, no maintenance is recommended.

6.4.8. Portal to Mill Foundation

Construction Details

A portal was driven beneath the Mill building in 1980 as part of emergency repair operations for the Mill. The portal is located approximately 70 m south of the Mill, adjacent to Twin Lakes Creek. The portal provided access to an ice lens which was present beneath the mill building. As part of the repair operations, the ice lens was mined out and concrete pillars were constructed to provide additional support for the Mill. After the repair operations were complete, the portal was plugged with shale rock fill.

Inspection Conditions

A photo from the inspection is provided in Appendix I (Photo 68). The main inspection observations are summarized by the following:

- No erosion of the armoured portal plug was observed
- No seepage was noted at the toe of the portal plug.

In general, the portal plug appears to be physically stable. No maintenance is recommended.

6.4.9. Shale Hill Raise

Construction Details

The Shale Hill Raise provided ventilation for the underground workings in the Shale Hill area. The location of the raise (E582524, N8107427, UTM NAD 83 Zone 16) is illustrated on Drawing 01. The 3 m diameter raise was approximately 47 m deep. During mining operations, the raise was sealed with a 3 m diameter steel tank with the bottom cut out and with two adaptors in the top for 36-inch ventilation fans. The tank was fixed to a cemented collar at the top of the raise.

Prior to 2005, the surface structure was removed and, according to mine site records, the Shale Hill raise was backfilled with waste rock. A mound of shale was constructed at surface with side slopes of approximately 3(H):1(V). In 2005, a 0.35 m thick layer of locally derived armour material was applied to the surface of the mound to complete the remediation of this raise.

Inspection Conditions

A photo from the inspection is provided in Appendix I (Photo 69). During the inspection, the armour surface appeared to be stable with no visual indications of erosion or surface deformation. As such, no maintenance is recommended.

6.4.10. Oceanview East Raise

Construction Details

The Oceanview East Raise was situated at the extreme east end of the Oceanview underground workings. The location of the raise (E585123, N8107506, UTM NAD 83 Zone 16) is illustrated on Drawing 01. The 4 m by 4 m raise was approximately 10 m deep and provided ventilation for the underground workings in the Oceanview area. During mining operations, the raise was covered with a wooden wind deflector with a locked door.

In 2002, the wooden deflector was removed and, according to mine site records, the raise was backfilled with waste rock. During backfilling, it was noted that an ice plug was present in the raise at a depth of approximately 1.5 m below ground surface. As such, waste rock was placed only to this depth. A 3 m high mound was placed on top of the raise to accommodate for possible future settlement of the ice plug. The mound was constructed of shale and surfaced with coarse rock.

Inspection Conditions

A photo from the inspection is provided in Appendix I (Photo 70). During the inspection, the armour surface appeared to be stable with no visual indications of erosion or surface deformation. As such, no maintenance was recommended.

It was noted that acid rock drainage water emanating from groundwater seepage upslope of the raise has caused staining of the ground surface around the raise. The source of the ARD is not known, but is likely related to near surface exposure of sulphidic soils and/or bedrock. This water is collecting in a disturbed area downslope of the raise. This low spot could be backfilled to prevent collection of this water.

6.4.11. Oceanview West Raise

Construction Details

The Oceanview West raise was located near the west end of the Oceanview underground workings (E584851, N8107466, UTM NAD 83 Zone 16), as shown on Drawing 01. The 3 m diameter raise is approximately 26 m deep and provided ventilation for the underground workings. The raise was covered by a steel enclosure with a locked wooden cover.

In 2002, the steel enclosure was removed and, according to mine site records, the raise was backfilled with waste rock as part of the progressive reclamation of the mine site. During backfilling, it was noted that an ice plug was present in the raise at a depth of approximately 1.5 m below ground surface. As such, waste rock was placed only to this depth. A 3 m mound was placed on top of the raise to accommodate for possible future settlement of the ice plug. The mound was constructed of shale and surfaced with coarse rock.

Inspection Conditions

A photo from the inspection is provided in Appendix I (Photo 71). During the inspection, the armour surface appeared to be stable with no visual indications of erosion or surface deformation. As such, no maintenance was recommended.

6.4.12. Area 14 Raise

Construction Details

The location of the Area 14 Raise (E584187, N8105663, UTM NAD 83 Zone 16) is illustrated on Drawing 01. The raise had a cross section of 5 m by 5 m and an approximate depth of 8 m. Mining ceased in this area around 1987 and the raise was completely backfilled to the floor of the underground workings. Backfilling was completed with waste rock and the surface was then covered and contoured with shale in the summer of 1987 and 1988.

Inspection Conditions

A photo from the inspection is provided in Appendix I (Photo 72). During the inspection, no settlement of the area surrounding the former raise was observed. As such, no maintenance was recommended.

6.5. Shale and Armour Borrow Areas

6.5.1. Shale Borrow Areas

Several shale borrow areas were developed during the reclamation process to provide material for construction of the thermal covers. The borrow areas include the following:

- Mt. Fuji
- Area 14
- West Twin
- East Twin
- Shale Hill
- Townsite.

The borrow areas were reclaimed when no longer required. The reclamation efforts included re-grading of slopes for stability and sufficient grading of the floor of each borrow area to provide for positive drainage of surface water.

Select photos from the inspection are provided in Appendix I (Photos 73 through 76). The main observations are summarized by the following:

- Mt. Fuji
  - The benches are continuing to slowly fill in from the raveling of the remaining bench faces and are expected to eventually form a stable slope at the natural angle of repose.
  - The floor had no significant areas of ponded water and is considered generally well drained.
  - No issues requiring maintenance were observed.
- Area 14
  - In general, the re-graded pit walls appear to be stable.
  - One area of erosion has occurred at the north end of the borrow area where natural surface water periodically discharges into the pit, typically during freshet. At this location, the overburden material has been eroded down to the top of the bedrock and has been deposited into the floor of the pit. This area was observed to have stabilized during recent inspections as down-cutting of these materials no longer appears to be occurring.
  - No ponding of water was observed at the time of the inspection, but there has been significant thermokarst development at the entrance to the pit. As such, it is likely that this impedes drainage at some point in the year. The material is sufficiently fractured that any ponded water likely drains when the ground thaws.
- West Twin
  - In general, the re-graded pit walls appear to be stable.
  - No ponding was observed in the floor of the pit.
  - No issues requiring maintenance were observed.
- East Twin
  - In general, the re-graded pit walls appear to be stable.
  - No ponding was observed in the floor of the pit.
  - Some thermokarst features were noted on some of the remnant benches within the interior of the pit. These thermokarst features have resulted in some ponding within the interior benches of the pit.
  - No issues requiring maintenance were observed.
- Shale Hill
  - In general, the re-graded pit walls appear to be stable.
  - No ponding was observed in the floor of the pit.
  - No issues requiring maintenance were observed.
- Townsite
  - In general, the re-graded pit walls appear to be stable.
  - No ponding was observed in the floor of the pit.
  - No issues requiring maintenance were observed.

6.5.2. Armour Borrow Areas

Several armour borrow areas were developed during the reclamation process to provide material for construction of the thermal covers. The borrow areas include the following:

- Twin Lakes Delta deposit
- Chris Creek “A” and “B” deposits
- Kuhulu Lake Road deposit
- 09S/17N Road deposit
- Area 14.

The borrow areas were reclaimed once no longer required. The reclamation efforts included sufficient grading of the floor of each borrow area to provide for positive drainage of surface water. The main observations are summarized by the following:

- Twin Lakes Delta deposit
  - The floor of the quarry was, in general, well drained. The surface water flows to the north edge of the borrow area and then proceeds to flow west to the Reservoir.
  - Only isolated thermokarst features were observed in the floor of the quarry.
  - No issues requiring maintenance were observed.
- Chris Creek “A” and “B” deposits
  - The floor of the quarry was observed to be well drained.
  - Some minor thermokarst features were observed in the floor of the quarry.
  - No issues requiring maintenance were observed.
- Kuhulu Lake Road deposit
  - The floor of the borrow area was graded in late 2006 in response to thermokarst features identified during the 2006 inspection. Since the grading in 2006, some additional thermokarst features have developed, but the area appears to be well drained with only limited ponding occurring in the bottom of the pit. No additional maintenance was recommended.
- 09S/17N deposit
  - The face of the borrow area did not exhibit any indications of erosion or thermokarst development.
  - No issues requiring maintenance were observed.
- Area 14 deposit
  - Some minor thermokarst features were observed in the borrow area.
  - Given the stability exhibited by the area over the past few years, additional grading is no longer considered necessary but the area should continue to be monitored.

6.6. Summary of 2016 Maintenance Recommendations

The maintenance items recommended throughout Section 6.0 are summarized in Table 6-1.

Table 6-1. Recommended 2016 Maintenance and Action Items.

Inspection Item	Recommended Maintenance and Action Items
West Twin Dyke Spillway	Base of spillway should be graded with a dozer. Review additional enhancements to armouring along left bank of spillway. The area should continue to be visually monitored for any signs of erosion or permafrost degradation induced deformation of the side slopes.
West Twin Outlet Channel	Monitor the water elevation in the Reservoir and Polishing Pond. Monitor slopes along perimeter of polishing pond for stability considerations. Consider seepage control measures such as backfilling the remnant polishing pond upstream of the wall.
East Twin Creek Diversion Channel	Additional armouring of the left bank should be considered to enhance long term performance of the channel. Monitor seepage discharge at toe of dyke.
Surface Cell Tailings Cover	No maintenance required. Continue to monitor thermokarst areas for additional deformation. Monitor area of cover where cracking has been observed.
East Open Pit/ East Trench Waste Rock Cover	No maintenance required. Continue to visually monitor cracking in EOP crown pillar and minor surficial erosion of EOP and East Trench covers.
Oceanview Pit Waste Rock Cover	No maintenance required. Continue to visually monitor surficial erosion along backslope.
00/01 Portals and crown pillar	No maintenance required. Continue to visually monitor cracking in WOP crown pillar.
Instrumentation/ Monitoring	Re-install water level logger in Reservoir and Polishing Pond during 2017 inspection.

No maintenance was recommended at other areas not specifically noted in Table 3.

6.7. 2017– 2019 Monitoring Schedule

As part of the Water License renewal process in 2013, BGC undertook a review of the geotechnical monitoring requirements for the Nanisivik Mine site. The intent of the review was to develop a revised monitoring schedule for the term of the next Water License. The results of this review are documented in a project memorandum (BGC 2013). In summary, monitoring of geotechnical instrumentation (thermistors, piezometers, frost gauges) will be undertaken as per the proposed schedule between July 1 and September 1, 2017. Additionally, the reclamation measures will continue to be inspected on an annual basis throughout the term of the next Water License by a qualified Geotechnical Engineer.

The proposed monitoring schedule was approved during the Water License renewal. The monitoring schedule incorporated within the new Water License is provided in Appendix III.

7.0 CONCLUSIONS AND RECOMMENDATIONS

The following paragraphs provide a summary of the significant observations, conclusions and recommendations based on the results of the 2016 Geotechnical Inspection Program undertaken at the Nanisivik Mine site.

Embankments

The West Twin Dyke was physically stable with no signs of erosion or seepage. The breaches in the remnant dykes at the East Adit Treatment Facility continue to permit natural drainage of the area with only limited ponding in the Retention Pond. The size of this ponding is gradually decreasing with time as the low spots in the pond area backfill with natural sediment transported from upslope areas.

Hydraulic Structures

The West Twin Dyke Spillway continues to effectively drain water from the Surface Cell cover into the Reservoir and is generally functioning as intended. Additional erosion of the left bank was noted in 2016, likely in response to elevated flows during freshet in combination with ice and snow blockage within the spillway channel. Due to the nature of the flows causing the erosion, it is likely that this erosion will continue without additional enhancement of the left bank armour. If not addressed, this may lead to decline in the effectiveness of the spillway over time.

As observed during previous inspections, a small head pond developed on the Surface Cell cover at the spillway inlet. The presence of the head pond is not considered to negatively impact the overall cover performance; hence the elimination of the head pond is not considered necessary. Reduction in pond size may continue over time as the intact rock in the base of the spillway inlet becomes more permeable due to freeze thaw effects.

The seepage at the West Twin Outlet Wall seems to have slowed in recent years, as the water level upstream of the wall has been maintained more consistently at or above the invert of the outlet wall.

The stability of the perimeter slopes of the upstream polishing pond was not observed to degrade further in 2016. Based on the water quality measurements collected since the East Twin Lake access road was breached in 2008, the seepage losses from the polishing pond do not appear to be affecting the overall performance of the West Twin Area reclamation measures. The seepage losses should continue to be monitored and additional seepage control measures should be considered.

Some erosion at the East Twin Diversion Dyke was noted during the inspection. The erosion was likely due to elevated flows during freshet in combination with snow blockage in the channel. The erosion appeared to be similar to what was observed in 2014 and 2015. In general, the dyke remains in stable condition. However, it is recommended that additional re-sloping and armouring of select areas of the channel be undertaken to enhance long term performance. As has been observed during inspections over the past couple of years, seepage was observed at the toe of the East Twin Diversion Dyke upstream of the convergence of flow from West Twin. This seepage did not appear to have increased in 2016, but should continue to be monitored in future inspections.

Thermal Covers

Although warming was observed in many of the instruments in 2016 related to warmer summer air temperatures, the thermal covers were generally performing adequately, maintaining the active layer thaw within the cover profile through much, if not all of the summer thaw season. Only minor erosion, cracking and thermokarsting/settlement was observed, which were not seen to negatively impact the thermal performance nor the water quality in the surrounding areas. Many of these features have been noted previously and have been observed to be physically stable for the past several years. Continued improvement has also been observed in the quality of the surface water runoff from the Surface Cell cover system. This is an indication of the beneficial impacts related to improved geothermal performance of the cover system. Additionally, the water quality observed at the final discharge point for the West Twin Disposal Area has also been observed to remain well below the discharge criteria.

It is anticipated that, over time, the ice saturation will continue to progress within the base of the cover materials. As this occurs, the geothermal performance of the covers will continue to improve, further confining the active layer thaw within the cover. No maintenance is required for the thermal covers at this time; however, visual monitoring is recommended to check for additional surface deformation.

Talik Freeze-back

Freeze-back of the talik in the Surface Cell and Test Cell appears to be proceeding at anticipated rates. Downward migration of the freezing front appears to have slowed in 2016, but is still progressing despite many instruments showing warming in the upper 10 m of the geothermal profile in 2016 related to warmer air temperatures.

Most piezometers within the Surface Cell have frozen back due to continued downward migration of the freezing front. Where the piezometers remain in thawed tailings, the pore pressures continue to increase. The increasing pore pressures are related to continued freeze-back of the tailings. The pore pressures are lowest near the dyke and highest in the centre of the talik. Pore pressures measured in the piezometers in the Test Cell and Surface Cell taliks are comparable to previous years.

Mine Openings, Crown Pillars and Raises

The covers constructed over the mine openings generally appear to be physically stable. Cracking at the East Open Pit crown pillar does not appear to have progressed since 2011. No maintenance is recommended, but continued visual inspection is warranted.

Shale and Armour Borrow Areas

In general, the shale and armour borrow areas appear to be physically stable and are not causing any significant ponding to occur. No maintenance was recommended at any of the borrow areas.

8.0 CLOSURE

This report provides a performance assessment of numerous structures at the Nanisivik Mine, based on visual observations recorded during the site inspection and a review of monitoring data collected from various instruments throughout 2016.

We trust the information provided herein meets your present requirements. Thank you for allowing BGC to be of service, once again, to Nanisivik Mine. If you have any questions or require additional details, please contact the undersigned.

Respectfully submitted,

BGC ENGINEERING INC.
per:

REGISTERED PROFESSIONAL ENGINEER
G.K. CLAYPOOL
LICENSEE
7-Mar-17
NWT/NU

Geoff Claypool, M.Eng., P.Eng.
Senior Geological Engineer

Scott Garrison, B.Sc., EIT
Geological Engineer

Reviewed by:

James W. Cassie, M.Sc., P.Eng.
Principal Geotechnical Engineer

PERMIT TO PRACTICE
BGC ENGINEERING INC.
Signature
Date 7-March-2017
PERMIT NUMBER: P 285
NT/NU Association of Professional Engineers and Geoscientists

GC/SG/JWC/sf/cs

REFERENCES

BGC Engineering Inc. 2004a. Assessment of Surface Cell and Test Cell Taliks. Submitted to CanZinco Ltd. February 6, 2004.

BGC Engineering Inc. 2004b. Engineering Design of Surface Reclamation Covers. Submitted to CanZinco Ltd. February 6, 2004.

BGC Engineering Inc. 2009a. Nanisivik Mine Reclamation – Project Completion Report. Submitted to Breakwater Resources Ltd. January 30, 2009.

BGC Engineering Inc. 2009b. Nanisivik Mine Reclamation – Post Closure Geotechnical Monitoring Contingency Plan. Submitted to Breakwater Resources Ltd. September 28, 2009.

BGC Engineering Inc. 2014. 2013 Annual Geotechnical Inspection – Nanisivik Mine, Nunavut. Submitted to Nyrstar, March 2014.

BGC Engineering Inc. 2015. 2014 Annual Geotechnical Inspection – Nanisivik Mine, Nunavut. Submitted to Nyrstar, March 2015.

BGC Engineering Inc. 2015. 2015 Annual Geotechnical Inspection – Nanisivik Mine, Nunavut. Submitted to Nyrstar, March 2016.

BGC Engineering Inc. 2013. 2014-2018 Geotechnical Monitoring Schedule – Nanisivik Mine, NU. Submitted to Nyrstar September 16, 2013.

CanZinco Ltd. 2004. 2004 Reclamation and Closure Plan. Submitted to Nunavut Water Board. March 2004.

Gartner Lee Ltd. 2004a. Nanisivik Mine Reclamation and Closure Monitoring Plan. Report submitted to Nanisivik Mine, a Division of CanZinco Ltd., Project No.: 23-625, February 2004.

Golder Associates Ltd. 1998. 1998 Geotechnical Inspection of Waste Containment Dykes, Nanisivik Mine, Baffin Island, NWT. Report submitted to Nanisivik Mine, a Division of CanZinco Ltd., Project No.: 982-2432.5100, October, 1998, 27 pages plus Drawings.

Jacques Whitford Stantec Limited 2009. Abandonment and Reclamation Plan, Fuel Tank Farm, Former Nanisivik Mine Site, Nunavut. Submitted to Breakwater Resources Ltd. October 2009.

Nunavut Water Board. 2004. Nunavut Water Board's Letter of Approval for Terms and Conditions Applying to the Nanisivik Mine 2004 Reclamation Plan and Closure Plan. Memorandum addressed to Breakwater Resources Ltd. July 6, 2004.

SRK Consulting (Canada) Inc. 2009. Nanisivik Mine, Summary of Contaminated Soil Remediation Progress – September 10, 2008. Submitted to CanZinco Ltd. January, 2009.

Stantec Consulting Ltd. 2017. 2016 Annual Water Quality Monitoring Report – Former Nanisivik Mine Site, Nunavut. Submitted to Nyrstar. February, 2017.

APPENDIX I
INSPECTION PHOTOS

LIST OF APPENDIX I INSPECTION PHOTOS

Photo 1. East Adit Treatment Facility—Retention pond area.

Photo 2. East Adit Treatment Facility—Treatment pond as seen from the East Open Pit.

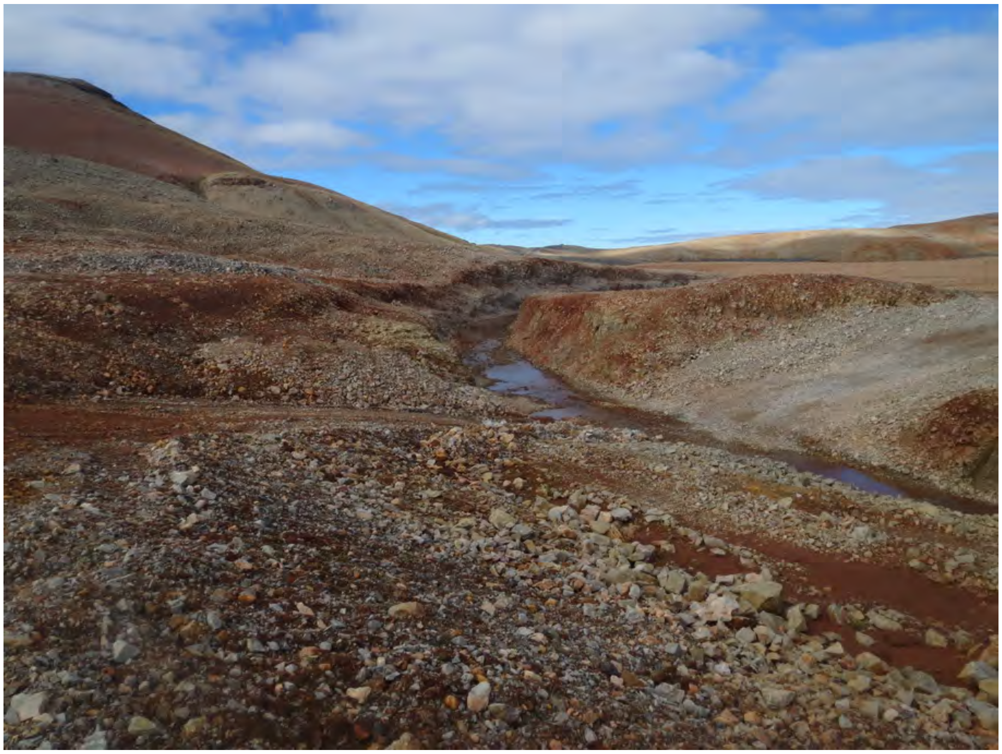

Photo 5. West Twin Dyke Spillway—Spillway as seen from edge of right bank upper slope.

Photo 6. West Twin Dyke Spillway—Erosion along left bank of spillway.

Photo 7. West Twin Dyke Spillway—Flow in bottom of spillway between entrance and access ramp.

Photo 8. West Twin Dyke Spillway—Deposition of eroded material in bottom of spillway.

Photo 9. West Twin Lake Outlet Channel—Cracking along edge of polishing pond. Similar condition to 2015.

Photo 10. West Twin Lake Outlet Channel—Looking upstream at wall.

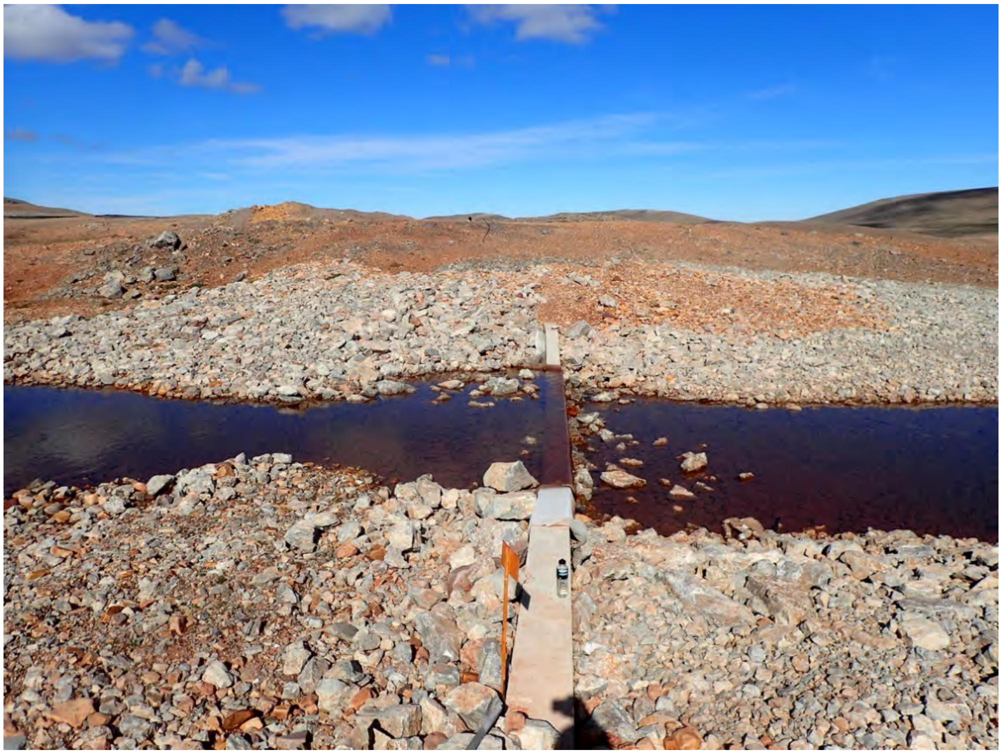

Photo 11. West Twin Lake Outlet Channel—Looking north along wall.

Photo 12. West Twin Lake Outlet Channel—Settlement and cracking along north edge of polishing pond.

Photo 13. East Twin Creek Diversion Channel—Erosion along face of dyke.

Photo 14. East Twin Creek Diversion Channel —Erosion along face of dyke.

Photo 15. East Twin Creek Diversion Channel —Inside face of dyke.

Photo 16. East Twin Creek Diversion Channel —Inside face of dyke.

Photo 17. Surface Cell—Surface Cell cover system. Note cracking of surface of cover.

Photo 18. Surface Cell—Settlement area along east edge of main N/S drainage swale. View looking north.

Photo 19. Surface Cell—Cracking in secondary N/S drainage swale. View looking north.

Photo 20. Surface Cell—E/W drainage channel on Surface Cell cover. View looking west.

Photo 21. West Twin Dyke—Crest of dyke, view looking north.

Photo 22. West Twin Dyke—Face of dyke, view looking south.

Photo 23. Test Cell—Settlement trough along edge of East/West Test Cell dyke.

Photo 24. Test Cell—Settlement trough along north/south arm of Test Cell dike.

Photo 25. Test Cell—View looking southwest along centre of Test Cell cover system.

Photo 26. Test Cell—Test Cell area as seen from crest of West Twin Dyke.

Photo 27. Test Cell—Looking towards toe of West Twin dyke from centre of Test Cell.

Photo 28. Test Cell—View looking west into centre of Test Cell cover.

Photo 29. Toe of Test Cell Dyke—Looking north along armoured shoreline at toe of Test Cell Dyke.

Photo 30. Toe of Test Cell Dyke— Looking west along armoured shoreline at toe of Test Cell Dyke.

Photo 31. Toe of Test Cell Dyke—Cover along toe of Test Cell Dike. View looking north.

Photo 32. Toe of Test Cell Dyke—Outlet of test cell cover to Reservoir.

Photo 33. Toe of West Twin Dyke—Toe of West Twin Dyke. View looking south.

Photo 34. Toe of West Twin Dyke—Toe of West Twin Dyke. View looking north.

Photo 35. Landfill–Surface of landfill cover system.

Photo 36. Landfill–Toe of landfill cover system. Note surface water flow along toe of cover.

Photo 37. West Open Pit—Crack in crown pillar. No visual change in the 10 years since closure.

Photo 38. West Open Pit— Crack in crown pillar. No visual change in the 10 years since closure.

Photo 39. West Open Pit—Surface of cover system looking downslope.

Photo 40. West Open Pit—Sloping face of cover system looking east.

Photo 41. East Open Pit— At transition from flat to sloping upper surface of cover system. Note minor settlement and cracking.

Photo 42. East Open Pit—Face of remnant highwall.

Photo 43. East Open Pit—Looking upslope along lower sloping face of cover. Note rill erosion.

Photo 44. East Open Pit—Cracking in crown pillar. Similar condition to 2015.

Photo 45. East Trench—Trench cover as seen from upslope edge. Note small flow of water on surface of cover causing minor rill erosion.

Photo 46. East Trench—Cover system, looking upslope.

Photo 47. Oceanview Open Pit—Toe of cover system. Note seepage emerging at the bottom of toe.

Photo 48. Oceanview Open Pit—Rill erosion along backslope. Note self armouring that is occurring.

Photo 49. Oceanview Open Pit—Main pit area as seen from backslope.

Photo 50. Oceanview Open Pit—Centre of cover system as seen from toe area.

Photo 51. Area 14—Upper flat surface of waste rock cover.

Photo 52. Area 14—Sloping face of waste rock cover.

Photo 53. Upper Dump Pond—Edge of cover system.

Photo 54. Upper Dump Pond—Edge of cover system.

Photo 55. Industrial Complex Cover—View across sloping face of cover.

Photo 56. Industrial Complex Cover—Looking upslope from toe of sloping cover system.

Photo 57. Industrial Complex Cover–Surface of cover system.

Photo 58. 17N Portal—Looking upslope along surface of cover.

Photo 59. 17N Portal—Looking downslope along surface of cover.

Photo 60. Oceanview Portal—Looking downslope along surface of portal cover.

Photo 61. Oceanview Portal—Settlement area along west edge of cover. Note very little to no change in 10 years.

Photo 62. K-Baseline Portal—Surface of cover system.

Photo 63. K-Baseline Portal—Sloping face of cover system looking upslope.

Photo 64. Area 14 Portal–Portal entrance.

Photo 65. 09S Portal—Portal plug looking downslope.

Photo 66. 09S Portal—Looking upslope along surface of cover.

Photo 67. Lower Adit—As seen from Industrial Complex cover.

Photo 68. Mill Portal—Portal plug as seen from right bank of Twin Lakes Creek.

Photo 69. Shale Hill Raise—Mound over backfilled raise. No settlement has been observed.

Photo 70. Oceanview East Raise—Mound over backfilled raise. No settlement has been observed.

Photo 71. Oceanview West Raise— Mound over backfilled raise. No settlement has been observed.

Photo 72. Area 14 Raise—Graded area above backfilled raise.

Photo 73. Area 14 Shale Quarry.

Photo 74. Shale Hill Quarry.

Photo 75. Mt. Fuji Shale Quarry—Note ongoing sloughing of bench faces reducing overall slope.

Photo 76. Mt. Fuji Shale Quarry—Note ongoing sloughing of bench faces reducing overall slope.

APPENDIX II
2016 GEOTECHNICAL MONITORING SCHEDULE

2016 Geothechnical and Geothermal Instrument Readings Completed

		01-Jan	01-Feb	01-Mar	01-Apr	01-May	01-Jun	15-Jun	30-Jun	02-Jul	04-Jul	05-Jul	13-Jul	14-Jul	23-Jul	24-Jul	27-Jul	28-Jul	29-Jul	02-Aug	04-Aug	05-Aug	19-Aug	25-Aug	01-Sep	22-Sep	29-Sep	06-Oct	03-Nov	01-Dec	08-Dec	15-Dec	22-Dec	29-Dec
West Twin Dyke																																		
TC12	Thermocouple	Not functioning																																
TC13A	Thermocouple	Not functioning																																
TC31	Thermocouple	Not functioning																																
TC32	Thermocouple	Not functioning																																
TC33	Thermocouple	Not functioning																																
BGC03-33	Thermistor																																	
BGC03-34	Thermistor																																	
BGC05-09	Thermistor																																	
BGC05-15	Thermistor																																	
BGC05-17	VW Piezo.																																	
Surface Cell																																		
BGC02-03	Thermistor	Not functioning																																
BGC03-07	Thermistor	No Data																																
BGC03-09	Thermistor																																	
BGC03-10	Thermistor																																	
BGC03-11	Thermistor	Not functioning																																
BGC03-12	VW Piezo.																																	
BGC03-14	VW Piezo.																																	
BGC03-15	Thermistor																																	
BGC03-20	Thermistor																																	
BGC03-21	Thermistor	Not functioning																																
BGC03-32	VW Piezo.																																	
BGC03-35	VW Piezo.																																	
BGC03-36	Thermocouple																																	
BGC03-37	Thermistor	Not functioning																																
BGC05-05	Thermistor																																	
BGC05-06	VW Piezo.	No Data																																
BGC05-07	VW Piezo.																																	
BGC05-08	Contingency																																	
BGC05-10	VW Piezo.																																	
BGC05-11	Monitoring Well	Not functioning																																
BGC05-12	Monitoring Well	Not functioning																																
BGC05-13	VW Piezo.																																	
BGC05-14	Contingency																																	
BGC05-16	Contingency																																	
FG-1	Frost Gauge																																	
FG-2	Frost Gauge																																	
FG-3	Frost Gauge																																	
FG-4	Frost Gauge																																	
FG-5	Frost Gauge																																	
FG-6	Frost Gauge																																	

Weekly Reading

Monthly Reading

Bi-Weekly Reading

2016 Geothechnical and Geothermal Instrument Readings Completed

		01-Jan	01-Feb	01-Mar	01-Apr	01-May	01-Jun	01-Jun	30-Jun	02-Jul	04-Jul	05-Jul	13-Jul	14-Jul	23-Jul	24-Jul	27-Jul	28-Jul	29-Jul	02-Aug	04-Aug	05-Aug	19-Aug	25-Aug	01-Sep	15-Sep	29-Sep	06-Oct	03-Nov	01-Dec	08-Dec	15-Dec	22-Dec	29-Dec
Toe of West Twin Dyke																																		
BGC03-18	Thermocouple	Not functioning																																
BGC03-19	Thermistor										Monthly				Bi-Weekly							Monthly	Bi-Weekly											
BGC05-26	Thermistor										Monthly											Bi-Weekly	Monthly											
Test Cell																																		
BGC05-04	Thermistor										Monthly					Bi-Weekly						Monthly	Bi-Weekly											
BGC05-18	VW Piezo.										Monthly					Monthly						Monthly												
BGC05-19	Thermistor										Monthly					Bi-Weekly		Monthly				Bi-Weekly												
BGC05-20	VW Piezo.										Monthly																							
BGC05-21	Monitoring Well	Not functioning																																
BGC05-22	VW Piezo.										Monthly					Monthly						Monthly												
BGC05-23	Monitoring Well	Not functioning																																
BGC05-24	VW Piezo.										Monthly					Monthly						Monthly												
BGC05-25	Contingency																																	
FG-7	Frost Gauge																Monthly					Bi-Weekly												
FG-8	Frost Gauge																Monthly					Bi-Weekly												
Test Cell Dyke																																		
BGC02-09	Thermistor	Not functioning																																
BGC03-22	Thermistor										Monthly											Monthly												
BGC05-29	Thermistor										Monthly					Bi-Weekly		Monthly				Bi-Weekly												
Toe of Test Cell Dyke																																		
BGC05-27	Thermistor										Monthly					Bi-Weekly						Monthly	Bi-Weekly											
BGC05-28	VW Piezo.										Monthly					Monthly						Monthly												
FG-9	Frost Gauge	No Data																																
FG-10	Frost Gauge																Monthly																	
Oceanview Pit																																		
BGC05-01	Thermistor										Monthly					Bi-Weekly						Monthly	Bi-Weekly											
FG-16	Frost Gauge																		Monthly			Bi-Weekly												
East Open Pit																																		
BGC05-02	Thermistor										Monthly					Bi-Weekly						Monthly	Bi-Weekly											
BGC05-03	Thermistor										Monthly					Bi-Weekly						Monthly	Bi-Weekly											
FG-13	Frost Gauge																		Monthly															
FG-14	Frost Gauge																		Monthly															
Landfill																																		
BGC05-30	Thermistor															Monthly						Bi-Weekly	Monthly											
FG-11	Frost Gauge										Monthly											Monthly												
Area 14																																		
TC7	Thermocouple																																	
FG-15	Frost Gauge																	Monthly				Bi-Weekly												
Upper Dump Road																																		
FG-17	Frost Gauge																		Monthly			Bi-Weekly												
West Open Pit																																		
BGC08-01	Thermistor										Monthly					Bi-Weekly						Monthly	Bi-Weekly											
Mill Cover																																		
BGC08-02	Thermistor										Monthly					Bi-Weekly						Monthly	Bi-Weekly											
Water Quality / Levels																																		
159-4	Water Level									Weekly	Weekly		Weekly			Weekly					Weekly													
159-4	Water Quality													Monthly						Monthly														
Spillway Inlet	Water Quality																			Monthly														

Weekly Reading

Monthly Reading

Bi-Weekly Reading

APPENDIX III
2017 - 2019 GEOTECHNICAL MONITORING PROGRAM SCHEDULE

2017-2019 Geothechnical and Geothermal Instrument Reading Schedule

		01-Jan	01-Feb	01-Mar	01-Apr	15-Apr	01-May	11-May	21-May	01-Jun	07-Jun	14-Jun	21-Jun	01-Jul	07-Jul	14-Jul	21-Jul	01-Aug	07-Aug	14-Aug	21-Aug	01-Sep	07-Sep	14-Sep	21-Sep	01-Oct	11-Oct	21-Oct	01-Nov	01-Dec	08-Dec	15-Dec	22-Dec	29-Dec
West Twin Dyke																																		
TC12	Thermocouple	Not functioning																																
TC13A	Thermocouple	Not functioning																																
TC31	Thermocouple	Not functioning																																
TC32	Thermocouple	Not functioning																																
TC33	Thermocouple	Not functioning																																
BGC03-33	Thermistor																																	
BGC03-34	Thermistor																																	
BGC05-09	Thermistor																																	
BGC05-15	Thermistor																																	
BGC05-17	VW Piezo.																																	
Surface Cell																																		
BGC02-03	Thermistor	Not functioning																																
BGC03-07	Thermistor																																	
BGC03-09	Thermistor																																	
BGC03-10	Thermistor																																	
BGC03-11	Thermistor	Not functioning																																
BGC03-12	Vibrating Wire																																	
BGC03-14	Vibrating Wire																																	
BGC03-15	Thermistor																																	
BGC03-20	Thermistor																																	
BGC03-21	Thermistor	Not functioning																																
BGC03-32	Vibrating Wire																																	
BGC03-35	Vibrating Wire																																	
BGC03-36	Thermocouple																																	
BGC03-37	Thermistor	Not functioning																																
BGC05-05	Thermistor																																	
BGC05-06	VW Piezo.																																	
BGC05-07	VW Piezo.																																	
BGC05-08	Contingency																																	
BGC05-10	VW Piezo.																																	
BGC05-11	Monitoring Well	Not functioning																																
BGC05-12	Monitoring Well	Not functioning																																
BGC05-13	VW Piezo.																																	
BGC05-14	Contingency																																	
BGC05-16	Contingency																																	
FG-1	Frost Gauge																																	
FG-2	Frost Gauge																																	
FG-3	Frost Gauge																																	
FG-4	Frost Gauge																																	
FG-5	Frost Gauge																																	
FG-6	Frost Gauge																																	

Weekly Reading
Monthly Reading
Bi-Weekly Reading

2017-2019 Geothechnical and Geothermal Instrument Reading Schedule

		01-Jan	01-Feb	01-Mar	01-Apr	15-Apr	01-May	11-May	21-May	01-Jun	07-Jun	14-Jun	21-Jun	01-Jul	07-Jul	14-Jul	21-Jul	01-Aug	07-Aug	14-Aug	21-Aug	01-Sep	07-Sep	14-Sep	21-Sep	01-Oct	11-Oct	21-Oct	01-Nov	01-Dec	08-Dec	15-Dec	22-Dec	29-Dec
Toe of West Twin Dyke																																		
BGC03-18	Thermocouple	Not functioning																																
BGC03-19	Thermistor																																	
BGC05-26	Thermistor																																	
Test Cell																																		
BGC05-04	Thermistor																																	
BGC05-18	VW Piezo.																																	
BGC05-19	Thermistor																																	
BGC05-20	VW Piezo.																																	
BGC05-21	Monitoring Well	Not functioning																																
BGC05-22	VW Piezo.																																	
BGC05-23	Monitoring Well	Not functioning																																
BGC05-24	VW Piezo.																																	
BGC05-25	Contingency																																	
FG-7	Frost Gauge																																	
FG-8	Frost Gauge																																	
Test Cell Dyke																																		
BGC02-09	Thermistor	Not functioning																																
BGC03-22	Thermistor																																	
BGC05-29	Thermistor																																	
Toe of Test Cell Dyke																																		
BGC05-27	Thermistor																																	
BGC05-28	VW Piezo.																																	
FG-9	Frost Gauge																																	
FG-10	Frost Gauge																																	
Oceanview Pit																																		
BGC05-01	Thermistor																																	
FG-16	Frost Gauge																																	
East Open Pit																																		
BGC05-02	Thermistor																																	
BGC05-03	Thermistor																																	
FG-13	Frost Gauge																																	
FG-14	Frost Gauge																																	
Landfill																																		
BGC05-30	Thermistor																																	
FG-11	Frost Gauge																																	
Area 14																																		
TC7	Thermocouple																																	
FG-15	Frost Gauge																																	
Upper Dump Road																																		
FG-17	Frost Gauge																																	
West Open Pit																																		
BGC08-01	Thermistor																																	
Mill Cover																																		
BGC08-02	Thermistor																																	
Water Quality / Levels																																		
159-4	Water Level																																	
159-4	Water Quality																																	
Spillway Inlet	Water Quality																																	

Weekly Reading

Monthly Reading

Bi-Weekly Reading