24 November 2010
YX00828

Dillon Consulting Limited
P.O. Box 1409,
4920 47th Street
Yellowknife, NT X1A 2P1

Attention: Mr. Gary Strong, P.Eng., Partner

Dear Mr. Strong:

Re: Dam Safety Review for the Kugaaruk Sewage Lagoon, Kugaaruk, NU

At the request of Mr. Gary Strong, on behalf of Dillon Consulting Limited (DCL), AMEC Earth and Environmental (AMEC), a division of AMEC Americas Limited conducted a geotechnical safety review for the sewage lagoon dam located in community of Kugaaruk, NU. Geotechnical investigations for the sewage lagoon were carried out by AMEC in 2005, the lagoon and dam design was completed by DCL in 2006, and construction of the sewage lagoon commenced in 2007 and was completed in 2008.

Authorization to proceed with the dam safety investigation was provided via a signed Dillon Short Form Agreement for Sub-Consultant Service, dated August 9, 2010 for the above noted project.

1.0 SCOPE OF WORK

In accordance with AMEC's proposal, dated July 30, 2009 and subsequent discussions with DCL, the scope of work outlined for the project is as follows:

- Conduct a review of design drawings and relevant normative documents.
- Perform the site reconnaissance and interview dam operating personnel,
- Review operational plans and operational records.
- Prepare a geotechnical report which presents results of the reviews and field reconnaissance.

2.0 EXISTING INFORMATION

The following is a review of the AMEC geotechnical report, DCL's design record drawings, AMEC construction monitoring report which pertains to lagoon dam design and construction and the Nunavut Water Board (NWB) Licence document. The AMEC reports can be found in

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Appendix A, the DCL record drawings are included in Appendix B and the NWB licence document is in Appendix C.

Report Titled "Geotechnical Investigation for Sewage Lagoon, Kugaaruk, NU" dated October 31, 2005, submitted to DCL by AMEC.

The original scope for the geotechnical investigation included a field reconnaissance visit, a drilling program consisting of 6 to 10 boreholes, interpretation of aerial photographs, and numerical modeling of the dam operational temperatures throughout the life cycle of the facility. Following the site reconnaissance visit and discussions with DCL, the drilling program and aerial photograph interpretation phases of the project were not undertaken due to sufficient information being obtained from the site reconnaissance and geothermal modeling.

Based on the site reconnaissance, it was concluded that the lagoon site is covered with an organic mat, 50 mm to 100 mm thick. Poorly drained, saturated, fine grained marine deposits, consisting of sand and silt with gravel and inclusions of cobbles and boulders, were found below the organic mat. It was calculated that the mean annual permafrost temperature at the site could be in a range of -10 ^{o}C to -11 ^{o}C at a depth of about 15 m below the ground surface. The thickness of the active layer was assessed to be in the order 0.7 m to 1.0 m.

Three design approaches for dam construction were discussed in the report. The first approach considered construction of the dam with a liner, whereby a suitable synthetic liner would be installed in a near vertical position to an assumed elevation of 98.5 m (1.5 m below the existing ground surface), in a cut-off trench near the upstream slope. The cut-off trench with liner was recommended to be backfilled with either compacted clayey soil or with grout. The liner curtain above the cut-off trench then extended vertically to the top of the dam, or alternatively followed the upstream slope of the dam.

The second potential approach considered construction of a frozen core dam with a 50 mm thick insulation layer placed at a shallow depth over the crest of the dam. The intent of the insulation was to reduce seasonal thawing at the dam crest, which could potentially lead to percolation of effluent through the dam. Geothermal analyses were carried out for the first and second approaches to confirm that the considered design options were suitable to provide low permafrost temperatures within the dam, and shallow thaw depths within the lagoon impoundment area.

The third approach considered repairing of the existing dam. It was recommended to re-design the dam with a frozen core. The report recommended removal of any loose material and backfilling of any erosion features, the dam would then have been raised to the design elevation in 250 mm (compacted) lifts. Similar to the second approach, placement of a 50 mm thick insulation layer was recommended along the dam crest.

The first design approach, with cut-off trench and liner, was adopted for the dam. The geometry for the cut-off trench and liner was modified somewhat from that outlined in the geotechnical

report. Also, since clayey backfill was not available at the site, geothermal calculations were undertaken to assess the potential to use sand backfill to install the liner. The geothermal calculations demonstrated that if sand backfill was used to install the liner, it would freeze subsequent to being compacted in place, and would remain in a frozen condition given the expected subsurface soil and thermal conditions with the lagoon in operation. Accordingly, sand backfill compacted and then frozen in place was adopted in the liner design to replace compacted clayey soil backfill in the cut-off trench.

Drawings Titled "Sewage & Solid Waste Sites – Record Drawings, Kugaaruk, NU" dated December, 2009, submitted to the Government of Nunavut by DCL.

Seven record drawings were reviewed as part of the geotechnical dam safety review. The drawings show as-built design details of the lagoon dam, manhole, spillway, drainage pipe, and other details associated with the facility.

Drawings No. 100 and 101, Titled "Lagoon Site" and "Design Lagoon Site View:"
The drawings display plan and profile views of the constructed lagoon with elevation contours. The lagoon impoundment is generally shaped like a bowl with the unloading area on the southeast slope of the lagoon, and the drainage outfall located in the northwest lagoon berm. The dam generally slopes at 2.5H:1V along the interior and exterior slopes. The drawing shows the unloading half-culverts, emergency overflow weir, lagoon drainage outfall, and manhole. The profiles show ground elevations starting from the ocean shore and ending at the truck turnaround pad.

Drawing No. 102, Titled "Lagoon Sections":
The Drawing displays a series of topographic profiles, provides data on invert elevations of the lagoon along various cross sections and presents a large scale profile of the turnaround pad. The topographic profiles for the lagoon are spaced approximately at 10 m intervals.

Drawing No. 103, Titled "Wetland Sections":
The drawing displays a plan view with drainage paths for the wetland area north from the lower pond. A series of the topographic profiles shows ground elevations across the wetland area at 20 m intervals extending from the lower pond.

Drawing No. 200, Titled "Discharge and Overflow Flume and Landfill Fence Details":
The first through fourth sections on the drawing show design details for the discharge flume. A profile view of the discharge flume indicates two flumes, made from high density polyethylene (HDPE) pipe shells, directed across the slope from the crest of the truck turnaround pad to nearly the bottom of the lagoon. The third and fourth sections show design details for pressure treated timbers used to support the discharge flume on the slope, and security bollards along the truck turnaround pad. The fifth through eighth sections show design details for the emergency overflow weir. It was understood that location of the liner near the emergency overflow weir follows the exterior slope of the dam down to the exterior slope toe.

Drawing No. 201, Titled "Berm Sections and Details":
The drawing displays details of the dam design for various soil conditions, including the portion of the dam encompassing the existing dam and the dam abutment to the native rock outcrop. Two sections on the drawing (fourth and fifth) show design details for placement of the liner for typical sections of the dam. The last two sections on the drawing provide design details for the lagoon drainage outfall pipe. It was understood that the liner in the vicinity of the lagoon drainage outfall pipe was placed over the internal slope of the dam.

Drawing No. 202, Titled "Manhole Derail":
The drawing illustrates manhole details, including water supply plan, hatch and lid framing, and access section.

Report Titled "Sewage Lagoon Cut-off Trench Construction Monitoring, Kugaaruk, NU" dated October 31, 2007, submitted to DCL by AMEC.

The Construction monitoring program included inspection of the cut-off trench excavation and monitoring backfilling/compaction activities during construction. The scope of work consisted primarily of the following duties:

- confirm that the cut-off trench was not less than 2 m deep;
- confirm that the cut-off trench was constructed in hard frozen soil/bedrock with a practical absence of visible ice;
- compile a record of soil composition and the ice content of the excavated soil along the cut-off trench.
- inspect engineered fill quality, including such fill parameters as gradation, moisture content, frozen/unfrozen state and inclusions of cobbles or boulders.
- review the compatibility of the lift thickness to the capacity of available compaction equipment, where necessary;
- test the compaction for each lift, using a nuclear dosimeter or other appropriate tests, and;
- record all geotechnical activities on the site, and direct that remedial measures be implemented where these activities are not in compliance with to the earth work specifications.

With the exception of the toe of the sewage lagoon berm, practically the entire cut-off trench is situated atop granite gneiss that is weathered, jointed, and foliated extensively. The lines of intersection of these discontinuities have created numerous large rock wedges that have been dislodged to some extent by repeated freeze-thaw cycles. The individual intact pieces of granite gneiss appeared to be extremely strong with little to no visible weathering observed.

Excavation of the cut-off trench was performed by Kudlik Construction Ltd. (Kudlik) by means of drilling and blasting with dynamite, which was necessary to excavate into the competent granite in which most of the cut-off trench was constructed. The drilling was done using an air rotary track mounted drill rig and diesel compressor.

The base of the excavated cut-off trench was at least 1 m wide, as specified in the design, throughout all of the excavated segments. After the cut-off trench was excavated and cleared of debris, approximately 200 mm to 300 mm of sand fill was placed along the trench bottom and side slopes to prevent the liner from tearing on the sharp faces/edges of the blasted bedrock. The side slopes were packed and smoothed by the bucket of the back-hoe and the trench bottom was packed with a plate tamper. The liner was lowered into place, and the trench was then backfilled with a sand and gravel fill in approximate 250 mm to 300 mm thick lifts compacted to minimum 95 percent of the standard Proctor maximum dry density (SPMDD).

The liner used during construction was a Bentofix Thermal Lock Geosynthetic Clay Liner. The compaction equipment used on site consisted of a Hatz Supra diesel plate tamper and CAT CS553 vibratory smooth drum roller (packer).

The on-site geotechnical activities that were not compliant with either the earth work specifications or the original design for the sewage lagoon are as follows:

- The manhole access and joining pipeline were relocated approximately 19 m to the east of the original location because the proposed top of the manhole access would have been significantly lower than the proposed top of the berm at the original location. It is understood that this decision to move the manhole was made between Kudlik and DCL personnel during construction.
- On September 7th, 2007, a hydraulic hose in the packer broke and the smooth drum was not able to vibrate for the duration of the construction for the year. In response to this, backfilling was done in thinner lifts, and packed with the packer, the diesel plate tamper, and also by trucks and bulldozers on occasion. Visual inspection as well as densometer testing confirmed that the compacted material met the 95% SPMDD requirement.
- In the summer of 2007, only a portion of the cut-off trench had been completed. The north segment of the cut-off trench had been successfully excavated, lined, and backfilled with sand fill to between approximately 23.6 m and 28 m, geodetic. The west segment of the cut-off trench was excavated to approximately Sta 0+100, but backfilling had only been completed approximately to Sta 0+005, to an approximate elevation of 24 m, geodetic. The remainder of the trench segment had been left exposed, to be completed the following spring. The east segment of cut-off trench had been completely excavated, but only backfilled and compacted to approximately Sta 0+020, with the remaining portion of the east segment left to be completed in the spring of 2008.

Based on the monitoring results, AMEC concluded that the cut-off trench was excavated into the hard frozen soils to depths specified in DCL design drawings. It is anticipated that the trenches will perform as designed, provided that the soils surrounding cut-off trench remain in a frozen state.

Report Titled "Licence Number: 3BM – PEL0712, Kugaaruk, NU" dated signed September 7, 2007, submitted to the Hamlet of Kugaaruk by Nunavut Water Board.

The licence document provides comprehensive information in regards to the potable water distribution system and sewage water facilities, including any required modifications, construction and/or repair, abandonment/remediation and a monitoring program. It was understood that the hamlet should submit to the Nunavut Water Board the following documents related to the potable water system and sewage water facilities.

- Water Distribution Facility Operation and Maintenance Plan;
- Sewage Treatment Facility Operation and Maintenance Plan;
- Solid Waste Facility Operation and Maintenance Plan;
- Environmental Emergency Contingency Plan for Water, Sewage and Solid Waste Operations in the Hamlet of Kugaaruk, Nunavut; and
- Monitoring Program Quality Assurance/Quality Control Plan

3.0 FIELD RECONNAISSANCE

The field inspection of the dam was carried out by Dr. Alexandre Tchekhovski, P. Eng. with AMEC, from September 13th through to September 16th, 2010. During the inspection, detailed visual observations were completed related to the dam slope stability, seepage, integrity of the discharge flume, integrity of the lagoon drainage outfall pipe, manhole, and emergency overflow weir. Two meetings were also held with the community public works foreman.

During the inspection, detailed visual observations were performed on the dam slopes to assess the dam stability and seepage. Other observations were also made in regards to the integrity of the discharge flume, lagoon drainage outfall pipe, manhole and emergency overflow weir.

The lagoon dimensions from berm crest to berm crest are approximately 130 m by 110 m. The long axis of the lagoon is oriented in a SE-NW direction. A general view of the lagoon and berms is shown at Photograph 1, Appendix C. The effluent level in the lagoon during the site visit was approximately 3.5 m below the dam crest. However, it can be seen in Photograph 2, Appendix C, that in the past the effluent level has been considerably higher – extending to approximately 2 m below the dam crest.

3.1 Seepage and Slope Stability

During the first day of the site visit (September 13, 2010), the exterior slopes of the dam were inspected for signs of seepage. All of the exterior slopes were found to be dry with no indications of any current seepage. Also there was no evidence of seepage that may have occurred in the past, when the effluent level in the lagoon was considerably higher.

The southeast slope of the lagoon consists of an undisturbed bedrock outcrop (Photograph 3, Appendix C) with a riprap blanket constructed to support the discharge flume culverts. The slope of the riprap blanket is about 2.5H:1V, and the length of the slope is approximately 9 m. The riprap blanket consists of (blast) rock fragments ranging in size from about 200 mm to 400 mm. There was no indication of problems within the natural slope, such as erosion features, slumps, or rock falls within the riprap blanket.

The effluent level along the northeast, northwest and southwest slopes of the dam was about 3.5 m below the dam crest. A general view of the internal slopes is provided in Photograph 2 and Photograph 4 through to Photograph 7, Appendix C. The internal slopes were found to be stable, consisting of rock fragments, up to 500 mm in size. The angle of the internal slopes was approximately 2.5H:1V, i.e. in a close agreement with the record drawings (Appendix B).

Depending on the topography of the surrounding natural terrain, the external slopes of the dam varied in height from about 1 m (central portion of the southwest slope, Photograph 8, appendix C), to about 10 m (central portion of the northwest slope, Photograph 9, Appendix C). Construction of the external slope was not required along the majority of the northeast slope, where the dam abuts with a relatively steep native rock outcrop (Photograph 10, Appendix C). Similar to the internal slopes, the external slopes were found to be stable with no indications of any erosion, moisture, slumps or rock falls. The angle of the external slopes was also about 2.5H:1V, i.e. in a close agreement with the record drawings (Appendix B).

The crest of the dam was about 4.5 m to 5 m wide, and was surfaced with fine crushed gravel and sand. No depressions, which would have indicated possible settlement or erosion, were observed on the dam crest surface (Photograph 11, Appendix C).

3.2 Drainage Fume Culvert

The fume culvert, consisting of two high density polyethylene half-pipe shells, was placed directly on the surface of the riprap blanket (internal southeast slope of the lagoon). The culvert extends from the truck turnaround pad down to an elevation approximately 0.5 m above the effluent level (Photograph 3, Appendix C). The culvert was found to be in good working condition with no visible cracks or holes along the shell invert (sliding surface).

3.3 Lagoon Drainage Outfall

The lagoon drainage outfall structure consists of a 300 mm diameter high density polyethylene (HDPE) pipe extending from the lagoon interior to a manhole which contains valves and heat tracing and finally a second section of 300 mm diameter HDPE pipe leading from the manhole to exit at the toe of the exterior slope. Short 4 m long sections of corrugated, galvanized steel culvert inserted over the upstream and downstream ends of the HDPE outfall pipe provide protection to the pipe ends. The corrugated pipe slopes down at approximately a 2 percent grade, effluent was being drained from the lagoon during the site visit (Photograph 12, Appendix C). The HDPE pipe and corrugated steel end protectors were found to be in proper working

conditions with no settlement of the slope immediately below the location where the effluent was discharging onto native ground.

The control valve manhole, located in the northwest berm external slope, was also inspected. The manhole lid had no hasp for a padlock (Photograph 13, Appendix C), and the community public works foremen noted that that the hasp was broken by unidentified persons in the spring of 2010. The manhole shaft was plumb, and no damage was observed either outside or inside of the manhole.

3.4 Emergency Overflow Weir

The emergency overflow weir is located at the crest of the northwest berm. The overflow weir consists of a ditch, approximately 0.3 m deep and 1 m wide, excavated across the crest of the northwest berm and along the external slope. The invert and slopes of the ditch are covered with riprap to reduce erosion potential (Photograph 14, Appendix C). The overflow weir was found to be dry during the site visit. It was also understood that the overflow weir has never been wet, meaning that there was no prior overflow of the lagoon to the date of the site visit. No settlement depressions or erosion features were observed along the overflow weir, meaning that the overflow weir has not impacted the overall stability of the northwest berm.

3.5 Lower or Secondary Effluent Pond

Effluent is being drained from the lagoon into the lower pond located immediately downslope from the northwest berm external slope toe. The lower pond is approximately 40 m by 30 m, and the height of the berm forming the lower lagoon is in a range from 2 m to 3 m (Photograph 15 and 16, Appendix C). DCL's record drawings do not provide design details for the lower pond, such as material used for berm construction and any liner application. Field observations have indicated that effluent is seeping under the lower pond berm from the lower pond toward the Arctic Ocean (Photograph 17, Appendix C). It appears likely that the lower pond berm has no cut-off trench, or embedded liner extending to the crest of the berm. Two posts with abbreviated signs were present on the lower pond berm. The purpose of the posts and meaning of the signs is not known (Photograph 18, Appendix C).

3.6 Meetings with Community Foreman

Two meetings were held with the community public works foreman. During the first meeting (September 14, 2010), Dr. Tchekhovski told to the foreman about the purpose of the dam safety inspection, and asked the foreman to provide the dam operation manual and operational records. The following information was obtained from the meeting:

- the community public works office does not have a copy of the lagoon operation manual;

- the senior administrative officer does not require lagoon operation records such as date used, volume and temperature of unloaded effluent, date for drainage commencing and completion and effluent levels on dates of drainage commencing and completion;

A second meeting took place on September 15, 2010, and Dr. Tchekhovski recommended that the community should obtain a copy of the sewage lagoon operation manual and maintain the records of operation activities as specified in the operation manual. A copy of the "Electrical Operation and Maintenance Manual for Heat Trace of Drainage Pipe" was the only document relating to operation of the sewage lagoon that could be found in the public works office.

4.0 CONCLUSIONS AND RECOMMENDATIONS

The dam berms were found in very good operating condition during the site visit. No effluent seepage was identified along the three constructed sewage lagoon berms: northeast, northwest, and southwest. However, the effluent level was very low during the site visit. AMEC recommends that the next site visit by a geotechnical/permafrost engineer be undertaken in about 2 years at a time when there is a maximum effluent level in the lagoon (likely early summer). Based on the experience from the first site visit, a detail program for geotechnical inspection of the dam could be prepared by AMEC.

The hasp for the manhole lid should be replaced and the manhole lid should be kept locked. The community public works office should be provided with the sewage lagoon operation manual, including templates for records of the operation activities.

5.0 CLOSURE

This report has been prepared for the exclusive use of Dillon Consulting Limited, the Hamlet of Kugaaruk and its agents for the specific application described in this report. The use of this report by third parties is done so at the sole risk of those parties. It has been prepared in accordance with generally accepted permafrost and foundation engineering practices. No other warranty, expressed or implied, is made.

We trust this information meet your current needs. Should you have any questions, please feel free to contact the undersigned.

Respectfully submitted,

AMEC Earth & Environmental,
a division of AMEC Americas Limited

REGISTERED PROFESSIONAL ENGINEER
Nov. 24/10
D. DUMSKY
LICENSEE
NWT/NU

Dmitry Dumsky, P.Eng.
Geotechnical and Permafrost Engineer

Nov. 24, 2010

Alexandre Tchekhovski, Ph.D., P. Eng.
Associate Geotechnical and Permafrost Engineer

PERMIT TO PRACTICE
AMEC Earth & Environmental, a
Division of AMEC Americas Limited
Signature
Date November 24, 2010
PERMIT NUMBER: P 047
The Association of Professional Engineers, Geologists and Geophysicists of the NWT / NU

Reviewed by:
Kevin Spencer, M. Eng., P. Eng.,
Associate Geotechnical Engineer

Appendix A - Reports

Report Titled "Geotechnical Investigation for Sewage Lagoon, Kugaaruk, NU" dated October 31, 2005, submitted to DCL by AMEC.

Report Titled "Sewage Lagoon Cut-off Trench Construction Monitoring, Kugaaruk, NU" dated October 31, 2007, submitted to DCL by AMEC.

Report Titled "Licence Number: 3BM – PEL0712, Kugaaruk, NU" dated signed September 7, 2007, submitted to the Hamlet of Kugaaruk by Nunavut Water Board.

31 October 2005
YX00749

Dillon Consulting Limited
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Attention: Mr. Gary Strong, P.Eng.
Project Manager.

Dear Mr. Strong:

Re: Geotechnical Investigation for Sewage Lagoon, Kugaaruk, NU

At the request of Mr. Gary Strong, on behalf of Dillon Consulting Limited (DCL), AMEC Earth & Environmental (AMEC), a division of AMEC Americas Limited conducted a site reconnaissance, compiled geotechnical information for the Kugaaruk area and conducted geothermal modeling for a proposed sewage treatment system in Kugaaruk, NU. The purpose of the investigation is to assist DCL in the design of a new Sewage and Solid Waste Facility in Kugaaruk, as requested by the Government of Nunavut, Department of Community and Government Services (DCGS).

Authorization to proceed with the investigation was received by signing Dillon's Short Form Agreement for Sub-Consultant Service dated June 3, 2005 for the above noted project.

1.0 BACKGROUND INFORMATION AND SCOPE OF WORK

The community of Kugaaruk is located on the southwest shore of the Simpson Peninsula on St Peter Bay near the mouth of the St. Peter River. The community is located approximately 1312 km northeast of Yellowknife.

The proposed sewage lagoon dyke is intended to replace the existing dyke that was built approximately 15 years ago. It is understood that the preferred design of the dyke consist of either a frozen-core, low permeability core, or synthetic liner dam concept. The purpose of the undertaken geothermal analysis was to confirm that the frozen core option is feasible for climate conditions of the Kugaaruk area.

In accordance with AMEC's proposal dated April 29, 2005 and subsequent discussions with DCL, the original scope of the study was to carry out a full scale of geotechnical investigation, including a field reconnaissance, drilling of 6 to 10 boreholes, interpretation of aerial photographs and numerical modeling of the temperature regime of the sewage lagoon dyke.

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Following the site reconnaissance and discussions with DCL, the drilling program and aerial photograph interpretation were not undertaken due to sufficient information being obtained to design the new lagoon dyke on the basis of the site reconnaissance alone.

AMEC conducted the site reconnaissance between July 3 and 6, 2005. Representatives of DCL and DCGS were also on site during the site reconnaissance. The site reconnaissance was conducted by Mr. Keith Barnes, P.Eng. of AMEC's Calgary office. Based on the initial review and site reconnaissance, AMEC was able to:

- Identify or characterize the climate, geological and permafrost conditions within the Kugaaruk area;
- provide a geotechnical characterization of existing dyke;
- perform geothermal modeling of the dyke temperatures; and
- prepare recommendations for the development of low permeability lagoon dyke.

Results and findings of this investigation are presented in subsequent sections of this report.

2.0 EXISTING DYKE DESCRIPTION

The existing lagoon dyke is located about 1 km, south-southwest of the community of Kugaaruk and about 2.4 km southwest of the airport (Figure 1, Appendix A). It is understood that the existing sewage lagoon has been in operation for about 15 years and is of a traditional operational design. Effluent in the lagoon is intended to slowly filter through the downstream berm. It is understood that current water quality tests from water taken downstream of the dyke appears to indicate that the effluent exceeds acceptable values.

Based on discussions with Hamlet personnel and observations made during the site reconnaissance, it appears that the crest of the downstream berm had been breached at times in the past. The effluent appears to flow directly from the lagoon, through or over the breached berm and then downstream. Hence, minimal filtering of the effluent by the berm occurs. Photos 1 and 2 (Appendix A) show the breached portion of the dyke.

One gravel sample was taken from the existing dyke structure in order to assess grain size and moisture content. Results of the testing are presented in Appendix C.

3.0 CLIMATE, GEOLOGY AND PERMAFROST

Kugaaruk is located geographically at approximately 68°32' N latitude and 89°49' W longitude. No weather station is located in the community and therefore climate records for Kugaaruk were estimated based on Igloolik data for the period from 1971 to 2000. Igloolik is located approximately 300 km to the northeast. The average annual mean temperature in Igloolik is reported to be –13.2 °C. The average thawing and freezing indices are calculated to be about 405 °C-days and -5169 °C-days, respectively.

The bedrock in the community and surrounding area generally consists of granite gneiss that is weathered, jointed and foliated extensively. The lines of intersection of these discontinuities have created numerous large rock wedges that have been dislodged to some extent by repeated freeze-thaw cycles.

During the period between the last glaciation and isostatic rebound (approximately 10000 years ago), the waters from Gulf of Boothia inundated coastal areas to an elevation of about 125 m above the recent sea level. The marine waters reworked the surficial glacial sediments and as a result, fine grained sediments can be found between bedrock ridges at the lower elevations.

Kugaaruk is located north of the Arctic Cycle within the continuous permafrost zone. The depth of seasonal thaw has been estimated to vary from about 0.7 m to 1.3 m, depending on ground vegetative cover and surface disturbance. Mean annual permafrost temperature within the study area is estimated to be about -7°C to –11°C at depth of 12 m to 15 m. The lower permafrost temperatures would be typical for terrains with organic cover and small snow cover, while warmer ground temperature would prevail near the ocean shoreline in gravelly and coarse grained sandy soils.

4.0 INFERRED SUBSURFACE CONDITIONS

Based on the field reconnaissance, it is concluded that lagoon site is covered with an organic mat, 50 mm to 100 mm thick (Photographs 3 and 4, Appendix A). Poorly drained, saturated fine grained marine deposits (sand and silt with gravel and inclusions of cobbles and boulders) likely underlie the organics. It is expected that the thickness of the overburden would be 1 to 3 meters. Bedrock outcrops can be encountered randomly over the lagoon impoundment (Photographs 5 and 6, Appendix A).

The mean annual permafrost temperature is expected to be in a range of -10 °C to -11 ^{o}C at a depth of about 15 m at the lagoon site. The thickness of the active layer is expected to be 0.7 m to about 1.0 m. This corresponds to sandy/gravelly saturated soil with the organic mat.

5.0 ENGINEERING RECOMMENDATIONS

This section provides recommendations on design and construction of the dyke and results of the dyke temperature modelling.

5.1 Proposed Sewage Dyke - Liner Option

Figure 2 and 3 (Appendix B) provides a cross section of the sewage dyke as it is proposed by DCL. The upstream and downstream slopes of the dyke are 1V:2 H, corresponding to a slope steepness of about 26.5 degrees. The proposed dyke is 5 m high and 4 m wide at the crest.

Silty sand, sand and gravel may be used for the dyke construction. This material should be screened and cobbles and boulders should be removed. One potential material could be from the granular deposit east of the proposed site. Results of material testing conducted on a stockpiled granular deposit east of the proposed site are presented in Appendix C.

The material used for dyke construction should be unfrozen at the time of placement and should be spread by lifts, 250 mm thick or less (compacted thickness). The compaction can be undertaken by bulldozers, D-6 or heavier. Placement and compaction of fill should not be conducted in freezing conditions. At least three bulldozer passes per lift should be applied. The

upper layer, 0.5 m thick can contain cobbles, up to 200 mm in size, protecting the dyke slopes against water erosion.

An appropriate synthetic liner should be installed in a near vertical position to an assumed elevation of 98.5 m, 1.5 m below existing ground surface, near the upstream slope. The liner should extend into a 1.5 m deep cut-off trench below the base of the dyke. The cut-off trench should be backfilled with compacted clayey material or grouted. The liner curtain should then extend straight up to the top of the dyke as shown at Figure 2, Appendix B. An alternative liner option is shown at Figure 3, Appendix B. It is understood that the constructability of the alternative option is more favourable however the liner is almost twice as long.

A low-permeability soil cut-off wall within the dyke, designed for unfrozen performance may also be considered. Due to the minimal amounts of fine grained soils observed in the lagoon area, this option was not considered feasible.

5.2 Proposed Sewage Dyke - Frozen Core Option

As it was described in Section 3.0, the Kugaaruk region is characterized by a mean annual air temperature of about -13.2 ^{o}C. AMEC considers that the concept of a frozen core dyke to provide primary containment of lagoon waters is technically feasible. Based on the proposed water level being located 1 m below the dyke crest, a 50 mm thick insulation layer (Styrofoam HI, or equivalent) should be placed immediately below the dyke crest. The intent of the insulation is to reduce the seasonal and long-term thawing that could penetrate the dyke crest, leading to increased percolation of effluent through the dyke. The insulation should be placed on the compacted and smooth gravelly / sandy surface. A sand layer, 100 mm thick, should be placed and compacted on the insulation to 95% of standard Proctor maximum dry density. A protective layer of rock fill about 400 mm thick should be placed over the sand layer (Figure 4, Appendix B).

5.3 Existing Dyke Repair

If it is desired to re-design the existing dyke with a frozen core, the dyke should be re-built to the dimensions presented in Figure 4. All loose material should be removed from the existing dyke surface and all erosion features should be cleaned of water and ice. The erosion features should be backfilled with engineered fill and compacted with a heavy bulldozer.

Following to the removal of the loose material and backfilling of the erosion features, the dyke should be raised to the design elevation in 250 mm (compacted) lifts. A 50 mm insulation layer should be placed on the compacted and smooth gravelly / sandy surface of the dyke crest as shown at Figure 4, Appendix B. A sand layer, 100 mm thick, should be placed and compacted on the insulation to 95% of standard Proctor maximum dry density. A protective layer of rock fill about 400 mm thick should be placed over the sand layer.

5.4 Sewage Dyke Geothermal Analyses

The geothermal modeling program SIMPTEMP, 2D version, (developed in-house by AMEC) was used to analyze the geothermal regimes for the two types of dykes. The geothermal simulator uses the finite element method to compute a numerical solution of the heat transfer problem. Physical/mathematical algorithms used in the SIMTEMP model have been published, and the simulation process has been verified- both against well-known analytical solutions of the heat transfer problem, and as compared with numerical solutions produced by other commercial/non-commercial geothermal software. AMEC has successfully used the SIMPTEMP program for a variety of geothermal applications over a ten years period.

Detailed geothermal analysis has been carried out to assess the present and future thermal regime within the Kugaaruk sewage lagoon dyke, and within the dyke foundation soils. The analysis considered the following geometry:

- Height of dyke is 5 m.
- Width of crest is 4 m.
- Upstream and Downstream slopes of dyke are 1V:2H.
- Local soil (silty sand, sand and gravel) is proposed for the dyke core construction.
- Water proof liner is proposed to place over core material at upstream slope of the dyke (see Figure 3).
- The dyke core will be covered up with rockfill, about 0.5 m thick.

This section briefly describes the initial geothermal conditions assumed for dyke subgrade, the model setup, input parameters and the result of the SIMPTEMP analysis.

5.4.1 Boundary Conditions for Dyke Numerical Analysis

The air temperature data and snow depth used for the present analysis were based on the Climate Normals for Igloolik weather station for period from 1970 to 2000. The data on snowfall were converted in thickness of the snow cover assuming the following snow densities:

- September through December - 0.22 g/cm^3;
- January through March – 0.25 g/cm^3;
- April and May – 0.27 g/cm^3.

The mean monthly air temperatures and calculated snow thicknesses used for the SIMPTEMP model are presented in Table 1.

Table 1: Mean Monthly Air Temperatures and Snow Thicknesses

Data	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temp., ^{o}C	-30.6	-31.2	-28.0	-19.3	-8.3	1.6	7.0	4.9	-0.4	-8.9	-19.5	-26.1
Snow, m	0.43	0.47	0.53	0.55	0.63	---	---	---	0.07	0.22	0.35	0.43

Mean monthly surface temperatures were applied over the exposed dyke surface, ground surface beyond downstream slope of the dyke and over water surfaces beyond upstream slope

of the dyke. To obtain the mean monthly surface temperatures, various n-factor coefficients were used over the dyke, downstream ground surface beyond the dyke and water surface. No allowance for climate warming was made to the air temperatures over the period of the simulation.

Dyke slopes and crest. It was assumed that practically no snow would accumulate on the dyke slopes and crest. Therefore, an n-factor of 0.9 was applied to the mean monthly air temperatures to obtain the mean monthly winter temperatures on the dyke surfaces. An n-factor of 1.2 (which corresponds to a bare rockfill surface) was applied to the mean monthly air temperatures to obtain the dyke surface temperature in the summertime.

Downstream Terrain Beyond Dyke. It was assumed that snow could accumulate beyond the toe of the dyke. The calculated snow thickness for the Kugaaruk area is similar to the measured snow thicknesses at the Cape Dorset weather station. It was therefore assessed that the n-factors for the Kugaaruk lagoon site would be 0.65 and 0.83 for the winter and summer air temperatures, respectively. The n-factors represent the insulating/warming effect of snow cover in the winter, and the cooling effect of the moss/lichen vegetation in the summer.

Water (Upstream Beyond Dyke). It was assumed that snow could accumulate on the ice surface. Similar to the downstream terrain area, an n-factor of 0.65 was applied to the mean monthly air temperatures for the winter months (October through May). From June through September, it was assumed that the water temperature over the entire depth of the water column was the same as the mean monthly air temperatures (n – factor = 1.0). Table 2 provides data on the mean monthly surface temperatures that were applied over the upper boundary of the geothermal models.

Table 2: Mean Monthly Surface Temperatures on Model Mesh

Data	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Dyke Crest and Slopes	-27.5	-28.0	-25.2	-17.4	-7.5	1.9	8.4	5.9	-0.4	-8.0	-17.6	-23.5
Downstream Surface	-19.9	-20.3	-18.2	-12.5	-5.4	1.3	5.8	4.1	-0.3	-5.8	-12.7	-17.0
Water / Ice Surface	-19.9	-20.3	-18.2	-12.5	-5.4	1.6	7.0	4.9	-0.3	-5.8	-12.7	-17.0
						Water Temperature equals air temperature						

5.4.2 Physical and Thermal Soil Properties

Estimates of physical properties for various typical soils expected to be encountered within the dyke and dyke foundation were based on the published information (see Section 3.0) and results of the tested material obtained during the site reconnaissance. Thermal properties of the materials (thermal conductivity and heat capacity) were selected based on available published data, and on previous experience with similar materials. Table 3 summarizes the material physical and thermal properties applied for the geothermal analyses.

Table 3: Physical and Thermal Soil Properties

Soil Type	Dry Density, kN/m^3	Moisture Content, %	Thermal Conductivity, W/m/^{o}C		Heat Capacity, MJ/m^3/^{o}C	
			Frozen	Unfrozen	Frozen	Unfrozen
Bedrock	28	2	2.90	2.90	2.58	2.58
Unsaturated overburden and dyke sand and gravel	20	7	2.90	2.73	2.26	2.68
Saturated rockfill, overburden and dyke sand and gravel	19.6	15	2.61	2.26	2.26	2.51
Unsaturated rockfill	20	5	2.9	2.73	2.09	2.26
Water	10	---	2.20	0.58	1.95	4.19

5.4.3 Grid and Soil Layers Description

The following soils/materials were identified within the sewage dyke cross-section:

- Unsaturated Rockfill on downstream face of dyke
- Saturated Rockfill on upstream face of dyke
- Unsaturated dyke core and native overburden
- Saturated dyke core and native overburden
- Bedrock
- Water

Dimensions of each of the individual layers are shown on the Figures of Appendix B. Physical and thermal properties of the constituent soils/materials identified are provided in Section 5.3.2.

The geothermal modeling grid extended about 104 m below the crest of the dyke and contained 9350 finite elements and 4816 nodes. The average dyke and active layer initial temperatures were taken as +2 ^{o}C, corresponding to the assumed dyke material temperature and active layer temperature at the end of summer. The initial water temperature was also taken as +2 ^{o}C. The initial soil temperature from the base of the active layer and to a depth of 12 m was taken to decrease gradually from 0 ^{o}C to -5 ^{o}C. The soil temperature was then warmed gradually down to the bottom of the grid with the geothermal gradient of 0.02 ^{o}C/m.

Zero heat flux was applied at lateral boundaries of the grid, while the heat flux at the mesh bottom corresponded to the geothermal gradient of 0.02 ^{o}C/m.

5.5 Results of Geothermal Modelling

Containment Dyke with Liner

Figure 5 (Appendix B) shows that after the first year of the dyke operation, the active layer at the dyke crest is about 1.7 m. The majority of the dyke core has a temperature in a range from -1 ^{o}C to -2 ^{o}C while the ground temperature under the dyke is about -4 ^{o}C. One can see that due

to the warming effect of the lagoon water the ground temperature beyond the upstream slope of the dyke is about 2 degrees warmer than the ground temperature beyond the downstream slope of the dyke.

Figures 6 through 9 (Appendix B) show that no significant changes in the dyke temperature regime were observed from the fifth to thirtieth year of the dyke operation. It can be seen that the thickness of the unfrozen zone under the lagoon increases up to 5 m, while the ground temperature at the base of the central part of the dyke decreases down to -5 ^{o}C.

Frozen Core Containment Dyke

Figure 10 (Appendix B) shows that the placement of insulation across the crest of the dyke decreases the thickness of the active layer at the crest to about 0.75 m. A comparison of Figures 5 and 10 shows that the active layer thickness is reduced by about 1 m. The insulation did not change the internal dyke temperature and after the first year of the operation, the majority of the dyke core has a temperature in a range from -1 ^{o}C to -2 ^{o}C.

Figures 11 through 14 (Appendix B) shows that after five years of the operation, the thickness of the active layer at the crest of the dyke is decreased to about 0.5 m. No significant changes in the dyke temperature regime are observed from the fifth to thirtieth year of the dyke operation (dyke temperature remains in a range from -1 ^{o}C to -5 ^{o}C, considerably colder than after the first year of operation). It can be seen that the unfrozen zone thickness under the lagoon is increased up to 5 m, while the ground temperature at the base of the central part of the dyke is decreased down to -7 ^{o}C. These latter temperatures are the same both design options.

Conclusions from Numerical Analyses

The numerical simulation of the liner and frozen core dyke options show that both options are technically feasible. The performance of each option are however dependant on many variables that can not be simulated in a numerical model. For example, for the liner option, cuts and tears in the liner will result in seepage that will cause warming of the core and the potential weakening and settlement of the dyke structure (and piping losses). Extreme climate warming effects could result in a thicker than predicted active layer across the dyke crest, which would lead to increased seepage.

5.6 Monitoring and Contingency Planning

If a frozen core design option is implemented, then monitoring observations should confirm that the design assumptions made during design are still valid over the life of the structure. Monitoring provides an opportunity to identify variations from the design basis and gives advance warning of developing issues. This monitoring is intended to provide lead time so that contingency measures may be developed and implement in a pro-active approach, rather than reacting to problems as they arise.

Monitoring should consist of the following:

- multi-bead thermistor cables installed through the dyke and into the native foundation. A minimum of two thermistor cables should be installed along the crest of the dyke. These thermistor cables are intended to provide information on the temperatures within the dyke and foundation. They should be read on a bi-monthly basis (six times per year) by

local personnel for the first ten years and quarterly (every three months) thereafter. If temperature anomalies are identified, increased monitoring should be initiated.

- At the time of bi-monthly temperature readings, a visual inspection should also be conducted of the dyke. The inspection should be conducted to confirm dyke integrity and locate any seepage paths that may have formed.

AMEC may provide additional information on the monitoring program and instrumentation upon request.

Contingency planning for potential performance issues in the dykes should be part of the design process. For example, in the event that deeper than expected thawing across the crest of the dyke occurs, the installation of thermosyphons to intercept surface warming may be needed. The design of the dykes should address how and when mitigation options should be installed.

The owner and operators of the dykes should be advised that monitoring of the dykes is an important component of an operations plan and that mitigation against potential seepage and thawing may be needed to address future events.

6.0 CLOSURE

The engineering recommendations presented herein are based on results of the site reconnaissance, geothermal analysis and review of the available information. No drilling was undertaken at the prospective borrow source locations to determine soil composition.

Results of the geothermal modeling have shown that the dyke temperature range should be from -1 ^{o}C to -5 ^{o}C during the operation years. The dyke may be designed with a liner placed as shown in Figures 2 and 3, Appendix B. An alternative option would be to construction a clayey cut-off core of the dyke. Implementation of this latter option depends on quality and quantity of the available clayey material within the Kugaaruk area (which is expected to be minimal in the vicinity of the site). If insulation is placed within the dyke structure as shown at Figure 4, Appendix B, then a frozen core dyke can be designed. A frozen core design is also suitable for the repair of the existing dyke structure. Monitoring of the performance of the dyke is considered an important component of the design of all options.

It should be stated that the results of modelling are valid for the boundary conditions and soil properties described in Section 5.4. If actual boundary conditions (soil properties) will differ considerably of applied parameters, then the actual temperatures of the dyke would vary from the predicted temperatures. Performance of the dyke will vary accordingly.

This report has been prepared for the exclusive use of Dillon Consulting Limited and its agents for the specific application described in this report. The use of this report by third parties is done so at the sole risk of those parties. It has been prepared in accordance with generally accepted permafrost and foundation engineering practices. No other warranty, expressed or implied, is made.

All field work conducted in regards to this work was for the sole purpose of determining geotechnical parameters. No environmental assessment of the existing dykes or surrounding areas was conducted by AMEC. An appropriate environmental assessment of the dykes and surrounding lands should be completed prior to undertaking any remedial work or new construction.

Respectfully submitted,

AMEC Earth & Environmental,
a division of AMEC Americas Limited

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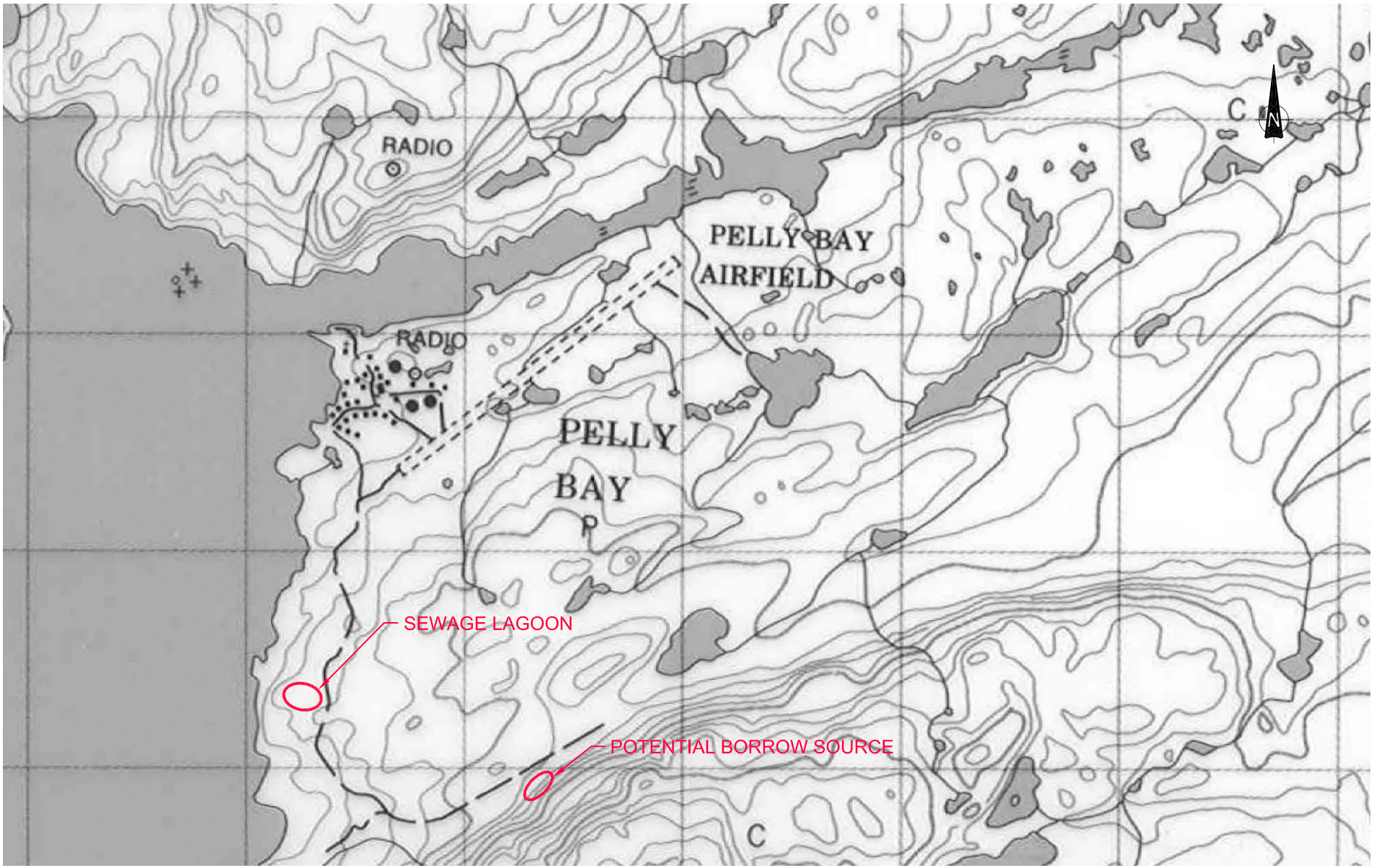
Reviewed by: Jim Oswell, P. Eng.,
Senior Permafrost Engineer

Appendix A

Figure 1: Site Location Plan
Plates: Select Photographs



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amec Earth & Environmental

CLIENT: DILLON CONSULTING LIMITED

PROJECT: GEOTECHNICAL INVESTIGATION FOR SEWAGE LAGOON, KUGAARUK, NU

TITLE: SITE LOCATION PLAN

DATE:	JOB No.:	CAD FILE:	FIGURE No.:	REV.
OCTOBER 2005	YX00749	00749B03.dwg	FIGURE 1	A

Plate 1: View looking east at existing downstream lagoon.
Note breach in dyke

Plate 2: View looking west at existing downstream lagoon.
Note breach in dyke

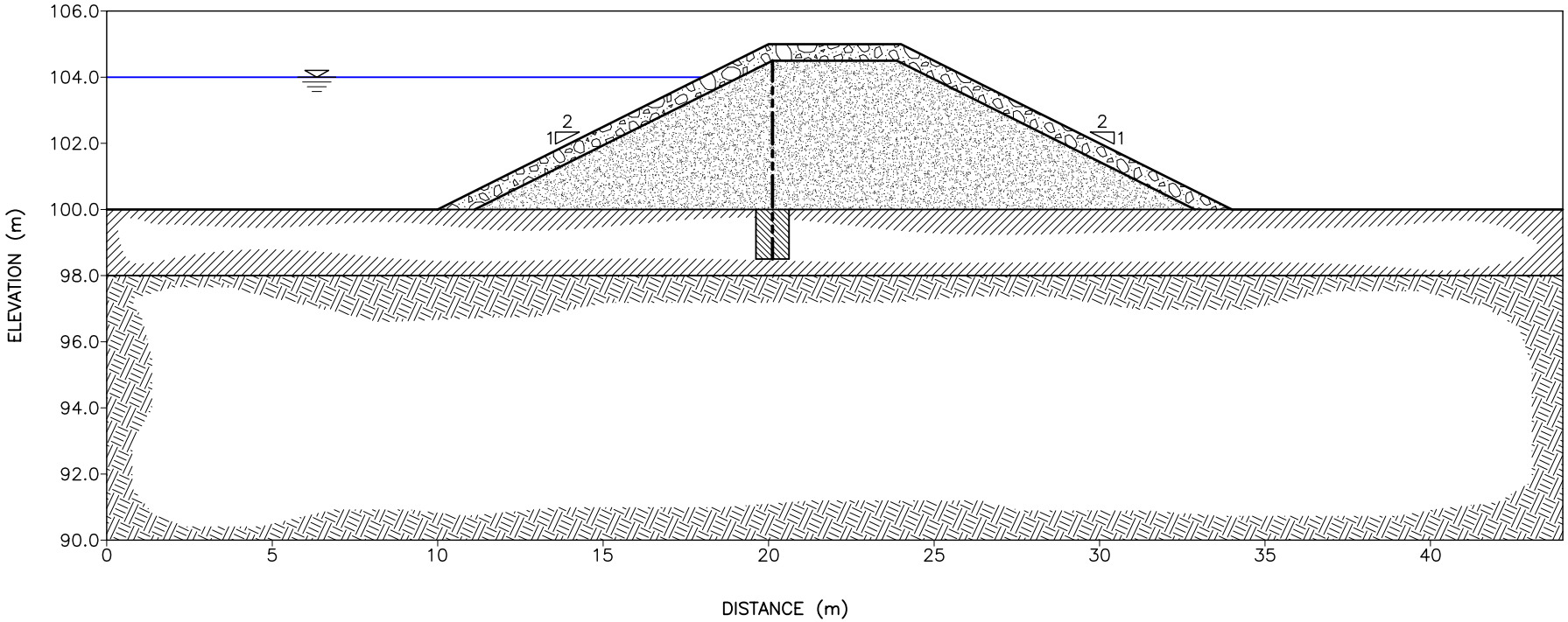
Plate 3: View looking west at potential site of new lagoon.
Note thin organic mat

Plate 4: View looking southwest at potential site of new lagoon.
Note thin organic mat

Plate 5: View looking northwest at potential site of new lagoon.
Note bedrock outcrops

Plate 6: View looking southwest at potential site of new lagoon.
Note bedrock outcrops

Appendix B



LEGEND:

- ROCKFILL
- SAND AND GRAVEL
- OVERBURDEN
- BEDROCK
- CLAY OR GROUT
- HDPE LINER

SCALE
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0 1 2 3 4 m

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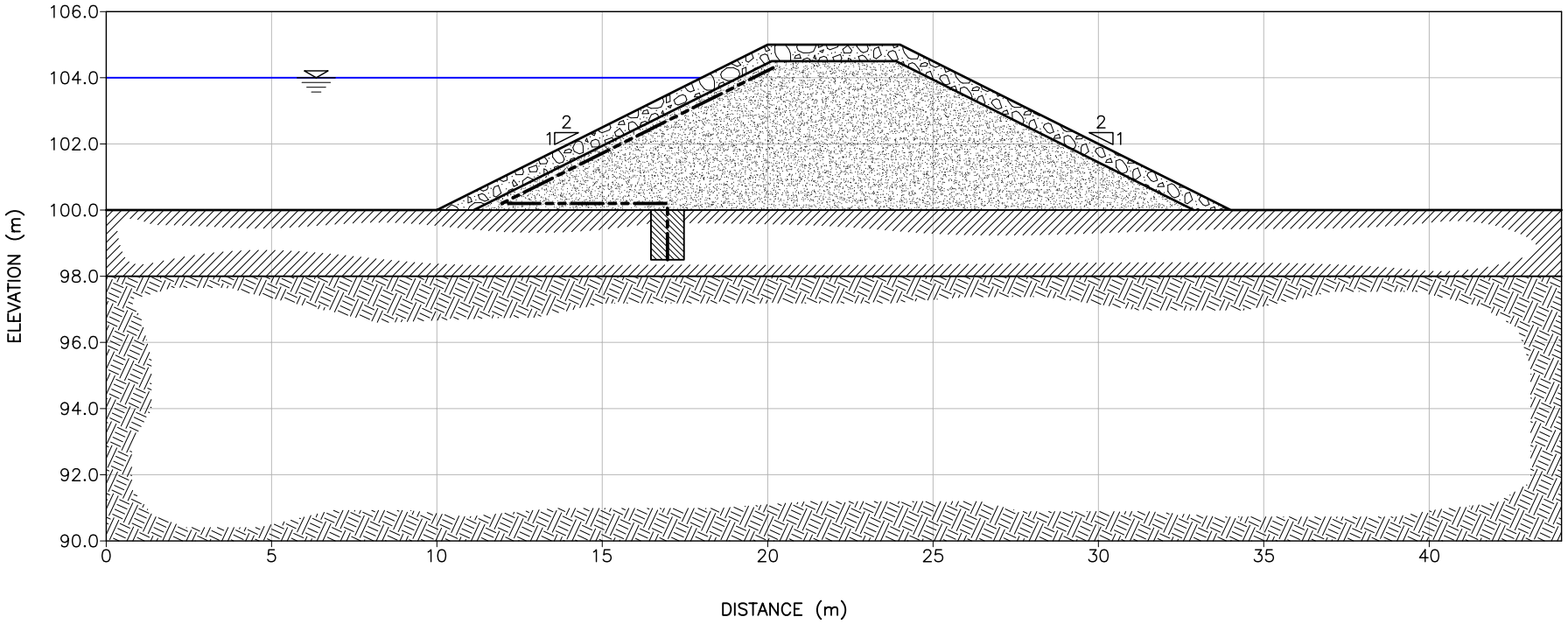
CLIENT: DILLON CONSULTING LIMITED

PROJECT: GEOTECHNICAL INVESTIGATION FOR SEWAGE LAGOON, KUGAARUK, NU

TITLE: PROPOSED DYKE CROSS SECTION OPTION 1

DATE:	JOB No.:	CAD FILE:	FIGURE No.:	REV.
OCTOBER 2005	YX00749	00749B01.dwg	FIGURE 2	A



LEGEND:

- ROCKFILL
- SAND AND GRAVEL
- OVERBURDEN
- BEDROCK
- CLAY OR GROUT
- HDPE LINER

SCALE
1: 200
0 1 2 3 4 m

amec Earth & Environmental

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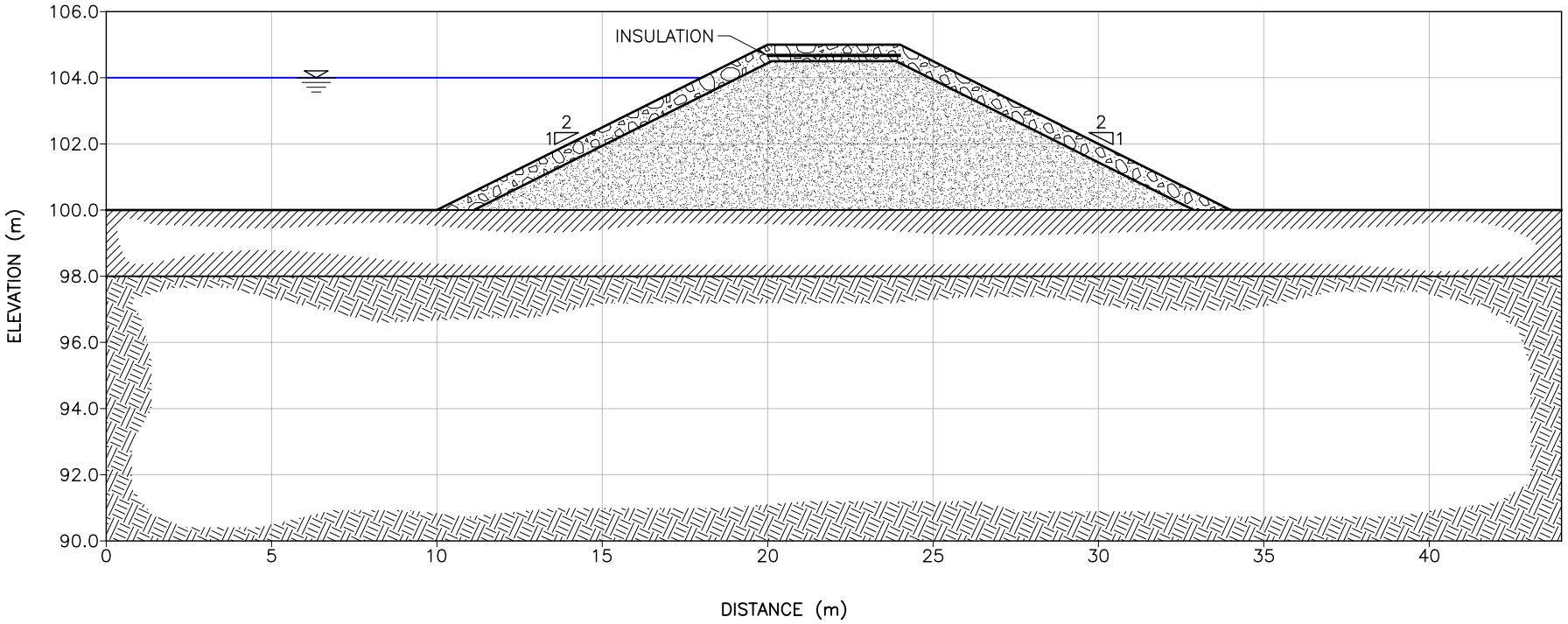
PROJECT: GEOTECHNICAL INVESTIGATION FOR SEWAGE LAGOON, KUGAARUK, NU

TITLE: PROPOSED DYKE CROSS SECTION OPTION 2

DATE:	JOB No.:	CAD FILE:	FIGURE No.:	REV.
OCTOBER 2005	YX00749	00749B01.dwg	FIGURE 3	A



LEGEND:

- ROCKFILL
- SAND AND GRAVEL
- OVERBURDEN
- BEDROCK

SCALE
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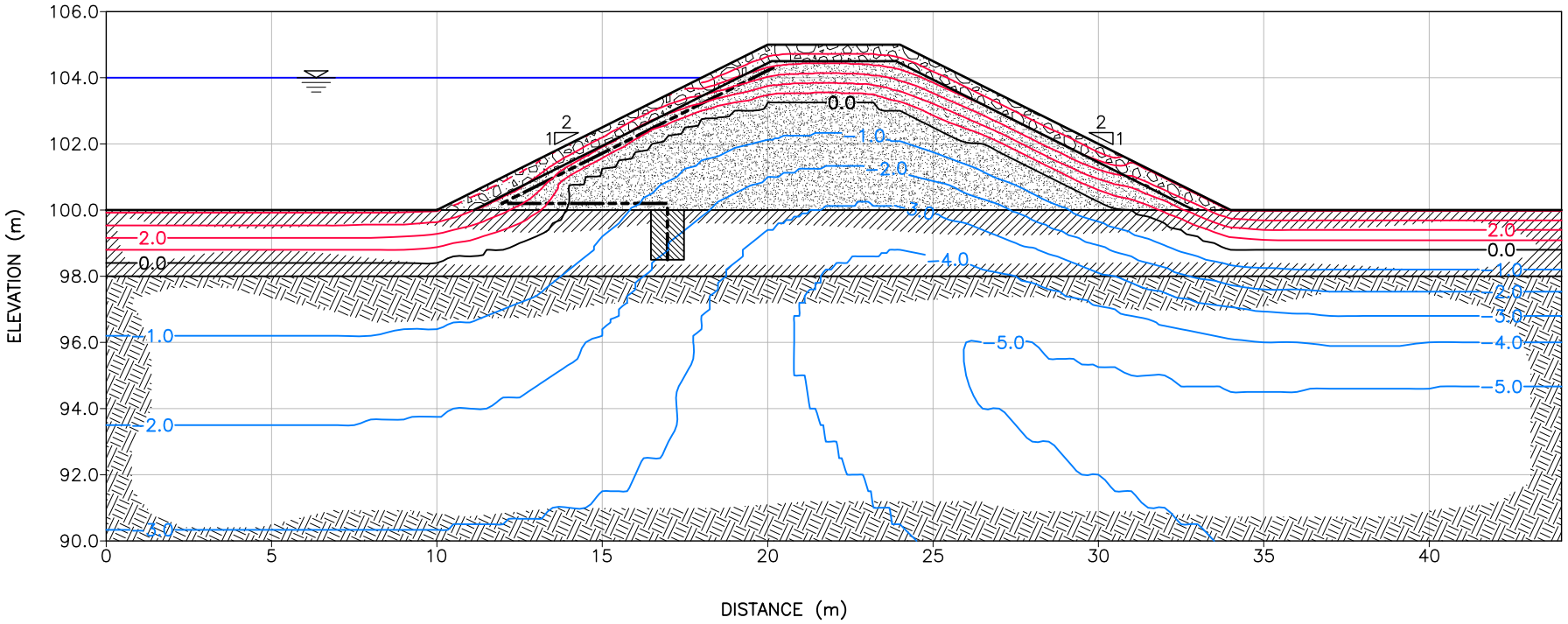
CLIENT: DILLON CONSULTING LIMITED

PROJECT: GEOTECHNICAL INVESTIGATION FOR SEWAGE LAGOON, KUGAARUK, NU

TITLE: PROPOSED DYKE CROSS SECTION - FROZEN CORE OPTION

DATE:	JOB No.:	CAD FILE:	FIGURE No.:	REV.
OCTOBER 2005	YX00749	00749B02.dwg	FIGURE 4	A



LEGEND:

- ROCKFILL
- SAND AND GRAVEL
- OVERBURDEN
- BEDROCK
- CLAY OR GROUT
- HDPE LINER

SCALE

1: 200

0 1 2 3 4 m

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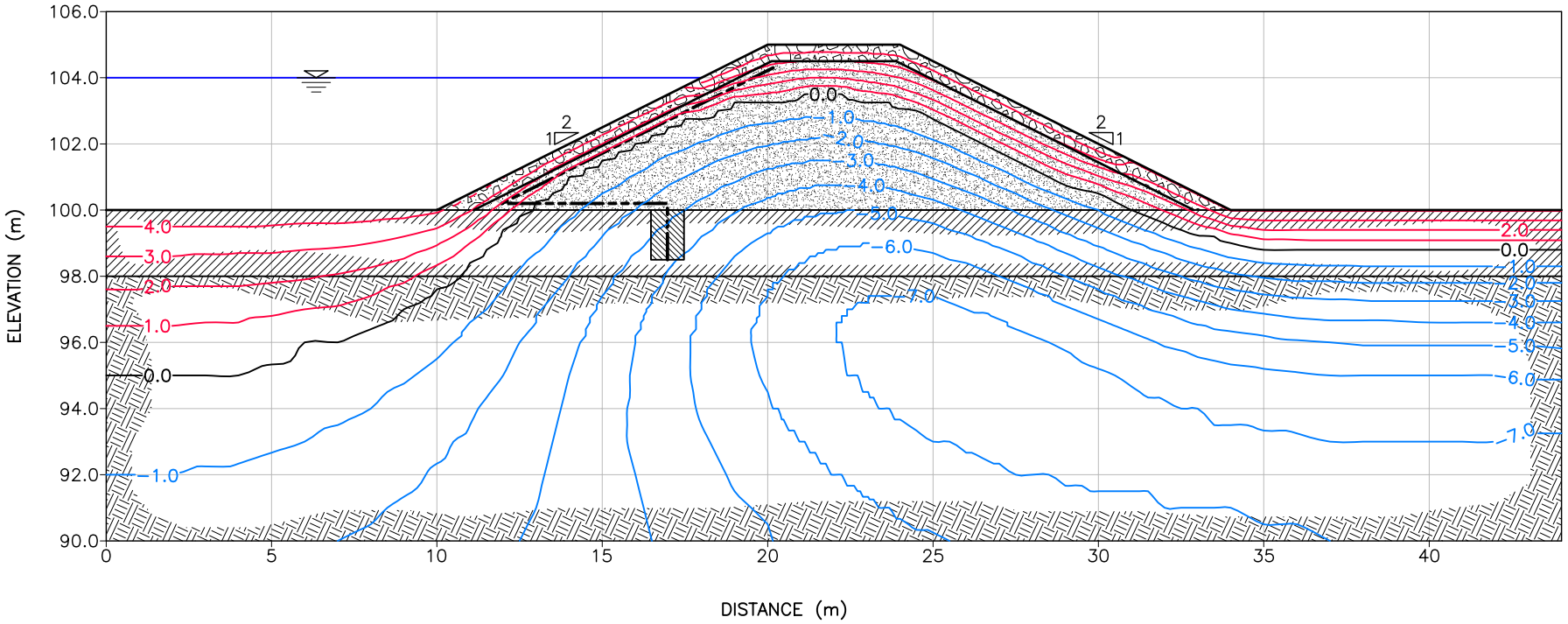
PROJECT: GEOTECHNICAL INVESTIGATION FOR SEWAGE LAGOON, KUGAARUK, NU

TITLE: DYKE TEMPERATURES AFTER 1 YEAR OF OPERATION, OPTION 1 & 2

DATE:	JOB No.:	CAD FILE:	FIGURE No.:	REV.
OCTOBER 2005	YX00749	00749B01.dwg	FIGURE 5	A



LEGEND:

- ROCKFILL
- SAND AND GRAVEL
- OVERBURDEN
- BEDROCK
- CLAY OR GROUT
- HDPE LINER

SCALE

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0 1 2 3 4 m

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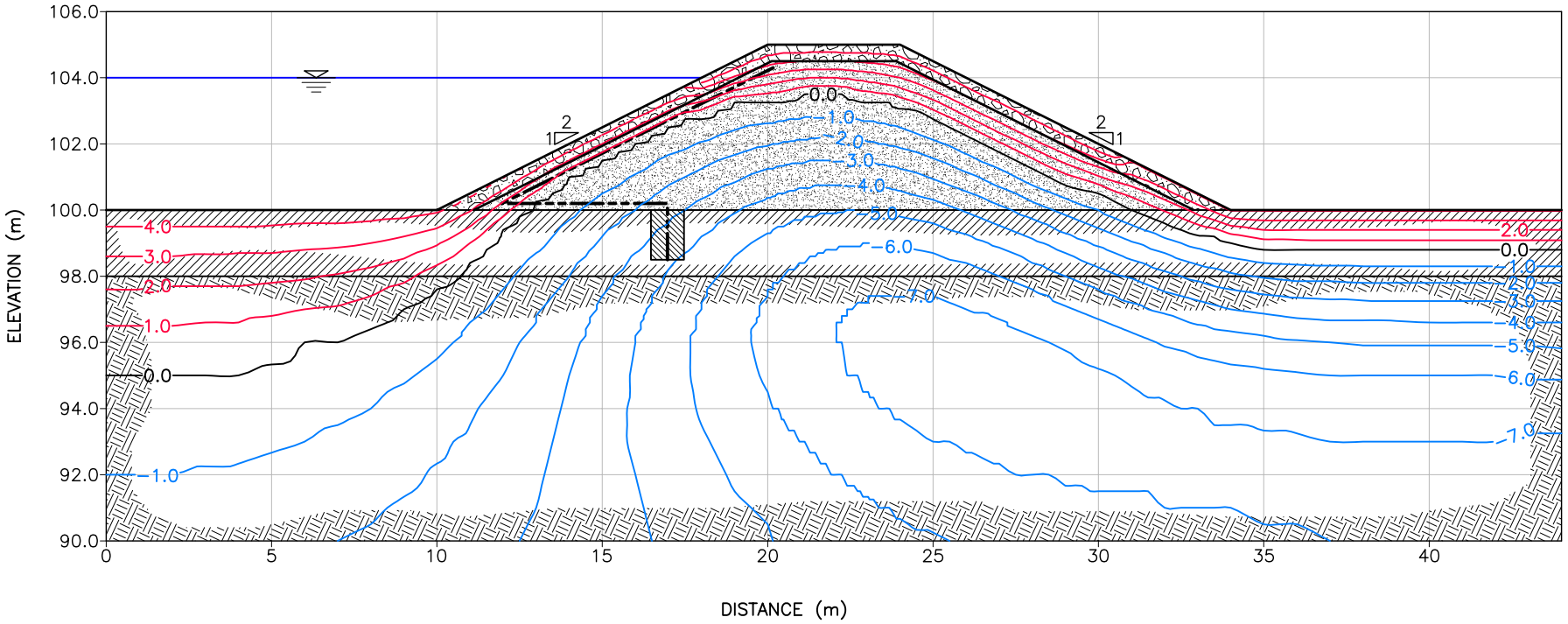
PROJECT: GEOTECHNICAL INVESTIGATION FOR SEWAGE LAGOON, KUGAARUK, NU

TITLE: DYKE TEMPERATURES AFTER 5 YEARS OF OPERATION, OPTION 1 & 2

DATE:	JOB No.:	CAD FILE:	FIGURE No.:	REV.
OCTOBER 2005	YX00749	00749B01.dwg	FIGURE 6	A



LEGEND:

- ROCKFILL
- SAND AND GRAVEL
- OVERBURDEN
- BEDROCK
- CLAY OR GROUT
- HDPE LINER

SCALE

1: 200

0 1 2 3 4 m

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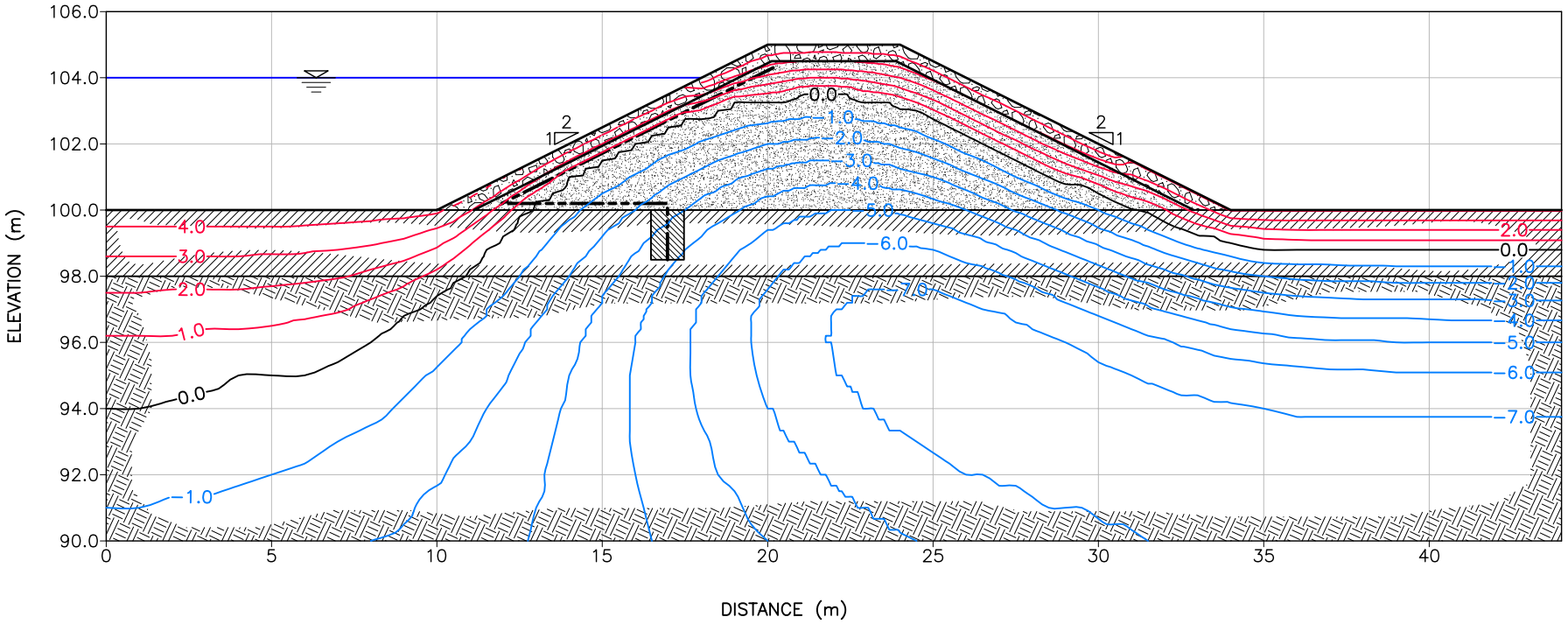
CLIENT: DILLON CONSULTING LIMITED

PROJECT: GEOTECHNICAL INVESTIGATION FOR SEWAGE LAGOON, KUGAARUK, NU

TITLE: DYKE TEMPERATURES AFTER 5 YEARS OF OPERATION, OPTION 1 & 2

DATE:	JOB No.:	CAD FILE:	FIGURE No.:	REV.
OCTOBER 2005	YX00749	00749B01.dwg	FIGURE 6	A



LEGEND:

- ROCKFILL
- SAND AND GRAVEL
- OVERBURDEN
- BEDROCK
- CLAY OR GROUT
- HDPE LINER

SCALE

1: 200

0 1 2 3 4 m

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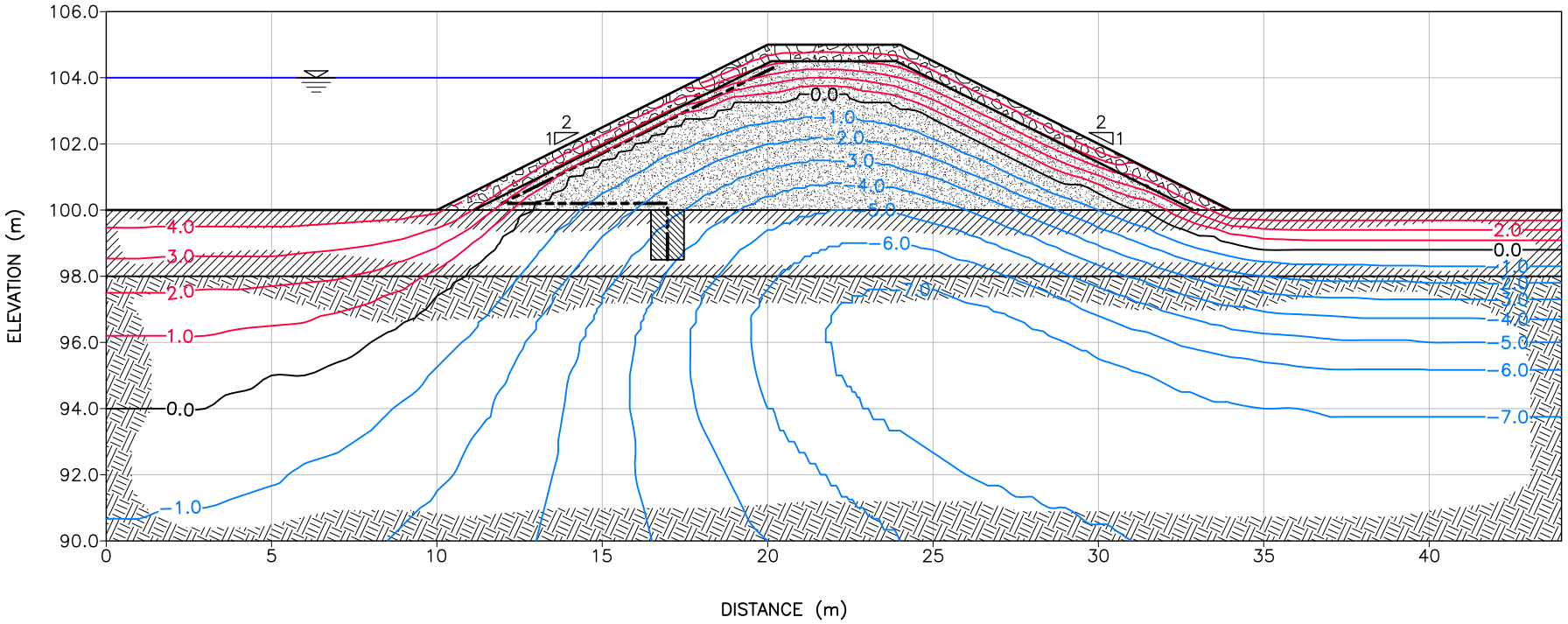
CLIENT: DILLON CONSULTING LIMITED

PROJECT: GEOTECHNICAL INVESTIGATION FOR SEWAGE LAGOON, KUGAARUK, NU

TITLE: DYKE TEMPERATURES AFTER 10 YEARS OF OPERATION, OPTION 1 & 2

DATE:	JOB No.:	CAD FILE:	FIGURE No.:	REV.
OCTOBER 2005	YX00749	00749B01.dwg	FIGURE 7	A



LEGEND:

- ROCKFILL
- SAND AND GRAVEL
- OVERBURDEN
- BEDROCK
- CLAY OR GROUT
- HDPE LINER

SCALE
1: 200
0 1 2 3 4 m

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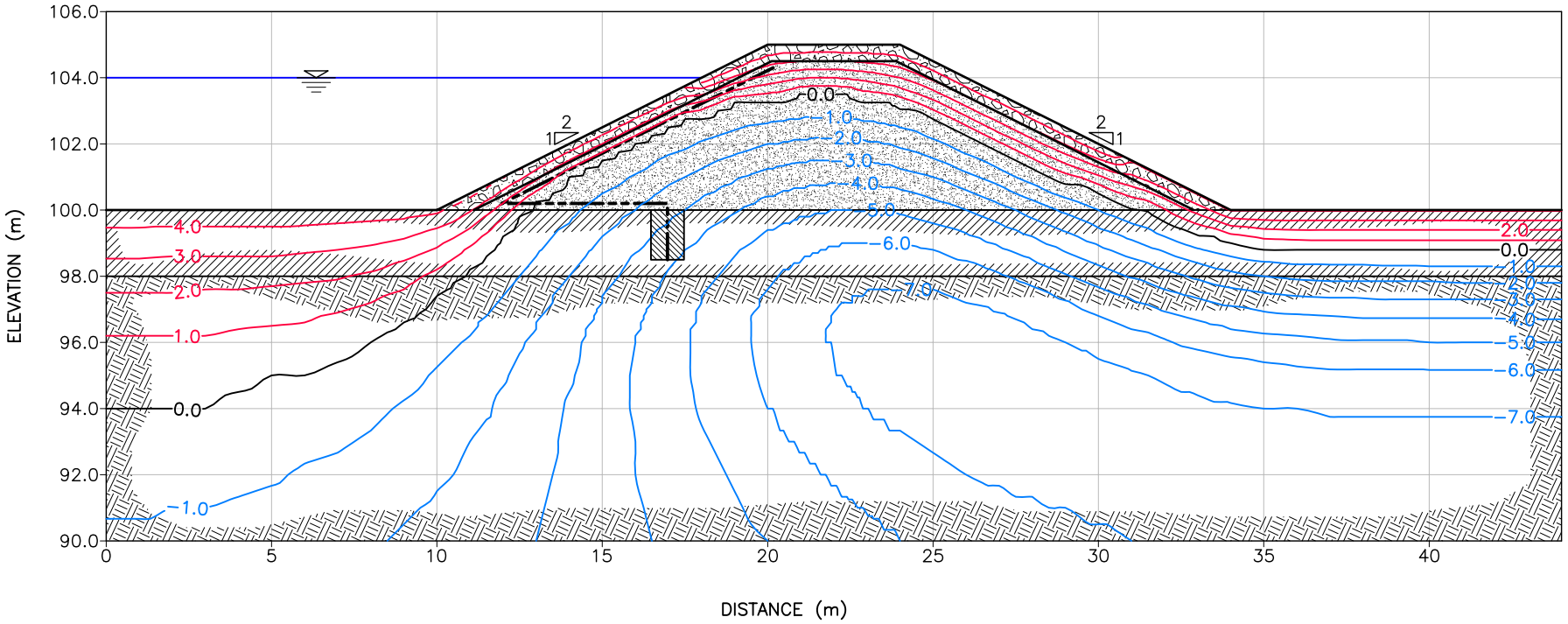
CLIENT: DILLON CONSULTING LIMITED

PROJECT: GEOTECHNICAL INVESTIGATION FOR SEWAGE LAGOON, KUGAARUK, NU

TITLE: DYKE TEMPERATURES AFTER 20 YEARS OF OPERATION, OPTION 1 & 2

DATE:	JOB No.:	CAD FILE:	FIGURE No.:	REV.
OCTOBER 2005	YX00749	00749B01.dwg	FIGURE 8	A



LEGEND:

- ROCKFILL
- SAND AND GRAVEL
- OVERBURDEN
- BEDROCK
- CLAY OR GROUT
- HDPE LINER

SCALE

1: 200

0 1 2 3 4 m

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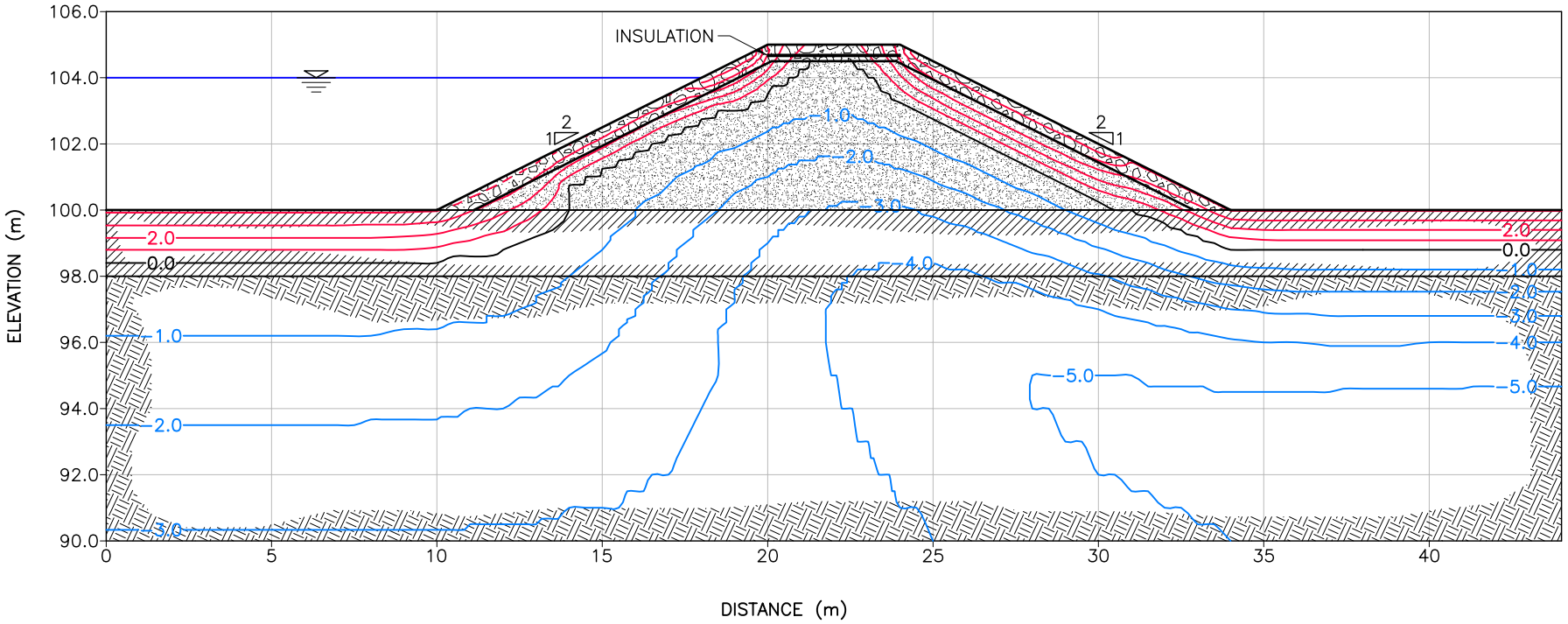
PROJECT: GEOTECHNICAL INVESTIGATION FOR SEWAGE LAGOON, KUGAARUK, NU

TITLE: DYKE TEMPERATURES AFTER 30 YEARS OF OPERATION, OPTION 1 & 2

DATE:	JOB No.:	CAD FILE:	FIGURE No.:	REV.
OCTOBER 2005	YX00749	00749B01.dwg	FIGURE 9	A



LEGEND:

- ROCKFILL
- SAND AND GRAVEL
- OVERBURDEN
- BEDROCK

SCALE
1: 200
0 1 2 3 4 m

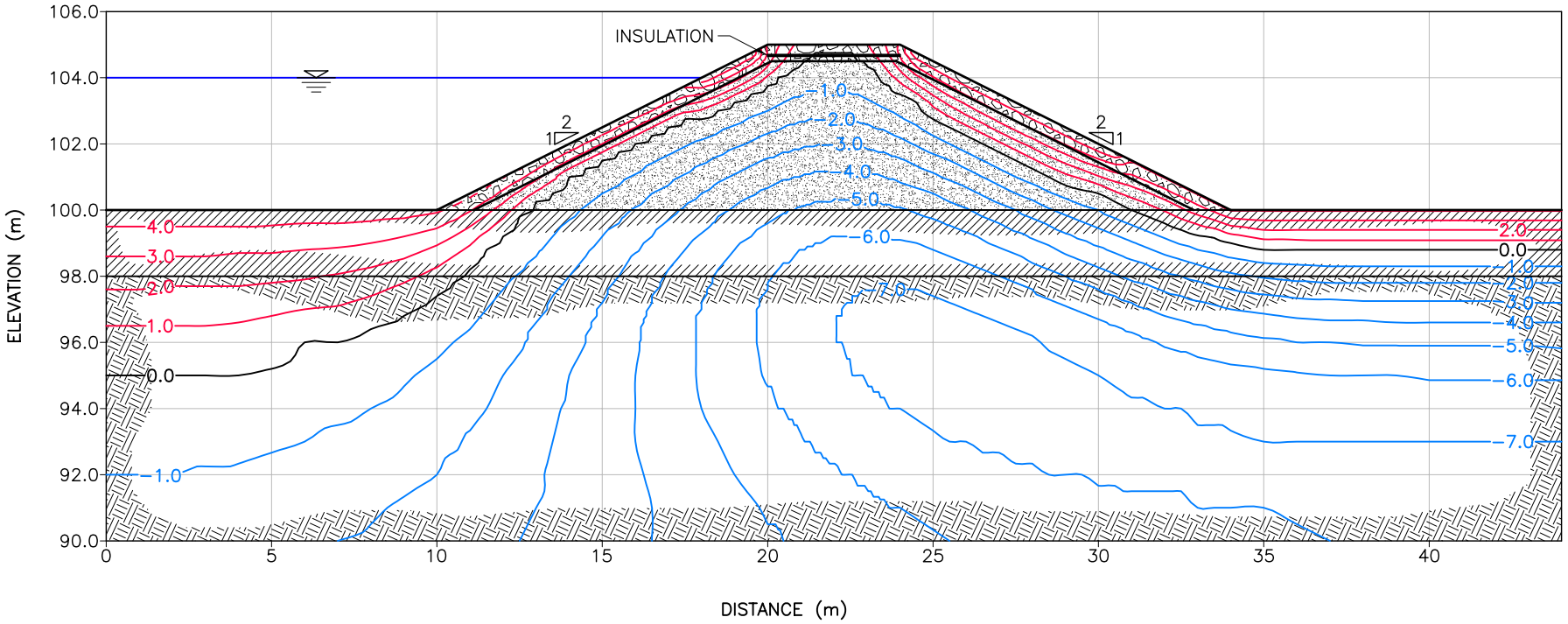
amec Earth & Environmental

CLIENT: DILLON CONSULTING LIMITED

PROJECT: GEOTECHNICAL INVESTIGATION FOR SEWAGE LAGOON, KUGAARUK, NU

TITLE: DYKE TEMPERATURES AFTER 1 YEAR OF OPERATION, FROZEN CORE OPTION

DATE:	JOB No.:	CAD FILE:	FIGURE No.:	REV.
OCTOBER 2005	YX00749	00749B02.dwg	FIGURE 10	A



LEGEND:

- ROCKFILL
- SAND AND GRAVEL
- OVERBURDEN
- BEDROCK

SCALE
1: 200
0 1 2 3 4 m

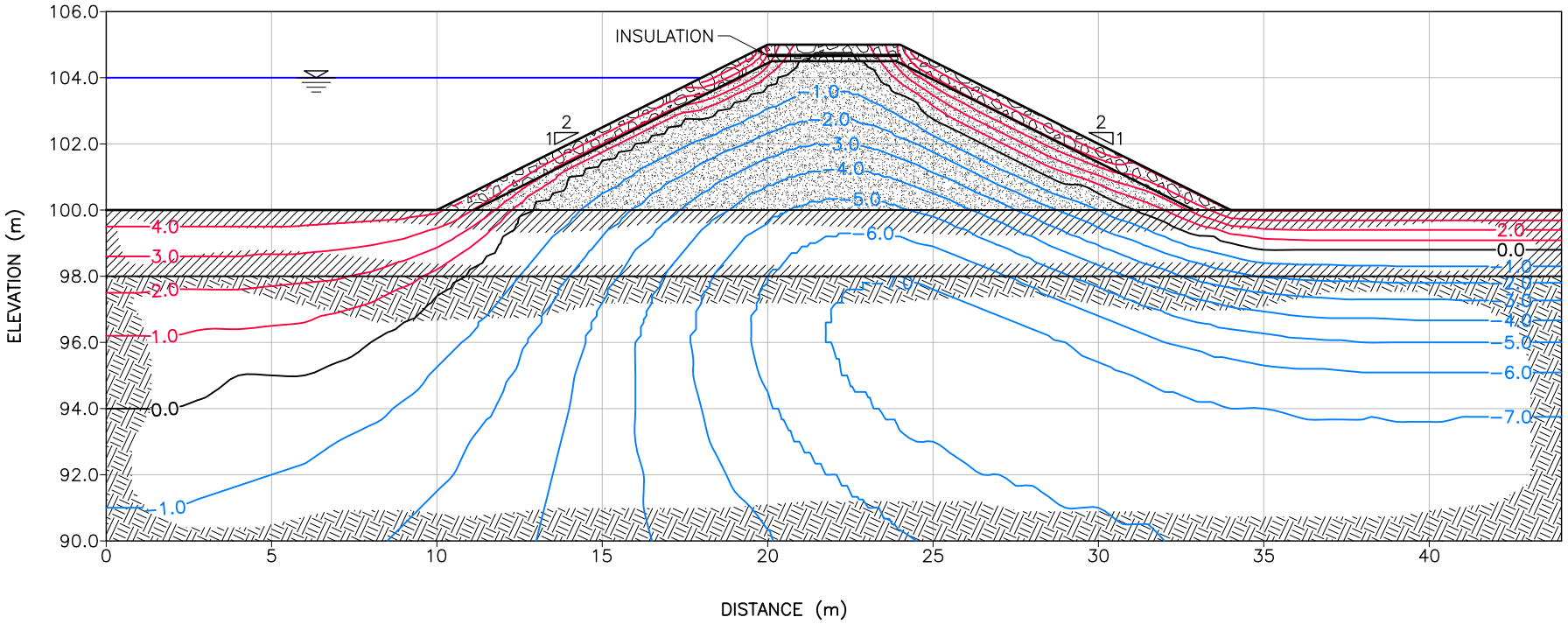
amec Earth & Environmental

CLIENT: DILLON CONSULTING LIMITED

PROJECT: GEOTECHNICAL INVESTIGATION FOR SEWAGE LAGOON, KUGAARUK, NU

TITLE: DYKE TEMPERATURES AFTER 5 YEARS OF OPERATION, FROZEN CORE OPTION

DATE:	JOB No.:	CAD FILE:	FIGURE No.:	REV.
OCTOBER 2005	YX00749	00749B02.dwg	FIGURE 11	A



LEGEND:

- ROCKFILL
- SAND AND GRAVEL
- OVERBURDEN
- BEDROCK

SCALE
1: 200
0 1 2 3 4 m

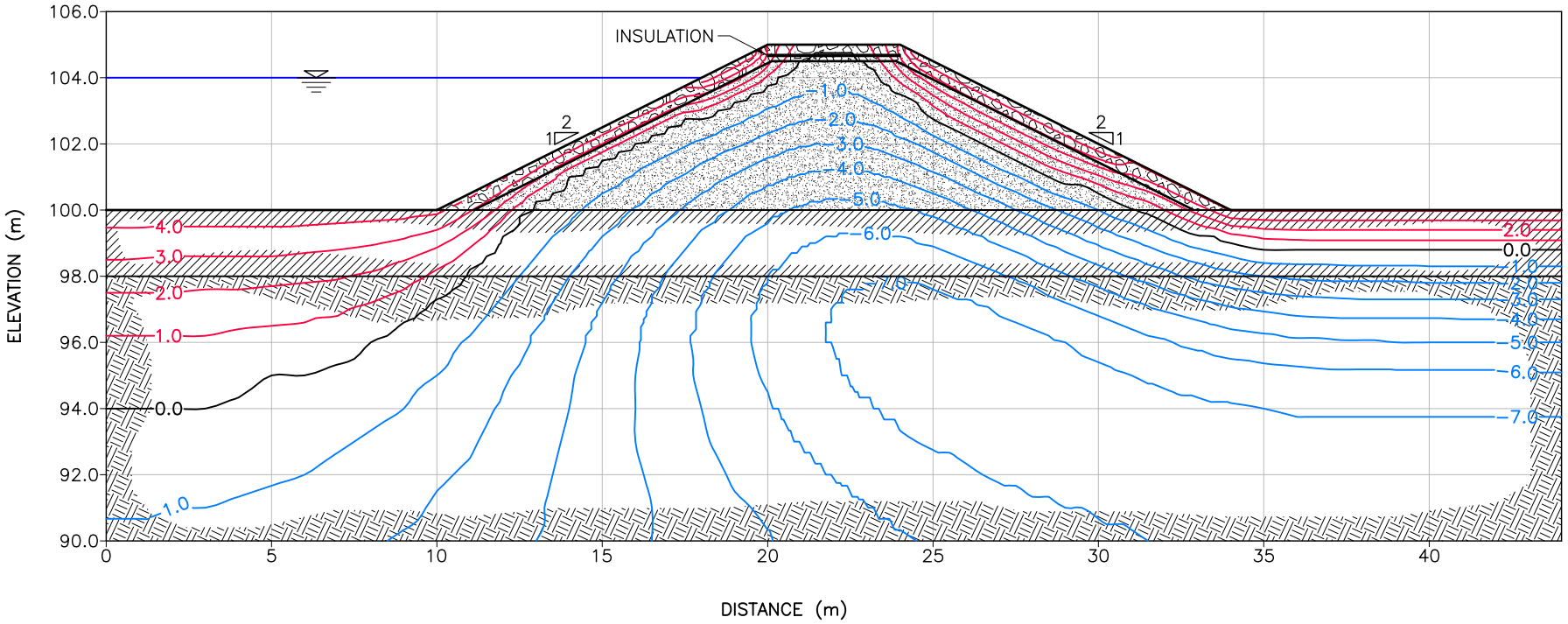
amec Earth & Environmental

CLIENT: DILLON CONSULTING LIMITED

PROJECT: GEOTECHNICAL INVESTIGATION FOR SEWAGE LAGOON, KUGAARUK, NU

TITLE: DYKE TEMPERATURES AFTER 10 YEARS OF OPERATION, FROZEN CORE OPTION

DATE:	JOB No.:	CAD FILE:	FIGURE No.:	REV.
OCTOBER 2005	YX00749	00749B02.dwg	FIGURE 12	A



LEGEND:

- ROCKFILL
- SAND AND GRAVEL
- OVERBURDEN
- BEDROCK

SCALE
1: 200
0 1 2 3 4 m

amec Earth & Environmental

CLIENT: DILLON CONSULTING LIMITED

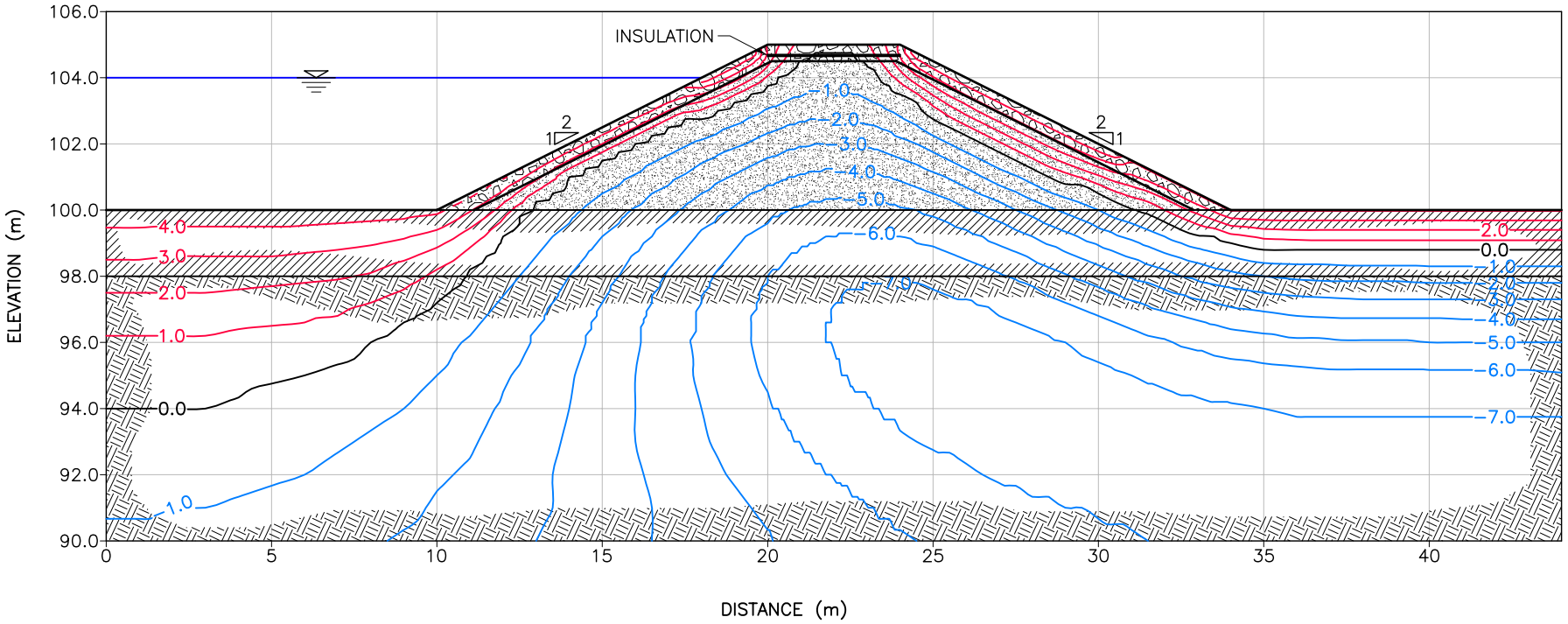
PROJECT: GEOTECHNICAL INVESTIGATION FOR SEWAGE LAGOON, KUGAARUK, NU

TITLE: DYKE TEMPERATURES AFTER 20 YEARS OF OPERATION, FROZEN CORE OPTION

DATE:	JOB No.:	CAD FILE:	FIGURE No.:	REV.
OCTOBER 2005	YX00749	00749B02.dwg	FIGURE 13	A

*PLOT 1:1=A (L)

I:\YX\00749\00749B02.dwg – FIGURE13 – Dec. 01, 2005 2:03pm – shelley.brown



LEGEND:

- ROCKFILL
- SAND AND GRAVEL
- OVERBURDEN
- BEDROCK

SCALE
1: 200
0 1 2 3 4 m

amec Earth & Environmental

CLIENT: DILLON CONSULTING LIMITED

PROJECT: GEOTECHNICAL INVESTIGATION FOR SEWAGE LAGOON, KUGAARUK, NU

TITLE: DYKE TEMPERATURES AFTER 30 YEARS OF OPERATION, FROZEN CORE OPTION

DATE:	JOB No.:	CAD FILE:	FIGURE No.:	REV.
OCTOBER 2005	YX00749	00749B02.dwg	FIGURE 14	A

Appendix C

Grain Size Analysis

SIEVE ANALYSIS REPORT

AMEC Earth & Environmental
a Division of AMEC Americas Limited

To: Dillon Consulting Limited
Suite 303, 4920 47 Street,
PO Box 1409
Yellowknife, NT X1A 2P4

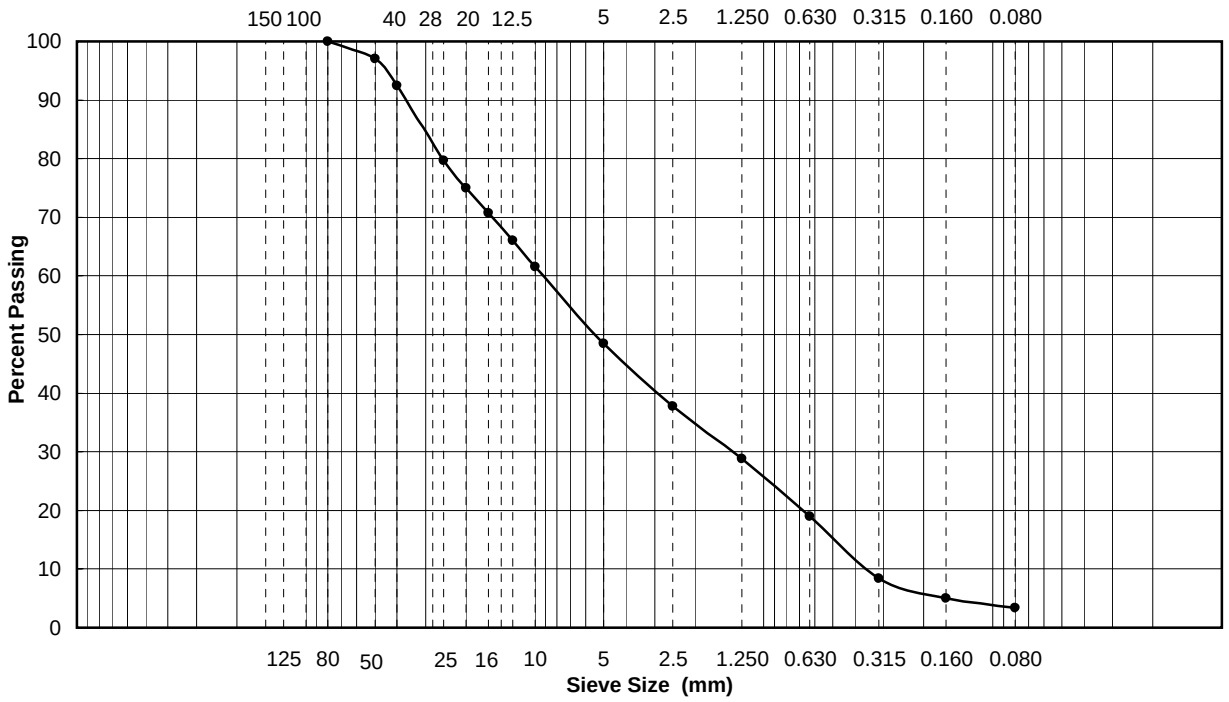
Office : Calgary
Project No: YX00749
Client : Dillon Consulting Limited
Copies to : Client

Attn: Gary Strong

Project: Sewage and Solid Waste Facility, Kugaaruk

Sample ID: 05-391 **Sample Type:** Sand and Gravel **Sampled By:** AMEC

Date Sampled: **Date Received:** **Date Tested:** 20-Oct-05



Sieve Size	% Passing
150.0	
125.0	
100.0	
80.0	100.0
50.0	97.1
40.0	92.4
28.0	
25.0	79.7
20.0	75.0
16.0	70.7
14.0	
12.5	66.1
10.0	61.6
5.0	48.5
2.5	37.8
1.250	28.8
0.630	19.0
0.315	8.4
0.160	5.0
0.080	3.4
C_u	
C_C	

Source: Bucket #1, Potential Borrow Source
Sample Description: Sand and Gravel with trace fines
Comments : No Specifications
Fracture Count = n/a

AMEC Earth & Environmental
a Division of AMEC Americas Limited

Per: _____

Reporting of these test results constitutes a testing service only. Engineering interpretation or evaluation of the test results is provided only on written request.

SIEVE ANALYSIS REPORT

AMEC Earth & Environmental
a Division of AMEC Americas Limited

To: Dillon Consulting Limited
Suite 303, 4920 47 Street,
PO Box 1409
Yellowknife, NT X1A 2P4

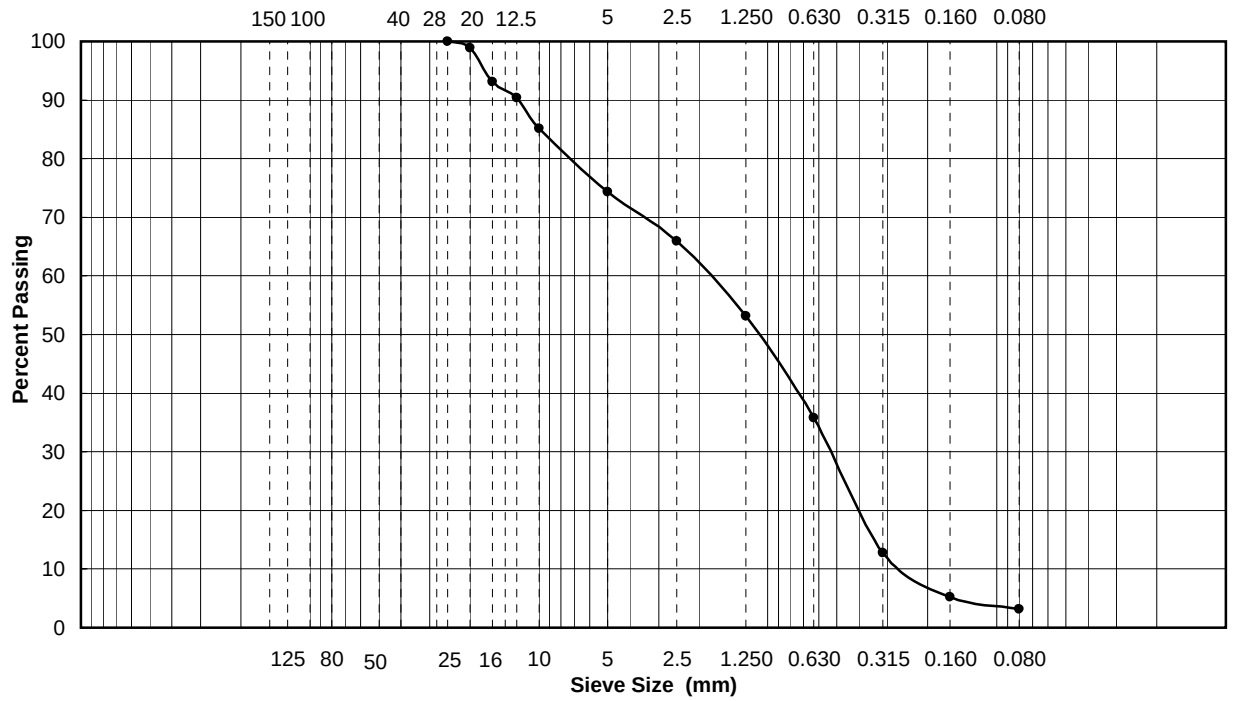
Office : Calgary
Project No: YX00749
Client : Dillon Consulting Limited
Copies to : Client

Attn: Gary Strong

Project: Sewage and Solid Waste Facility, Kugaaruk

Sample ID: 05-392 **Sample Type:** Gravelly Sand **Sampled By:** AMEC

Date Sampled: **Date Received:** **Date Tested:** 20-Oct-05



Sieve Size	% Passing
150.0	
125.0	
100.0	
80.0	
50.0	
40.0	
28.0	
25.0	100.0
20.0	99.0
16.0	93.1
14.0	
12.5	90.4
10.0	85.2
5.0	74.4
2.5	65.9
1.250	53.1
0.630	35.8
0.315	12.7
0.160	5.3
0.080	3.1
C_u	
C_C	

Source: Bucket #2, Existing Dyke
Sample Description: Gravelly Sand with trace fines
Comments : No Specifications
Fracture Count = n/a
Sample had a distinct odor

AMEC Earth & Environmental
a Division of AMEC Americas Limited

Per: _____

31 October 2007
YX00749.100

Dillon Consulting Limited
P.O. Box 1409,
4920 - 47th Street
Yellowknife, NT X1A 2P1

Attention: Mr. Gary Strong, P.Eng.
Project Manager

Dear Mr. Strong:

Re: Sewage Lagoon Cut-off Trench Construction Monitoring
Kugaaruk, NU

1.0 INTRODUCTION

Presented herein is a summary of the construction monitoring services conducted during the excavation and backfilling of the cut-off trench for the sewage lagoon berm in Kugaaruk, NU. AMEC Earth & Environmental, a division of AMEC Americas Limited (AMEC), provided onsite visual inspection, as well as compaction testing services, for construction of the aforementioned cut-off trench from August 24th through September 14th, 2007.

2.0 SCOPE OF WORK

The scope of the work consisted primarily of the following duties:

- confirmation that the cut-off trench was not less than 2 m deep;
- confirmation that the cut-off trench was excavated in hard frozen soil or bedrock with a practical absence of visible ice;
- record of the soil composition and ice content in the trench wall and bottom;
- engineered fill inspection, including such fill parameters as gradation, moisture content, frozen/unfrozen state, inclusions of cobbles/boulders;
- review of lift thicknesses to the capacity of available compaction equipment;
- measurement of the compacted soil density for each lift, using a nuclear densometer;
- inspection of geotechnical activities at the site and direction of these activities if they contradicted the earth work specifications.

AMEC Earth & Environmental
A division of AMEC Americas Limited
221 – 18th Street SE
Calgary, AB, CANADA T2E 6J5
Tel +1 (403) 248-4331
Fax +1 (403) 248-2188 www.amec.com

3.0 SITE BACKGROUND INFORMATION

The community of Kugaaruk is geographically positioned on the west side of the Simpson Peninsula, south of the Boothia Gulf, where the Kugaaruk River enters Pelly Bay. The community is located at 68°32' N Latitude and 89°49' W Longitude and is approximately 1213 km northeast of Yellowknife.

The sewage lagoon site is situated approximately 1.5 km south-southwest of the Kugaaruk community (Figure 1, Appendix A) and approximately 2.4 km southwest of the airport. Almost the entire cut-off trench alignment passes atop granite gneiss that, with the exception of rounded edges from physical weathering and frequent jointing, generally appeared to be strong with no visible signs of material weathering. The occasional to frequent jointing, has created numerous large rock wedges that have been dislodged to some extent by repeated freeze-thaw cycles.

4.0 CUT-OFF TRENCH EXCAVATION

Excavation of the cut-off trench was performed by Kudlik Construction Ltd. (Kudlik) with the use of blasting operations. Boreholes for the explosives were advanced by an air rotary track mounted drill rig (Photograph 1, Appendix B).

For reporting, description, and visualization purposes, the cut-off trench has been divided into three segments: northern, eastern, and western. Elevations of the cut-off trench alignment prior to the excavation are shown on Figure 2, Appendix A. Elevations of the levelling sand layer (the layer of sand between the exposed bedrock and the installed liner), placed on the trench bottom as well as backfill elevations are presented on Figure 3, Appendix A. It is noted that the actual elevations of the trench bottom are lower than those presented on Figure 3, because most of the observed surveying in the cut-off trench was done following placement of the levelling sand layer, about 0.2 m thick. All of the elevations presented on Figures 2 and 3 were provided by Kudlik personnel.

The following paragraphs provide results of the observations made during excavating of the each segment.

4.1 Eastern Segment of Cut-off Trench

The pre-construction elevations along the eastern segment of the cut-off trench varied between approximately 24.0 m, in the area of Sta 0+005, and 28.7 m, geodetic, in the area of Sta 0+030 (Figure 2, Appendix A). This segment of the cut-off trench spans approximately 100 m in length (Sta 0+000 to Sta 0+100) and was aligned entirely in the relatively competent granite gneiss bedrock (Photograph 2, Appendix B). As shown on Figure 3, the invert elevations along the eastern segment after excavation and placement of the levelling sand layer typically varied between 21.9 m and 23.4 m, geodetic.

Thus, the excavated depths along the eastern segment were at least 2 m below existing grade, and were almost 3 m deep in some areas. The eastern segment of the cut-off trench had been completely excavated, but only backfilled and compacted to approximately Sta 0+020. The remaining portion of the eastern segment was left exposed as of 14 September 2007.

4.2 Northern Segment of Cut-off Trench

No elevations were surveyed in the immediate area of the northern segment of the cut-off trench prior to construction. It was understood after discussions with Kudlick and Dillon personnel that this segment follows an alignment of a berm which was situated in this area previously. A general view of the northern segment and pre-existing berm are shown on Photograph 3, Appendix B. In accordance with the existing survey data, the ground surface elevations in this area were in a range from 24 m to 26 m, geodetic. As shown on Figure 3, the invert elevations along the northern segment after removal of the existing berm and cut-off trench excavation varied between 20.5 m and 21.7 m, geodetic. The segment length is approximately 80 m and the excavation was carried out through both existing berm fill and granite gneiss bedrock. The excavated depth along this segment is in a range from about 3.5 m to 4 m. The northern segment of the cut-off trench had been successfully excavated, lined, and backfilled with sand fill to between approximately 23.6 m and 24.0 m, geodetic on September 14, 2007.

4.3 Western Segment of Cut-off Trench

The pre-construction elevations along the western segment of the cut-off trench varied between approximately 25.1 m and 26.5 m, geodetic (Figure 2, Appendix A). This segment of the cut-off trench spans approximately 100 m (Sta 0+000 to Sta 0+100) and is situated entirely within the competent granite gneiss bedrock, requiring blasting in order to excavate. Invert elevations of the western segment after the excavation were typically between 22.5 m and 22.6 m, geodetic, confirming the excavated depth from 2.5 m to 3.0 m below the existing grade (Figure 3, Appendix A). The western segment was excavated for the entire length (to Sta 0+100), but backfilled only to about Sta 0+005 to an approximate elevation of 24.0 m, geodetic. The remainder of the trench segment was left exposed.

5.0 CUT-OFF TRENCH BACKFILLING AND COMPACTION

Following blasting for the cut-off trench, the loose rock debris were removed from the trench. The base of the excavated cut-off trench was at least 1 m wide, as specified in the design, throughout the cut-off trench alignment. After the cut-off trench was cleared, an approximately 200 mm to 300 mm thickness of sand was placed over the trench bottom and slopes to prevent the liner (Bentofix Thermal Lock GCL) from tearing on the sharp faces/edges of the blasted bedrock (Photograph 4, Appendix B). A sand sample was taken for the Standard Proctor Maximum Dry Density (SPMDD) tests and grain size analyses. The results of the laboratory testing program are provided in Appendix C. Prior to placement of the levelling sand layer, any particle sizes larger than coarse gravel were removed by hand.

The trench side slopes were packed and smoothed by the bucket of the backhoe and the trench bottom was packed with a diesel plate tamper. The levelling sand layer was not tested for compaction so as not to damage the nuclear densometer by striking the underlying bedrock. Following placement of the levelling sand layer, the liner was installed and covered with a protective sand layer, about 150 mm to 200 mm thick (Photograph 5, Appendix B). The cut-off trench was then backfilled with sand and gravel fill in approximate 250 mm to 300 mm thick lifts. Each lift was tested at random locations to measure compacted soil density. Backfill compaction within the cut-off trench was required to be greater than 95% of the SPMDD. Areas with compacted densities below 95% of the SPMDD were compacted again and retested until a 95% compaction result was obtained. The compaction tests were carried out using a Troxler 3300 nuclear densometer. The test results are shown in Table 1, Appendix D. Compaction tests, which recorded fill densities below 95% of the SPMDD are not presented in Table 1, since these results were superseded by subsequent retest results.

The compaction equipment used on the site consisted of a Hatz Supra diesel plate tamper and a CAT CS553 vibratory smooth drum roller (packer).

6.0 CONSTRUCTION DISCREPANCIES

The following discrepancies were noted between actual construction conditions and those presented in the earthwork specifications of the proposed sewage lagoon design:

- The manhole access and joining pipeline were relocated approximately 19 m east of the original location (Figure 4, Appendix A). This decision was made between Kudlik and Dillon personnel on the site.
- Ingress of groundwater was noted along the eastern segment of the cut-off trench at approximately Sta 0+070 (Photograph 6, Appendix B). An available submersible pump was not capable of drawing down the water which flowed into the trench from fractured bedrock in the active layer. The water inflow prevented packing of the sand fill in this section of the cut-off trench which was left open for the winter to facilitate freezing of the active layer.
- On September 7th, 2007, a hydraulic hose in the packer broke and the smooth drum was not able to vibrate during compaction. In response to this, backfilling was carried out in thinner lifts, and packed with the plate tamper and occasionally by trucks and bulldozers. Densometer tests have confirmed that the compacted material met the 95% SPMDD requirement.

7.0 CLOSURE

The findings summarized in this report are based on the construction monitoring carried out by AMEC from August 20th through September 14th, 2007. Based on the construction monitoring results, AMEC concludes that the cut-off trench was excavated into the hard frozen soils/competent bedrock to depths specified in Dillon Design Drawing 111.

If you have any questions or concerns, please feel free to contact the undersigned at your convenience.

Yours truly,

AMEC Earth & Environmental
A Division of AMEC Americas Limited

PERMIT TO PRACTICE
AMEC Earth & Environmental Limited
Signature _____
Date November 8, 2007
PERMIT NUMBER: P 047
The Association of Professional Engineers, Geologists and Geophysicists of the NWT / NU

Kane Keller, E.I.T.

Geotechnical Engineer

REGISTERED PROFESSIONAL ENGINEER
A. TCHEKHOVSKI
LICENSE
NWT/NU

NOV. 8, 2007

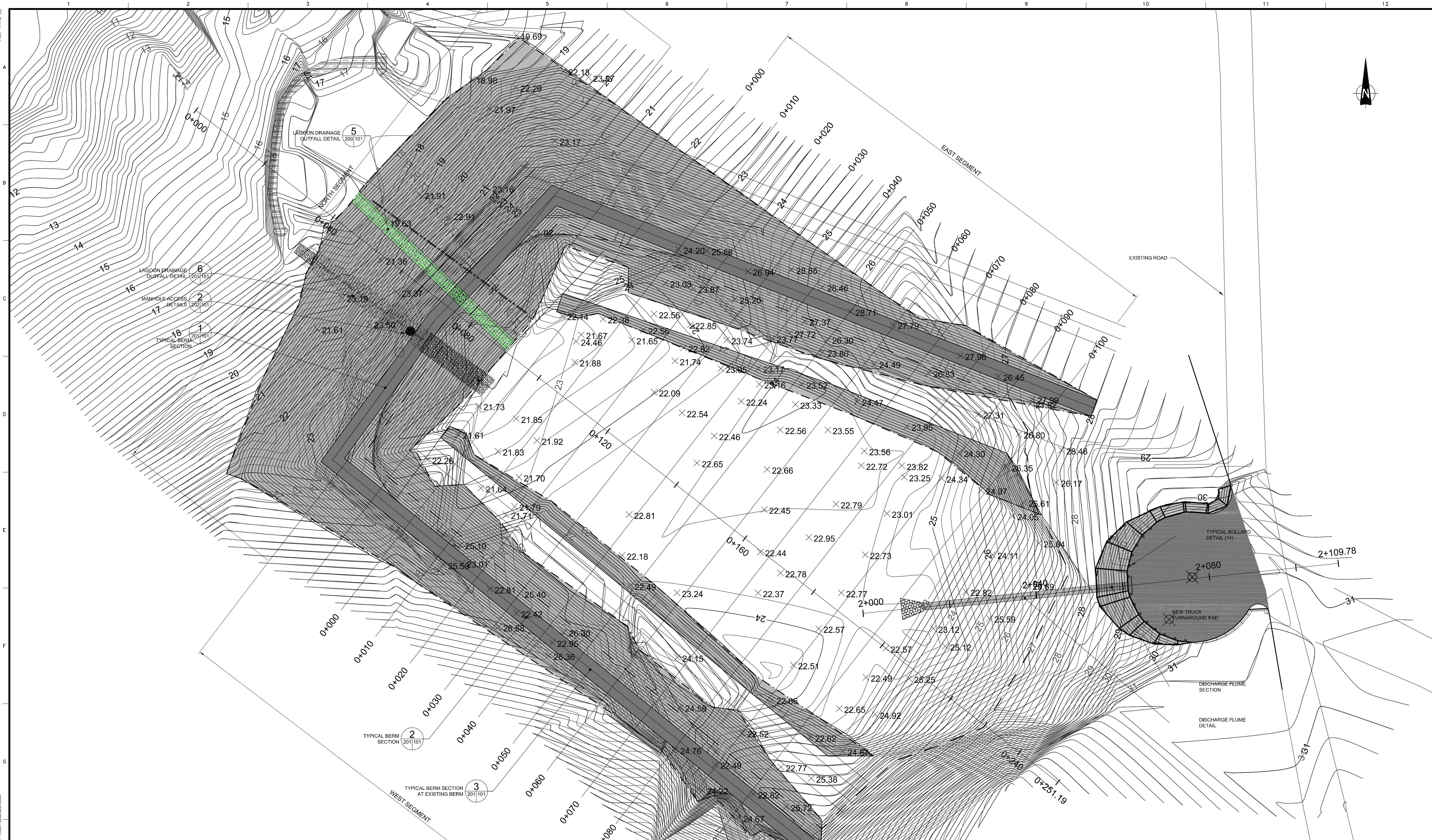
Alexandre Tchekhovski, Ph.D., P.Eng.
Associate Permafrost/Geotechnical Engineer

Reviewed by:
Kevin Spencer, M. Eng., P. Eng.,
Associate Geotechnical Engineer

APPENDIX A

Figure 1: Community of Kugaaruk
Figure 2: Sewage Lagoon Pre-Construction Elevations
Figure 3: Cut-Off Trench Excavated Depths and Backfill Elevations
Figure 4: Relocated Manhole

Client	Dillon Consulting		
Project	**Kugaaruk Sewage Lagoon**	Date: / Revision	
Figure 1: Community of Kugaaruk		**Job No. YX00749**	amec



SCALE 1:400 0 2 4 6 8 m

THIS DRAWING MAY HAVE BEEN REDUCED. ALL SCALE NOTATIONS INDICATED (i.e. 1:1000 etc.) ARE BASED ON 22" X 34" FORMAT DRAWINGS

REV	D	M	Y	ISSUE/REVISION DESCRIPTION	ENG.	APPR.
G						
F						
E						
D						
C						
B						
A	00	00	00	ISSUED FOR CLIENT REVIEW	X.X.	X.X.

amec Earth & Environmental

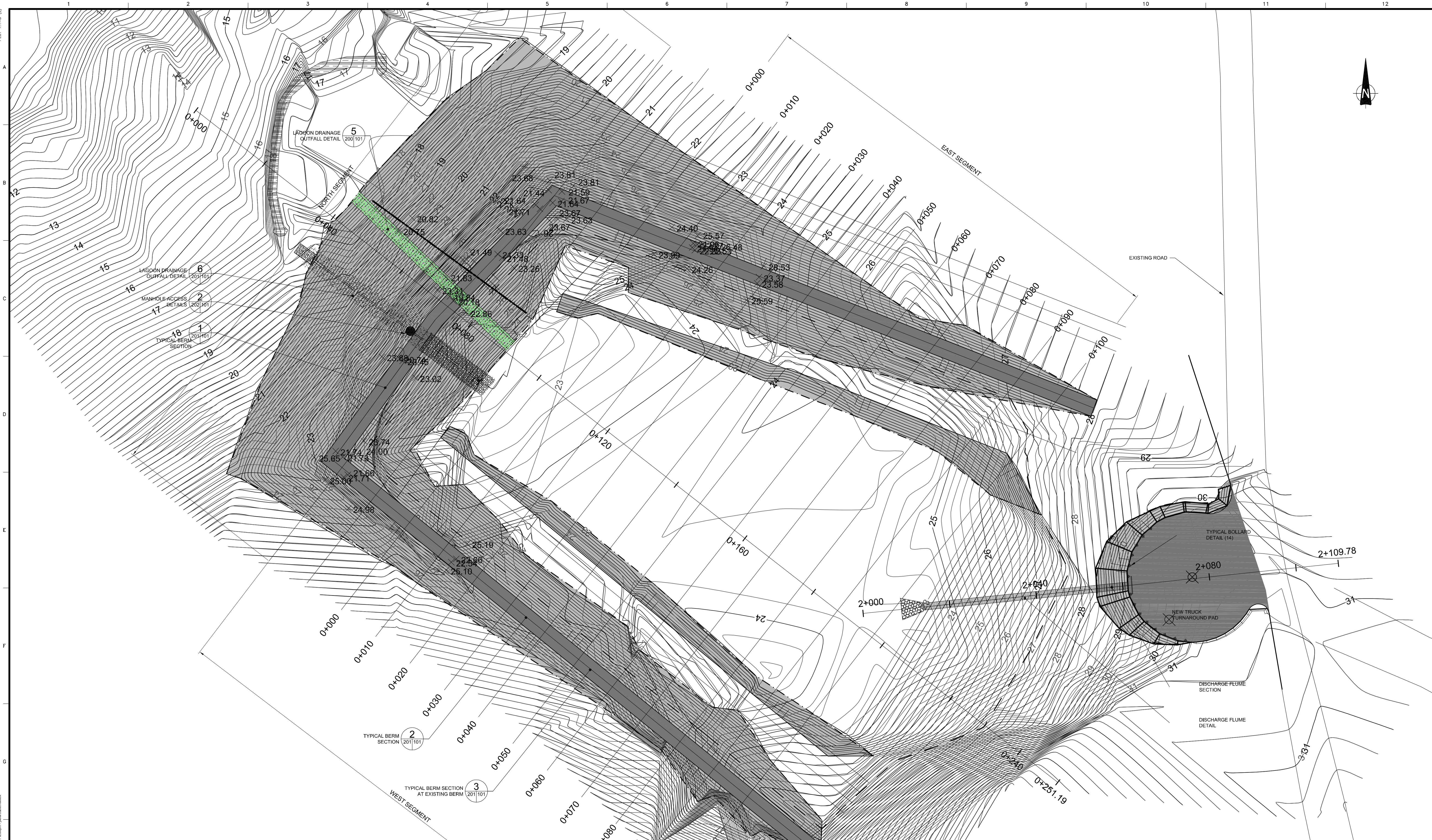
Client: DILLOW CONSULTING

Designed By: Engineer
Drawn By: Draftsperson
Checked By: Project Eng.
Approved By: Project Mngr.
Scale: AS SHOWN

Project: KUGAARUK SEWAGE LAGOON

Title: SEWAGE LAGOON PRE-CONSTRUCTION ELEVATIONS

Project No.: YX00749.100
CADD File: 00749J00.dwg
Date: OCTOBER 2007
Drawing No.: 0000–D00
Sheet No.: 1 of 1



SCALE 1:400 0 2 4 6 8 m

THIS DRAWING MAY HAVE BEEN REDUCED. ALL SCALE NOTATIONS INDICATED (i.e. 1:1000 etc.) ARE BASED ON 22" X 34" FORMAT DRAWINGS

REV	D	M	Y	ISSUE/REVISION DESCRIPTION	ENG.	APPR.
G						
F						
E						
D						
C						
B						
A	00	00	00	ISSUED FOR CLIENT REVIEW	X.X.	X.X.

amec Earth & Environmental

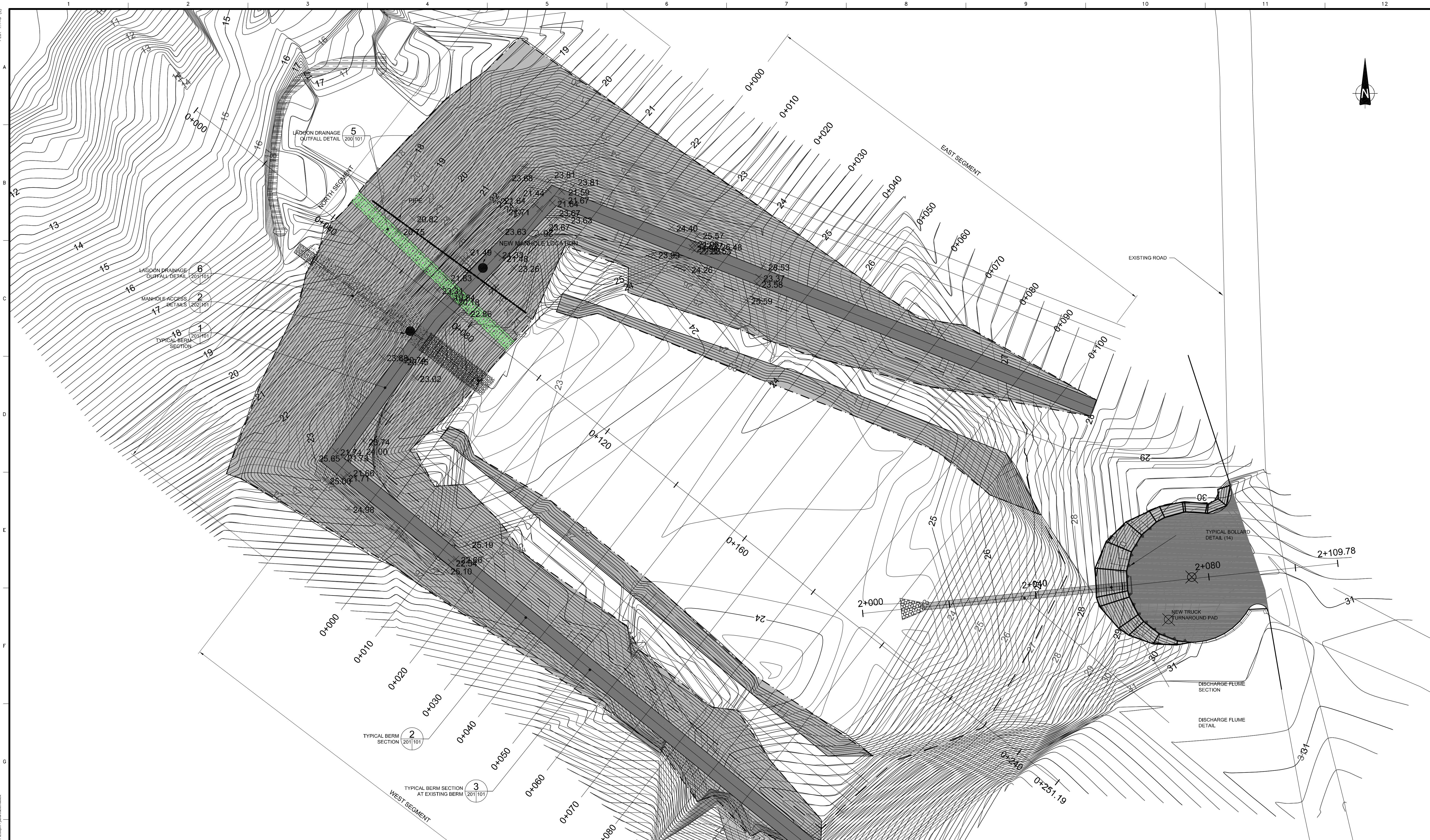
Client: DILLON CONSULTING

Designed By: Engineer
Drawn By: Draftsperson
Checked By: Project Eng.
Approved By: Project Mngr.
Scale: AS SHOWN

Project: **KUGAARUK SEWAGE LAGOON**

Title: **CUT OFF TRENCH EXCAVATED DEPTHS & BACKFILL ELEVATIONS**

Project No.: YX00749.100
CADD File: 00749J00.dwg
Date: OCTOBER 2007
Drawing No.: FIGURE 3
Sheet No.: 1 of 1



THIS DRAWING MAY HAVE BEEN REDUCED. ALL SCALE NOTATIONS INDICATED (i.e. 1:1000 etc.) ARE BASED ON 22" X 34" FORMAT DRAWINGS

SCALE 1:400 0 2 4 6 8 m

REV	D	M	Y	ISSUE/REVISION DESCRIPTION	ENG.	APPR.
G						
F						
E						
D						
C						
B						
A	00	00	00	ISSUED FOR CLIENT REVIEW	X.X.	X.X.

amec Earth & Environmental

Client: DILLON CONSULTING

Designed By: Engineer
Drawn By: Draftsperson
Checked By: Project Eng.
Approved By: Project Mngr.
Scale: AS SHOWN

Project: KUGAARUK SEWAGE LAGOON

Title: RELOCATED MANHOLE

Project No.: YX00749.100
CADD File: 00749J00.dwg
Date: OCTOBER 2007
Drawing No.: FIGURE 4
Sheet No.: 1 of 1

APPENDIX B

Photographs

Photograph 1: Track mounted air rotary rig completing blasting holes.

Photograph 2: Eastern segment of cut-off trench excavated in competent and jointed bedrock.

Photograph 3: Existing berm (at left) along northern segment of cut-off trench.

Photograph 4: Excavator placing sand material along trench bottom and slopes.

Photograph 5: Placement and backfilling of sand fill atop liner.

Photograph 6: Groundwater ingression along eastern segment of cut-off trench.

APPENDIX C

Proctor and Sieve Results

AMEC Earth &
Environmental Limited
221 - 18th Street S.E.
Calgary, Alberta
Canada, T2E 6J5
Tel: (403) 248-4331
Fax: (403) 569-0737

MOISTURE-DENSITY RELATIONSHIP REPORT

Dillon Consulting Limited

Project No: YX00749
Test Date: October 16, 2007
Client P.O.:
CC:

Attention:

Project: Sewage and Solid Waste Facility

Type Of Construction: Fill Material

Applicable Standard: ASTM D698-91 **Method:** A

Wet Density (kg / m³):		2182					
Dry Density (kg / m³):		2043					
Moisture Content (%):		6.8					

Maximum Dry Density: 2040 kg / m³

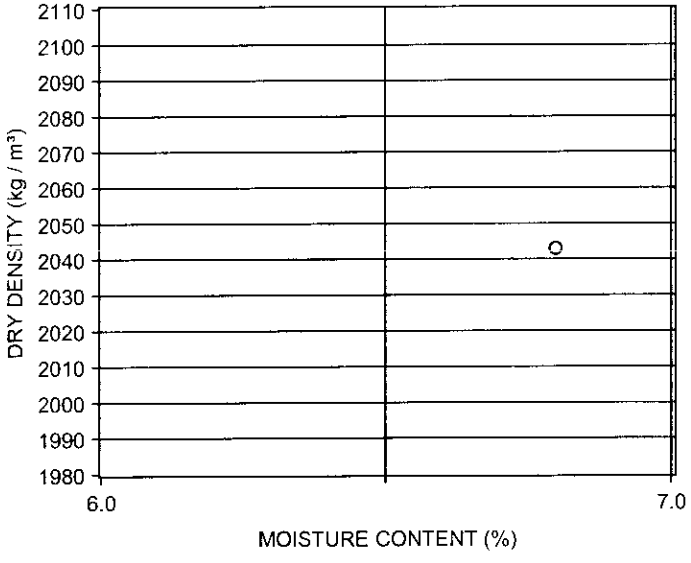
Optimum Moisture: 6.8 %

Source: Site Stock pile

Date Sampled: October 12, 2007
Sampled By: KK
Date Received: October 12, 2007
Tested By: SR

Proctor No: 1
Rammer Type: Auto
Preparation: Moist

MOISTURE-DENSITY RELATIONSHIP



Soil Description: Sand, some gravel

07-546

Approved By: Dave Gallup

SIEVE ANALYSIS REPORT

AMEC Earth & Environmental Limited

To: Dillion Consulting

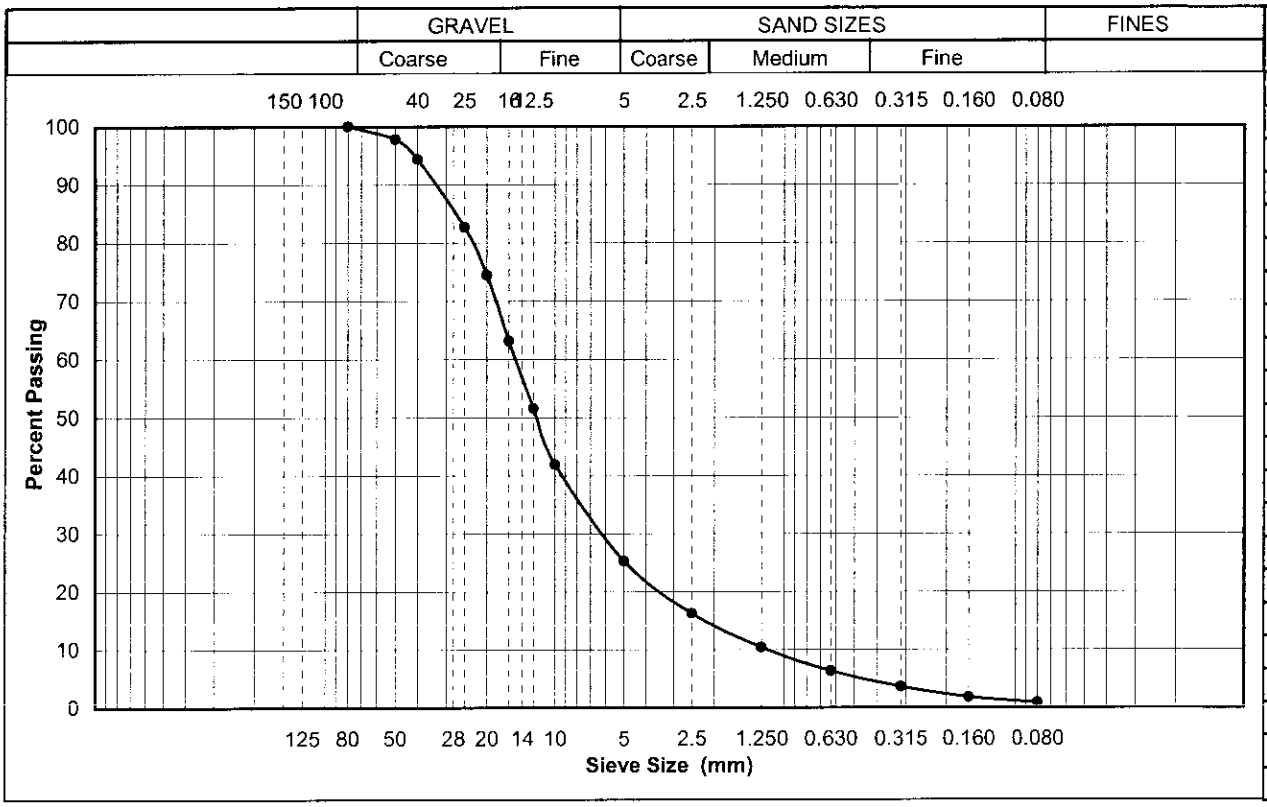
Office : Calgary
Project No: YX00749.100
Client : Dillion Consulting
Copies to :

Attn:

Project: Sewage & Soil Waste Facility

Sample ID: 07-546B **Sample Type:** 25 mm Gravel **Sampled By:** KK

Date Sampled: 12-Oct-07 **Date Received:** 12-Oct-07 **Date Tested:** 16-Oct-07



Sieve Size	% Passing
150.0	
125.0	
100.0	
80.0	100
50.0	98
40.0	94
28.0	
25.0	83
20.0	74
16.0	63
14.0	
12.5	52
10.0	42
5.0	25
2.5	16
1.250	10
0.630	6
0.315	4
0.160	1.8
0.080	0.8

Source: Site Stockpile
Sample Description: Gravel, sandy
Comments :

AMEC Earth & Environmental Limited

Per:

AMEC Earth &
Environmental Limited
221 - 18th Street S.E.
Calgary, Alberta
Canada, T2E 6J5
Tel: (403) 248-4331
Fax: (403) 569-0737

MOISTURE-DENSITY RELATIONSHIP REPORT

Dillon Consulting Limited

Project No: YX00749
Test Date: October 17, 2007
Client P.O.:
CC:

Attention:

Project: Sewage and Solid Waste Facility

Type Of Construction: Fill Material

Applicable Standard: ASTM D698-91 **Method:** C

Wet Density (kg / m³):	1884	1957	1963	1939			
Dry Density (kg / m³):	1784	1848	1850	1824			
Moisture Content (%):	5.6	5.9	6.1	6.3			

Maximum Dry Density: 1850 kg / m³

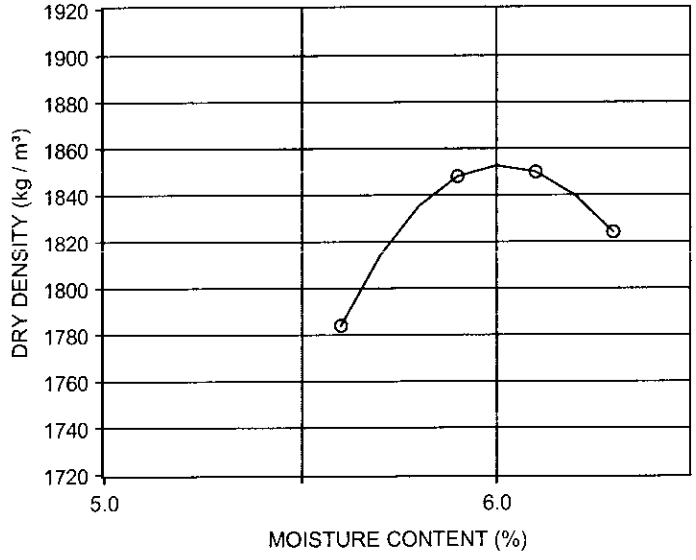
Optimum Moisture: 6.0 %

Source: Site Stock pile

Date Sampled: October 12, 2007
Sampled By: KK
Date Received: October 12, 2007
Tested By: TS

Proctor No: 2
Rammer Type: Auto
Preparation: Moist

MOISTURE-DENSITY RELATIONSHIP



Soil Description: Gravel, trace of sand

07-546 B

Approved By: Dave Gallup

APPENDIX D

Table 1: Compaction Tests Results Summary

Table 1: Compaction Tests Summary Results

Date	Test Location (approximate stations/locations)	Elevation (m a.s.l.)	Material Tested	SPMDD and OMC (kg/m3 , %)	Dry Density (kg/m3)	Moisture (% by Weight)	Compaction (% SPMDD)
31-Aug-07	8 m S, 30 m E	21.6	sand + oversize	1800, 13	1733	7.4	96%
	Sta 0 + 000 East, 20 m N	21.6	sand + oversize	1800, 13	1793	7.7	100%
	Sta 0 + 000 East, 15 m N	21.7	sand + oversize	1800, 13	1863	6	100%
	Sta 0 + 000 East, 8 m N	21.6	sand + oversize	1800, 13	1830	6.7	100%
	Sta 0 + 000 East	21.6	sand + oversize	1800, 13	1845	6.5	100%
		22.1	sand & gravel + oversize	2230, 6	2193	5.2	98%
	Sta 0 + 000 East, 8 m N	22.2	sand & gravel + oversize	2230, 6	2177	5.3	98%
	Sta 0 + 000 East, 15 m N	22	sand & gravel + oversize	2230, 6	2186	5.4	98%
	8 m S, 30 m E manhole column	22.1	sand & gravel + oversize	2230, 6	2190	5.1	98%
	8 m S, 35 m E manhole column	22	sand & gravel + oversize	2230, 6	2197	5.2	99%
5-Sep-07	12 m S along manhole water supply line	22.0	sand, some gravel	2040, 6.8	1975	5.6	97%
	2 m S, 1 m W of manhole column	22.2	sand, some gravel	2040, 6.8	1930	5.4	95%
	12 m S along manhole water supply line	22.5	sand, some gravel	2040, 6.8	1928	5.8	95%
6-Sep-07	10 m E, 8 m S manhole column	22.4	sand, some gravel	2040, 6.8	1937	6.7	95%
	13 m W, 7 m S manhole column	22.0	sand, some gravel	2040, 6.8	1931	6.5	95%
	13 m E, 7 m S manhole column	23.0	sand, some gravel	2040, 6.8	1936	6.2	95%
	7 m W, 7 m S manhole column	22.2	sand, some gravel	2040, 6.8	1961	7.7	96%
	16 m E, 8 m S manhole column	23.1	sand, some gravel	2040, 6.8	1931	6.3	95%
	1 m W, 8 m S manhole column	22.4	sand, some gravel	2040, 6.8	1976	7.0	97%
	25 m W, 8 m S manhole column	22.1	sand, some gravel	2040, 6.8	1970	8.2	97%
	33 m E, 8 m S manhole column	23.2	sand, some gravel	2040, 6.8	1929	5.3	95%
7-Sep-07	25 m W, 7 m S manhole column	22.6	sand, some gravel	2040, 6.8	2014	7.8	99%
	13 m W, 8 m S manhole column	23.2	sand, some gravel	2040, 6.8	2008	6.8	98%
	7 m E, 7 m S manhole column	23.0	sand, some gravel	2040, 6.8	2061	6.7	101%
	26 m E, 12 m S manhole column	22.2	sand, some gravel	2040, 6.8	2032	7.5	100%
	Sta 0 + 000 East	22.3	sand, some gravel	2040, 6.8	2033	6.8	100%
	35 m W, 8 m S manhole column	22.9	sand, some gravel	2040, 6.8	2026	7.6	99%
	Sta 0 + 000 West	22.4	sand, some gravel	2040, 6.8	2050	5.5	100%

Date	Test Location (approximate stations/locations)	Elevation (m a.s.l.)	Material Tested	SPMDD and OMC (kg/m3 , %)	Dry Density (kg/m3)	Moisture (% by Weight)	Compaction (% SPMDD)
8-Sep-07	Sta 0 + 005 West	22.2	sand, some gravel	2040, 6.8	1941	7.6	95%
	Sta 0 + 008 West	22.3	sand, some gravel	2040, 6.8	1985	6.9	97%
	Sta 0 + 012 West	22.2	sand, some gravel	2040, 6.8	1960	7.6	96%
	Sta 0 + 005 East	23.2	sand, some gravel	2040, 6.8	1953	7.0	96%
	Sta 0 + 015 East	23.1	sand, some gravel	2040, 6.8	1956	6.0	96%
	1 m W manhole column	23.3	sand, some gravel	2040, 6.8	1952	6.2	96%
	1 m W, 4 m S manhole column	23.4	sand, some gravel	2040, 6.8	1939	6.1	95%
	Sta 0 + 002 West	23.2	sand, some gravel	2040, 6.8	2000	6.9	98%
9-Sep-07	Sta 0 + 015 West	23.2	sand, some gravel	2040, 6.8	1932	5.6	95%
	Sta 0 + 005 West	23.3	sand, some gravel	2040, 6.8	1941	6.6	95%
	14 m W, 8 m S manhole column	22.9	sand, some gravel	2040, 6.8	1962	6.5	96%
	8 m W, 7 m S manhole column	23.1	sand, some gravel	2040, 6.8	2001	8.6	98%
	Sta 0 + 007 West	23.4	sand, some gravel	2040, 6.8	2008	6.2	98%
	18 m W, 7 m S manhole column	22.9	sand, some gravel	2040, 6.8	1966	8.6	96%
10-Sep-07	8 m S, 25 m W manhole column	23.4	sand, some gravel	2040, 6.8	1944	6.6	95%
	9 m S, 15 m W manhole column	23.3	sand, some gravel	2040, 6.8	1947	7.6	95%
	6 m S, 15 m W manhole column	23.4	sand, some gravel	2040, 6.8	1963	6.4	96%
	8 m S, 8 m W manhole column	23.3	sand, some gravel	2040, 6.8	1935	6.3	95%
11-Sep-07	6 m S, 12 m W manhole column	23.4	sand, some gravel	2040, 6.8	1976	6.6	97%
	21 m W, 7 m S manhole column	23.3	sand, some gravel	2040, 6.8	1937	7.5	95%
	Sta 0 + 000 West	23.7	sand, some gravel	2040, 6.8	1957	7.1	96%
	35 m W manhole column	23.4	sand, some gravel	2040, 6.8	1987	7.1	97%
	Sta 0 + 005 West	23.8	sand, some gravel	2040, 6.8	1964	6.8	96%

P.O. Box 119
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NUNAVUT WATER BOARD
NUNAVUT IMALIRIYIN KATIMAYINGI
OFFICE DES EAUX DU NUNAVUT

DECISION

LICENCE NUMBER: 3BM-PEL0712

This is the decision of the Nunavut Water Board (NWB) with respect to an application for a Licence amendment and renewal originally received May 31, 2006, made by:

Hamlet of Kugaaruk

to allow for the use of water and disposal of waste for the Hamlet of Kugaaruk, located within the Kitikmeot Region, Nunavut. With respect to this application, the NWB gave notice to the public that the Hamlet had filed an application for a water licence.

DECISION

After having been satisfied that the application was exempt from the requirement for screening by the Nunavut Impact Review Board in accordance with S. 12.3.2 of the *Nunavut Land Claim Agreement* (NLCA), the NWB decided that the application could proceed through the regulatory process. After reviewing the full submission of the Applicant and written comments expressed by interested parties, the NWB, having given due regard to the facts and circumstances, the merits of the submissions made to it and to the purpose, scope and intent of the *NLCA* and of the *Nunavut Waters and Nunavut Surface Rights Tribunal Act* (NWNSRTA), decided to waive the requirement to hold a public hearing and determined that:

Licence Number 3BM-PEL0712 be issued subject to the terms and conditions contained therein. (Motion #: 2007-24)

SIGNED this _7th_ day of September, 2007 at Gjoa Haven, NU.

Original signed by:

Thomas Kabloona
Acting Chief Executive Officer

TABLE OF CONTENTS

I. BACKGROUND

The Hamlet of Kugaaruk is located 68°32' north latitude and 89°49' west longitude in central Nunavut, within the Kitikmeot Region. This places Kugaaruk along the east coast of Pelly Bay, which is roughly nine hundred and sixty kilometers (960 km) west of the capital of Iqaluit. The annual snowfall in Kugaaruk is approximately 125 cm and the annual rainfall is approximately 11 cm. In January the daily mean temperatures is approximately minus 33^0C while in July the daily mean temperature is approximately plus 6^0C. Freeze up usually occurs during the month of November but may happen as early as September or October while spring thaw usually happens between late May and June.

II. PROCEDURAL HISTORY

On May 31, 2006, an application for the amendment and renewal of water licence NWB3PEL9803 was filed by Dillon Consulting Ltd.(Dillon), Yellowknife, NT, on behalf of the Hamlet of Kugaaruk. The Hamlet of Kugaaruk is applying for the renewal of its Water License, which was issued on November 1, 1998 and expired on October 31, 2003. The scope of the application included the planned upgrades to the sewage (lagoon) and solid waste disposal facilities (improved fencing).

An initial assessment of the Hamlet's application for water use and waste disposal activities within the Hamlet was undertaken, so that the Board could make a fully informed decision on the merits of application. An internal technical assessment was completed and a request for additional information and clarification was made by the NWB on November 14, 2006. The response to this request and to comments received from interested parties on an initial request in May, 2007, was received on July 19, 2007.

Information contained in the July 19, 2007 submission and distributed for review was as follows:

- Detailed Design Phase II (July, 2007; Dillon Consulting Ltd.), with the following Appendices
    - Appendix A: Stamped Design Drawings
    - Appendix B: Population Statistics
    - Appendix C: Laboratory Analyses
    - Appendix D: Sample Tables of Contents (Spill Contingency, O&M)
    - Appendix E: NWB letter of November 14, 2006
    - Appendix F: Laboratory Analysis & INAC inspection
    - Appendix G: Letters from Hamlet & from NWB
    - Appendix H: Community poster
    - Appendix I: GCL specification sheet
    - Appendix J: Letters from INAC, Env. Can., GN Dept of Env.
- Response to the NWB letter of November 14, 2006
- GN/Dillon response (Questions 1-3)

- AMEC response (Questions 4-14)
- GN response to previous INAC, Environment Canada, and GN-DOE comments

The Nunavut Water Board publicly posted notice of this application, in accordance with the *Nunavut Waters and Nunavut Surface Rights Tribunal Act* S. 55.1 and Article 13 of the *Nunavut Land Claims Agreement,* on May 7, 2007. This assessment process included the referral of the application to a variety of Federal, Territorial and local organizations for their review and comment. The additional information received on July 19, 2007 from the Department of Community and Government Services, Government of Nunavut on behalf of the Hamlet, containing information prepared by Dillon, was forwarded to the parties for additional review on July 24, 2007.

As no public concern was expressed, the NWB waived the requirement to hold a public hearing and proceeded with the application process.

Based upon the results of the detailed assessment, including consideration of any potential accidents, malfunctions, or impacts to water, that the overall project might have in the area, the Board approved the application and has issued Licence 3BM-PEL0712.

III. ISSUES

Term of the Licence, Reporting, Manual and Plan Submissions

In accordance with the *Nunavut Waters and Nunavut Surface Rights Tribunal Act* S. 45, the NWB may issue a licence for a term not exceeding twenty-five years. In determining an appropriate term of a water licence, the Board considers a number of factors, including, but not limited to, the results of the Department of Indian Affairs and Northern Development (INAC) site inspections and the compliance record of the Applicant. In review of the previous water licence NWB3PEL9803, the NWB has noted that there were several issues of non-compliance with conditions contained therein. The issues varied throughout the duration of the Licence, however re-occurring items were significant and as follows:

i. The Licensee did not include in Annual Reports, the water quality results for monitoring under Schedule 1: Surveillance Network Program;
ii. The Licensee did not submit an Operations and Maintenance Plan during the Licence term; and
iii. Based on Inspectors sample results, effluent standards regarding Biochemical Oxygen Demand, Suspended Solids and Fecal Coliforms were not met.

Term of Licence

In review of the application and the comments received from interested persons, there were no objections to the Applicants request for a term of five (5) years for the Licence renewal. The NWB concurs that a term of five (5) years is appropriate, and will allow enough time for the Hamlet to establish a consistent compliance record with the terms and conditions of its licence. Appropriate Plans need to be developed to the satisfaction of the NWB for the operation and maintenance of the facilities as well as for the protection of the environment with regard to potential spills through day-to-day operations.

Annual Report

The NWB has imposed on the Licensee, the requirement to produce an Annual Report. These Reports are for the purpose of ensuring that the NWB has an accurate annual update of municipal activities during a calendar year. This information is maintained on the public registry and is available to interested parties upon request. A *"Standardized Form for Annual Reporting"* is to be used by the Licensee and is available from the NWB file transfer protocol (FTP) site under the Public Registry link at the NWB Website.

Operational Plans

The NWB recognizes the significant efforts put forward by the Licensee within the renewal application. It is noted, however, that the Licensee has not submitted an Operations and Maintenance (O&M) Plan or an Environmental Emergency Contingency Plan with the Application for Renewal of Licence, filed with the Board on May 31, 2006 or in its follow-up submissions. This Licence has therefore, included the requirement to provide to the NWB the following Plans, as identified within the Licence:

i. *Water Distribution Facility Operation and Maintenance (O&M) Plan*;
ii. *Sewage Treatment Facility Operation and Maintenance (O&M) Plan*;
iii. *Solid Waste Facility Operation and Maintenance (O&M) Plan*;
iv. *Environmental Emergency Contingency Plan For Water, Sewage and Solid Waste Operations in the Hamlet of Kugaaruk, Nunavu*t; and the
v. *Monitoring Program Quality Assurance/Quality Control Plan*

The purpose of the *Plans* noted above is to assist Hamlet staff in the proper operation and maintenance of their water distribution and waste disposal facilities. The *Plans* should demonstrate to the Nunavut Water Board that the Hamlet is capable of operating and maintaining the infrastructure related to water use and waste disposal adequately and to meet the requirements of the Licence. The Plans should be based, at a minimum on the various NWB-approved guidelines available (i.e. *Guidelines for the Preparation of an Operations and Maintenance Manual for Sewage and Solid Waste Disposal Facilities in the Northwest Territories,* Duong and Kent, 1996) and other regulatory guidelines as deemed appropriate.

The purpose of the Monitoring Program, the *Quality Assurance/Quality Control (QA/QC) Plan* is to

ensure that samples taken in the field, as part of the Monitoring Program, will maintain a high quality, so as to accurately represent the physical and chemical nature of the samples being taken. It should also be noted that while sampling requirements have been imposed, additional sampling may be requested by an Inspector.

Water Use

The Hamlet of Kugaaruk currently utilizes the Kugajuk River as a source of potable water. The intake for the Hamlet's Water Supply Facility is located approximately one kilometer (1 km) upriver from the community. The intake consists of two (2) one hundred and fifty two millimeter (152 mm) submerged lines that extend from the shore approximately fifteen meters (15 m) along the bottom of the river. The two intake lines travel up from the shoreline about ten meters (10 m) where they enter the Water Supply Facility truck fill station. Water is transferred by submersible pump to the distribution vehicles following chlorine treatment, and is then distributed to the community by truck. Water consumption in 2006 was reported to be 23,507 m^3. Projected water use in 2012 is reported to be 31,205 m^3. The amount of water use requested by the Applicant for the term of the Licence is 35,000 cubic metres per year.

No concerns were raised by the parties in their written submissions as to the amount of water required by the Applicant, the manner in which it is obtained or in the manner in which this water will be used. The NWB has determined that the increase in water use volume requested within this application will not substantially affect the quality, quantity or flow of waters, and has set the terms and conditions associated with water use by the Hamlet accordingly.

Deposit of Waste

Sewage

The Hamlet of Kugaaruk currently provides trucked sewage services for the Community's residents, businesses and institutions. The Sewage Treatment Facility, operated by the Hamlet of Kugaaruk is located approximately 1.0 km from the Hamlet. Sewage is collected by vacuum truck from customer holding tanks and discharged to the sewage lagoon located to the east of the community, north of the Access Road and adjacent to the solid waste disposal facility. The Hamlet currently utilizes a two cell facultative lagoon system that began operating about 14 years ago. The original lagoon was designed as a single cell. The second cell was only constructed later as an ad hoc addition to the system by Hamlet crews and has little capacity. The system developed leaks and attempts were made to reinforce the berms surrounding the cells in the summer of 2004. Subsequent to the repairs, the leaking was reduced however the effluent continues to leak from the system at an elevated rate. Dillon Consulting made an initial site visit to the community in July 2005 to assess the breaches in the lagoon berms and to test the quality of the effluent being discharged into the ocean.

Upgrading of the current sewage lagoon system has been applied for within the current application

for amendment and renewal, to provide annual sewage treatment for the Hamlet for the projected twenty (20) year period.

Sewage effluent from the new lagoon system will be discharged as before, annually overland through a Wetland Treatment Area to the Final Discharge Point approximately one hundred and sixty meters (160 m) at the ocean shoreline. The wetland is contained by rock outcroppings on both sides. The change in elevation is roughly seventeen meters (17 m) and consists of multiple channels with three or four ponding areas.

Discharge from this upgraded facility is planned to take place annually, weather dependent, from July until October.

During the construction phase, a packaged two stage temporary sewage treatment system is to be used to treat the Hamlet wastewater while the Lagoon is being completed. This system is expected to provide treatment well above primary treatment, and will be close to secondary sewage treatment (TSS and BOD_5 below 45 mg/L). This system will be subject to the same effluent quality criteria as the lagoon system and will be required to comply under Part D, Item 3.

Specific comments relevant to sewage disposal operations in the Hamlet were provided by GN-DOE, INAC and Environment Canada.

Environment Canada noted that any effluent discharged must be in compliance with Section 36(3) of the Fisheries Act. The Department of the Environment (GN) also noted the requirements that effluent quality meet applicable legislative requirements. Monitoring of the Sewage Lagoon effluent (Sewage Disposal Facility) was requested, by both Parties, in order to assess the treatment efficiency within the wetland treatment area. The NWB concurs with this and has included monitoring requirements for the Sewage Lagoon. In order to effectively monitor these effluents for compliance purposes, the NWB has imposed acute toxicity testing as a licence requirement under Part D, Item 10.

Both the Department of the Environment (GN) and Environment Canada noted that maintenance should include removal and disposal of sewage sludge. Environment Canada recommended that prior to de-sludging occurring, the Licensee submit for approval a Sewage Sludge Management Plan that clearly outlines the chemical composition of the sludge, and how sludge will be stored, treated and eventually disposed of. The NWB concurs with this recommendation, and has imposed this requirement in Part F, Item 1(ii).

The NWB recognizes the need to determine the treatment efficiencies of the wetland treatment over a suggested period of 5 years. In order to provide the additional design data required to adequately assess the system, a Wetland Treatment Area Assessment Report is to be developed that will provide the criteria needed in order to properly assess the efficiency of the system over time. Verification of assumed flow pattern, residence time and determination of a focal point of release for the Final

Discharge Point are all needed in order to demonstrate the effectiveness of the system. This requirement is detailed in Part D, Item 7.

In considering that the Licence term has been set to five (5) years, and in allowing for the construction of the facilities, the Board has determined that a future treatment efficiency of the Wetland Treatment Area be assessed in year 5 of this Licence. For future planning a further assessment may be considered by the Board in an application for Licence renewal.

Both the Department of the Environment (GN) and Environment Canada noted that an Environmental Emergency Contingency Plan for Water, Sewage and Solid Waste Operations in the Hamlet of Kugaaruk, Nunavut has not yet been prepared, and submitted to the NWB by the Licensee. Both Parties recommended that the Licensee develop this Plan as soon as possible, and submit it to the NWB for approval. The NWB concurs with this recommendation, and has imposed this requirement in Part F, Item 2

Solid Waste

The Hamlet's Solid Waste Facility is located southeast of the sewage treatment lagoon, approximately 2.3 km east of the community, north of the Access Road. Waste is collected by the Hamlet and transported to the waste disposal facility. The bulky metal/hazardous waste storage area is locate approximately half a kilometer (500m) southeast of the sewage lagoon and landfill sites. The information submitted to the NWB has indicated that the storage of these materials is in need of clean-up, planning, design and implementation. Recommendations have been provided to the GN by Dillon within the additional information received July 10, 2007, however no formal plan has been developed to address this issue. The development of an Operations and Maintenance Plan for the Solid Waste Disposal Facility will be required to set out procedures for the segregation, storage and eventual removal for disposal of hazardous wastes.

Environment Canada noted in their comments, the requirement for a Solid Waste Disposal Facility Operation and Maintenance (O&M) Plan, which reflects a commitment to waste reduction and proper handling of hazardous waste. The NWB notes that a Plan for this facility has not yet been prepared and submitted to the Board.

Accordingly, this Plan has been requested under Part F, Item 1 to ensure the Plan is current and takes into consideration concerns presented during the review of the Application, including any incineration planned at the Solid Waste Disposal Facility.

Additionally, in their comments regarding the disposal of solid wastes, the Department of the Environment (GN) recommended that groundwater monitoring wells be installed downstream of the solid waste landfill and the existing metals dump area. Although diversion ditches or berms are commonly installed around landfills to redirect surface runoff, groundwater monitoring wells are intended to help verify that historical contaminants which may be present in the landfill are not

migrating off site as a result of precipitation or snowmelt. The NWB concurs with this recommendation and has specifically requested that the inclusion of groundwater monitoring be addressed in the Solid Waste Disposal Facility's Operation and Maintenance Plan as presented in Part F, Item 1.

Abandonment and Restoration

To ensure that all future abandoned facilities are reclaimed in an appropriate manner, the NWB requires Licensees to submit an *Abandonment and Restoration Plan*. This plan is to be submitted at least six (6) months prior to final closure of Licenced facilities or upon submission of the final design drawings for the construction of new facilities to replace existing ones. The requirements for the Plan are outlined in Part G of this License. The NWB encourages the Licensee to undertake progressive reclamation on sites where possible.

IV. LICENCE 3BM-PEL0712

Pursuant to the *Nunavut Waters and Nunavut Surface Rights Tribunal Act* and the *Agreement Between the Inuit of the Nunavut Settlement Area and Her Majesty the Queen in Right of Canada*, the Nunavut Water Board, hereinafter referred to as the Board, hereby grants to

HAMLET OF KUGAARUK

(Licensee)

of **P.O. BOX 205, KUGAARUK, NUNAVUT X0B 1K0**

(Mailing Address)

hereinafter called the Licensee, the right to alter, divert or otherwise use water for a period subject to restrictions and conditions contained within this licence:

Licence Number **3BM-PEL0712**

Water Management Area **NUNAVUT 07**

Location **KUGAARUK, NUNAVUT (Latitude 68°32'N and Longitude 89°49'W**

Purpose **WATER USE AND WASTE DISPOSAL**

Description **MUNICIPAL UNDERTAKINGS**

Quantity of Water Not to Exceed **35,000 CUBIC METRES ANNUALLY**

Date of Licence **September 7, 2007**

Expiry Date of Licence **December 31, 2012**

Dated this 7th of September 2007 at Gjoa Haven, NU.

Original signed by:

Thomas Kabloona
Acting Chief Executive Officer

PART A: SCOPE AND DEFINITIONS

1. Scope

a. This Licence allows for the use of water and the disposal of waste for municipal undertakings at the Hamlet of Kugaaruk, Kitikmeot Region, Nunavut (68°31' N; 89°54'W);

b. This Licence is issued subject to the conditions contained herein with respect to the taking of water and the depositing of waste of any type in any waters or in any place under any conditions where such waste or any other waste that results from the deposits of such waste may enter any waters. Whenever new Regulations are made or existing Regulations are amended by the Governor in Council under the *Nunavut Waters and Nunavut Surface Rights Tribunal Act*, or other statutes imposing more stringent conditions relating to the quantity or type of waste that may be so deposited or under which any such waste may be so deposited, this Licence shall be deemed, upon promulgation of such Regulations, to be subject to such requirements; and;

c. Compliance with the terms and conditions of this Licence does not absolve the Licensee from responsibility for compliance with the requirements of all applicable Federal, Territorial and Municipal legislation.

2. Definitions

In this Licence: **3BM-PEL0712**

"Act" means the *Nunavut Waters and Nunavut Surface Rights Tribunal Act;*

"Amendment" means a change to original terms and conditions of this licence requiring correction, addition or deletion of specific terms and conditions of the licence; modifications inconsistent with the terms of the set terms and conditions of the Licence;

"Analyst" means an Analyst designated by the Minister under Section 85 (1) of the *Act*;

"Appurtenant undertaking" means an undertaking in relation to which a use of waters or a deposit of waste is permitted by a licence issued by the Board;

"Average Concentration" means the arithmetic mean of the last four consecutive analytical results for composite or grab samples collected from the monitoring stations identified in Part H;

"Board" means the Nunavut Water Board established under the *Nunavut Land Claims*

Agreement;

"**Chief Administrative Officer**" means the Executive Director of the Nunavut Water Board;

"**Commercial Waste Water**" means water and associated waste generated by the operation of a commercial enterprise, but does not include toilet wastes or greywater;

"**Composite Sample**" means a water or wastewater sample made up of four (4) samples taken at regular periods over a 24 hour period;

"**Effluent**" means treated or untreated liquid waste material that is discharged into the environment from a structure such as a settling pond or a treatment plant;

"**Engineer**" means a professional engineer registered to practice in Nunavut in accordance with the *Engineering, Geological and Geophysical Act (Nunavut)* S.N.W.T. 1998, c.38, s.5;

"**Final Discharge Point**" means the discharge location at the Sewage Disposal Facility as described in the Final Design Report, to be confirmed through on-site investigation and approval by an Inspector under Part D, Items 3 and 9;

"**Freeboard**" means the vertical distance between water line and the designed maximum operating height on the crest of a dam or dyke's upstream slope;

"**Geotechnical Engineer**" means a professional engineer registered with the Association of Professional Engineers, Geologist and Geophysicists of Nunavut and whose principal field of specialization with the engineering properties of earth materials in dealing with man-made structures and earthworks that will be built on a site. These can include shallow and deep foundations, retaining walls, dams, and embankments;

"**Grab Sample**" means a single water or wastewater sample taken at a time and place representative of the total discharge;

"**Greywater**" means all liquid wastes from showers, baths, sinks, kitchens and domestic washing facilities, but does not include toilet wastes;

"**Inspector**" means an Inspector designated by the Minister under Section 85 (1) of the *Act*;

"**Licensee**" means the holder of this Licence;

"**Modification**" means an alteration to a physical work that introduces new structure or eliminates an existing structure and does not alter the purpose or function of the work, but does not include an expansion, and changes to the operating system that are consistent with the terms of this Licence and do not require amendment;

"Monitoring Program" means a monitoring program established to collect data on surface water and groundwater quality to assess impacts to the freshwater aquatic environment of an appurtenant undertaking;

"Nunavut Land Claims Agreement" (NLCA) means the *"Agreement Between the Inuit of the Nunavut Settlement Area and Her Majesty the Queen in right of Canada"*, including its preamble and schedules, and any amendments to that agreement made pursuant to it;

"Sewage" means all toilet wastes and greywater;

"Sewage Disposal Facilities" comprises the engineered lagoon and decant structures designed to contain and treat sewage as described in the Application for Water Licence filed by the Applicant on May 31, 2006 along with the additional information and final design drawings, signed and stamped submitted July, 2007;

"Solid Waste Disposal Facilities" means the facilities designated for the disposal of solid waste, as described in the Application for Water Licence filed by the Licensee on May 31, 2006 along with the additional information and final design drawings, signed and stamped submitted July, 2007;

"Toilet Wastes" means all human excreta and associated products, but does not include greywater;

"Waste" means, as defined in S.4 of the *Act*, any substance that, by itself or in combination with other substances found in water, would have the effect of altering the quality of any water to which the substance is added to an extent that is detrimental to its use by people or by any animal, fish or plant, or any water that would have that effect because of the quantity or concentration of the substances contained in it or because it has been treated or changed, by heat or other means;

"Water Supply Facilities" comprises the area and associated intake infrastructure at the Kugajuk River, as described in the Application for Water Licence filed by the Licensee on May 31, 2006;

"Wetland Treatment Area" comprises the area of land immediately downstream of the Waste Water Treatment Facility (Sewage Lagoon), to the Final Discharge Point approximately one hundred and sixty meters (160 m) down to the ocean shoreline as described in the Application for Water Licence filed by the Applicant on May 31, 2006.

PART B: GENERAL CONDITIONS

1. The Licensee shall file an Annual Report with the Board not later than March 31st of the year following the calendar year reported which shall contain the following information:

   i. tabular summaries of all data generated under the "Monitoring Program";

   ii. the monthly and annual quantities in cubic metres of fresh water obtained from the Water Supply Facilities;

   iii. the monthly and annual quantities in cubic metres of each and all waste discharged;

   iv. a summary of modifications and/or major maintenance work carried out on the Water Supply and Waste Disposal Facilities, including all associated structures and facilities;

   v. a list of unauthorized discharges and summary of follow-up action taken;

   vi. a summary of any abandonment and restoration work completed during the year and an outline of any work anticipated for the next year;

   vii. Any updates or revisions for manuals and plans (i.e., *Operations and Maintenance, Abandonment and Restoration, QA/QC*) as required by changes in operation and/or technology;

   viii. a summary of any studies or reports requested by the Board that relate to water use and waste disposal or reclamation, and a brief description of any future studies planned;

   ix. any other details on water use or waste disposal requested by the Board by November 1st of the year being reported; and

2. The Licensee shall comply with the "Monitoring Program" described in this Licence, and any amendments to the "Monitoring Program" as may be made from time to time, pursuant to the conditions of this Licence.

3. The "Monitoring Program" and compliance dates specified in the Licence may be modified at the discretion of the Board.

4. Meters, devices or other such methods used for measuring the volumes of water used and waste discharged shall be installed, operated and maintained by the Licensee to the satisfaction of an Inspector.

5. The Licensee shall, within ninety (90) days after the first visit by the Inspector following

issuance of this Licence, post the necessary signs, where possible, to identify the stations of the "Monitoring Program." All signage postings shall be in the Official Languages of Nunavut, and shall be located and maintained to the satisfaction of an Inspector.

6. The Licensee shall immediately report to the 24-Hour Spill Report Line (867-920-8130) any spills of Waste, which are reported to, or observed by the Licensee, within the municipal boundaries or in the areas of the Water Supply or Waste Disposal Facilities.

7. The Licensee shall ensure a copy of this Licence is maintained at the Municipal Office at all times. Any communication with respect to this Licence shall be made in writing to the attention of:

(i) Manager of Licensing:
Nunavut Water Board
P.O. Box 119
Gjoa Haven, NU X0B 1J0
Telephone: (867) 360-6338
Fax: (867) 360-6369
Email: licensing@nunavutwaterboard.org

(ii) Inspector Contact:
Water Resources Officer
Nunavut District, Nunavut Region
P.O. Box 100
Iqaluit, NU X0A 0H0
Telephone: (867) 975-4295
Fax: (867) 979-6445

(iii) Analyst Contact:
Taiga Laboratories
Department of Indian and Northern Affairs
4601 – 52 Avenue, P.O. Box 1500
Yellowknife, NT X1A 2R3
Telephone: (867) 669-2781
Fax: (867) 669-2718

8. The Licensee shall submit one paper copy and one electronic copy of all reports, studies, and plans to the Board. Reports or studies submitted to the Board by the Licensee shall include a detailed executive summary in Inuktitut.

9. The Licensee shall ensure that any document(s) or correspondence submitted by the Licensee to the Board is received and acknowledged by the Manager of Licensing.

10. This Licence is not assignable except as provided in Section 44 of the Act.

PART C: CONDITIONS APPLYING TO WATER USE

1. The Licensee shall obtain all fresh water from the Kugajuk River using the Water Supply Facilities or as otherwise approved by the Board.

2. The annual quantity of water used for all purposes shall not exceed 35,000 cubic metres.

3. The Licensee shall maintain the Water Supply Facilities to the satisfaction of the Inspector.

4. The Licensee shall equip all water intake hoses with a screen of an appropriate mesh size to ensure that fish are not entrained and shall withdraw water at a rate such that fish do not become impinged on the screen.

PART D: CONDITIONS APPLYING TO WASTE DISPOSAL

1. The Licensee shall direct all Sewage to the Sewage Disposal Facilities or as otherwise approved by the Board.

2. The Licensee shall provide notice to an Inspector at least ten (10) days prior to initiating any decant of the Sewage Disposal Facilities.

3. All Effluent discharged from the Sewage Disposal Facilities at Monitoring Program Station PEL-3 shall meet the following effluent quality standards:

Parameter	Maximum Average Concentration
BOD_5	120 mg/L
Total Suspended Solids	180 mg/L
Faecal Coliforms	1×10^4 CFU/100mL
Oil and grease	No visible sheen
pH	between 6 and 9

4. The Licensee shall maintain at all times, a freeboard of at least 1.0 metre, or as recommended by a qualified geotechnical engineer and as approved by the Board, for all dams, dykes or other structures intended to contain, withhold, divert or retain water or wastes.

5. The Sewage Disposal Facility shall be maintained and operated, to the satisfaction of an Inspector in such a manner as to prevent structural failure.

6. The Licensee shall provide to the Board for approval, prior to the commissioning of the Enhanced Wetland Treatment Area as an integral component of the sewage treatment or within ninety (90) days of completion, whichever occurs first, a Wetland Treatment Area assessment that includes, but is not limited to:

   i. Final, as built plans/drawings that have been signed, stamped and sealed by an Engineer, of the Wetland Treatment Area that include but are not limited to a topographical map, cross and longitudinal sections of the treatment area indicating anticipated flow patterns;

   ii. Identify the Final Discharge Point as required to complete monitoring requirements under Part D, Item 9;

   iii. An ecological/vegetative assessment of the area to be used, including a prediction of the time required to achieve the effluent quality as described in the Application for Water Licence renewal filed by the Licensee on May 31, 2006; and

   iv. A Description of the gradient, holding capacity, and verification of the total area utilized which has been predicted as required to attain the proposed effluent quality, describing any discrepancies and the affects it will have on the predictive model outcome along with contingencies.

7. The Licensee shall notify the Board and the Inspector, at least sixty (60) days prior to the commissioning of the Wetland Treatment Area for sewage treatment.

8. Upon commissioning of the Wetland Treatment Area, all effluent discharges from the Wetland Treatment Area at its Final Discharge Point, Monitoring Program Station PEL-4 shall meet the following effluent quality standards:

Parameter	**Maximum Average Concentration**
BOD_5	45 mg/L
Total Suspended Solids	45 mg/L
Faecal Coliforms	(1×10^4 CFU/100ml)
Oil and grease	No visible sheen
pH	between 6 and 9

9. All Effluent discharged from the Wetland Treatment Area Final Discharge Point (PEL-4), shall be demonstrated to be Not Acutely Toxic under the following tests to be conducted once annually approximately mid-way through discharge:

   i. Acute lethality to Rainbow Trout, *Oncorhynchus mykiss* (as per Environment Canada's Environmental Protection Series Biological Test Method EPS/1/RM/13); and

   ii. Acute lethality to the crustacean, *Daphnia magna* (as per Environment Canada's Environmental Protection Series Biological Test Method EPS/1/RM/14).

10. The Licensee shall dispose of and contain all solid wastes at the Solid Waste Disposal Facilities or as otherwise approved by the Board.

11. The Licensee shall segregate and store all hazardous materials and/or hazardous waste within the Solid Waste Disposal Facility in a manner as to prevent the deposit of deleterious substances into any water until such a time as proper disposal arrangements are made.

PART E: CONDITIONS APPLYING TO MODIFICATION AND CONSTRUCTION

1. The Licensee shall submit to the Board for approval, design drawings stamped by a qualified engineer registered in Nunavut, prior to the construction of any dams, dykes or structures intended to contain, withhold, divert or retain water or wastes.

2. The Licensee may, without written approval from the Board, carry out modifications to the Water Supply and Waste Disposal Facilities provided that such modifications are consistent with the terms of this Licence and the following requirements are met:

   i. the Licensee has notified the Board in writing of such proposed modifications at least sixty (60) days prior to beginning the modifications;
   ii. these modifications do not place the Licensee in contravention of the Licence or the Act;
   iii. the Board has not, during the sixty (60) days following notification of the proposed modifications, informed the Licensee that review of the proposal will require more than sixty (60) days; and
   iv. the Board has not rejected the proposed modifications.

3. Modifications for which all of the conditions referred to in Part E, Item 2, have not been met may be carried out only with written approval from the Board. The Licensee shall provide as-built plans and drawings of the Modifications referred to in this Licence within ninety (90) days of completion of the Modification. These plans and drawings shall be stamped by an Engineer.

4. All activities shall be conducted in such a way as to minimize impacts on surface drainage and the Licensee shall immediately undertake any corrective measures in the event of any impacts on surface drainage

5. The Licensee shall ensure that sediment and erosion control measures are implemented prior to and maintained during the operation to prevent the release of sediment and minimize erosion.

6. The Licensee shall designate an area for the deposition of excavated and stockpiled materials that is at least thirty (30) metres above the ordinary high water mark of any water body and in such a manner as to prevent sediment from entering any surrounding water body.

7. All activities shall be conducted in such a way as to minimize impacts on surface drainage and the Licensee shall immediately undertake any corrective measures in the event of any impacts on surface drainage.

8. The Licensee shall ensure that all fill material used in construction and that the ground to be constructed upon, is free of contaminants. If contaminated soils are identified, notification shall be made in the Licensee's annual report. All contaminated soils shall be treated and disposed of as approved by the Board.

9. The Licensee shall provide a Final Construction Report, within ninety (90) days of completion of the construction, outlining any alteration or deviation from the Final Design and Specifications, which will include, but not be limited to, as built plans/drawings that have been signed, stamped and sealed by an Engineer, of the upgrades to the Sewage Disposal Facilities and Solid Waste Disposal Facilities as described in the Application for Water Licence renewal filed by the Licensee on May 31, 2006 and the additional information submitted on July 10, 2007.

PART F: CONDITIONS APPLYING TO OPERATION AND MAINTENANCE

1. The Licensee shall submit to the Board for approval, within ninety (90) days of issuance of the Licence, the following operations and maintenance manuals prepared where appropriate, in accordance with the *"Guidelines for the Preparation of an Operation and Maintenance Manual for Sewage and Solid Waste Disposal Facilities in the Northwest Territories; 1996"*. These Manuals shall take into consideration, at a minimum, the comments received during the application review process and any necessary changes to be consistent with this Licence:

   i *"Water Collection and Distribution Operation and Maintenance (O&M) Manual"*;
   ii *"Sewage Treatment Facility Operation and Maintenance (O&M) Manual"*. This Plan shall also include a Sewage Sludge Management Plan that will specifically address, but not be limited to, characterization of the sludge, identifying the chemical

composition of the sludge and how the sludge will be stored, treated and eventually disposed of ; and

iii "*Solid Waste Disposal Facility Operation and Maintenance (O&M) Manual*". In addition to the guidelines, the Licensee shall include a design, implementation and monitoring schedule for the placement of monitoring wells at the Solid Waste Disposal Facility.

2. The Licensee shall submit to the Board for approval within ninety (90) days of issuance of the Licence, an Environmental Emergency Contingency Plan For Water, Sewage and Solid Waste Operations in the Hamlet of Kugaaruk, Nunavut" for any upsets, breakages or malfunctions that may occur as a result of operating these facilities. This Plan is to take into consideration at a minimum, the comments received during the Application review process and any applicable guidance documents approved by the NWB.

3. If the Manuals or Plans referred to in this Part are not approved, the Licensee shall make the necessary revisions and resubmit the Manual(s) or Plan within thirty (30) days following notification from the Board.

4. The Licensee shall implement the Manuals and Plan specified in this Part as and when approved by the Board.

5. The Licensee shall review the Manuals and Plan referred to in this Part as required by changes in operation and/or technology and modify accordingly. Revisions are to be submitted in the form of an Addendum to be included with the Annual Report, unless directed otherwise by an Inspector

6. An inspection of all engineered facilities related to the management of water and waste shall be carried out annually in July or August by a Geotechnical Engineer. The engineer's report shall be submitted to the Board within sixty (60) days of the inspection, including a covering letter from the Licensee outlining an implementation plan addressing each of the Engineer's recommendations.

7. The Licensee shall perform more frequent inspections of the engineered facilities at the request of an Inspector.

8. If, during the period of this Licence, an unauthorized discharge of waste occurs, or if such a discharge is foreseeable, the Licensee shall:

i. employ the appropriately approved contingency plan for the Hamlet of Kugaaruk;
ii. report the incident immediately via the 24-Hour Spill Reporting Line at (867) 920-8130 and to the Inspector at (867) 975-4295; and
iii. submit to the Inspector, a detailed report on each occurrence, not later than thirty (30) days after initially reporting the event, that provides the necessary information on the

location (including the GPS coordinates), initial response action, remediation/clean-up, status of response (ongoing, complete), propose disposal options for dealing with contaminated materials and preventative measures to be implemented.

PART G: CONDITIONS APPLYING TO ABANDONMENT AND RESTORATION

1. The Licensee shall submit to the Board for approval an *Abandonment and Restoration Plan* at least six (6) months prior to abandoning any facilities or the construction of new facilities to replace existing ones. The Plan shall include, but not be limited to: (where applicable)

   i. water intake facilities;
   ii. the water treatment and waste disposal sites and facilities;
   iii. petroleum and chemical storage areas;
   iv. any site affected by waste spills;
   v. leachate prevention;
   vi. an implementation schedule;
   vii. maps delineating all disturbed areas, and site facilities;
   viii. consideration of altered drainage patterns;
   ix. type and source of cover materials;
   x. future area use;
   xi. hazardous wastes; and
   xii. a proposal identifying measures by which restoration costs will be financed by the Licensee upon abandonment.

2. If the Plan referred to in Part G, Item 1 is not approved, the Licensee shall make the necessary revisions and resubmit the Plan within thirty (30) days following notification from the Board.

3. The Licensee shall implement the plan specified in Part G, Item 1 as and when approved by the Board.

4. The Licensee shall complete the restoration work within the time schedule specified in the Plan, or as subsequently revised and approved by the Board.

PART H: CONDITIONS APPLYING TO THE MONITORING PROGRAM

1. The Licensee shall maintain Monitoring Program Stations at the following locations:

Monitoring Program Station Number	Description	Status
PEL-1	Raw water supply intake at the Kugajuk	Active

	River	(Volume)
PEL-2	Raw Sewage from pump-out truck	Active (Volume)
PEL-3	Discharge from the Sewage Disposal Facilities at the controlled point of release following treatment; including the Temporary Packaged Sewage Treatment Plant operation during construction	Active
PEL-4	Final Discharge Point of the Wetland Treatment Area	New
PEL-5	Ocean water five (5) metres from point where effluent enters ocean	New
PEL-6	Run-off from the Solid Waste Disposal Facility	Active
PEL-7	Monitoring well located up gradient of the Solid Waste Disposal Facilities	New
PEL-8-1	Monitoring well located down gradient of the Solid Waste Disposal Facilities	New
PEL-8-2	Monitoring well located down gradient of the Solid Waste Disposal Facilities	New

2. The Licensee shall sample at Monitoring Program Stations PEL-3, PEL-4 and PEL-5 once at the beginning, middle and near the end of discharge. Samples shall be analyzed for the following parameters:

Biochemical Oxygen Demand - BOD
Total Suspended Solids
Conductivity
Oil and Grease (visual)
Magnesium
Sodium
Chloride
Total Hardness
Ammonia Nitrogen
Total Cadmium
Total Cobalt
Total Chromium
Total Copper
Faecal Coliforms
pH
Nitrate-Nitrite
Total Phenols
Calcium
Potassium
Sulphate
Total Alkalinity
Total Zinc
Total Iron
Total Manganese
Total Nickel
Total Lead

Total Aluminum	Total Arsenic
Total Mercury	Total Organic Carbon (TOC)

3. The Licensee shall sample at Monitoring Program Station PEL-6 annually during periods of runoff or seepage. Samples shall be analyzed for the following parameters:

TPH (Total Petroleum Hydrocarbons)	
PAH (Polycyclic Aromatic Hydrocarbons)	
BTEX (Benzene, Toluene, Ethylbenzene, Xylene)	
BOD	Faecal Coliforms
pH	Conductivity
TotalSuspended Solids	Oil and Grease
Nitrate-Nitrite	Ammonia Nitrogen
Total Phenols	Total Alkalinity
Total Hardness	Calcium
Magnesium	Potassium
Sodium	Sulphate
Total Arsenic	Total Cadmium
Total Copper	Total Chromium
Total Iron	Total Lead
Total Mercury	Total Nickel

4. The Licensee shall install groundwater monitoring wells at the Solid Waste Disposal Facilities in accordance with the proposal set out in the Solid Waste Disposal Facility's Operation and Maintenance Plan, as approved by the Board. At a minimum, these wells shall be located with at least one upstream of the facility for background data collection and at least two downstream of the landfill.

5. Upon installation of any monitoring wells, the Licensee shall sample at Monitoring Program Stations PEL-7, PEL-8-1 and PEL-8-2, and any other locations as determined by the SWDF O&M Plan, giving due consideration to adequate ground thaw and obtaining a representative groundwater sample. Samples shall be analyzed for the following parameters:

BOD	Faecal Coliforms
pH	Conductivity
Total	Suspended Solids Ammonia
Nitrogen	
Nitrate-Nitrite	Oil and Grease
Total Phenols	Total Alkalinity
Total Hardness	Calcium
Magnesium	Potassium

Sodium	Sulphate
Total Arsenic	Total Cadmium
Total Copper	Total Chromium
Total Iron	Total Lead
Total Mercury	Total Nickel

TPH (Total Petroleum Hydrocarbons)
PAH (Polycyclic Aromatic Hydrocarbons)
BTEX (Benzene, Toluene, Ethylbenzene, Xylene)

6. The Licensee shall report all results of acute toxicity testing as required under Part D, Item 9 within the Annual Report as per Part B, Item 1.

7. The Licensee shall measure and record in cubic metres, the monthly and annual quantities of water pumped at Monitoring Program Station PEL-1, for all purposes.

8. The Licensee shall measure and record in cubic metres the monthly and annual quantities of raw sewage offloaded from trucks at Monitoring Program Station PEL-2 for all purposes.

9. Additional monitoring stations, sampling and analysis may be requested by an Inspector.

10. The Licensee shall submit to the Board, for approval within ninety (90) days of issuance of the Licence, a "*Quality Assurance/Quality Control (QA/QC) Plan for the Hamlet Sewage Lagoon and Solid Waste Disposal Facility Monitoring Program*" prepared in accordance with the INAC *"Quality Assurance (QA) and Quality Control (QC) Guidelines for use by Class "B" Licensees in Collecting Representative Water Samples in the Field, 1996"*.

11. The Plan shall to take into consideration comments received during the Application review process.

12. If the Plan referred to in Part H, Item 10 is not approved, the Licensee shall make the necessary revisions and resubmit the Plan within thirty (30) days following notification from the Board.

13. The Licensee shall implement the Plan referred to in Part H, Item 10 as and when approved by the Board.

14. All sampling, sample preservation and analyses shall be conducted in accordance with methods prescribed in the current edition of *Standard Methods for the Examination of Water and Wastewater*, or by such other methods approved by the Board.

15. All analyses shall be performed in a Canadian Association of Environmental Analytical Laboratories (CAEAL) Certified Laboratory, or as otherwise approved by an Analyst.

16. The Licensee shall measure and record the annual quantities of sewage solids removed from the Sewage Disposal Facility.

17. The Licensee shall include all of the data and information required by the "Monitoring Program" in the Licensee's Annual Report, as required *per* Part B, Item 1, or as requested by an Inspector.

Appendix B – Drawings

Drawings Titled "Sewage & Solid Waste Sites – Record Drawings, Kugaaruk, NU" dated December, 2009, submitted to the Government of Nunavut by DCL.

THE GOVERNMENT OF NUNAVUT
COMMUNITY AND GOVERNMENT SERVICES

SEWAGE & SOLID WASTE SITES - RECORD DRAWINGS
LOCATION: KUGAARUK, NUNAVUT
PROJECT NO: 05-4755-3000
DATE: DECEMBER 2009

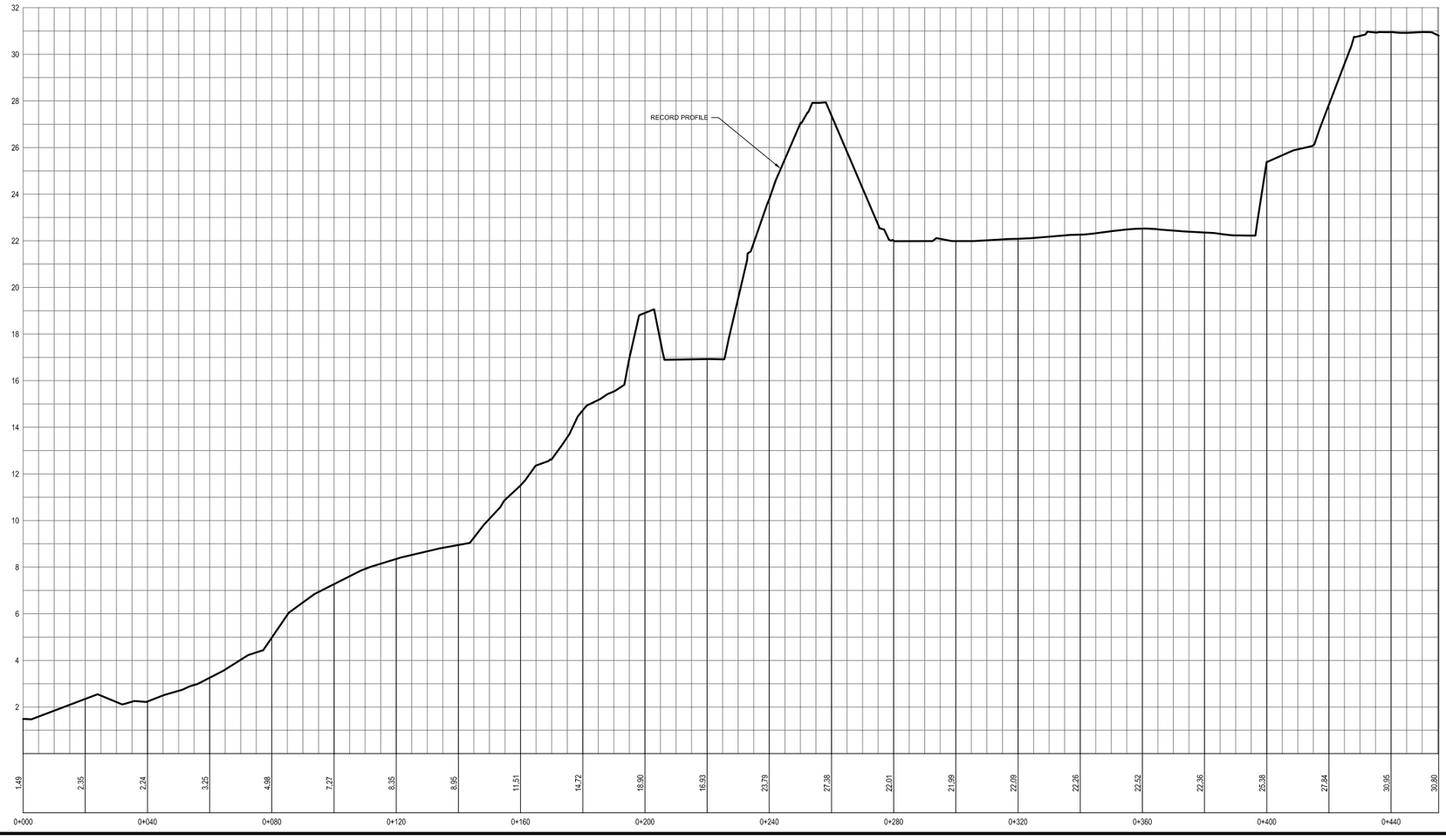
LOCATION PLAN

LIST OF DRAWINGS	
Sheet Number	Sheet Title
000	Cover
100	Lagoon Site
101	Design Lagoon Site Plan View
102	Lagoon Sections
103	Wetland Sections
200	Discharge and Overflow Flume and Landfill Fence Details
201	Berm Sections and Details
202	Manhole Details

DILLON CONSULTING

EDIT DATE: 10.12.2009 PLOT DATE: 41tpw 11.12.2009 ACAD FILE: 41tpw g:\cad\054755\record\cover.dwg

DRAWING NUMBER 000



EDIT DATE: 11.12.2009 PLOT DATE: 41tpw 11.12.2009 ACAD File:tpw g:\cad\05475\record\pond.dwg

LEGEND

PLAN:

DESIGN:
MINOR CONTOUR (0.2m)
MAJOR CONTOUR (1.0m)

BERM WALLS
BERM TOP
TOE OF SLOPE
LAGOON CONTAINMENT
DRAINAGE DIRECTION

NOTES

DIMENSIONS ARE IN MILLIMETERS UNLESS SPECIFIED OTHERWISE

1 (100|101) — DETAIL NUMBER; DRAWING SHEET WHERE DETAIL IS SHOWN; DETAIL REFERENCED (THIS DRAWING SHEET)

RECORD DRAWING

APPROVED BY — DATE 07/09

DRAWING REDUCED NOT TO SCALE

CHANGE	DATE	DESCRIPTION	CHECK
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5	07/10/07	REVISED FOR NWB APLLICATION	GS
4	01/31/07	REVISED FOR NWB COMMENTS	GS
3	05/05/06	ISSUED FOR TENDER	GS
2	08/29/05	ISSUED FOR 95% REVIEW	GS

REVISIONS

DESIGN	DRAWN	CHECKED	DATE
GS	TPW	GS	JAN 2009

THE ASSOCIATION OF PROFESSIONAL ENGINEERS, GEOLOGISTS and GEOPHYSICISTS OF THE NORTHWEST TERRITORIES
PERMIT NUMBER P 010
DILLON CONSULTING LIMITED

REGISTERED PROFESSIONAL ENGINEER — G. STRONG — NWT.

Nunavut

PROJECT
SEWAGE & SOLID WASTE FACILITY
KUGAARUK, NUNAVUT

TITLE
LAGOON SITE

DILLON CONSULTING

SCALE 1:500
DILLON PROJECT NUMBER 05-4755-3000
CLIENT PROJECT NUMBER NA
DRAWING NUMBER 100

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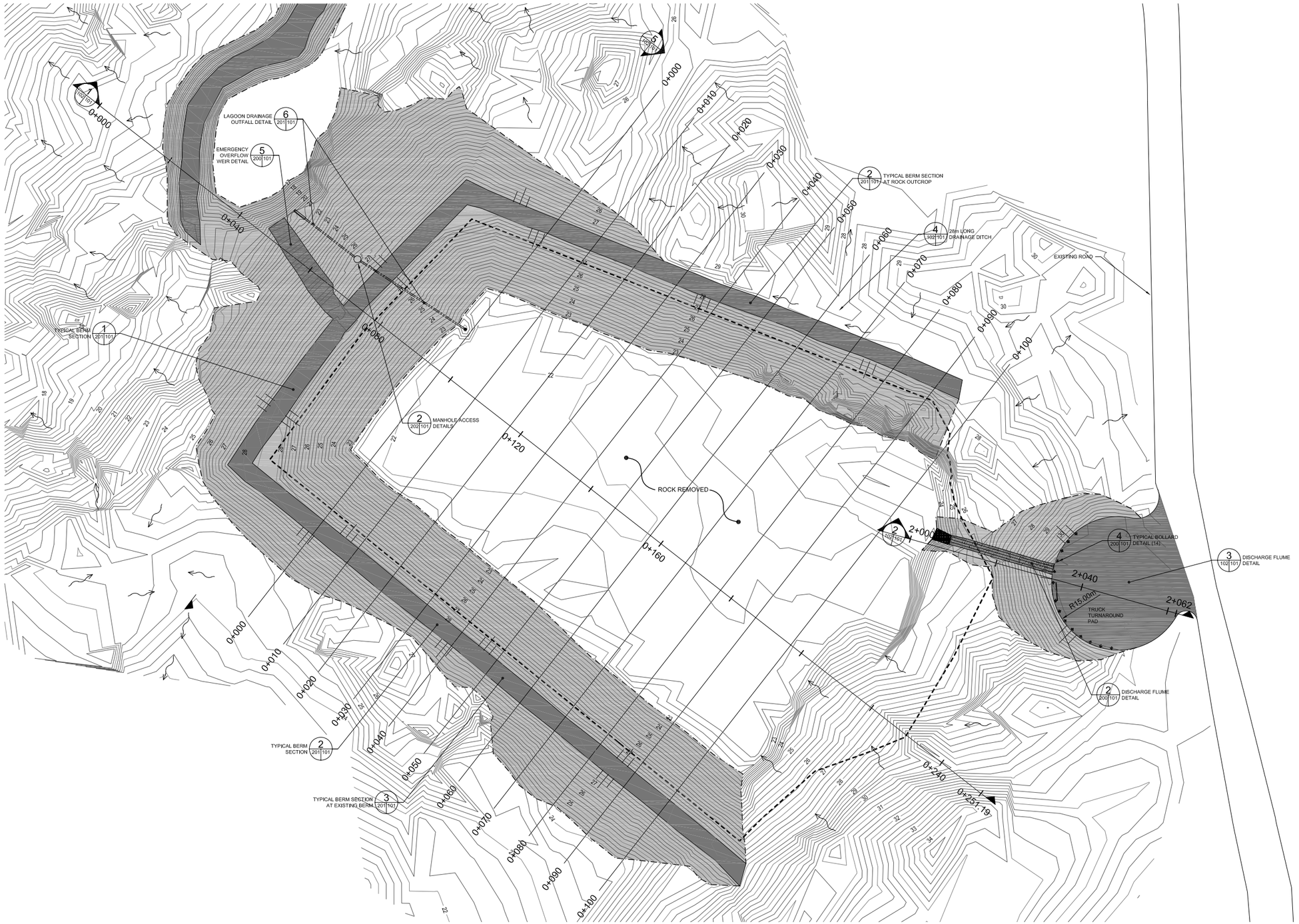

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SCALE 1:500

LEGEND

PLAN:

DESIGN:
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MAJOR CONTOUR (1.0m)

BERM WALLS
BERM TOP
TOE OF SLOPE
LAGOON CONTAINMENT
DRAINAGE DIRECTION

NOTES

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1 100 101 — DETAIL NUMBER; DRAWING SHEET WHERE DETAIL IS SHOWN; DETAIL REFERENCED (THIS DRAWING SHEET)

RECORD DRAWING

APPROVED BY — DATE 07/09

DRAWING REDUCED NOT TO SCALE

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4	01/31/07	REVISED FOR NWB COMMENTS	GS
3	05/05/06	ISSUED FOR TENDER	GS
2	08/29/05	ISSUED FOR 95% REVIEW	GS
CHANGE	DATE	DESCRIPTION	CHECK

REVISIONS

DESIGN	DRAWN	CHECKED	DATE
GS	TPW	GS	JAN 2009

THE ASSOCIATION OF PROFESSIONAL ENGINEERS, GEOLOGISTS AND GEOPHYSICISTS OF THE NORTHWEST TERRITORIES
PERMIT NUMBER P 010
DILLON CONSULTING LIMITED

REGISTERED PROFESSIONAL ENGINEER — G. STRONG — NWT

Nunavut

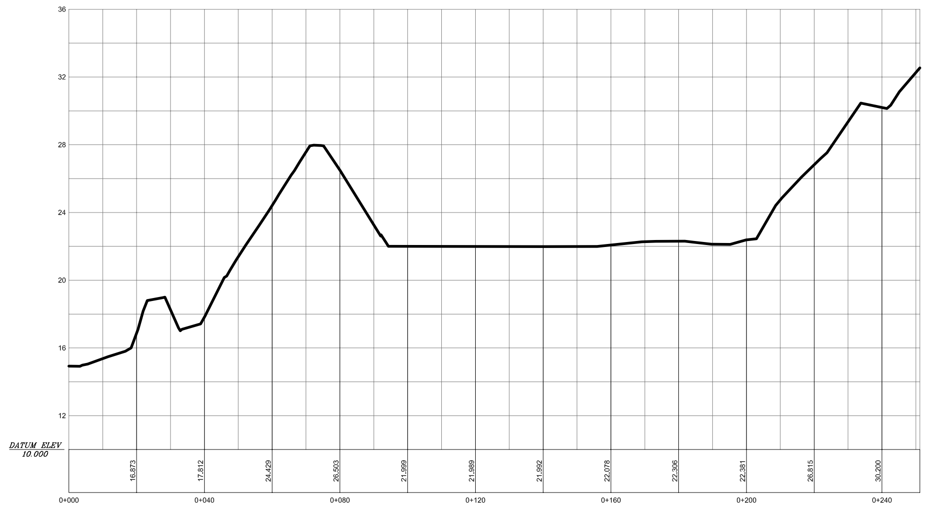
PROJECT
SEWAGE & SOLID WASTE FACILITY
KUGAARUK, NUNAVUT

TITLE
DESIGN LAGOON SITE PLAN VIEW

DILLON CONSULTING

SCALE	1:500
DILLON PROJECT NUMBER	05-4755-3000
CLIENT PROJECT NUMBER	NA
DRAWING NUMBER	101

EDIT DATE: 11.12.2009 PLOT DATE: 41tpw 11.12.2009 ACAD File: tpw c:\cad\05-4755\recordpond.dwg



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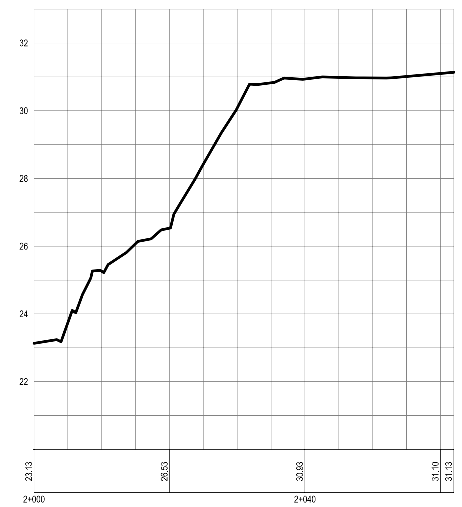

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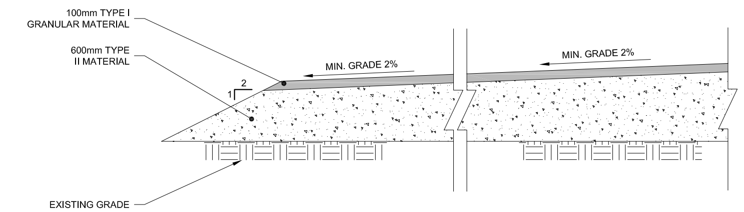

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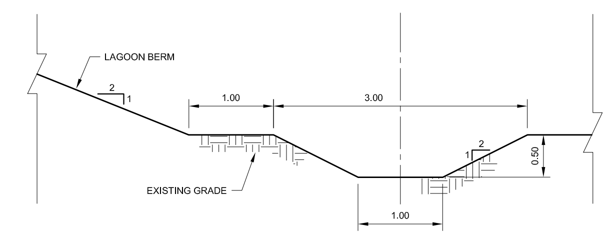

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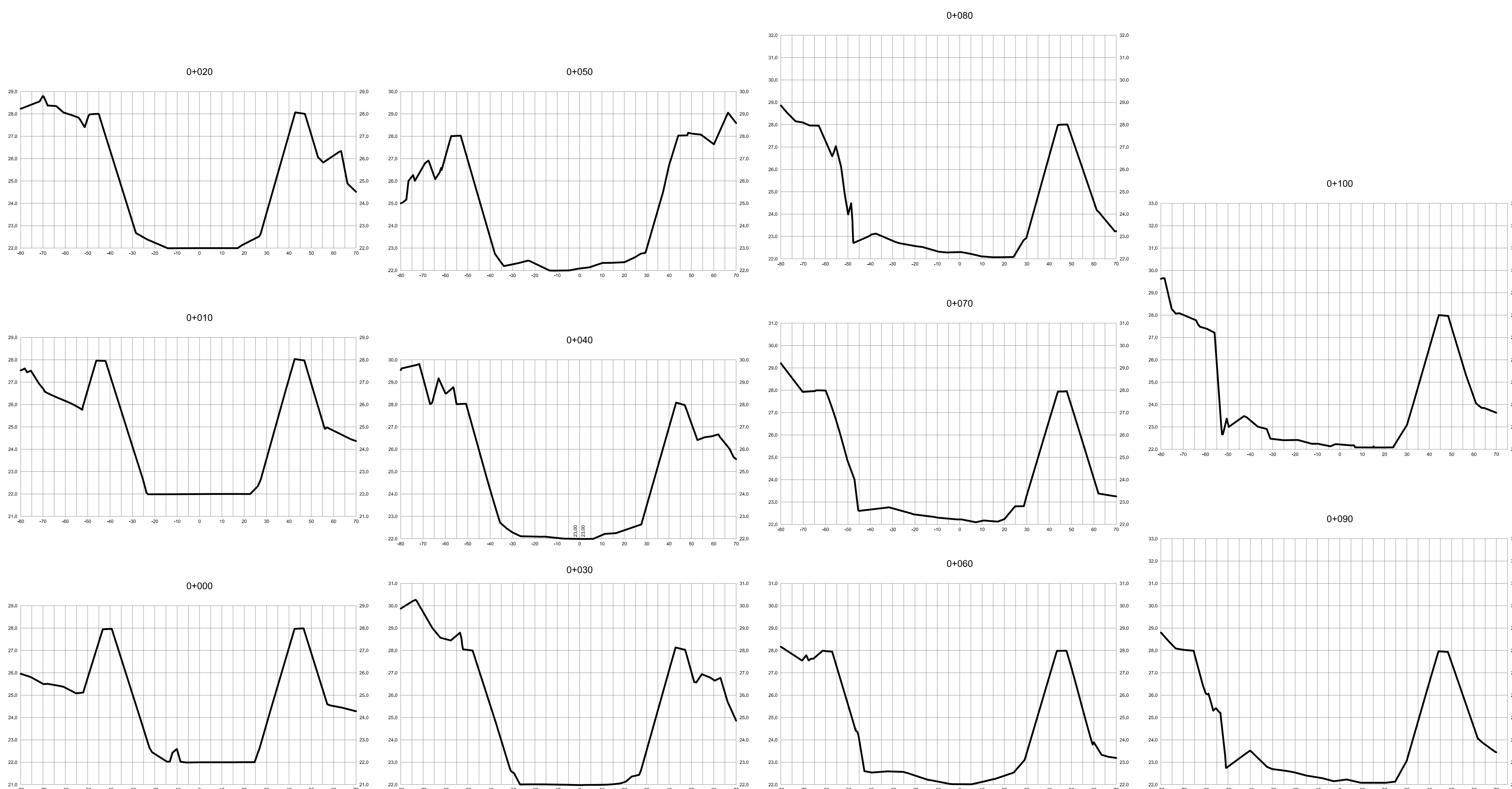

5 LAGOON CROSS SECTIONS
101 102 SCALE 1:1000hor 1:100ver

NOTE:

SEE DWG. 201 SECTION 1 AND SECTION 2 FOR BERM CONSTRUCTION DETAILS.

RECORD PROFILE:

RECORD DRAWING

APPROVED BY — DATE Jan 07/09

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4	01/31/07	REVISED FOR NWB COMMENTS	GS
3	05/05/06	ISSUED FOR TENDER	GS
2	08/29/05	ISSUED FOR 95% REVIEW	GS

REVISIONS

DESIGN	DRAWN	CHECKED	DATE
GS	TPW	GS	JAN 2009

THE ASSOCIATION OF PROFESSIONAL ENGINEERS, GEOLOGISTS and GEOPHYSICISTS OF THE NORTHWEST TERRITORIES
PERMIT NUMBER
P 010
DILLON CONSULTING LIMITED

REGISTERED PROFESSIONAL ENGINEER
G. STRONG
N.W.T.

Nunavut

PROJECT

SEWAGE & SOLID WASTE FACILITY
KUGAARUK, NUNAVUT

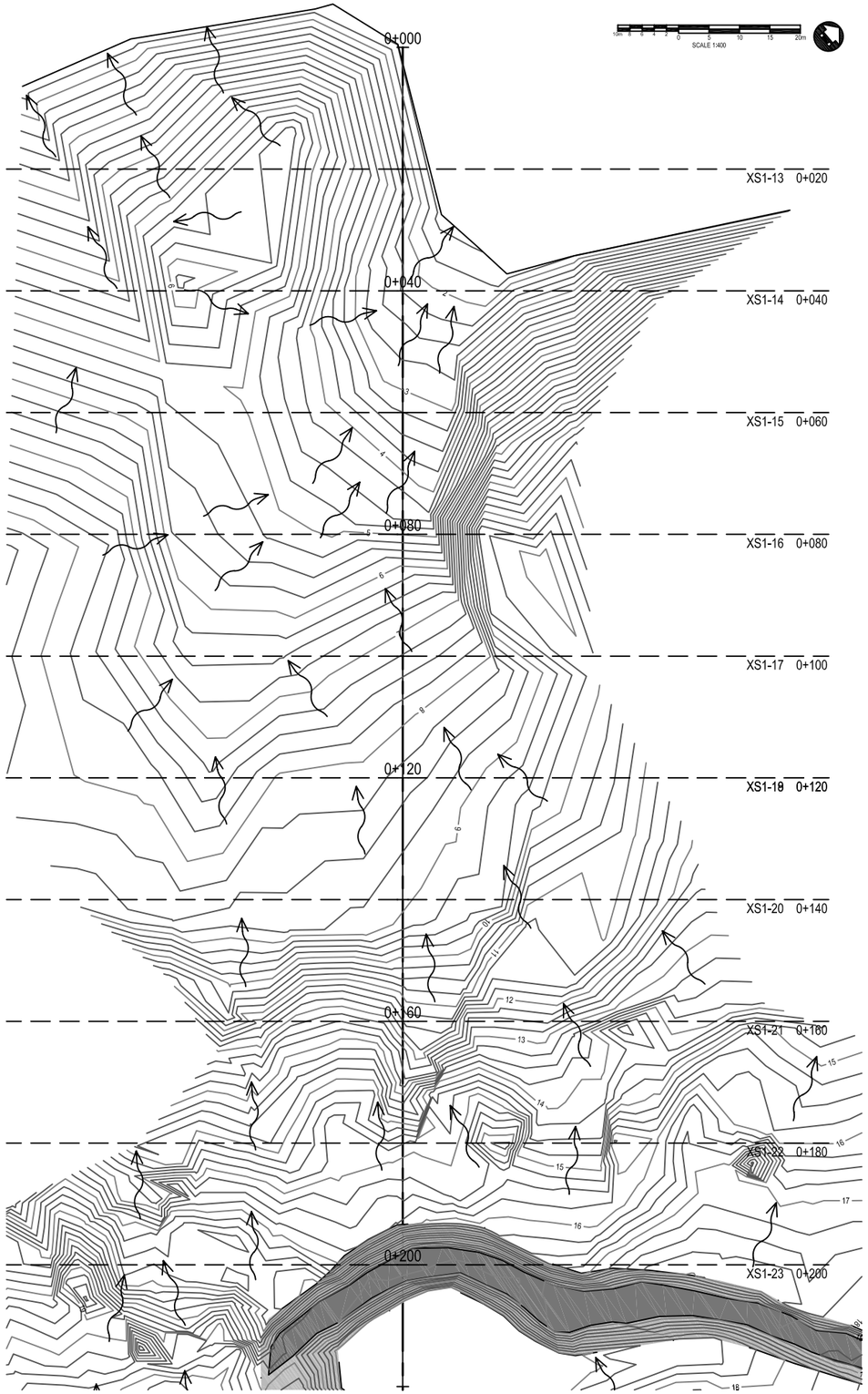
TITLE

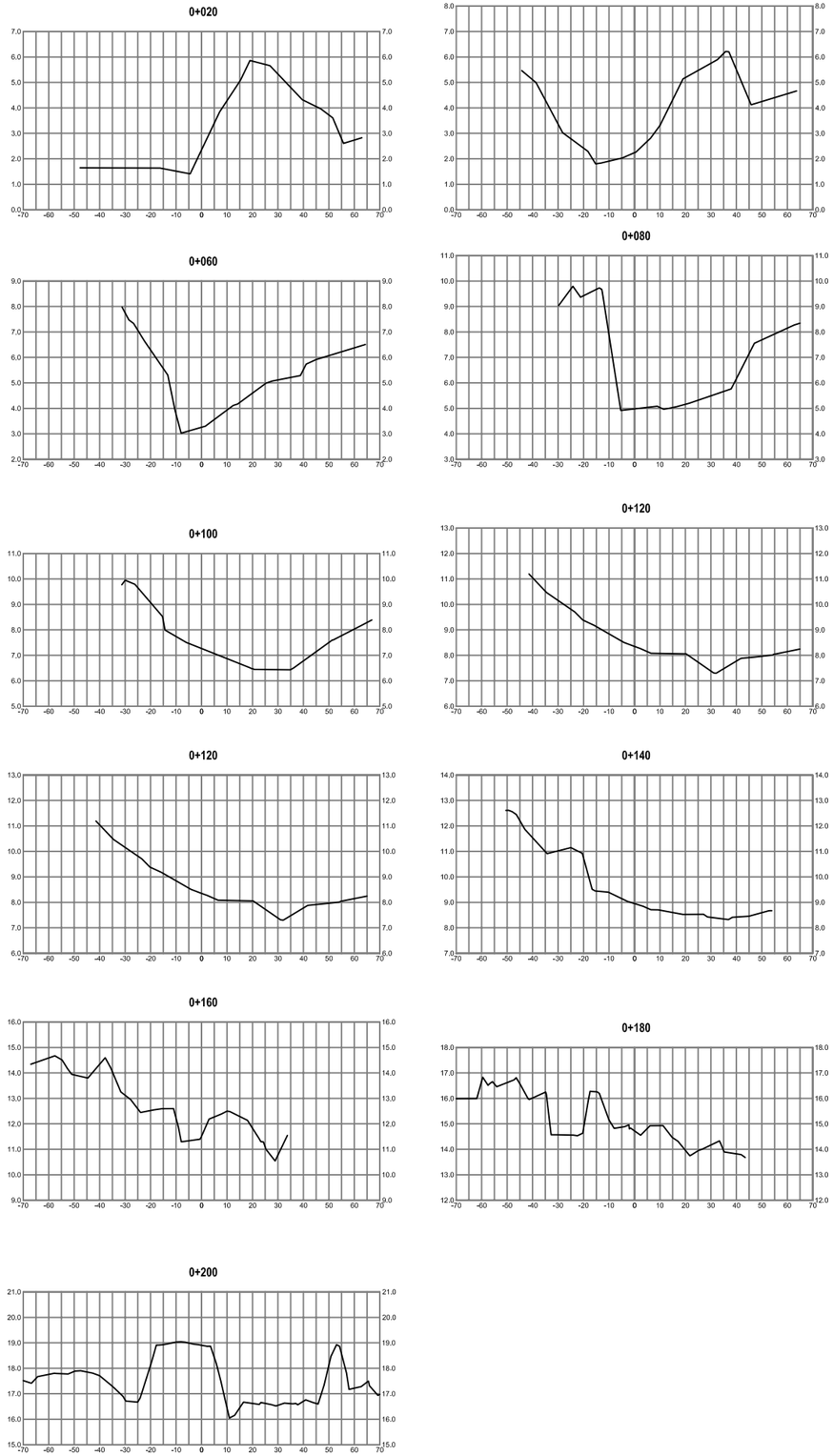
LAGOON SECTIONS

DILLON CONSULTING

SCALE	AS SHOWN
DILLON PROJECT NUMBER	05-4755-3000
CLIENT PROJECT NUMBER	NA
DRAWING NUMBER	102

EDIT DATE: 11.12.2009 PLOT DATE: 41tpw 11.12.2009 ACAD FILE: g:\cad\054755\record\pond.dwg





LEGEND

PLAN:

DESIGN:
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MAJOR CONTOUR (1,0m)

BERM WALLS
BERM TOP
TOE OF SLOPE
LAGOON CONTAINMENT
DRAINAGE DIRECTION

NOTES

DIMENSIONS ARE IN MILLIMETERS UNLESS SPECIFIED OTHERWISE

1 / 101 — DETAIL NUMBER; DRAWING SHEET WHERE DETAIL IS SHOWN; DETAIL REFERENCED (THIS DRAWING SHEET)

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APPROVED BY — DATE 07/09

DRAWING REDUCED NOT TO SCALE

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REVISIONS

DESIGN	DRAWN	CHECKED	DATE
GS	TPW	GS	JAN 2009

THE ASSOCIATION OF PROFESSIONAL ENGINEERS, GEOLOGISTS and GEOPHYSICISTS OF THE NORTHWEST TERRITORIES
PERMIT NUMBER P 010
DILLON CONSULTING LIMITED

REGISTERED PROFESSIONAL ENGINEER — G. STRONG — NWT

Nunavut

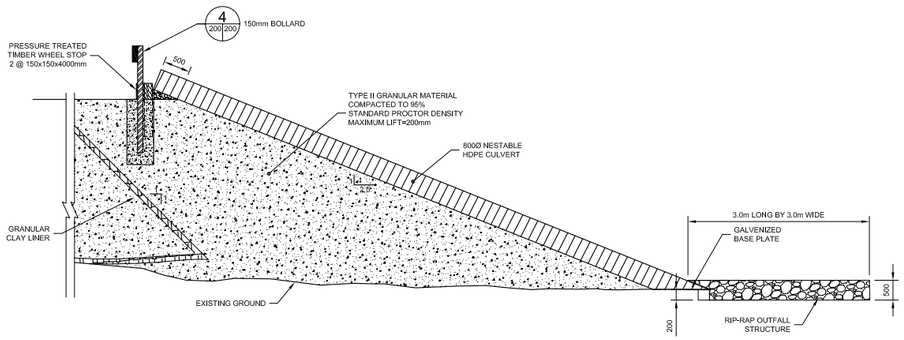
PROJECT
SEWAGE & SOLID WASTE FACILITY
KUGAARUK, NUNAVUT

TITLE
WETLAND SECTIONS

DILLON CONSULTING

SCALE	1:500
DILLON PROJECT NUMBER	05-4755-3000
CLIENT PROJECT NUMBER	NA
DRAWING NUMBER	103

EDIT DATE: 11.12.2009 PLOT DATE: 41pw 11.12.2009 ACAD File: G:\cad\05\4755\record\pond c3d sections.dwg



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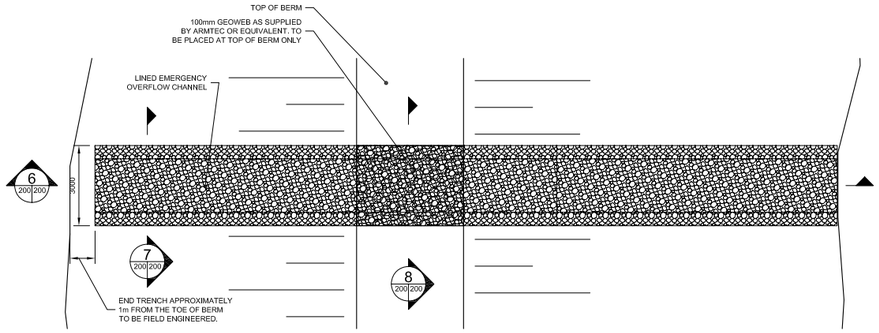

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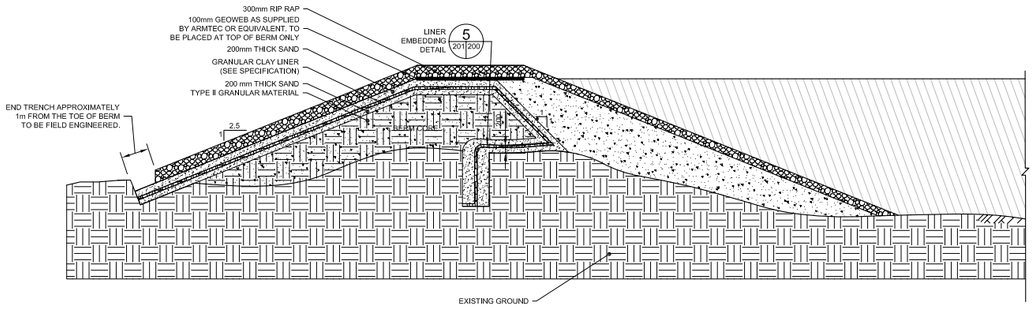

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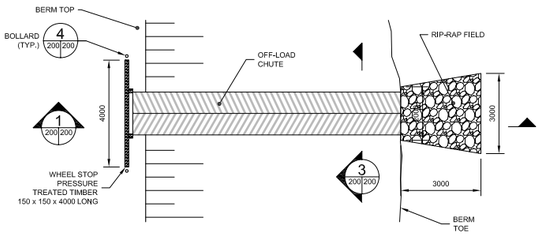

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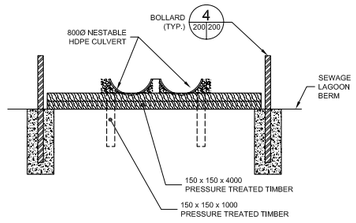

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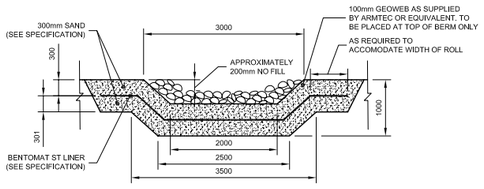

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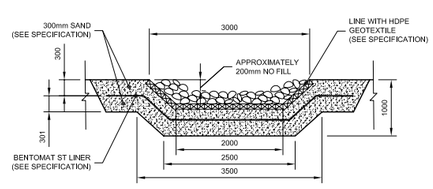

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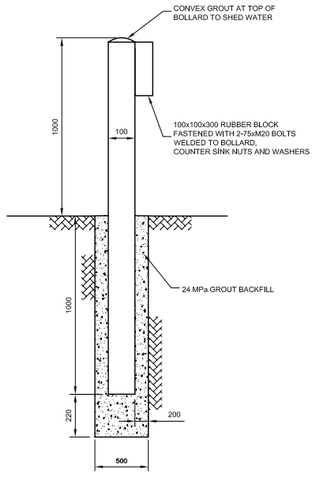

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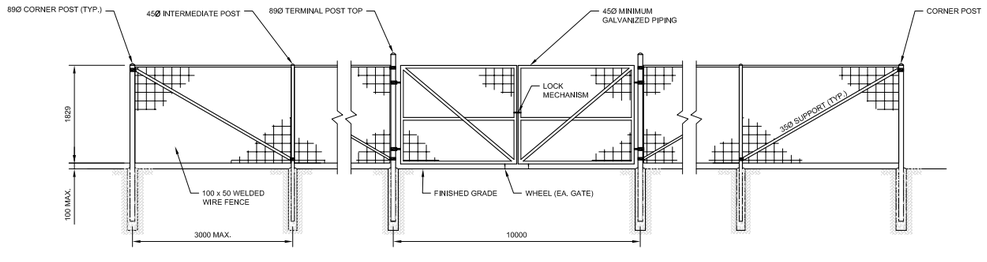

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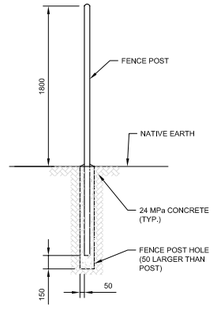

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1 100 101 — DETAIL NUMBER; DRAWING SHEET WHERE DETAIL IS SHOWN; DETAIL REFERENCED (THIS DRAWING SHEET)

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2	08/29/05	ISSUED FOR 95% REVIEW	GS

REVISIONS

DESIGN	DRAWN	CHECKED	DATE
GS	41TPW	GS	JAN 2009

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PERMIT NUMBER P 010
DILLON CONSULTING LIMITED

REGISTERED PROFESSIONAL ENGINEER G. STRONG 07169 NWT.

Nunavut

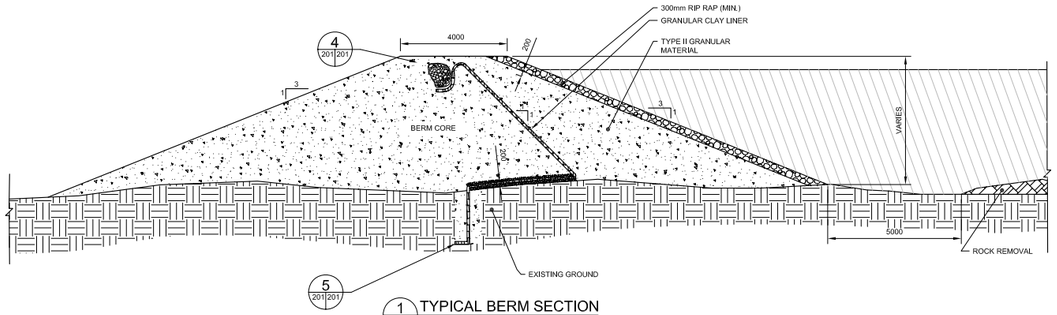
PROJECT
SEWAGE & SOLID WASTE FACILITY
KUGAARUK, NUNAVUT

TITLE
DISCHARGE AND OVERFLOW FLUME AND LANDFILL FENCE DETAILS

DILLON CONSULTING

SCALE	AS SHOWN
DILLON PROJECT NUMBER	05-4755-3000
CLIENT PROJECT NUMBER	NA
DRAWING NUMBER	200

EDIT DATE: 11.12.2009 PLOT DATE: 11.12.2009 ACAD FILE:41tpw g:\cad\05475\recorddetails.dwg



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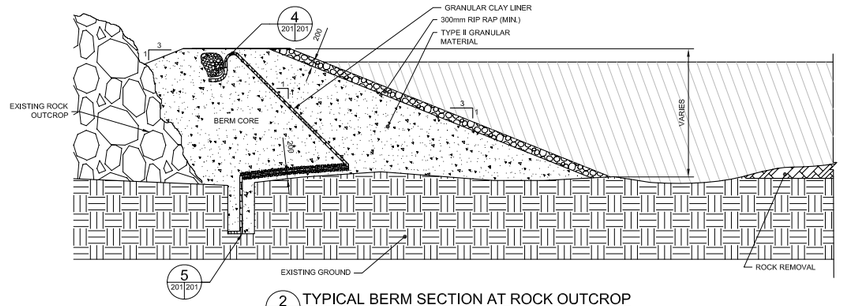

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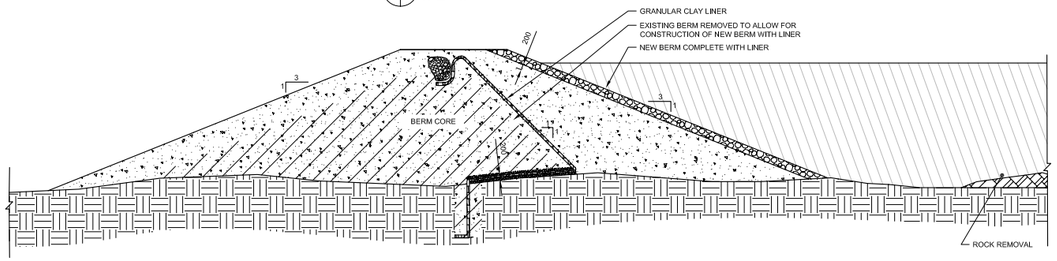

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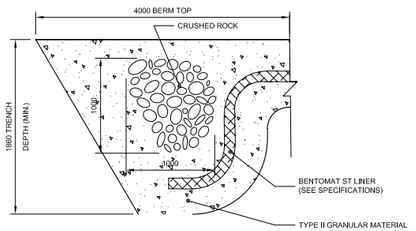

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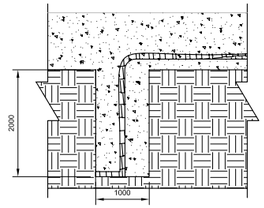

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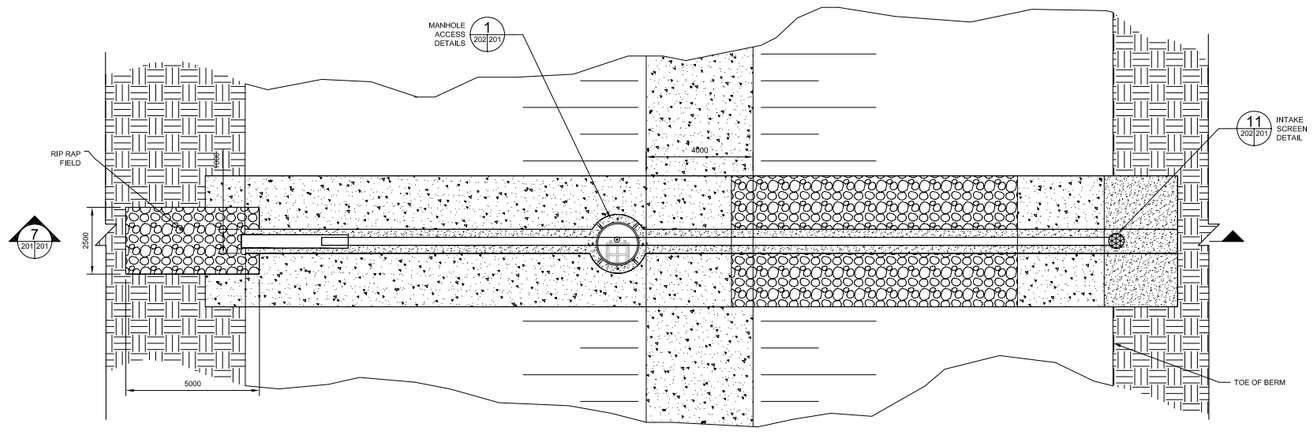

6 101 201 LAGOON DRAINAGE OUTFALL PLAN
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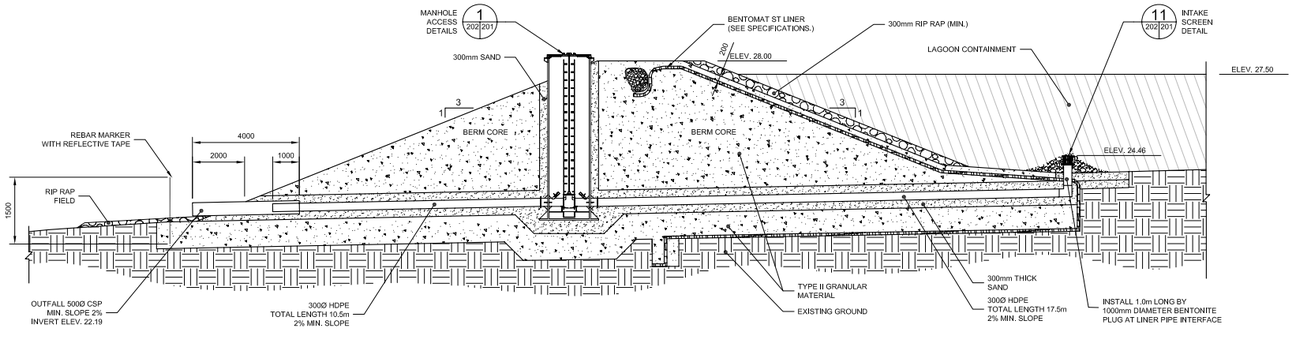

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EDIT DATE: 11.12.2009 PLOT DATE: wotherspoon, trevor 11:12 FILE: g:\cad\05475\record\details.dwg

NOTES

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RECORD DRAWING

APPROVED BY: GS DATE: Jan 07/09

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REVISIONS

DESIGN	DRAWN	CHECKED	DATE
GS	41TPW	GS	JAN 2009

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PERMIT NUMBER P 010
DILLON CONSULTING LIMITED

REGISTERED PROFESSIONAL ENGINEER — G. STRONG — NWT.

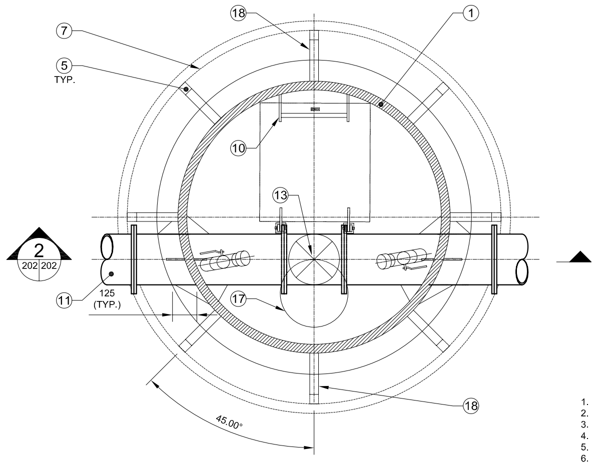
Nunavut

PROJECT
SEWAGE & SOLID WASTE FACILITY
SEWAGE & SOLID WASTE

TITLE
BERM SECTIONS AND DETAILS

DILLON CONSULTING

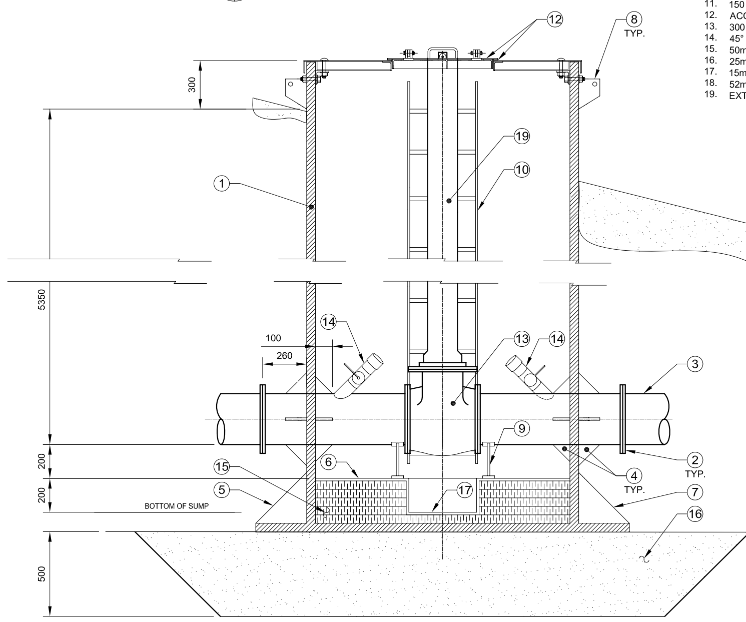
SCALE: AS SHOWN
DILLON PROJECT NUMBER: 05-4755-3000
CLIENT PROJECT NUMBER: NA
DRAWING NUMBER: 201



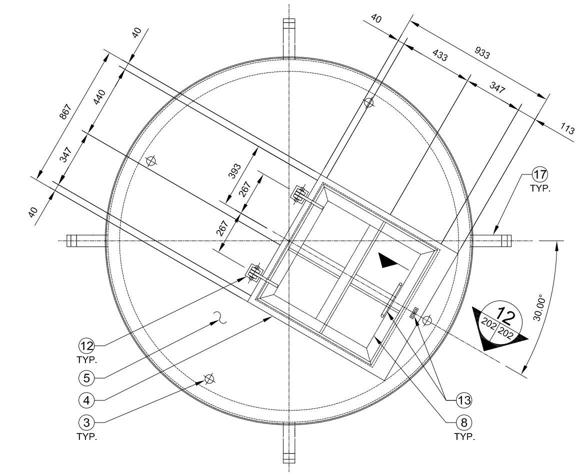
1 WATER SUPPLY LINE MANHOLE PLAN
201 202 SCALE 1:20

KEYNOTES:

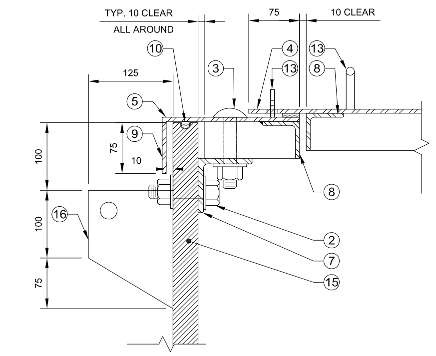
1. 1600mm DIA. HDPE PIPE DR 32.5
2. FLANGE TO FLANGE CONNECTION
3. 300 DIA. HDPE DR 17 PIPE FLANGED TO MANHOLE
4. 15mm HDPE STIFFENER (TYP. OF 4)
5. 52mm HDPE STIFFENER (TYP. OF 6)
6. 15mm HDPE FLOOR (SLOPE FLOOR TO SUMP), WELD TO MANHOLE
7. 52mm HDPE BASE, WELD TO MANHOLE
8. 52mm HDPE LIFTING HOOK (TYP. OF 4)
9. HUNT PIPE SUPPORT
10. BUILT UP HDPE LADDER 400mm WIDE C/W RUNGS @ 300 O.C. FIX TO HDPE MANHOLE
11. 150 DIA. HDPE DR 17 PIPE WELD TO MANHOLE
12. ACCESS VAULT LID C/W ACCESS HATCH
13. 300 DIA RESILENT SEAT GATE VALVE
14. 45° - 75mm DIA. HDPE ACCESS PORT C/W 75mm BALL VALVE AND CAP. INSTALL @ 10° SKEW FROM C
15. 50mm THK. BUILT UP BOARD INSULATION
16. 25mm MINUS GRANULAR BASE COURSE @ 97% S.P.D.
17. 15mm HDPE x 400mm DIA. SUMP
18. 52mm HDPE STIFFENER AND SEEPAGE CUT OFF 300mm X 1000mm HIGH (TYP. OF 6)
19. EXTENSION SPINDLE



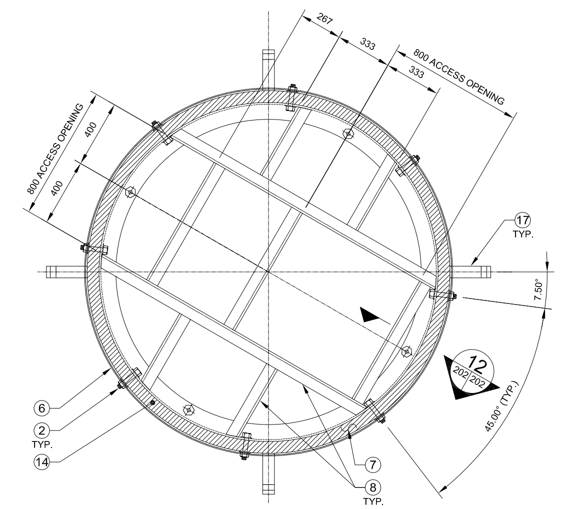
2 WATER SUPPLY LINE MANHOLE SECTION
202 202 SCALE 1:20



7 MANHOLE ACCESS HATCH FRAMING DETAIL
202 202 SCALE 1:20



12 MANHOLE ACCESS SECTION
202 202 SCALE 1:5



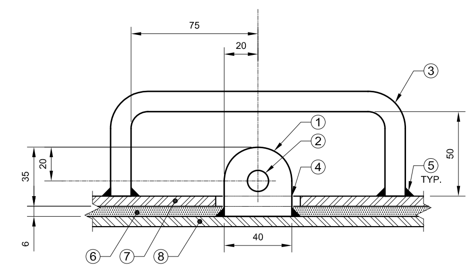
8 MANHOLE LID FRAMING DETAIL
202 202 SCALE 1:20

NOTES:

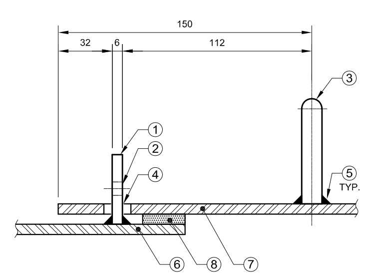
1. FOR ACCESS MANHOLE LID FRAMING PLANS 6mm THK. GALV. STEEL PLATE LID NOT SHOWN FOR CLARITY.
2. ALL WELDS AND ABRASIONS TO BE REPAIRED WITH TWO COATES OF GALVCON.

KEYNOTES:

1. 1220mm DIA. HDPE DR 32.5 MANHOLE WALL
2. 19mm DIA. GALV. NUT, BOLT & WASHER (8 REQ'D) SEE ACCESS MANHOLE LID FRAMING PLAN FOR ARRANGEMENT
3. 19mm DIA. GALV. NUT, CARRIAGE BOLT & WASHER (4 REQ'D) SEE ACCESS HATCH FRAMING PLAN FOR ARRANGEMENT
4. 6mm THK. GALV. STEEL PLATE ACCESS HATCH COVER
5. 6mm THK. GALV. STEEL PLATE MANHOLE LID
6. 6mm THK. x 75mm DEEP GALV. STEEL BAND, WELD TO LID
7. 75x75x8 GALV. ROLLED ANGLE CONTINUOUS ALL AROUND AND BOLTED TO HDPE MANHOLE
8. 55x55x6 GALV. ANGLE SEE LID FRAMING **DETAIL 4**
9. 55x55x6 GALV. ANGLE SEE ACCESS HATCH FRAMING **DETAIL 3**
10. 12.5mm DIA. RUBBER GASKET IN ROUTERED SLOT CONTINUOUS ALL AROUND WEATHER TIGHT
11. 25mm WIDE x 6mm THK. RUBBER GASKET, MASTIC TO UNDERSIDE OF HATCH COVER (TYP. 4 SIDES)
12. ACCESS HATCH COVER HINGE (TYP. OF 2/PER) SEE **DETAIL 8** THIS DWG.
13. ACCESS HATCH COVER HASP & LIFTING HANDLE SEE **DETAIL 6** THIS DWG.
14. 1600mm DIA. HDPE DR 32.5 MANHOLE WALL
15. HDPE MANHOLE WALL
16. HDPE LIFTING HOOK SEE FRAMING DETAIL FOR ARRANGEMENT
17. 52mm HDPE LIFTING HOOK C/W 25mm DIA. HOLE (4 REQ'D)



3 HASP AND LIFTING HANDLE DETAIL
202 202 SCALE 1:2



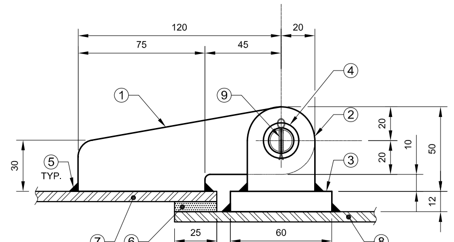
4 HASP AND LIFTING HANDLE SECTION
202 202 SCALE 1:2

NOTES:

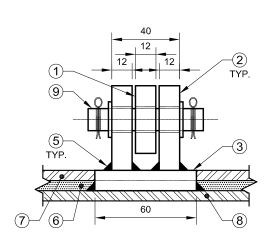
1. ACCESS MANHOLE LID & HATCH ANGLE FRAMING ARE NOT SHOWN FOR CLARITY. FOR DETAIL REFER TO FRAMING PLAN AS PER DETAIL
2. ALL WELDS AND ABRASIONS TO BE REPAIRED WITH TWO COATES OF GALVCON.

KEYNOTES:

1. 6mm THK. GALV. STEEL STAPLE
2. 12.5mm DIA. DRILLED HOLE FOR PADLOCK
3. 12.5mm DIA. GAVL. STEEL BAR LIFTING HANDLE
4. 50mmx15mm SLOT HOLE
5. 6mm FILLET WELD ALL AROUND (TYP.)
6. 25mm WIDE x 6mm THK. RUBBER GASKET MASTIC TO UNDERSIDE OF HATCH COVER (TYPICAL 4 SIDES)
7. 6mm THK. GALV. STEEL PLATE ACCESS HATCH COVER
8. 6mm THK. GALV. STEEL PLATE MANHOLE LID



5 MANHOLE ACCESS HATCH HINGE DETAIL
202 202 SCALE 1:2



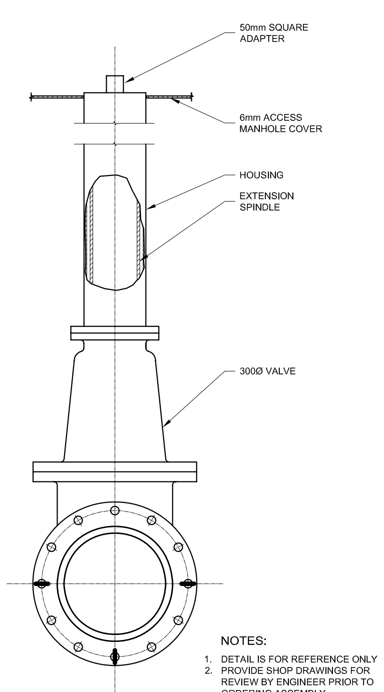
6 MANHOLE ACCESS HATCH HINGE SECTION
202 202 SCALE 1:2

NOTES:

1. ACCESS MANHOLE LID & HATCH ANGLE FRAMING ARE NOT SHOWN FOR CLARITY. FOR DETAIL REFER TO FRAMING PLAN AS PER DETAIL.
2. ALL WELDS AND ABRASIONS TO BE REPAIRED WITH TWO COATES OF GALVCON.

KEYNOTES:

1. 12mm THK. GALV. STEEL HINGE ARM C/W HOLE FOR 13mm DIA. PIN
2. 12mm THK. GALV. STEEL HINGE ARM SUPPORT C/W HOLE FOR 13mm DIA. PIN (TYPICAL OF 2)
3. 60mm x 60mm x 12mm THK. GALV. STEEL BASE PLATE
4. GAVL. STEEL WASHER (TYP.)
5. 6mm FILLET WELD ALL AROUND
6. 25mm WIDE x 6mm THK. RUBBER GASKET MASTIC TO UNDERSIDE OF HATCH COVER (TYPICAL 4 SIDES)
7. 6mm THK. GALV. STEEL PLATE ACCESS HATCH COVER
8. 6mm THK. GALV. STEEL PLATE MANHOLE LID
9. 13mm DIA. GALV. STEEL PIN C/W 2 COTTER PIN



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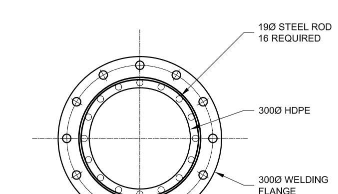
1. DETAIL IS FOR REFERENCE ONLY
2. PROVIDE SHOP DRAWINGS FOR REVIEW BY ENGINEER PRIOR TO ORDERING ASSEMBLY

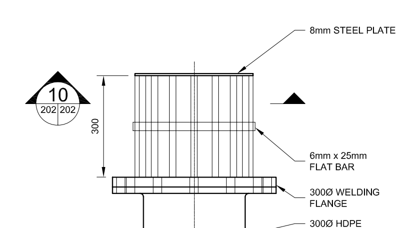
9 EXTENSION SPINDLE DETAIL
202 202 SCALE 1:10



NOTES:

1. ALL ITEMS TO BE GALVENIZED

10 INTAKE SCREEN SECTION
202 202 SCALE 1:10



NOTES:

1. ALL ITEMS TO BE GALVENIZED

11 INTAKE SCREEN DETAIL
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DETAIL NUMBER
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APPROVED BY — DATE: Jan 07/09

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GS	41TPW	GS	JAN 2009

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PERMIT NUMBER P 010
DILLON CONSULTING LIMITED

REGISTERED PROFESSIONAL ENGINEER — G. STRONG — N.W.T.

Nunavut

PROJECT
SEWAGE & SOLID WASTE FACILITY
KUGAARUK, NUNAVUT

TITLE
MANHOLE DETAILS

DILLON CONSULTING

SCALE	AS SHOWN
DILLON PROJECT NUMBER	05-4755-3000
CLIENT PROJECT NUMBER	NA
DRAWING NUMBER	202

EDIT DATE: 11.12.2009 PLOT DATE: wotherspoon, trevor 11.12.2009

Appendix C – Photographs

Photographs 1 through 18

Photograph 1: General view of lagoon looking southeast from the northwest berm of the dam.

Photograph 2: Northwest berm of dam. Maximum effluent level represented as a broken line of white litter.

Photograph 3: Southeast slope of lagoon with rip rap blanket and half culverts for unloading effluent from waste trucks into the pond.

Photograph 4: General view of northeast internal slope.

Photograph 5: Close up view of northwest internal slope.

Photograph 6: General view of southwest internal slope.

Photograph 7: General view of southwest internal slope with the Arctic Ocean in the background.

Photograph 8: One meter high external slope along southeast berm.

Photograph 9: About 10 m high external slope along northwest berm.

Photograph 10: A portion of northeast berm with rip rap blanket overlying a native rock outcrop.

Photograph 11: Crest of northwest berm.

Photograph 12: Close up view of corrugated outfall pipe at external slope of northwest berm.

Photograph 13: Manhole lid with no hasp or padlock.

Photograph 14: General view of overflow weir.

Photograph 15: General view of lower pond and outfall pipe.

Photograph 16: Close up view of lower pond.

Photograph 17: Terrain downstream from lower pond. Green grass shows area where effluent is seeping below lower pond embankment.

Photograph 18: Lower pond berm with post.