Tahera Diamond Corporation

JERICHO PROJECT
EAST AND SOUTHEAST DAM
DESIGN REPORT

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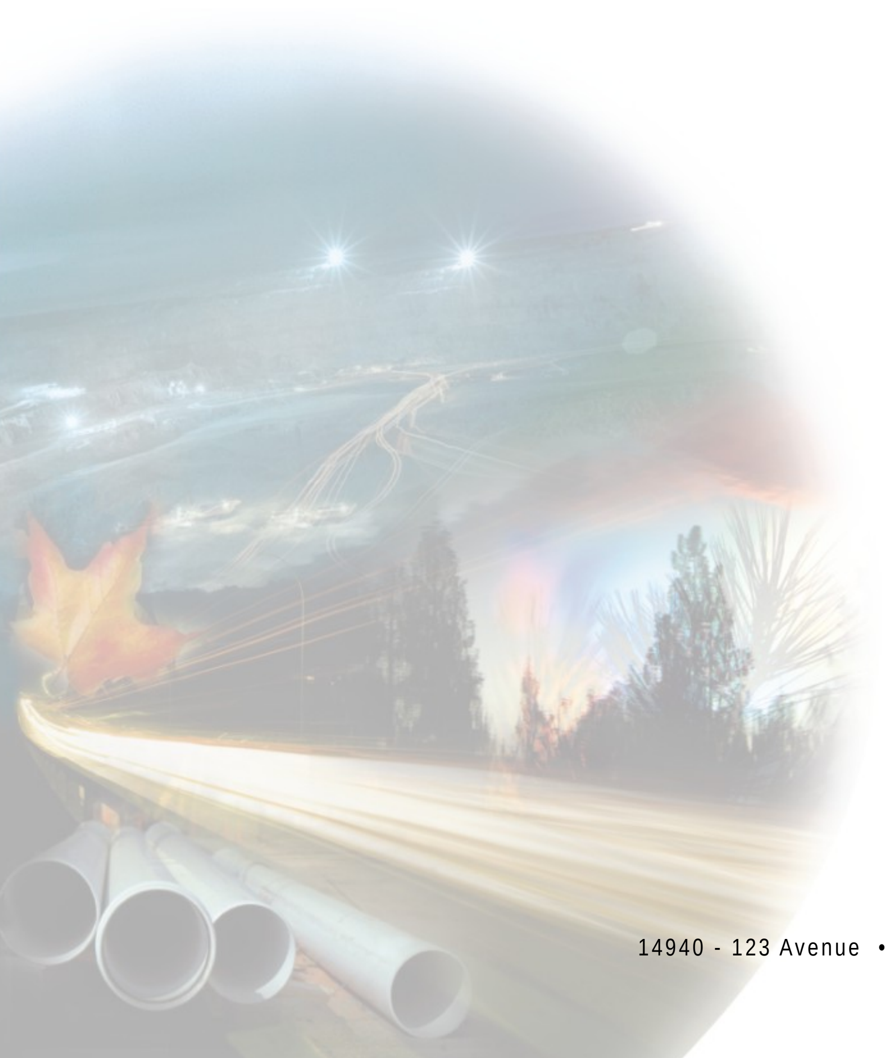
August 2005



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1.0 INTRODUCTION

Tahera Diamond Corporation is presently developing the Jericho Diamond Mine, Nunavut, located approximately 420 km northeast of Yellowknife. Processed kimberlite will be deposited in a small lake as described in the report titled "Design of the Processed Kimberlite Containment Area" (SRK, 2004). The Processed Kimberlite Containment Area (PKCA) consists of several perimeter dams and cross-lake divider dykes as shown in Drawing ED-1.

This document describes the design and construction of the PKCA East and Southeast Dams. Further details of the PKCA operation will be described under separate cover in a PKCA management plan that is currently being prepared.

The East and South East Dams are situated at the east end of the PKCA. Fine Processed Kimberlite solids (fine PK) will be beached off of the dams throughout the life of the mine. The fine PK will be retained between these dams and the divider dykes in the PKCA. Water will pass through the divider dykes into the western portion of the PKCA. The western portion of the PKCA will perform as a 'polishing pond' to facilitate the settlement of any remaining suspended solids so that excess water can be discharged to Stream C3 during the spring, summer and fall.

This report summarizes available site geotechnical data and discusses the basis for selecting dyke design concepts. Reduced size construction drawings are presented in Appendix B of this report. Construction specifications are presented in a separate document.

2.0 DESIGN INTENT

The design criteria for the divider dyke are as follows:

- The dams should retain the fine PK solids.
- Water may pond against the dams for short periods of time during the spring freshet and summer.
- The dams will remain physically stable during the operational life of the mine and following mine closure.

2.1 DAM SITING AND ALIGNMENT SELECTION

The Dams are located at the east end of Long Lake, immediately south of the mine process plant as shown on Drawing ED-1. The dams are located in small saddles between bedrock ridges.

2.2 FOUNDATION CONDITIONS

The estimated surficial geology of the East and Southeast Dam is shown in Drawing ED-2.

Bedrock outcrops are visible at the abutments of the East Dam and Southeast Dam.

Two boreholes drilled at the East Dam and one borehole was drilled at the Southeast Dam as shown in Drawing ED-3.

Borehole BH-03-10 (SRK 2003) drilled near the center of the East Dam alignment encountered thin organics (0.1 m) overlying 23 m of silty sand till with cobbles and boulders. Ice descriptions were not logged during drilling; and based on core photos it appears that most of the core thawed during drilling. Three till samples had moisture contents ranging from 8 to 9% indicating relatively low excess ice contents; however photos of core indicate some of the material was very wet upon thaw which indicates that zones of the till may be ice rich. Ground temperatures below 10 m in September ranged from –5°C to –7°C. Granite bedrock was encountered at a depth of 23 m with a 2 m thick layer of broken rock overlying competent rock.

Borehole 00SRKGeotech1 was drilled on the north abutment of the East Dam. The drill hole encountered approximately 7.6 m of silty sand till overlying fractured rock with bedrock at 8.5 m. No details were provided in the borehole log on the ice characteristics of the overburden.

Borehole 01-Geotech5 was drilled near the center of the Southeast Dam alignment. The drill hole encountered approximately 4.1 m of overburden over granite. The borehole log provides no details of the overburden or bedrock characteristics.

For design purposes, it has been assumed that the tills are ice rich in the low-lying areas between the bedrock abutments. This assumption provides a conservative design for stability analyses and dam design.

2.3 LAKE AND TAILINGS LEVEL PROJECTIONS

The natural water level in Long Lake is approximately 515.4 m. The maximum allowable water level during operation of the PKCA will be 523 m. The water level in the PKCA will be governed by the west dam and pumping to maintain the water level, below the maximum level. The water levels are intended to be kept as low as possible to the natural level (515.4 m) by pumping the clean water out of the facility on a regular basis. The water level will initially be lowered approximately 2 m below the natural water level before fine PK is deposited into the PKCA.

The water level in the eastern portion of the PKCA will be affected by the divider dyke. The initial portion of Divider Dyke A will be constructed in the summer and fall of 2005 to the level required for mine operations in the summer of 2006. The solids level in the PKCA will be at an approximate elevation of 516 m by the beginning of the summer 2006.

The divider dyke's filter layer may freeze during the winter thereby restricting water flow through the dyke until the active layer develops the following spring. Assuming no flow through the divider dyke, the water level in the eastern portion of the PKCA may rise to elevation 520 m in the spring of 2006.

The lowest original ground surface elevation (El.) at the centerline of the East Dam is 517 m, and at the South East Dam is elevation 518 m. The design crest elevation of both dams is 524 m, providing 1 m of freeboard above the allowable maximum water level in the PKCA.

3.0 DESIGN CROSS-SECTIONS

The planned layouts and cross sections of the intermediate dykes are in Drawings ED-3 and ED-4.

Both dams contain a central geomembrane liner surrounded by bedding and filter layers. The liner will be keyed into the foundation materials, and sufficient cover over the key trench will maintain the base of the liner in a frozen condition.

The downstream shell of the dam will be constructed of rockfill. This will provide a strong material and will have minimal settlement. The rockfill shells are designed to be constructed with a 2.0H:1V outside slope.

The upstream shell will be constructed of till mined from the open pit overburden. The till is variable, from a sand and gravel with cobbles and boulders to a silty sand and gravel with cobbles. The till will provide an additional layer of medium permeability to reduce water flow through the dam. A thick layer of coarse processed kimberlite will regularly be placed over the till to maintain ponded water well away from the liner; reducing the possibility of thawing the foundation soils under the liner. The upstream till and coarse tailings will be constructed at slope of 3.5H:1V. The slopes will be flattened over time as fine PK is beached off the dam's upstream slope.

4.0 SLOPE STABILITY

4.1 ANALYSIS METHODOLOGY

Limit equilibrium analyses have been carried out to determine the factors of safety for slope stability during construction and operation of the intermediate dykes. All analyses were conducted using the commercial, two-dimensional, slope stability computer program, SLOPE-W. The factors of safety have been computed using the Morgenstern - Price Method.

The dams are designed to meet Canadian Dam Association guidelines (CDA, 1999). The design criteria for computed minimum factors of safety are given in Table 1.

TABLE 1: SLOPE STABILITY DESIGN CRITERIA

Loading Conditions	Minimum Factor of Safety	Slope
Static Loading, full reservoir	1.5	Downstream and Upstream
Full or partial rapid drawdown	1.2 to 1.3	Upstream
Earthquake, full reservoir	1.1	Downstream and Upstream

The stability analyses were carried out for the deepest dyke cross-section, which is considered to be the worst cases in evaluating intermediate dyke stability. The analyses were carried out without fine PK upstream of the dyke

4.2 MATERIAL PROPERTIES

The material properties chosen for the embankment and foundation materials in the stability analysis are presented in Table 2. The properties for granular materials were selected based on experience with similar materials used and encountered by EBA in dam designs at other sites across the Arctic.

TABLE 2: MATERIAL PROPERTIES USED IN STABILITY ANALYSES

Material	Angle of Internal Friction (º)	Cohesion (kPa)	Unit Weight (kN/m3)
Run-of-Mine	42	--	20
200 mm Material	35	--	21
20 mm Material	32	--	20
Composite Liner System (Interface)	10	--	18
Ice-Poor Till	30	--	18.5
Ice-Rich Till	0	75	16.5

The friction angle presented in Table 2 for the run-of-mine material is conservative for shallow depths where confining stresses are low (Jansen, 1988). The friction angle presented in Table 2 for rockfill is applicable for higher confining stresses that would be found at depth below the dam crest. The friction angle for similar rockfill under low confining stresses may approach 55º. The interface friction angle between the polypropylene geomembrane and the nonwoven geotextile was based on published test results (Jones and Dixon, 1998).

4.3 PORE WATER PRESSURE CONDITIONS

4.3.1 Coarse Tailings

The pore pressures assigned to the coarse tailings on the upstream face of the dam correspond to the pool level. It was assumed that phreatic surface would drop approximately 0.5 m from the dam face during rapid drawdown.

4.3.2 Till

The pore water pressures assigned to the till on the upstream side of the liner corresponded to the pond elevation for the static and seismic full reservoir stability analyses. Intermediate water levels were also analyzed to determine the minimum factor of safety for the upstream analyses. Pore pressures were conservatively assumed to remain at the original level during rapid drawdown situations.

4.3.3 Rockfill

Pore water pressures assigned to the downstream rockfill equalled the original ground elevation. The liner is not expected to leak significant volumes of water and, furthermore, the rockfill is free draining and will not sustain a rising water level within it.

4.3.4 Liner System

The pore water pressures assigned to the nonwoven geotextile/polypropylene interfaces corresponded to the maximum pond levels for the static, seismic, and rapid drawdown stability analyses.

4.3.5 Foundation Till

It was assumed that negligible excess pore water pressures would be generated due to thaw of the till under the upstream or downstream portions of the dams. This is considered to be appropriate for the following reasons:

- thaw progresses relatively slowly into the foundation, and
- the till is non-plastic and has a significant sand and gravel content, which increases permeability.

Given these conditions, the thaw consolidation parameter (Morgenstern and Nixon, 1971) will be low, indicating that excess pore water pressures generated in the till during thaw will be negligible. Furthermore, the permeability of the coarse-grained till is expected to prevent the build-up of excess pore water pressures during rapid drawdown.

4.4 SEISMICITY

The project area lies in a region of low seismicity, but magnitude 4+ earthquakes have recently occurred within a similar part of the shield. NRCan (NRCan 2003a and NRCan 2003b) recommends that a probabilistic approach should be adopted to estimate the peak ground accelerations (PGA); particularly the new proposed National Building Code of Canada (NBCC) PGA values.

The CDA indicates that the usual minimum criterion for the design earthquake for a dam, which coincides with the "low" consequence category, would be an earthquake with an annual exceedance with return periods of 100 to 1,000 years. NRCan (2003a and 2003b) indicates that the 1,000-year event has a peak acceleration of 0.016 g. However, in conjunction with proposed changes to the NBCC, NRCan indicates that performance of the dams be designed for an earthquake with a 2,475 year return period which has a peak ground acceleration of 0.06 g. This has been adopted as the design earthquake.

4.5 ANALYSES RESULTS

Table 3 summarizes the factors of safety under static, rapid drawdown and seismic conditions for different failure surfaces on the upstream and downstream slopes.

TABLE 3: SUMMARY OF STABILITY ANALYSIS RESULTS					
Slip Surface	Location	Factor Safety			
		Static	Static, Rapid Drawdown of Reservoir	Seismic	End of Construction (No Coarse Tailings or Water)
1	Upstream, rotational	2.2	1.2	1.2	2.0
2	Upstream, along liner	2.2	1.4	1.4	1.5
3	Downstream rotational	1.6	1.6	1.4	1.6
4	Downstream along the liner	2.3	2.3	1.4	3.0

The computed minimum factors of safety exceed the design criteria of 1.5, 1.2 and 1.1 for static, rapid drawdown and seismic loading conditions, respectively, in accordance with the CDA, Dam Safety Guidelines (CDA 1999).

5.0 SETTLEMENT

Distortion and stressing of the liner must be avoided to maintain the integrity of the liner system. A portion of the dams is founded on till that may be ice-rich, which would settle if allowed to thaw. Settlement movements due to thaw settlement of in situ foundation soils and/or settlement of dam superstructure fill materials must be minimized.

The dam is designed with till and coarse tailings on the upstream side of the dam. Thaw due to ponded water on the upstream dam face side is minimized by configuring the dam so that the upstream dam face is located at a distance ahead of the liner key trench. The frozen condition of the foundation soils below the liner will be maintained; therefore, foundation settlement is not expected to occur.

All dam fill materials must be properly compacted to reduce post construction settlements. Compaction of rockfill in dams with sloping upstream water retention membranes is commonplace. Several dam construction case histories illustrating compaction of rockfill are presented in Cooke (1985). CDA, Dam Safety Guidelines further state that membrane faced rockfill dams should be constructed using compacted thin lifts (CDA, 1999).

6.0 WORST CASE FAILURE SCENARIO

The environmental impact of a hypothetical worst-case failure scenario must be considered in the event that the dam fails. The probability of a sudden release of impounded water due to slope instability is remote. There is some risk that reduction of the liner integrity could occur, allowing seepage to pass through the dam. There is also a risk of seepage flow under the liner foundation. Seepage volumes that may occur are expected to be very low as the till and tailings on the upstream of the dam will restrict flow. Much of the till on the upstream will also freeze, becoming a permafrost condition. Water will be kept away from the dam face, as tailings are spigotted off of the upstream face. The liner bedding materials meet filtering criteria, reducing the risk of piping failure due to seepage.

In the event seepage through the dam occurs, the water level in the PKCA should be kept as low as practically possible. Seepage should be collected downstream and pumped back to the PKCA. Seepage collection ditches, sumps and/or dams can be constructed to collect seepage for pumping back into the PKCA if needed.

7.0 MATERIAL PROPERTIES

The following provides a summary of the dam materials. Specifications for the material gradation and placement are presented in the East Dam and Southeast Dam construction specifications.

7.1 SLOPE PROTECTION

The upstream dam slopes of the East and Southeast Dams may be exposed to water during spring freshet and the short summer season. Fine PK will eventually be beached up against the dam; therefore there will be not be direct contact with the reservoir and the dams over the long term.

There is no plan to place erosion protection on the dams. The coarse tailings and fine PK will be placed on the dam face on a regular basis. The course tailings will be replaced if wave action erodes them. The initial performance will be monitored, and slope protection added if required.

7.2 COARSE PROCESSED KIMBERLITE TAILINGS

The upstream slope of the dam will be covered with a layer of coarse processed kimberlite tailings. This material is composed of sand sized particles ranging from approximately 0.1 mm to 5 mm. This material will be placed after plant startup and throughout the mine operation, as opposed to being placed during the dam construction.

7.3 TILL

The upstream shell of the dam will be constructed with till. The natural till deposits on site vary from sand and gravel with some cobbles and boulders to silty sand and gravel with cobbles and boulders. Silty till, as opposed to sandy till should be used where practical. Boulders larger than 250 mm must be removed by blading them out of each lift of material to allow for compaction the till. The large particles can be wasted on the upstream dam slope.

7.4 GEOMEMBRANE LINER

The geomembrane liner is recommended to be a 40 mil polypropylene liner. The liner is flexible at cold temperatures. A 16 oz non-woven geotextile is recommended to be placed above and below the geomembrane.

7.5 LINER BEDDING

Bedding material must be placed on either side of the geomembrane. The bedding material can consist of 20 mm minus crush material, or 40 mm minus esker material with round particles.

7.6 TRANSITION MATERIAL

A transition material is required between the liner bedding material and the downstream rockfill material. The transition material must meet filter criteria between the liner bedding and the rockfill as follows:

- D15 of the transition < 5 * D85 of the filter
- D15 of the rockfill < 5 * D85 of the transition

7.7 ROCKFILL

The downstream shell materials will be run-of-mine granitic rock and have a maximum size of 700 mm. The material shall be placed in lifts of a maximum of 700 mm. Any boulder larger than 700 mm can be wasted to the outside downstream edge of the dam.

7.8 QUANTITIES

Table 4 presents the in-place quantities of material required for each zone of the intermediate dykes if constructed as per design geometry. The quantities of material do not include any contingency for waste.

TABLE 4: DAM MATERIAL QUANTITIES

Structure	Geomembrane (m^2)	Geotextile (m^2)	Fill Material Type				Coarse Tailings (m^3)
			Bedding (m^3)	Transition (m^3)	Rockfill Shell (m^3)	Till (m^3)	
East Dam	4,900	9,800	6,804	2,100	17,000	8,400	12,000
Southeast Dam	4,200	8,400	5,800	2,600	14,000	8,600	12,000

Note: Quantities are "in-place". Seaming allowance and contingencies must be added to geomembrane and geotextile quantities. It is recommended that 20% extra quantities be available on site. Bulking factors and contingencies must be added to fill quantities; 20% should be added to reported quantities for stockpile volumes.

8.0 CONSTRUCTION PLAN

8.1 GENERAL

Construction of the dams will be conducted in accordance to the Construction Specifications and Construction Drawings. The Construction Specifications have been issued to Tahera in a separate document that is intended to accompany this report. The Construction Drawings have also been issued as a separate document package. A set of construction drawings (reduced in size) are included, for ease of reference, with this report. The Construction Specifications and Construction Drawings must be among the governing documents used for construction planning and supervision, and ultimate construction of the dams.

8.2 CONSTRUCTION REQUIREMENTS

The Construction Specifications present the details regarding foundation preparation, fill materials, fill placement, the geomembrane liner system, instrumentation and quality assurance program. It is anticipated that the contractor chosen to conduct the work will develop a construction plan. The construction plan must satisfy the requirements presented in the Construction Specifications to meet their design intent.

8.3 SCHEDULE

The requirements for construction of the lined dams dictates that fill placement will occur in both cold and warm weather conditions. Key trench construction (backfill, liner system) will take place during the months when air temperatures are below -15ºC. A portion of the fill above ground can occur prior to freeze-up. The following generalized schedule for dam construction is suggested for construction planning purposes:

- Prior to October: Preparation for Construction - Develop material sources, excavate, process and separately stockpile 20 mm and 200 mm. Preparation of foundation upstream of key trench. Initial placement of upstream till shell at dam locations.
- October to December: Dam Construction - Excavation of the key trench, key trench fill placement, composite liner system installation, installation of ground temperature cables. Placement of superstructure fill, geomembrane liner system, and of survey monitoring points.
- January to April and ongoing during operations: Coarse Tailing placement. The coarse tailings must be maintained a minimum of 2 m above the water level.

Successful construction of the key trench is of paramount importance in meeting the design intent of the dams. Cold weather construction will require careful preparation and attention to equipment selection and maintenance on the part of the contractor.

8.4 FOUNDATION PREPARATION

The footprint under the upstream shell for each dam must be grubbed to remove boulders and loose, fractured bedrock.

A key trench must be excavated into permafrost so that the geomembrane liner system is keyed into permanently frozen ground. The width and depth of the key trench will vary along the axis of each dam. The minimum depth of excavation is shown on the Construction Drawings. The actual depth of excavation will be determined on site during key trench excavation, as the key trench must extend into ice-saturated permafrost soil or rock. The key trench within bedrock areas will be excavated using drill and blast techniques with removal of material by excavators and/or front end loaders. Loose frozen soil, fractured boulders and fractured bedrock, as well as protruding frozen ground, boulders or bedrock, must be removed to provide a relatively smooth key trench base. Additional excavation (blasting or mechanical) may be required to achieve this end.

The key trench within till areas can be excavated just after initial freeze up using conventional excavation methods. The liner and key trench must immediately follow key trench excavation.

Groundwater may be encountered during key trench excavation. Any inflow of ground water into the excavation will be controlled using sumps and pumps and discharged into the PKCA.

8.5 MOISTURE CONDITIONING OF EMBANKMENT MATERIALS

Granular material used for construction of the key trench, liner bedding and transition zones within the dam cross-sections will be processed from rock developed from mining operations. Processing will be required to achieve the specified gradations. Separate stockpiles of the different granular materials must be developed prior to the start of construction. The processed materials must be stockpiled as dry as possible to prevent any ice bonding of particles within the stockpile.

The 20 mm material used to backfill the key trench must be placed in a semi-slurry condition. Water must be added to the 20 mm material to bring the moisture content to about 2% above the optimum water content as determined by ASTM 698 (by mass). The water must be heated to prevent freezing before placement in the key trench.

8.6 MATERIAL PLACEMENT

8.6.1 Key Trench Backfill

Air temperatures during key trench construction shall be –15°C or colder. The 20 mm material slurry used as key trench backfill must be trucked to the dam site and be placed and compacted before freezing during transport occurs. The first lift of 20 mm material placed at the base of the key trench shall be placed as a slurry similar to core material used in frozen core dam construction. The remainder of the 20 mm material placed in the key trench will have a moisture content of at least 2% in excess of the optimum moisture content determined from test method ASTM D698-91. Compaction will be achieved by construction equipment traffic used to spread the material and a 10 tonne (minimum weight) vibratory, smooth drum compactor. When required, the moisture content of the key trench backfill must be maintained so that excessive water is not available to form ice lenses.

The key trench backfill must be spread in lifts thin enough to freeze completely before the next lift is placed. A lift thickness of 250 mm should be sufficient to permit daily freezing during cold weather (<-15°C) placement. However, parameters such as mixing water content, surface cleaning and lift thickness should be optimized by controlled experimentation early in the construction season. These parameters may need to be periodically changed to suit varied weather conditions.

The first lift of 20 mm material placed in the key trench must be placed at a moisture content of 12% or greater with an average degree of saturation no less than 85% and with no individual value falling below 80%. The first lift of key trench backfill will act as a bedding layer between the liner and the base of the key trench as well as a seepage barrier beneath the liner system.

8.6.2 Liner System

A minimum 300 mm thick bedding layer of compacted saturated 20 mm crush material or 40 mm minus esker must be used as bedding for liner. Nonwoven geotextile must be placed on both sides of the polypropylene geomembrane.

Welding the polypropylene geomembrane during the cold weather conditions will require careful planning and equipment selection by the geomembrane installer. Welding during the coldest time of year will likely require a heated portable shelter to shield the welding operation from the cold and wind. The effects of various factors (such as sudden cooling and speed of welding) on the integrity of the welds will be assessed by controlled experimentation early in the welding operation to determine their effect on the integrity of the polypropylene welds.

The designated liner installation subcontractor has installation experience on similar projects in cold weather conditions.

8.6.3 Run-of-Mine Material

The run-of-mine rockfill material shall be placed in lifts no thicker than 700 mm. Compaction of this material will be achieved by routing heavy equipment (bulldozers, haul trucks) evenly over each lift.

Run-of-mine must be placed in an unsegregated state. This material must be placed in a manner that will not cause segregation or nesting of coarse particles. The effectiveness of this construction technique will be evaluated in the field by the site engineer and changes to the construction procedure will be made as required. Boulders greater than 700 mm size should be bladed out of the fill wasted on the outside slope.

8.6.4 200 mm Transition Material

The 200 mm material must be placed in lifts not exceeding 400 mm in thickness. This material must be placed in a manner that will not cause segregation and/or nesting of coarse particles.

Compaction will be achieved by at least four passes with a smooth drum vibratory roller weighing 10 tonnes or more. It is anticipated that the number of passes, vibration frequency and volume of water required will be checked periodically throughout construction using a proof roll. The number of passes, vibration frequency and volume of water added should correspond to the point when deflection is not visible.

8.6.5 Bedding Material

The bedding material must be placed in the superstructure of the dams in lifts not exceeding 300 mm in thickness in such a manner that will not cause segregation and/or nesting of coarse particles. This material must be moisture conditioned, as required, and compacted to a minimum of 95% of the maximum dry density determined by test method ASTM D698-91 prior to placing a subsequent lift.

8.7 QUALITY ASSURANCE

The construction quality assurance program must be structured so that construction-sensitive features of the design are achieved. The elements of the program will include:

- Careful surveying to establish material quantities on a daily basis and allow preparation of as-built drawings.
- Specific quality control approvals at critical times such as key trench excavation, key trench backfill and superstructure fill placement.
- Monitoring and field testing of fill materials.
- Monitoring of fill mixing procedures.
- Specific approval of construction procedures for moisture conditioning and placement of all embankment materials.
- Daily field testing of the key trench fill to show complete lift freezeback and uniform distribution of moisture and density parameters.
- Observation and approval of contractors' proposed material placement sequences and preparation of surfaces below each lift placement.
- Periodic processing of temperature data collected from ground temperature cables installed in the fill as part of long-term monitoring (see Section 9.2) and evaluation of these data.
- Observation of polypropylene geomembrane welding operation and testing to confirm design requirements are met.

- Defined procedures for reporting with identified responsibilities for decision-making during construction.
- Specific requirements and testing frequencies for the Quality Assurance process during construction are set out in the Construction Specifications.

9.0 LONG-TERM MONITORING

9.1 PURPOSE

Performance monitoring is an integral part of the operation of any water retention structure. This section describes a recommended monitoring program for the construction and operation for the East and Southeast Dams.

The proposed monitoring program will serve the following three functions:

- Monitor the thermal regime of the dams,
- Monitor movements of the dam, and
- Satisfy regulatory requirements for dam performance monitoring.

Each of the components of the monitoring program is detailed in the following sections. The recommended instrumentation program for each dam is presented in the Construction Drawings.

9.2 THERMAL MONITORING

Horizontal ground temperature cables will be installed in the key trench backfill of each dam. The layout of the horizontal ground temperature cables within the key trench geometry is presented in the Construction Drawings.

9.3 SURVEY MONITORING

Survey monitoring points will be installed along the crest of each dam as shown in the Construction Drawings. They will be used to monitor settlement or horizontal movements of the dams through their service lives.

Survey monitoring points shall consist of either wooden survey stakes and/or iron bars embedded 300 mm into 20 mm material or Hilti-bolts installed in the top of boulders where run-of-mine material exists at the dam crests. The actual survey point will be the top of the survey stake/iron bar and Hilti-bolt.

The survey monitoring points should be installed and surveyed immediately upon completion of the dams. The survey point elevations and coordinates should be surveyed on a monthly basis for the first two years of operation. Survey data should be reviewed by a geotechnical engineer until deformations are minor or at least until after the second filling of the reservoir.

10.0 ANNUAL INSPECTION

An annual site inspection will be conducted by the design team to document the performance of each of the dams. These visits should take place at the end of summer when maximum annual thaw has developed. It would be preferable to conduct the visits when the reservoir is empty to permit inspection of the upstream slope and toe of the dams.

The specific tasks conducted during these visits include:

- Inspection of the upstream and downstream slopes for any sign of distress,
- Inspection of the dam crests for any sign of transverse cracking, and
- Inspection of the abutments and downstream toes for any evidence of seepage.

11.0 CLOSURE

The recommendations and design provided herein are based on our review of the information described in Section 2.0. It is recommended that site preparation and observation of the fill placement for the embankments shall be monitored by qualified personnel under the direction of an EBA geotechnical engineer. Quality control of the liner materials and installation should be undertaken by liner specialists. Time of construction changes which may or may not be required to field-fit the design should be approved by a qualified geotechnical engineer.

This report has been prepared in accordance with generally accepted geotechnical engineering practices. No other warranty is made, either express or implied. Reference should be made to EBA's Geotechnical General Conditions, attached to this report, for further limitations.

EBA trusts that this report satisfied your present requirements. Should you require any additional information, please contact us.

Respectfully submitted,
EBA Engineering Consultants Ltd.

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APPENDIX

APPENDIX A CONSTRUCTION DRAWINGS

APPENDIX

APPENDIX B EBA GEOTECHNICAL GENERAL CONDITIONS

GEOTECHNICAL REPORT – GENERAL CONDITIONS

This report incorporates and is subject to these "General Conditions".

1.0 USE OF REPORT AND OWNERSHIP

This geotechnical report pertains to a specific site, a specific development and a specific scope of work. It is not applicable to any other sites nor should it be relied upon for types of development other than that to which it refers. Any variation from the site or development would necessitate a supplementary geotechnical assessment.

This report and the recommendations contained in it are intended for the sole use of EBA's client. EBA does not accept any responsibility for the accuracy of any of the data, the analyses or the recommendations contained or referenced in the report when the report is used or relied upon by any party other than EBA's client unless otherwise authorized in writing by EBA. Any unauthorized use of the report is at the sole risk of the user.

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2.0 NATURE AND EXACTNESS OF SOIL AND ROCK DESCRIPTIONS

Classification and identification of soils and rocks are based upon commonly accepted systems and methods employed in professional geotechnical practice. This report contains descriptions of the systems and methods used. Where deviations from the system or method prevail, they are specifically mentioned.

Classification and identification of geological units are judgmental in nature as to both type and condition. EBA does not warrant conditions represented herein as exact, but infers accuracy only to the extent that is common in practice.

Where subsurface conditions encountered during development are different from those described in this report, qualified geotechnical personnel should revisit the site and review recommendations in light of the actual conditions encountered.

3.0 LOGS OF TESTHOLES

The testhole logs are a compilation of conditions and classification of soils and rocks as obtained from field observations and laboratory testing of selected samples. Soil and rock zones have been interpreted. Change from one geological zone to the other, indicated on the logs as a distinct line, can be, in fact, transitional. The extent of transition is interpretive. Any circumstance which requires precise definition of soil or rock zone transition elevations may require further investigation and review.

4.0 STRATIGRAPHIC AND GEOLOGICAL INFORMATION

The stratigraphic and geological information indicated on drawings contained in this report are inferred from logs of test holes and/or soil/rock exposures. Stratigraphy is known only at the locations of the test hole or exposure. Actual geology and stratigraphy between test holes and/or exposures may vary from that shown on these drawings. Natural variations in geological conditions are inherent and are a function of the historic environment. EBA does not represent the conditions illustrated as exact but recognizes that variations will exist. Where knowledge of more precise locations of geological units is necessary, additional investigation and review may be necessary.

5.0 SURFACE WATER AND GROUNDWATER CONDITIONS

Surface and groundwater conditions mentioned in this report are those observed at the times recorded in the report. These conditions vary with geological detail between observation sites; annual, seasonal and special meteorologic conditions; and with development activity. Interpretation of water conditions from observations and records is judgmental and constitutes an evaluation of circumstances as influenced by geology, meteorology and development activity. Deviations from these observations may occur during the course of development activities.

6.0 PROTECTION OF EXPOSED GROUND

Excavation and construction operations expose geological materials to climatic elements (freeze/thaw, wet/dry) and/or mechanical disturbance which can cause severe deterioration. Unless otherwise specifically indicated in this report, the walls and floors of excavations must be protected from the elements, particularly moisture, desiccation, frost action and construction traffic.

7.0 SUPPORT OF ADJACENT GROUND AND STRUCTURES

Unless otherwise specifically advised, support of ground and structures adjacent to the anticipated construction and preservation of adjacent ground and structures from the adverse impact of construction activity is required.

8.0 INFLUENCE OF CONSTRUCTION ACTIVITY

There is a direct correlation between construction activity and structural performance of adjacent buildings and other installations. The influence of all anticipated construction activities should be considered by the contractor, owner, architect and prime engineer in consultation with a geotechnical engineer when the final design and construction techniques are known.

9.0 OBSERVATIONS DURING CONSTRUCTION

Because of the nature of geological deposits, the judgmental nature of geotechnical engineering, as well as the potential of adverse circumstances arising from construction activity, observations during site preparation, excavation and construction should be carried out by a geotechnical engineer. These observations may then serve as the basis for confirmation and/or alteration of geotechnical recommendations or design guidelines presented herein.

10.0 DRAINAGE SYSTEMS

Where temporary or permanent drainage systems are installed within or around a structure, the systems which will be installed must protect the structure from loss of ground due to internal erosion and must be designed so as to assure continued performance of the drains. Specific design detail of such systems should be developed or reviewed by the geotechnical engineer. Unless otherwise specified, it is a condition of this report that effective temporary and permanent drainage systems are required and that they must be considered in relation to project purpose and function.

11.0 BEARING CAPACITY

Design bearing capacities, loads and allowable stresses quoted in this report relate to a specific soil or rock type and condition. Construction activity and environmental circumstances can materially change the condition of soil or rock. The elevation at which a soil or rock type occurs is variable. It is a requirement of this report that structural elements be founded in and/or upon geological materials of the type and in the condition assumed. Sufficient observations should be made by qualified geotechnical personnel during construction to assure that the soil and/or rock conditions assumed in this report in fact exist at the site.

12.0 SAMPLES

EBA will retain all soil and rock samples for 30 days after this report is issued. Further storage or transfer of samples can be made at the client's expense upon written request, otherwise samples will be discarded.

13.0 STANDARD OF CARE

Services performed by EBA for this report have been conducted in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practising under similar conditions in the jurisdiction in which the services are provided. Engineering judgement has been applied in developing the conclusions and/or recommendations provided in this report. No warranty or guarantee, express or implied, is made concerning the test results, comments, recommendations, or any other portion of this report.

14.0 ENVIRONMENTAL AND REGULATORY ISSUES

Unless stipulated in the report, EBA has not been retained to investigate, address or consider and has not investigated, addressed or considered any environmental or regulatory issues associated with development on the subject site.

15.0 ALTERNATE REPORT FORMAT

Where EBA submits both electronic file and hard copy versions of reports, drawings and other project-related documents and deliverables (collectively termed EBA's instruments of professional service), the Client agrees that only the signed and sealed hard copy versions shall be considered final and legally binding. The hard copy versions submitted by EBA shall be the original documents for record and working purposes, and, in the event of a dispute or discrepancies, the hard copy versions shall govern over the electronic versions. Furthermore, the Client agrees and waives all future right of dispute that the original hard copy signed version archived by EBA shall be deemed to be the overall original for the Project.

The Client agrees that both electronic file and hard copy versions of EBA's instruments of professional service shall not, under any circumstances, no matter who owns or uses them, be altered by any party except EBA. The Client warrants that EBA's instruments of professional service will be used only and exactly as submitted by EBA.

The Client recognizes and agrees that electronic files submitted by EBA have been prepared and submitted using specific software and hardware systems. EBA makes no representation about the compatibility of these files with the Client's current or future software and hardware systems.