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Chevron Canada Resources Limited

MT. NANSEN GOLD PROJECT

TAILINGS DAM
PRELIMINARY DESIGN REPORT

YUKON ENERGY, MINES
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P.O. Box 2703
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KLOHN LEONOFF YUKON
CONSULTING ENGINEERS

PB 3574 03

December 1988

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KLOHN LEONOFF
CONSULTING ENGINEERS

Our File: PB 3574 0301
WP 29

December 7, 1988

Archer Cathro & Associates 1981 Ltd.
Consulting Geological Engineers
1016 - 510 West Hastings Street
Vancouver, British Columbia
V6B 1L8

Mr. D. Eaton, Project Manager

Mt. Nansen Feasibility Level
Tailings Dam Design Report

Dear Sir:

Please find enclosed five (5) copies of our above referenced report as requested. The report provides preliminary engineering recommendations and first order cost estimates for the construction of a tailings pond at the existing Mt. Nansen minesite.

Should you have any questions, please don't hesitate to call. We would be pleased to meet with you in the near future to discuss the report.

Yours very truly,

KLOHN LEONOFF LTD.

Iain Bruce

Iain G. Bruce, P.Eng.
Project Manager

IGB/bp

Encls.

TAILINGS DAM
PRELIMINARY DESIGN REPORT

PROJECT:	MOUNT NANSEN GOLD PROJECT
LOCATION:	DAWSON RANGE YUKON TERRITORY
CLIENT:	CHEVRON RESOURCES CANADA LTD.

OUR FILE: PB 3574 0301 DECEMBER 1988

PB 3574 0301
WP 29

December 7, 1988

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December 7, 1988

EXECUTIVE SUMMARY

This report presents a site appraisal and preliminary design for two potential tailings pond sites at Mt. Nansen, Yukon. The purpose of this preliminary report is to provide sufficient information for a feasibility-level cost estimate.

Soil in the valley bottoms near the mine site consists of fine-grained, poorly-graded outwash sand overlying the glacial till or bedrock. A localized deposit of silty clay 7.7 m thick was identified in one borehole in the valley bottom. The upper valley slopes of Dome Creek above the sand deposits consist of colluvium or exposed bedrock. The colluvium is formed from weathered bedrock which has been transported downslope, possibly by solifluction, creep or landsliding. The colluvium is in a loose, open state. The bedrock at the site appears to consist of igneous rocks of the Mt. Nansen group, which is highly shattered and broken at the ground surface as observed in exploration trenches.

The site lies within the discontinuous permafrost zone, close to the southern boundary of widespread areas of permafrost islands. All the boreholes indicate frozen ground beneath the moss cover. The existing permafrost is considered marginally stable and has been observed to thaw and remain thawed when the natural vegetation cover is stripped.

The Mt. Nansen mine site lies within a seismically active area of the Canadian North. A peak horizontal ground acceleration of approximately 10% g is expected with probability of exceedence no greater than 0.0021, or 1 in 475 years, while a peak horizontal acceleration of 12% g is expected with a return period of .001, or 1 in 1,000 years.

Two dam alignments have been assessed for this study. Site No. 1 lies northwest and uphill of the millsite. Site No. 2 is located east and downhill of the existing mill.

Site No. 1 lies at elevation 1290 m, approximately 400 m northwest of and 60 m above the existing mill grade. Nearby exploration trenches indicate that foundations are likely to consist of a thin, colluvial sand and gravel mixture overlying bedrock or weathered, fractured bedrock at surface.

The dam has been designed for construction in two stages. Stage I requires a crest elevation of 1296 m to completely contain two years production of tailings. This corresponds to a maximum dam height of 16 m. The rockfill embankment volume for Stage I is approximately 45 000 m^3. Volume of Stage II embankment is approximately 50 000 m^3. A final dam elevation of 1299 m is required to contain the expected four years production of 300 000 tonnes.

It is considered that the dam will be constructed of a homogeneous rockfill borrowed from within the pond. A downstream drainage blanket may be required. The drainage blanket will consist of 1 m thick select, processed drain rock surrounded by a 0.5 m thick filter blanket. The drain rock shall be placed in 0.5 m thick lifts and compacted in a similar fashion to the general fill.

Seepage through the bedrock foundation could occur along cracks that are interconnected. It is considered that seepage out of an unlined tailings pond would be unacceptably high, and lining of the pond is recommended.

Lining of the pond using a sand-bentonite soil mix is considered most suitable, although plastic liner may be necessary. A soil bentonite layer with a thickness of 0.3 m is considered adequate. The layer will have to be thicker on sloping surfaces to allow placement.

Seepage from the lined pond has been estimated to be on the order of 2 l/s, assuming that an intact seepage barrier of sand-bentonite mix is placed in the pond. It is recommended that sampling wells be located downhill from the tailings pond to monitor seepage volumes and water quality for verification of the estimated values.

For either of the proposed liners, an appropriate bedding or filter layer will be required. A plastic liner will require a bedding layer to remove the threat of punctures by sharp, larger gravel. The bentonite-sand liner will require a suitable filter to control erosion, and maintain the impervious characteristics of the liner.

Site No. 2 lies near elevation 1190 m, approximately 500 m east of the existing mill and approximately 40 m below the existing mill grade. The subsoil profile consists of approximately 9 m to 12 m of fine, poorly graded sand overlying 2 m to 4 m of silty sand and gravel overlying 4.5 m to greater than 12 m of glacial till over weathered bedrock. The ground is permanently frozen and has been found to contain individual lenses of ice with soil as thick as 10 cm.

The dam has been designed for construction in two stages. Stage I requires a crest elevation of 1200 m for storage of 150 000 tonnes of tailings, while Stage II requires a crest elevation of 1203 m. Stripping of the vegetation will immediately cause the start of permafrost degradation and will result in difficult, soft wet construction conditions. Consequently, stripping should be undertaken well in advance of construction to allow dissipation of excess water. The dam will be constructed as a homogeneous rockfill or sandfill dam, with a downstream drainage blanket. The first lift shall be placed in a layer no thicker than 0.5 m and compacted by a 10-tonne vibrating roller. The drain blanket at Site No. 1 will be 1.0 m thick, surrounded by a 0.5 m thick filter blanket. The rock shall be placed in 0.5 m lifts and compacted in a similar manner to the general fill. Fill placement for the tailings dam at Site No. 2 will require construction of a haul road from the proposed open pit area down into Dome Creek. All fill material shall be placed in a thawed condition.

Settlement of the dam crest will occur as the foundation thaws and deforms. Maintenance of the dam crest by the addition of some extra rockfill may be required during the life of the mine.

Both upstream and downstream slopes of 3H:1V have been assumed to allow estimation of fill quantity slopes. Slopes of 3H:1V are considered suitable for foundations constructed over thawing sand. However, a detailed assessment of the sand density will be required for final design of the dam.

Seepage from the base of the confined pond has been estimated using hand drawn flow nets. Seepage is estimated to be on the order of 100 to 140 l/s, or 50 times greater than the seepage expected from the pond 1 site. Use of a liner will reduce the seepage to the same order of magnitude as predicted for the dam at Site No. 1.

Tailings will be deposited in either pond utilizing a discharge system of a series of spigot points along the upstream slope of the tailings dam. Water separated from the tailings slurry will form a pond where it can be reclaimed for use at the mill. A minimum water depth of 2.0 m has been selected. Due to the limited pond area behind the proposed tailings dam at Site No. 1, and the need for 2.0 m of water reclaim, it may happen that tailings are discharged underwater without the formation of a beach. Sand densities may be less than those assumed, and excess water loss to the voids may result. Additional tailings volume may be required under these conditions.

During winter operations, ice lens formation or glaciation will occur. Single point subaqueous deposition of the tailings through the ice covered pond will likely be required.

Tailing beaches should be developed around the pond to protect the liner and to establish a deep pond in the centre. The sand-bentonite liner cannot be installed in freezing weather. The plastic liner can be installed in somewhat colder weather. In either case, installation in the summer is preferable.

Water available for reclaim from the pond has been calculated for a dry year, mean year and wet year. Reclaim water available varies from a maximum of 3.4 l/s to a minimum of 0.1 l/s.

A preliminary cost estimate has been prepared for the two schemes discussed. The cost summary is based on unit rates estimated for direct costs only. The use of direct costs implies that all work will be done by the mine work force and not by a private contractor.

For Site No. 1, a total cost of $1,210,480 is estimated. For Site No. 2, a total cost of $1,546,800 is estimated. Contingencies of 30% over and above these costs are recommended for feasibility evaluations.

1. INTRODUCTION

1.1 SCOPE

This report presents a site appraisal and preliminary design for two potential tailings pond sites at Mt. Nansen, Yukon. The purpose of this preliminary report is to provide sufficient information for a feasibility-level cost estimate.

The client is Archer Cathro and Associates (1981) Ltd., Project Managers for the Mt. Nansen Mine project. The prospect is jointly owned by Chevron Resources Canada Ltd. and BYG Resources Ltd.

Tailings will be permanently stored on site. One of two ponds presently under study will be developed. Excess water will be reclaimed and returned to the mill. The tailings dam will be designed as a water retention structure to minimize seepage losses.

1.2 PROJECT DESCRIPTION

The proposed gold mine is located about 60 km west of Carmacks, Yukon Territory (Drawing D-3001). Access is by gravel road. A number of mining-placer properties are located in this area. The mine was operated by others in the past and the underground workings, mill buildings, two tailings ponds, a water reclaim pond and many bulldozer trenches are still present. These and current details are shown in plan on Drawing B-3002.

The proposed project will refurbish and utilize the existing mill. The present plan is to develop an open pit over the Brown McDade ore zone for two years, followed by two years of underground mining. The mill will be designed to process 200 tons of ore per day, and almost all of this will represent tailings when the gold is removed. The tailings will be pumped to the tailings pond at about 35% pulp density, and process water will be reclaimed for re-use in the mill. The gold which flows into the Yukon River. The mine elevation is about 1250 m (about 4,100 ft).

Elevations have been determined from an orthophoto provided by Archer Cathro & Associates. The drawing, at a scale of 1:5000, with 10 m contour intervals, has no title or date. The date of air photography is not indicated. The topographic detail ends just west of the old campsite. It does not include the western divide of Dome Creek.

2.2 SURFICIAL GEOLOGY

Four glacial advances have been defined across the central Yukon Territory. These are, from oldest to youngest, the Nansen, Klaza, Reid and McConnell advances. The Mt. Nansen minesite is situated within the Nansen drift (Bostock, 1966). Volcanic ash fell on this area up to a foot in depth. This occurred at least 2,000 years ago and has been reported by Botash, 1966 and Lerbekmo and Campbell, 1969.

Glacial till deposits were identified in boreholes DH-88-3 and DH-88-4 in Dome Creek valley (see Appendix I for the borehole logs). The till was between 4.5 m to 12.5 m thick and was overlain by glacio-fluvial or glacio-lacustrine deposits. Glacial till deposits were also noted by Bostock (1966), in tributaries of the Nansen and Victoria Creeks. The glacial till deposit consists of a dense to medium dense silty sand and gravel and has some ice inclusions.

Fine-grained, poorly-graded outwash sand overlies the glacial till or bedrock in the valley bottom below approximately elevation 1200 m. The sand consists of a greyish brown fine sand 6 m to 12 m deep overlying a brown sand and gravel layer. A localized deposit of silty clay 7.7 m thick was identified in borehole DH-88-2 in the valley bottom. Remnants of old alluvial fans along the south valley wall indicate that the meltwaters had flowed mainly from the south, carrying the sand into the valley. Subsequent runoff eroded the sand deposit in the lower regions of Dome Creek, creating sand terraces.

The upper valley slopes of Dome Creek above the sand deposits consist of colluvium. The colluvium is formed from weathered bedrock which has been transported downslope, possibly by solifluction, creep or landsliding. The colluvium is in a loose, open state.

2.3 BEDROCK GEOLOGY

The bedrock at the site appears to consist of igneous rocks of the Mt. Nansen group which have intruded into the Pelly formation metamorphic rocks. The metamorphic rocks have been mapped as undifferentiated schists, gneisses, quartzites and marbles (Archer Cathro, 1986). The bedrock is highly shattered and broken at the ground surface as observed in exploration trenches. We understand from Archer Cathro that the degree of shattering does decrease with depth, but the rock is considered to be shattered within the zone of influence of the tailings pond. The bedrock is a purplish to brown colour. Bedrock is exposed on the ridge tops where there is very little tree or vegetation cover.

2.4 PERMAFROST

The site lies within the discontinuous permafrost zone, close to the southern boundary of widespread areas of permafrost islands. This location corresponds roughly to the -4°C mean annual air isotherm. All the boreholes indicate frozen ground immediately beneath the moss cover except for borehole DH-88-3, which has a thawed depth or active layer of 2.4 m. The active layer is identified by the temperature of the SPT samples at depth 0.6 and 1.8 m, and also by the sudden increase in drilling resistance at a depth of 2.4 m. The moss cover is fairly thin locally around this borehole, which allows seasonal thaw within the fine sand deposit. An approximate temperature was measured on several soil samples using a handheld alcohol thermometer. The ground temperature ranged from -2° to -6°C.

The existing permafrost is considered marginally stable, and has been observed to thaw and remain thawed when the natural vegetation cover is stripped. Dome Creek valley is generally tree-covered along the north side and moss-covered on the south side, and the valley bottom has a thicker cover of moss and shrubs. This vegetation acts as an insulating layer for the permafrost ground condition. The creek channel meanders within the moss cover for most of the length along Dome Creek.

Visible ice was observed in most recovered soil samples in the form of ice lenses or discrete inclusions. All boreholes showed visible ice in the samples, which may amount to roughly 5% to 10% ice volume of a representative column of soil within the total borehole depth. Based on the auger reaction during drilling, no layers of pure ice were encountered in the boreholes, but layers of ice with soil as thick as 10 cm were encountered.

2.5 SEISMICITY

The Mt. Nansen mine site lies within a seismically active area of the Canadian north in acceleration seismic zone 2, as defined by the National Building Code of Canada. The site lies within the Northern British Columbia (NBC) source zone between the McKenzie (MKZ) zone and the Denali Shakwak (DSK) zone.

A probabilistic assessment of the seismic risk at the site has been undertaken by the Pacific Geoscience Centre for the Mt. Nansen site. The results are enclosed in Appendix III. A peak horizontal ground acceleration of approximately 10% g is expected, with probability of exceedence no greater than 0.0021, or 1 in 475 years, while a peak horizontal acceleration of 12% g is expected, with a return period of .001, or 1 in 1,000 years.

Two tailings pond sites are being considered at this time. Site No. 1 will be located on thawed bedrock. Detailed designs which will be undertaken in the final design stage will include a pseudo-static stability analysis for the embankment at Site No. 1.

Site No. 2, the less-preferred site, is located on frozen sand deposits with some ice lenses. The density of the sand in a thawed condition could not be assessed during the recent site investigation. Standard penetration tests provide erratic information in permafrost soil. If tailing dam Site No. 2 is preferable, then a detailed liquefaction assessment of the sand foundations, including seismic risk assessment, will be required. This assessment will require careful bulk sampling and density testing of the frozen sand.

3. CLIMATE

Climatological data has been obtained from the nearest Environment Canada meteorological station, No. 2100300, which is located 60 km east of the site at Carmacks. The weather station is at an elevation of 524 m, 776 m below the minesite elevation of 1300 m. Snowfall and rainfall data from this station were used for the water balance studies. Evaporation data was obtained from Fort Selkirk, Environment Canada Station No. 2100600, located approximately 80 km northwest of the minesite at elevation less than 600 m.

Precipitation at Mt. Nansen falls in the form of both rain and snow. Snow begins falling in November and remains on the ground until May. We understand from Archer Cathro personnel that typically, a snowpack of 1 m occurs. Approximately 40% of the annual precipitation falls as snow. Some rainfall occurs as early as April, but the majority of rainfall occurs from June to August. The most intense rainfall occurs in July. Mean annual precipitation values on a monthly basis are summarized on Table 3.1.

The highest evaporation rate occurs at the site in June. Water losses due to evaporation drop off significantly in the winter as temperature drops. During the summer months of May through August, evaporation is nearly 5 times the value of the local precipitation.

Site-specific data in the form of stream flow measurements, obtained from Norecol Environmental Consultants Ltd., were also reviewed. The flow measurements summarized on Table 3.2 are presented in terms of l/s/km^2 to normalize the data for various sized catchments.

TABLE 3.1

SUMMARY OF PRECIPITATION AND EVAPORATION DATA MEAN ANNUAL VALUES

SUMMARY OF HYDROLOGY DATA

	EVAPORATION	PRECIPITATION		
MONTH	MEAN ANNUAL (mm/month)	10-YEAR RETURN PERIOD DRY YEAR (mm/month)	MEAN YEAR (mm/month)	200-YEAR RETURN PERIOD WET YEAR (mm/month)
January	0.0	14.0	19.0	25.9
February	0.0	10.0	13.6	18.5
March	0.0	8.0	10.8	14.8
April	0.0	6.0	8.1	11.1
May	107.6	12.0	16.3	22.2
June	120.3	30.0	40.7	55.5
July	108.0	34.0	46.1	62.9
August	79.8	26.0	35.2	48.1
September	37.2	20.0	27.1	37.0
October	0.0	14.0	19.0	25.9
November	0.0	14.0	19.0	25.9
December	0.0	12.0	16.3	22.2
Total	452.9	200.0	271.0	370.0

TABLE 3.2

FLOW DISCHARGE RATES - DOME CREEK*

DATE	FLOW $l/s/km^2$
May 26, 1988	3.48
May 27, 1988	3.15
May 29, 1988	7.20
June 2, 1988	5.74
June 12, 1988	3.19
July 4, 1988	10.90
August 4, 1988	15.30
September 22, 1988	2.70

*Measured on Dome Creek in a V-notch weir approximately 2 km downstream of the minesite. Data supplied by Norecol Environmental Consultants Ltd.

3.1 EXTREME CLIMATIC EVENTS

3.1.1 General

Precipitation from a 1 in 200 year return period storm, a 1 in 200 year wet period and a 1 in 10 year return period dry year were appraised for the site. The storm event and wet year are required to design adequate freeboard for the selected tailing storage facility. The drought event is required to determine the maximum amount of makeup water required to maintain the mill operations.

3.1.2 Normal Precipitation

Precipitation for an average year is about 271 mm. Precipitation for a 10-year return period dry year is about 200 mm, while for the 200-year return period wet year precipitation is about 370 mm.

3.1.3 Extreme Storm Event

High-intensity, short-duration storms occur in July. For purposes of storm freeboard design, a 24-hour, 200-year period storm was estimated to be 40 mm. For specific design such as diversion ditch capacity, a 1-hour, 200-year return period storm was estimated. The intensities are presented in Table 3.3 below and represent a total depth of 200 mm.

TABLE 3.3

ONE-HOUR 200-YEAR RETURN PERIOD STORM

Time (minutes)	Intensity (mm/hr)
5	5.2
10	5.2
15	5.2
20	5.2
25	5.6
30	30.6
35	121.2
40	30.6
45	5.6
50	5.6
55	5.2
60	5.2

4. PROJECT DESCRIPTION

4.1 EXISTING FACILITIES

MILLSITE

An underground mine operated at this site between September 1968 and April 1969, and again between April and November of 1976 (Environment Canada, 1984). The mine buildings with some existing equipment are located on the existing millsite shown on Drawing B-3002. The mill structures appear to be founded on a cut excavated into the hillside, with the excavated material pushed out to form an area for smaller buildings for packing and storage. The present mill will be refurbished to process about 200 tonnes per day, about 75 000 tonnes per year. For the first two years of operation, the ore would be obtained from an open pit downstream across the valley, about 1 km northeast of the millsite. The approximate open pit outline is shown on Drawing B-3002. About 10 000 tonnes of waste rock will be moved to develop the open pit. Another 90 000 tonnes of waste rock will be available over the first two years of operation. A tailings pond is required which will store about 300 000 tonnes.

4.2 TAILINGS PONDS AND SEEPAGE RECOVERY POND

Two tailings storage ponds and a seepage recovery pond are located downslope from the millsite. The ponds appear to have been constructed by excavating into the hillside, perhaps by bulldozer and pushing the slightly silty sand and gravel into the form of dykes. The two tailings ponds have almost no watershed.

The three existing ponds show signs of structural distress. This may be due to poor compaction of each embankment constructed simply by bulldozing soil from the side slopes. Alternatively, there may have been buried ice in the foundation which has subsequently melted and deformed the dykes.

4.2.1 Upper Tailings Pond

The upper pond was probably used first, and the smaller downstream pond was developed later. The upper dyke had a wood flume spillway. However, seepage presently flows downstream through a naturally eroded channel in the dyke. The upper dam embankment has cracks in the crest indicating partial slope failure upstream and downstream. Water was ponded and tailings were just visible at the upstream edge of the pond. The dyke is grass-covered, with some bushes. There appears to be a relatively small volume of tailings stored in this pond.

4.2.2 Lower Tailings Pond

The lower tailings pond was also apparently constructed by slope material bulldozed to form a dyke. There is some indication of upstream slope instability with longitudinal cracks in the crest. The dyke has grass cover, and some bushes. Some water is ponded, and surplus water drains through a pipe in the dyke.

We have the impression from air photographs and other photographs of the tailings pond that a very small volume of tailings is stored in the existing ponds.

4.2.3 Seepage Recovery Pond

The seepage recovery pond dyke appears to have been constructed from material from an exploration trench on the right slope. This collected water from the full watershed. The spillway is collapsed in this dyke. It is wooden flume, lined with metal siding. The soil pressure from the embankment appeared to have collapsed one flume wall.

A pipeline from the seepage recovery pond appears to have been a water source for the mill. However, we understand from Archer Cathro that the existing plant obtained make-up water from wells in another valley, although there is no visible evidence of a pipeline remaining. Water supply for the present project is being studied by others.

5. TAILINGS STORAGE

5.1 GENERAL

The plant is expected to process approximately 200 tonnes of ore per day. This will be (ground) milled to a sand-silt slurry for gold extraction by cyanide leaching and carbon-in-pulp recovery. The gold grade is low, and virtually all the sand-silt slurry will be sent to tailing storage. No thickeners are planned, so the tailing slurry will be approximately 35% pulp density.

The tailings water will contain some cyanide and, consequently, the storage facility will be operated as a closed system. Clarified process water will be returned to the mill for re-use.

The ore is believed to contain significant fines which will require time to settle adequately in solution. We assume a minimum retention time of seven days will be required. If the fines contain excessive clay particles, the required retention time may be longer. This implies the volume of free water in the pond must be increased, or flocculent agents may have to be added to the tailings to cause the clay particles to settle quickly.

The tailings pond will be operated with the minimum inflow of runoff water. Make-up water will be supplied at the mill, probably from wells elsewhere. Diversion ditches will be provided to divert runoff around the pond. However, in the event that the ditches become plugged, flood freeboard will be supplied in the tailings pond to accommodate an extreme storm event.

5.2 DAM ALIGNMENTS

Two dam alignments have been assessed for this study. Site No. 1 lies northwest and uphill of the millsite. Site No. 2 is located east and downhill of the existing mill. A third area, Site No. 3 downstream of the mill, was originally chosen as a potential side-valley tailing damsite to avoid water diversions on Dome Creek and to maintain gravity flow of tailings slurry from the mill. However, the nearest suitable site for a side-valley dam lies outside of the existing Chevron mineral claim area. Consequently, Archer Cathro requested that no further consideration be given to this site. The detailed assessments following discuss Sites No. 1 and 2 only. The sites are identified on Drawing B-3002.

Drilling was carried out at Sites No. 2 and 3 in the Dome Creek valley below the mill in an effort to locate foundations suitable for supporting a tailing dam site which could be supplied by gravity flow from the mill.

Site No. 1, 400 m northwest of the mill at the original camp area, has been assessed without drilling. The Site No. 1 assessment is based on reconnaissance walkover and examination of nearby exploration trenches only.

6. SITE NO. 1 - "CAMPSITE AREA" TAILINGS DAM DESIGN

6.1 GENERAL DESCRIPTION

Site No. 1 lies at elevation 1290 m, approximately 400 m northwest of and 60 m above the existing mill grade. The ultimate dam and reservoir site has an area of approximately 150 m x 250 m, which was cleared for the original Mt. Nansen mine campsite and an access road. Two very small creeks run down the hillside at either end of the proposed containment facility. Most vegetation cover has been removed. Nearby exploration trenches indicate that foundations are likely to consist of a thin colluvial sand and gravel mixture overlying bedrock or weathered, fractured bedrock at surface. Drilling has not been carried out at tailings dam Site No. 1. However, we understand from discussions with Archer Cathro and Associates that bedrock is expected to be close to the surface and sufficiently weathered and fractured that it can be ripped and pushed by a bulldozer for use as fill material in the dam.

We assume the removal of the moss cover during the initial clearing in the late 1960's has changed the thermal regime, and we understand the permafrost has thawed to some unknown depth. The increased depth of the thawed active layer will aid in the excavation and probably in the overall stability of the site.

We assume this area was originally cleared of all organics for camp development. However, any original moss cover buried during the initial site clearing of the campsite must be removed as part of the foundation preparation for the dam.

6.2 DAM AND RESERVOIR DETAILS

A proposed dam section is shown on Klohn Leonoff Drawing B-3002. The ground surface slopes at an average grade of 7H:1V. The downstream slope of the structure should be 2H:1V. The upstream should not be steeper than 3H:1V to allow placement of an impervious liner.

We understand the shattered bedrock can be obtained from within the proposed reservoir. A homogeneous compacted rockfill dam with a lined reservoir is recommended. The rock would be piled, conveyed onto the damsite, dumped, spread, watered and compacted. The rockfill cannot be reliably bulldozed onto the dam to create the uniform horizontal layers to be watered and compacted. Many of the problems of the existing storage embankments can be attributed to the casual manner in which they were constructed.

6.3 TAILINGS DAM DESIGN - GENERAL

The dam has been designed for construction in two Stages. Stage I has been sized to contain 150 000 tonnes of tailings from the first two years of operation. A volume elevation curve for the pond has been generated by assuming that the fill used in the compacted embankment is removed from within the pond perimeter. Drawing A-3004 shows the volume storage-elevation curve for the selected dam alignment. Stage I requires a crest elevation of 1296 m to completely contain two years production of tailings. This corresponds to a maximum dam height of 16 m. The rockfill embankment volume for Stage I is approximately 45 000 m^3.

Fill material required for the Stage II dam construction can be obtained from within the expanded tailings pond area, or from waste rock excavated from the open pit in the first two years. A final dam elevation of 1299 m is required to contain the expected four years production of 300 000 tonnes. Borrowed rock obtained from within the pond will require ripping, loading, hauling and then placement on the dam. The haul distance, however, will be small. Volume of Stage II embankment is approximately 50 000 m^3.

The dam will be constructed of a homogeneous rockfill with a downstream drainage blanket. The rockfill will be placed in lifts no greater than 0.5 m and will be compacted in-place using 10-tonne vibratory rollers. It is expected that the rockfill will contain some fines and can be compacted to a suitable density. The rockfill and the final compaction requirements will be evaluated in the final design. A drainage blanket may not be required at Site No. 1 if the rock foundation is suitable. However, in the event that a blanket is required, the drainage blanket will consist of 1 m of select, processed drain rock surrounded by a 0.5 m thick filter blanket. The drain rock shall be placed in 0.5 m thick lifts and compacted in a similar fashion to the general fill. The drainage material may be obtained from sand and gravel tailings from placer mine operations located on Back Creek.

An emergency spillway 0.5 m deep and 10 m wide should be excavated in bedrock on the northwest pond corner. The spillway should carry water from the toe of the dam. The spillway channel should direct water to a small holding pond where the water can be recovered and treated prior to release. The holding pond has not been sized or located at this stage.

6.4 SEEPAGE CONSIDERATIONS

The foundations at Site No. 1 are expected to consist of fractured bedrock. Seepage through this bedrock could occur along cracks that are interconnected, resulting in locally high coefficients of permeability (Sowers, 1981). As a result, seepage out of an unlined tailings pond would be unacceptably high and lining of the pond is recommended.

Lining using locally available natural soils such as till is not considered feasible, as the only till locally available is buried beneath a deep sand layer and would be very expensive to recover. No other locally available soils are considered to have a coefficient of permeability low enough to warrant consideration. Lining using high density polyethylene is considered feasible, given the relatively small size of the pond, although the relative cost of the liner is high. Sand asphalt emulsion is also considered technically feasible for use as a liner. However, due to the high cost of $80/tonne quoted by contractors in Whitehorse for a sand-asphalt membrane, this type of liner system has not been pursued to a design level.

Lining of the pond using a sand-bentonite soil mix is considered most suitable. Gipson (1985) has indicated that a fine-grained sand similar to that found at the Mt. Nansen site, when mixed with approximately 5% bentonite by weight, will produce a soil liner with a permeability of approximately 10^{-7} cm/s. A soil layer with a thickness of 0.3 m is considered adequate.

The sand liner would be composed of a mixture of sand and bentonite clay, mixed with water and compacted. This layer may shrink and crack when exposed to sun and wind. The liner exposed above the water level may have to be kept moist during the summer exposure.

This liner is also subject to erosion by concentrated flowing tailings.

The tailings may have to be discharged close to the water level to avoid such damage.

Seepage from the lined pond has been estimated to be on the order of 2 l/s, assuming that an intact seepage barrier of sand-bentonite mix is placed in the pond. A mix of a sand-bentonite liner coupled with a plastic liner on the dam may prove to be more suitable for construction, but will be more costly than that estimated in Section 9. This combination will be evaluated during final design. It is recommended that sampling wells be located downhill from the tailings pond to monitor seepage volumes and water quality for verification of the estimated values.

The sampling wells should be of sufficient size to act as pumping wells capable of intercepting seepage from the pond, if the quantity of the water is greater than expected or if the quality of water in the effluent is worse than expected.

6.5 LINER BEDDING

For either of the proposed liners, an appropriate bedding or filter layer will be required. A plastic liner will require a bedding layer to remove the threat of punctures by sharp, larger gravel. In addition, bedding will eliminate voids into which plastic can stretch and fail under pressure. The bentonite-sand liner will require a suitable filter to control erosion and maintain the impervious characteristics of the liner.

6.6 LINER PROTECTION

The liner, either plastic or sand-bentonite, is subject to damage from ice or from plant facilities, such as the reclaim water pump barge intake, or pipe floats.

Exposed plastic liners can be displaced by windstorms. Appropriate anchor weights, sand and gravel liner, etc. should be applied to secure the plastic.

Tailing beaches should be developed around the pond to protect the liner and to establish a deep pond in the centre. This will allow tailings to be discharged through the ice next winter to avoid glaciation. The liner should have a sand and gravel protective zone established at the pump and floating pump facility for servicing activity.

6.7 LINER INSTALLATION - WEATHER LIMITATIONS

The sand-bentonite liner cannot be installed in freezing weather. The permeability of the liner can be increased if constructed with frozen lumps of sand, or on the surface of frozen, previously placed material. In addition, the bentonite and the water cannot be satisfactorily mixed to create the required impervious mixture.

The plastic liner can be installed in somewhat colder weather by experienced installers. The plastic has to be dry, and the heat sealing of the sheets has to be performed carefully.

In either case, installation in the summer is preferable.

7. "CROSS VALLEY" TAILINGS DAM DESIGN

7.1 GENERAL DESCRIPTION

Site No. 2 lies near elevation 1190 m, approximately 500 m east of the existing mill and approximately, 40 m below the existing mill grade. The site was chosen to provide a cross valley dam on upper Dome Creek where apparently stable ground was identified on air photos. A cross valley tailings dam was previously considered possible by Klohn Leonoff below the existing millsite on Dome Creek, provided that an area could be found with limited ice in the foundations. Two boreholes, DH 88-3 and DH 88-4, were drilled at Site No. 2 to investigate the foundations. The borehole locations are shown on Drawing B-3002.

The subsoil profile consists of approximately 9 m to 12 m of fine, poorly-graded sand overlying 2 m to 4 m of silty sand and gravel overlying 4.5 m to greater than 12 m of glacial till over weathered bedrock. The ground is permanently frozen and contains individual lenses of ice with soil as thick as 10 cm. Sampling was discontinuous. Standard penetration test samples were recovered at 1.5 m intervals only. However, on the basis of samples recovered and drill bit reaction during drilling, it is estimated that as much as 5% to 10% of the soil above bedrock could consist of ice.

Small dams have previously been successfully constructed over degrading permafrost. Side slopes can be built to provide overall embankment stability, and drainage measures can be provided to remove meltwater from the ice and relieve any excess pore water pressures generated by thawing.

7.2 TAILINGS DAM DESIGN - GENERAL

A tailings impoundment facility at Site No. 2 is considered possible. Borrow for the embankment can be obtained from waste rock prestripped from the open pit mine or from areas of thawed weathered bedrock and/or colluvium. Sand borrow can be used as fill, provided the sand is thawed prior to placement. Suitable sand may be locally present in terraces or localized prestripped areas. It is expected that use of waste rock from the mine area would result in a net saving to the project over the use of regular borrow, as the waste has to be removed for mine development.

A volume elevation curve for the pond is shown on Drawing A-3006. The results indicate that Stage I requires a crest elevation of 1200 m for storage of 150 000 tonnes of tailings, while Stage II requires a crest elevation of 1203 m. This corresponds to maximum dam heights of 15 m and 18 m. Placement of the entire dam in one stage or changing Stage I to contain only a one-year supply of tailings (75 000 tonnes) could be considered in final design. The final dam height has been sized to contain 300 000 tonnes of tailings.

Stripping of the vegetation will immediately cause the start of permafrost degradation and will result in difficult, soft, wet construction conditions. Consequently, stripping should be undertaken well in advance of construction to allow dissipation of excess water.

The dam will be constructed as a homogeneous rockfill or sandfill dam, with a downstream drainage blanket. The first lift shall be placed in a layer no thicker than 0.5 m and compacted by a 10 tonne vibrating roller. The drain blanket at Site No. 1 will be 1.0 m thick surrounded by a 0.5 m thick filter blanket. The rock shall be placed in 0.5 m lifts and compacted in a similar manner to the general fill. Fill placement for the tailings dam at Site No. 2 will require construction of a haul road from the proposed open pit area down into Dome Creek. All fill material shall be placed in a thawed condition to prevent the formation of frozen pervious layers within the dam.

Settlement of the dam crest will occur as the foundation thaws and deforms. Maintenance of the dam crest by the addition of some extra rockfill may be required during the life of the mine.

TABLE 8.1

SUMMARY OF AVAILABLE RECLAIM WATER

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
CASE I												
NET INFLOW	4.2	4.2	4.2	4.2	5.9	4.7	4.8	4.6	4.5	4.2	4.2	4.2
NET OUTFLOW	2.8	2.8	2.8	2.8	3.1	3.2	3.2	3.8	2.4	2.8	2.8	2.8
AVAILABLE RECLAIM	1.4	1.4	1.4	1.4	2.8	1.5	1.6	0.8	1.6	1.4	1.4	1.4
CASE II												
NET INFLOW	4.2	4.2	4.2	4.2	6.5	4.9	5.0	4.8	4.6	4.2	4.2	4.2
NET OUTFLOW	2.8	2.8	2.8	2.8	3.1	3.2	3.1	2.9	2.8	2.8	2.8	2.8
AVAILABLE RECLAIM	1.4	1.4	1.4	1.4	3.4	1.7	1.9	1.9	1.8	1.4	1.4	1.4
CASE III (1 in 10 year period dry year)												
NET INFLOW	4.2	4.2	4.2	4.2	5.4	4.5	4.6	4.5	4.4	4.2	4.2	4.2
NET OUTFLOW	2.8	2.8	2.8	2.8	4.2	4.4	4.2	3.8	3.3	2.8	2.8	2.8
AVAILABLE RECLAIM	1.4	1.4	1.4	1.4	1.2	0.1	0.4	0.7	1.1	1.4	1.4	1.4

TABLE 8.1

SUMMARY OF AVAILABLE RECLAIM WATER

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
CASE I												
NET INFLOW	4.2	4.2	4.2	4.2	5.9	4.7	4.8	4.6	4.5	4.2	4.2	4.2
NET OUTFLOW	2.8	2.8	2.8	2.8	3.1	3.2	3.2	3.8	2.4	2.8	2.8	2.8
AVAILABLE RECLAIM	1.4	1.4	1.4	1.4	2.8	1.5	1.6	0.8	1.6	1.4	1.4	1.4
CASE II												
NET INFLOW	4.2	4.2	4.2	4.2	6.5	4.9	5.0	4.8	4.6	4.2	4.2	4.2
NET OUTFLOW	2.8	2.8	2.8	2.8	3.1	3.2	3.1	2.9	2.8	2.8	2.8	2.8
AVAILABLE RECLAIM	1.4	1.4	1.4	1.4	3.4	1.7	1.9	1.9	1.8	1.4	1.4	1.4
CASE III (1 in 10 year period dry year)												
NET INFLOW	4.2	4.2	4.2	4.2	5.4	4.5	4.6	4.5	4.4	4.2	4.2	4.2
NET OUTFLOW	2.8	2.8	2.8	2.8	4.2	4.4	4.2	3.8	3.3	2.8	2.8	2.8
AVAILABLE RECLAIM	1.4	1.4	1.4	1.4	1.2	0.1	0.4	0.7	1.1	1.4	1.4	1.4

8.3.3 Surface Runoff

Surface runoff will be controlled by placing cutoff ditches to redirect water around the tailings pond area. Due to the small upslope drainage areas, only minor ditches need be constructed. The locations and design sections for both Site No. 1 and Site No. 2 ditches are shown on Drawing B-3002. The ditches were designed for the 1-hour 200-year return period storm presented in Section 4.3.4. This high intensity storm is expected to occur in July when no snow is on the ground. Thus no allowance was made for snowmelt during this event. Rain or snow events are not expected to be as severe.

Water may infiltrate into ditches excavated in the fractured bedrock. Lining of the ditches may be required to ensure that runoff is diverted away from the pond.

In the spring, when snowmelt begins or when infrequent rainstorms may occur, excessive snow and snow drifts must be cleared from the ditches to allow for the safe diversion of surface runoff. Every spring and fall, the ditch must be checked for vegetation build-up and subsidence due to permafrost action. Both of these may render the ditches useless for runoff control.

A longitudinal ditch slope of .5%, as shown on Drawing B-3002, is considered necessary to maintain safe conveyance of the storm water runoff within the ditches. Steeper gradients would result in excessively high velocities, leading to scour and possible loss of the ditches. The ditch dimensions shown on Drawing A-3008 may be exceeded without detrimental effects. The material removed from the ditches should be piled on the downslope side of the ditch to assist in surface water diversion.

8.3.4 Acid Mine Drainage

A detailed assessment of Acid Mine Drainage (AMD) is being undertaken by others. It is our understanding from preliminary results that the tailings have only a slight potential to create AMD (Environmental Protection Service 1982). The existing tailings ponds show no signs of AMD either at the pond or downstream in any seepage water. Vegetation downstream of the existing tailings pond does not appear to be showing signs of distress.

8.3.5 Reclamation

Abandonment and reclamation of the tailings pond is not considered to be a significant problem at Mt. Nansen. The ponds have a very small catchment area, hence water flows into the area will be limited.

Following completion of mining, all water remaining in the pond will be pumped to the mill, treated to acceptable standards and released. A spillway will be cut in bedrock to allow snowmelt or precipitation water to drain, and the tailings will be allowed to dry for one season. The dried pond surface will then be scarified and seeded to ensure stabilization of the fine sand.

9. COST ESTIMATE

A preliminary cost estimate has been prepared for each of the schemes previously discussed in Sections 6 and 7. A summary of the estimated costs for each scheme is summarized on Tables 9.1 and 9.2 below. The cost summary is based on unit rates estimated for direct costs only. The use of direct costs implies that all work will be done by the mine work force and not by a private contractor. Prices should be increased by 10% to allow for profit, and 10% to allow for office indirect costs if the work is contracted out. The estimate does not include the tailings transfer or water reclaim capital costs or any other operating costs. The estimate does not contain any future costs for engineering investigations, final design or construction inspection.

TABLE 9-1

COST ESTIMATE FOR TAILINGS POND SITE NO. 1

STAGE I

Item	Units	Quantity	Unit Rate	Cost
Mobilization and Demobilization	Lump Sum			$ 20,000
Rockfill	m^3	45 000	$ 4.20	189,000
Sandfill	m^3	7 500	5.20	39,000
Bentonite/Sand Mix Liner	m^2	30 000	7.60	228,000
Rock Drain	m^3	3 440	12.00	41,280
Ditching	lin m	650	12.00	7,800
Groundwater Monitoring/Pump Wells	each	6	3,000.00	18,000

LEAST COST COMBINATION FOR STAGE I = $543,080

STAGE II

Item	Units	Quantity	Unit Rate	Cost
Rockfill *Note 1	m^3	50 000	$ 5.00	250,000
Sandfill	m^3	8 900	5.20	46,280
Bentonite/Sand Mix Liner	m^2	35 000	7.60	266,000
Rock Drain	m^3	8 760	12.00	105,120

Note 1: Unit rate for rockfill in Stage II has risen due to the need to haul borrow around the pond.

LEAST COST COMBINATION FOR STAGE II = $ 667,400

TOTAL COST = $1,210,480

CONTINGENCY COST (30%) = $ 360,000

TOTAL ESTIMATE = $1,570,480

TABLE 9.2

COST ESTIMATE FOR TAILINGS POND SITE NO. 2

STAGE I

Item	Units	Quantity	Unit Rate	Cost
Rockfill	m^3	104 200	$ 5.00	$521,000
Sandfill	m^3	13 500	2.85	38,475
Bentonite/Sand Mix Liner	m^3	45 000	6.72	302,400
Drain	m^3	2 800	12.00	33,600
Ditching	lin m	550	12.00	6,600
Groundwater Monitoring/Pump Wells	each	6	3,000.00	18,000

LEAST COST COMBINATION FOR STAGE I = $920,075

STAGE II

Item	Units	Quantity	Unit Rate	Cost
Rockfill	m^3	72 500	$ 5.00	$362,500
Sandfill	m^3	6 900	2.85	19,665
Bentonite/Sand Mix Liner	m^3	23 000	6.72	154,560
Rock Drain	m^3	7 500	12.00	90,000

LEAST COST COMBINATION FOR STAGE II = $626,725

TOTAL COST = $1,546,800

CONTINGENCY COST (30%) = $ 464,000

TOTAL ESTIMATE = $2,010,800

10. CONCLUSIONS AND RECOMMENDATIONS

10.1 DAM DESIGN AND LOCATION

Two tailings pond sites have been evaluated as part of this study. Site No. 1 overlies bedrock at or near the surface and does not likely present stability problems for a compacted rockfill dam. However, due to the highly fractured nature of the bedrock, a liner is required to minimize seepage out of the pond. A total seepage rate of 2 l/s is estimated with a sand-bentonite liner in place.

Site No. 2 overlies frozen sand of considerable depth. The sand contains discrete ice lenses which will gradually melt following construction of the tailings pond facility. Deformation of the dam is expected due to the permafrost degradation, and monitoring of the dam crest elevation and possible maintenance of the dam to enhance stability will be required during the life of the mine. The proposed dam embankment will be designed to accommodate foundation deformation and crest spillway.

The density of the sand below the proposed structure is not known, but is probably compacted to loose when thawed. The possible design earthquake event which could occur at this site could liquefy loose, saturated sand. Consequently, additional work will be required if dam Site No. 2 is chosen.

If additional work indicates that the foundation soil deposits are too loose to be considered safe, then soil densification may be required as part of future work.

Calculated seepage quantities from both potential pond sites are similar, assuming a liner is used on both ponds. However, considerably more expense is required to construct the required liner at Site No. 2.

Additional foundation information will be required if Site 1 is selected. This was proposed late in the study, and no definitive on-site information was obtained.

Borrow material will have to be confirmed with test pits, and a source of filter/bedding sand and gravel will have to be defined.

The sand-bentonite liner, if selected, will require testing with some on-site sand to define the appropriate material proportions, the optimum water content and the resulting permeability.

Construction of embankment structures is influenced by weather conditions. Rockfill should not be placed in freezing weather, to avoid irregular settlements in the reservoir lining. A bentonite-sand liner is moisture and freezing weather sensitive. These operations should be scheduled for the brief summer months.

11. FIELD PROGRAM

11.1 DRILLING PROGRAM

A site investigation was carried out from October 7 to 13, 1988, using a CME 750 drill rig owned by Midnight Sun Drilling Company Ltd., to drill a total of four boreholes. The borehole locations are shown on Drawing B-3002.

Drilling was initially undertaken using 222 mm diameter, hollow stem augers. However, penetration was very slow, so the drill string was switched to 150 mm diameter, solid stem augers. A significantly faster penetration rate was achieved.

Standard penetration tests (SPT) were performed every 5 ft (1.5 m) to obtain a sample. The soil was identified visually, then the ground temperature was measured. The SPT blow counts were recorded as shown in the borehole logs in Appendix I. However, because permafrost was encountered in all holes, the SPT numbers do not provide relative density information since the established relationships are based on thawed ground conditions.

Borehole depths varied from 13.7 m to 29.0 m. Weathered bedrock was encountered in holes DH-88-1 and DH-88-3. Bedrock was not encountered in holes DH-88-2 and DH-88-4. The solid stem augers were able to penetrate the weathered bedrock without the use of coring equipment.

Relative densities of the soil deposits encountered in the drilling program were estimated in the field to vary from loose to medium compact. This approximation is based on the visual examination of the soil structure of the frozen SPT sample, and from the observation of some of the unfrozen portions of the sample after they were bagged and thawed. The water content of the bagged samples could only be compared to the approximate saturation level of that particular soil type. The sample depths are shown on the borehole logs in Appendix I.

Standpipe piezometers were not installed in the borehole due to the presence of permafrost. Groundwater was not encountered during drilling.

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APPENDIX I

BOREHOLE LOGS

TEST HOLE LOG

VERTICAL SCALE 1:100

DATE DRILLED October 7-8, 1988

DRILL TYPE C.M.E. 750, solid stem auger

ELEVATION GROUND ~ 1135 m from topo drawings

CO-ORD. LOCATION not surveyed (refer to Dwg. B-3002)

SAMPLE DATA

HAMMER MASS 63.5 kg

DROP HEIGHT 0.762 m

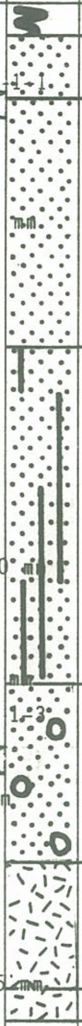
PIEZOMETER DETAILS

COHESION kPa 10 30 50 70 90

● FIELD VANE △ LAB VANE ■ UNCONF.

PLASTIC LIMIT X ----- WATER CONTENT O ----- LIQUID LIMIT X

10 30 50 70 90%



DEPTH ELEV. (m)	O.D. I.D.	BLOWS 0.3m	NO.	SYMBOL		DESCRIPTION OF MATERIAL
					0.4	Organics, black moss
			Sa-1	1-1		
2		49			1.3	Grey medium sand - trace of silt ~10% fines content - no visible ice
		37 for 25 mm				Light grey, fine to medium, sand - little silt ~5% fines content - some gravel below 3.0 m depth - visible ice lenses below 3.0 m depth (V_s, V_x)
4						
		60			4.6	Brown silty sand - some gravel - ~15% fines content - visible ice inclusions and lenses (V_s, V_x)
6		106				
8		82 for 250 mm				
		20 for 25 mm			9.1	Light brown sand and gravel - some silt ~10% fines content - visible ice in the form of one ice inclusion 5 mm diameter and 0.5 mm horizontal lens. (V_s, V_x)
			Sa-2	1-3		
10		53 for 175 mm				
					11.4	Black and light brown colour weathered rock - from silt to gravel size particles - ice inclusions 3 mm diameter - ice lenses 2mm thick (V_s,V_x)
12						
		48 for 75 mm			13.2	
					13.7	Light brown colour rock fragments Unweathered bedrock
14	Total Depth = 13.7 m					
16						

Note: Hole was backfilled with cuttings, then sealed at depth 0.5 to 0.8 m with a bentonite plug. No piezometer installation.

The symbols shown in the sample no. column represent undisturbed samples that were bagged and taken to the Richmond office.

KLOHN LEONOFF
CONSULTING ENGINEERS

JOB No. PB 3574 0301

PROJECT Mt. Nansen Gold Mine

LOCATION Yukon Territory

HOLE No. DH-88-1

DATE October 7,8/88 PLATE page 1 of 1

TEST HOLE LOG

VERTICAL SCALE 1:100

DATE DRILLED October 8 to 10, 1988

DRILL TYPE CME 750, solid stem auger

ELEVATION GROUND ~ 1130 m from topo drawings

CO-ORD. LOCATION not surveyed (refer Dwg. B-3002)

SAMPLE DATA

HAMMER MASS 63.5 kg

DROP HEIGHT 0.762 m

DEPTH ELEV. (m)	O.D. I.D. 17.8	BLOWS 0.3m cm	NO.
		39	
2		30 for 25 mm	
		117	Sa-1
4		128	
6		37 for 100 mm	
8		39 for 150 mm	
		32 for 25 mm	
10		64 for 150 mm	
12		30 for 25 mm	Sa-2
14		55 for 150 mm	
		75 for 75 mm	
16		79 for 150 mm	Sa-3
18		64 for 150 mm	Sa-4
20		152	Sa-5

SYMBOL

DESCRIPTION OF MATERIAL

Moss, grass, black organics

0.6

Grey medium sand
- ~5% fines content
- visible ice inclusions 4 mm dia.
- visible ice lenses 0.5 mm thick (vertical)
- temperature -4°C
- no visible ice in sample at 3.1 m
- one visible ice lense at depth 4.5 m (V_s)

6.1

Light brown sand and gravel
- ~10% fines content
- angular gravel particles
- visible ice coatings on some gravel particles
- temperature -4°C (V_c)

9.1

Grey fine to medium sand
- visible ice in sample, two 1 cm thick ice lenses. Some sections were ice with grey sand
- ~5% fines content (V_x,V_s)

11.1

Light brown sand and gravel
- subangular gravel particles
- no visible ice
- temperature -4°C
- ~10 to 15% fines content

13.0

Grey fine sand ~5% fines content
- contains trace of organics (reed like)
- no visible ice
- temperature -4°C

15.2

Olive green silty sand, changing to silty sand and gravel at 16.8 m
- no visible ice
- temperature -2 to -3°C

18.3

See page 2 for soil description

PIEZOMETER DETAILS

COHESION kPa

10 30 50 70 90

● FIELD VANE △ LAB VANE ■ UNCONF.

PLASTIC LIMIT X ---- WATER CONTENT O ---- LIQUID LIMIT X

10 30 50 70 90%

KLOHN LEONOFF
CONSULTING ENGINEERS

JOB No. PB 3574 0301

PROJECT Mt. Nansen Tailings Dam

LOCATION Yukon Territory

HOLE No. DH-88-2

DATE Oct. 8-10/88 PLATE 1 of 2

~~KLOHN LEONOFF~~

TEST HOLE LOG

VERTICAL SCALE 1:100

SAMPLE DATA

HAMMER MASS 63.5 kg

DROP HEIGHT 0.762 m

DATE DRILLED October 8 to 10, 1988

DRILL TYPE CME 750, solid stem auger

ELEVATION GROUND ~ 1130 m from topo drawings

CO-ORD. LOCATION not surveyed (refer Dwg. B-3002)

PIEZOMETER DETAILS

COHESION kPa 10 30 50 70 90

● FIELD VANE △ LAB VANE ■ UNCONF.

PLASTIC LIMIT X ---- WATER CONTENT O ---- LIQUID LIMIT X

10 30 50 70 90%

DEPTH ELEV.	O.D. I.D.	BLOWS 0.3m	NO.
20.0			
		58	Sa-6
22			
24			
26			
28			Sa-7
		Total	Depth

SYMBOL

DESCRIPTION OF MATERIAL

Black silty sand and gravel
(weathered rock?)
- no visible ice
- temperature -3°C
- depth 18.0 to 18.3 m

21.3

Olive green silt to silty sand
- visible ice, one 5 mm thick horizontal lens found in SPT sample
- temperature -2°C

(V_s)

26.8

Brown silty clay
- visible ice in SPT samples and off the end of the augers was in the form of horizontal ice layers 3 mm thick, and ice inclusions
- sample DH-88-2-6 did not have visible ice
- temperature -4 to -1°C

(V_s, V_x)

29.0

Light grey silt
- some fine gravel particles

Note: Hole was backfilled with cuttings, then a bentonite seal was installed at depth 0.6 m to 0.9 m.
No piezometer installation.

The symbols shown in the sample no. column represent undisturbed samples that were bagged and taken to the Richmond office.

KLOHN LEONOFF
CONSULTING ENGINEERS

JOB No. PB 3574 0301

PROJECT Mt. Nansen Tailings Dam

LOCATION Yukon Territory

HOLE No. DH-88-2

DATE Oct. 8-10/88 PLATE 2 of 2

TEST HOLE LOG

VERTICAL SCALE 1:100

DATE DRILLED October 10 to 12, 1988

DRILL TYPE CME 750, solid stem auger

ELEVATION GROUND ~ 1160 m from topo drawing

CO-ORD. LOCATION not surveyed (refer Dwg. B-3002)

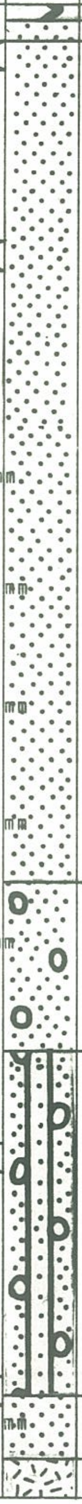
SAMPLE DATA

HAMMER MASS 63.5 kg

DROP HEIGHT 0.762 m

DEPTH ELEV. (m)	O.D. I.D.	BLOWS 0.3m	NO.
		Sieve	Sa-1
		7	
2		35	
		Sieve	Sa-2
		127	
4		113	
6		27 for 25 mm	
8		32 for 100 mm	
		68 for 150 mm	
10		87 for 150 mm	
12		33 for 75 mm	
14		35	
		Sieve	Sa-3
		39	
16		81	
18			Sa-4
		84 for 250 mm	
20			

SYMBOL



PIEZOMETER DETAILS

DESCRIPTION OF MATERIAL

0.05 — Moss, grass, organics

0.4 — White silty sand (volcanic ash) mixed with organics

Light brown, clean fine to medium sand
- banded colour layers angled ~30° to the horizontal
- occassional gravel particles detected by reaction of augers to drilling
- ~2 to 10% fines content range
- visible ice noted in SPT samples at depth 9.4 m in the form of one lens 4 mm thick, plus a 0.1 m length of ice with sand and (V_s,V_x) gravel interspaced within the ice
- no other SPT samples had visible ice
- temperature -3 to -5°C below depth 2.4 m. Above depth 2.4 m was +2°C.
- dense deposit with active zone (loose surface at depth 0.6 m)

Light brown, clean sand and gravel
- angular gravel particles
- no visible ice
- temperature -5°C

11.7

14.0 — Medium brown, silty sand and gravel
- 30.9% fines content
- visible ice in the form of layers from 2 mm to 50 mm thick in SPT samples (V_s,V_x)
- no visible ice in SPT sample at depth 17.1 m
- temperature -4.5 to -5.5°C
- sample DH-88-3-3 did not have visible ice
  (GLACIAL TILL)

18.5 — Purple/grey silty sand (weathered rock)
- no visible ice
- temperature -6°C

19.4

COHESION kPa

10 30 50 70 90

● FIELD VANE △ LAB VANE ■ UNCONF.

PLASTIC LIMIT X ----- WATER CONTENT O ----- LIQUID LIMIT X

10 30 50 70 90%

o 4.3% water content

o 20.4% water content

o 13.9% water content

o 14.9% water content

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CONSULTING ENGINEERS

JOB No. PB 3574 0301

PROJECT Mt. Nansen Tailings Dam

LOCATION Yukon Territory

HOLE No. DH-88-3

DATE Oct. 10-12/88 PLATE 1 of 2

KLOHN LEONOFF

TEST HOLE LOG

VERTICAL SCALE 1:100

SAMPLE DATA

HAMMER MASS 63.5 kg

DROP HEIGHT 0.762 m

DEPTH ELEV.	O.D. I.D.	BLOWS 0.3m	NO.	SYMBOL
(m) -	Total Depth			

DATE DRILLED October 10 to 12, 1988

DRILL TYPE CME 750, solid stem auger

ELEVATION GROUND ~ 1160 m from topo drawing

CO-ORD. LOCATION not surveyed (refer Dwg. B-3002)

PIEZOMETER DETAILS

COHESION kPa: 10 30 50 70 90

● FIELD VANE △ LAB VANE ■ UNCONF.

PLASTIC LIMIT X ----- WATER CONTENT O ----- LIQUID LIMIT X

10 30 50 70 90%

DESCRIPTION OF MATERIAL

20.1 Purple/grey bedrock
- rock fragments found on auger drill bit. No SPT sample taken

Note: Hole was backfilled with cuttings then a bentonite seal was placed from depth 2.4 to 2.7 m (at bottom of active zone)
No piezometer was installed.
The symbols shown in the sample no. column represent undisturbed samples that were bagged and taken to the Richmond office.

KLOHN LEONOFF
CONSULTING ENGINEERS

JOB No. PB 3574 0301

PROJECT Mt. Nansen Tailings Dam

LOCATION Yukon Territory

HOLE No. DH-88-3

DATE Oct. 10-12/88 PLATE 2 of 2

~~KLOHN LEONOFF~~

TEST HOLE LOG

VERTICAL SCALE

DATE DRILLED October 12 to 13, 1988

DRILL TYPE CME 750, solid stem aguer

ELEVATION GROUND ~ 1155 m from topo drawing

CO-ORD. LOCATION not surveyed (refer Dwg. B-3002)

SAMPLE DATA

HAMMER MASS 63.5 kg

DROP HEIGHT 0.762 m

DEPTH ELEV. (m)	O.D. I.D.	BLOWS 0.3m	NO.
		36	
			Sieve Sa-4
2		82	☒
		101	
4			
		99 for 175 mm	
6		25 for 25 mm	
8		50 for 125 mm	
		23 for 75 mm	
10			
		14 for 25 mm	
12			
		25 for 50 mm	
14		15 for 100 mm	
			Sa-2
16		80	☒
18			
20			

SYMBOL

PIEZOMETER DETAILS

DESCRIPTION OF MATERIAL

0.2 — Moss, grass, organics

Dark brown fine sand
- 7.5% fines content
- with organics
- visible ice in organic contaminated layers in the form of ice inclusions (V_x)
- temperature -5°C to -6°C

3.4 — Grey fine to medium sand
- visible ice in the form of one 1.0 mm thick vertical lens at depth 3.4 m (V_x)

  Other SPT samples had no visible ice
- temperature -5 to -6°C

9.4 — Greyish brown sand and gravel
- ~5 to 10% fines content
- angular gravel particles (colluvium?)
- no visible ice
- temperature -6°C

13.0 — Black silty sand (weathered rock)
- as detected on the augers when pulling out for SPT test at depth 13.0 m

14.0 — Olive brown silty sand and gravel
- ~20 to 25% fines content (Glacial Till)
- visible ice in the form of 1.0 mm thick vertical lenses. Otherwise no visible ice (V_x)
- temperature -6°C

COHESION kPa

10 30 50 70 90

● FIELD VANE △ LAB VANE ■ UNCONF.

PLASTIC LIMIT X ----- WATER CONTENT O ----- LIQUID LIMIT X

10 30 50 70 90%

O 24.5% water content

O 14.5% water content

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CONSULTING ENGINEERS

JOB No. PB 3574 0301

PROJECT Mt. Nansen Tailings Dam

LOCATION Yukon Territory

HOLE No. DH-88-4

DATE Oct. 12-13/88 PLATE 1 of 2

TEST HOLE LOG

VERTICAL SCALE 1:100

SAMPLE DATA

HAMMER MASS 63.5 kg

DROP HEIGHT 0.762 m

DATE DRILLED October 12 to 13, 1988

DRILL TYPE CME 750 , solid stem auger

ELEVATION GROUND ~ 1155 m from topo drawing

CO-ORD. LOCATION not surveyed (refer Dwg. B-3002)

PIEZOMETER DETAILS

COHESION kPa: 10 30 50 70 90

● FIELD VANE △ LAB VANE ■UNCONF.

PLASTIC LIMIT X ----- WATER CONTENT O ----- LIQUID LIMIT X

10 30 50 70 90%

DEPTH ELEV.	O.D. I.D.	BLOWS 0.3m	NO.
22			
24			
		27 for 50 mm	
			Sa-3
26		15 for 20 mm	
	Total Depth		

DESCRIPTION OF MATERIAL

- continued silty sand and gravel as described on page 1

Brown sand and gravel
- ~10 to 15% fines content
- less silt than overlying deposit

24.7

Brown silty sand and gravel
- ~20 to2 5% fines content (Glacial Till)
- Similar to deposit of depth 14.0 to 24.7 m

26.2

Note: Total depth of borehole did not reach bedrock. The hole was backfilled with cuttings with a bentonite seal from depth 0.2 to 0.7 m

No piezometer was installed.

The symbols shown in the sample no. column represent undisturbed samples that were bagged and taken to the Richmond office.

KLOHN LEONOFF
CONSULTING ENGINEERS

JOB No. PB 3574 0301

PROJECT Mt. Nansen Tailings Dam

LOCATION Yukon Territory

HOLE No. DH-88-4

DATE Oct. 12-13/88 PLATE 2 of 2

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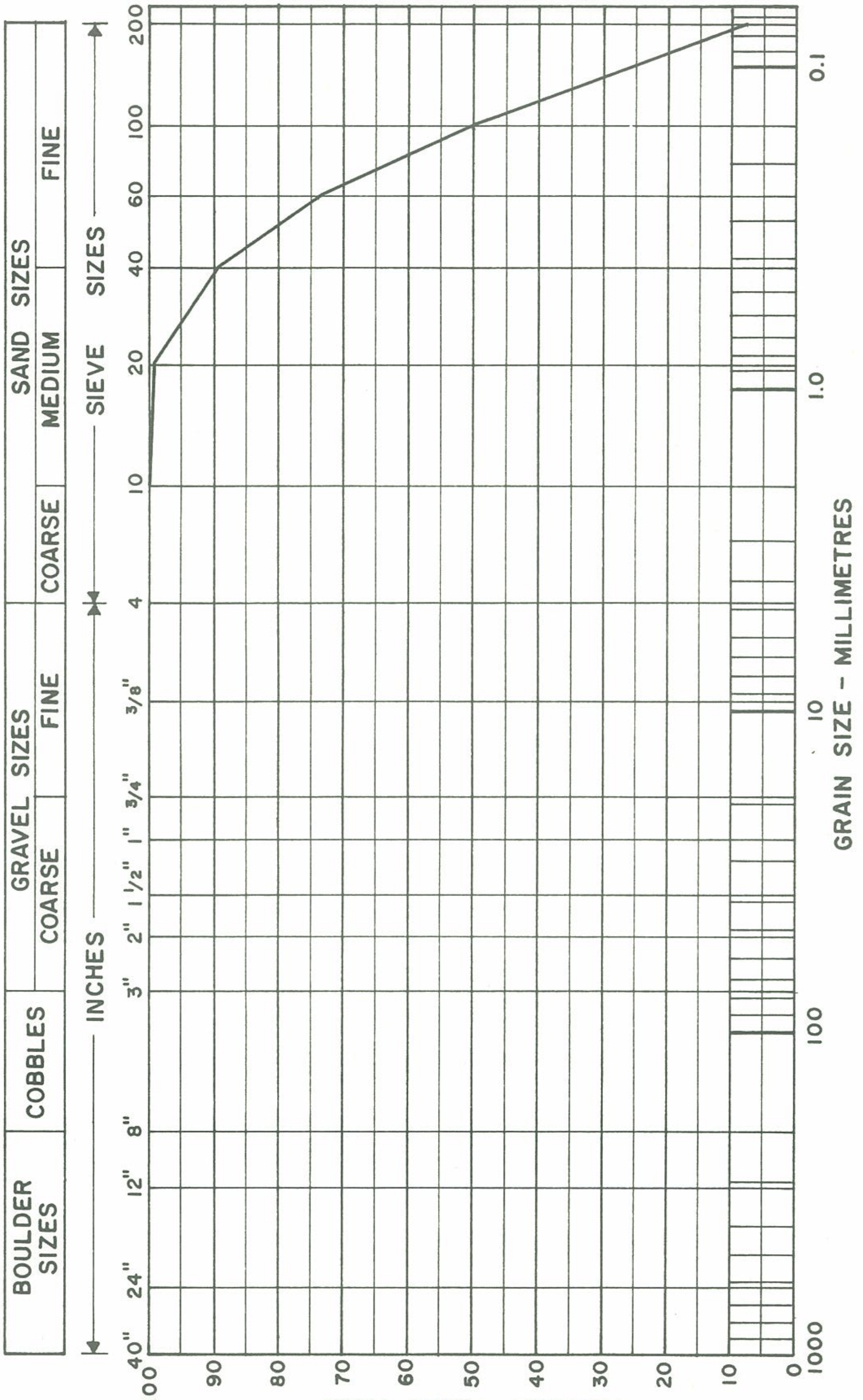
APPENDIX II

LABORATORY TESTS

GRAIN SIZE CURVE

GRANULAR SOILS



REMARKS: Drillhole DH 88-4 S.P.T. Sample

Sa-1 Depth 1.8 m

KLOHN LEONOFF
CONSULTING ENGINEERS

JOB No. PB 3574 0301

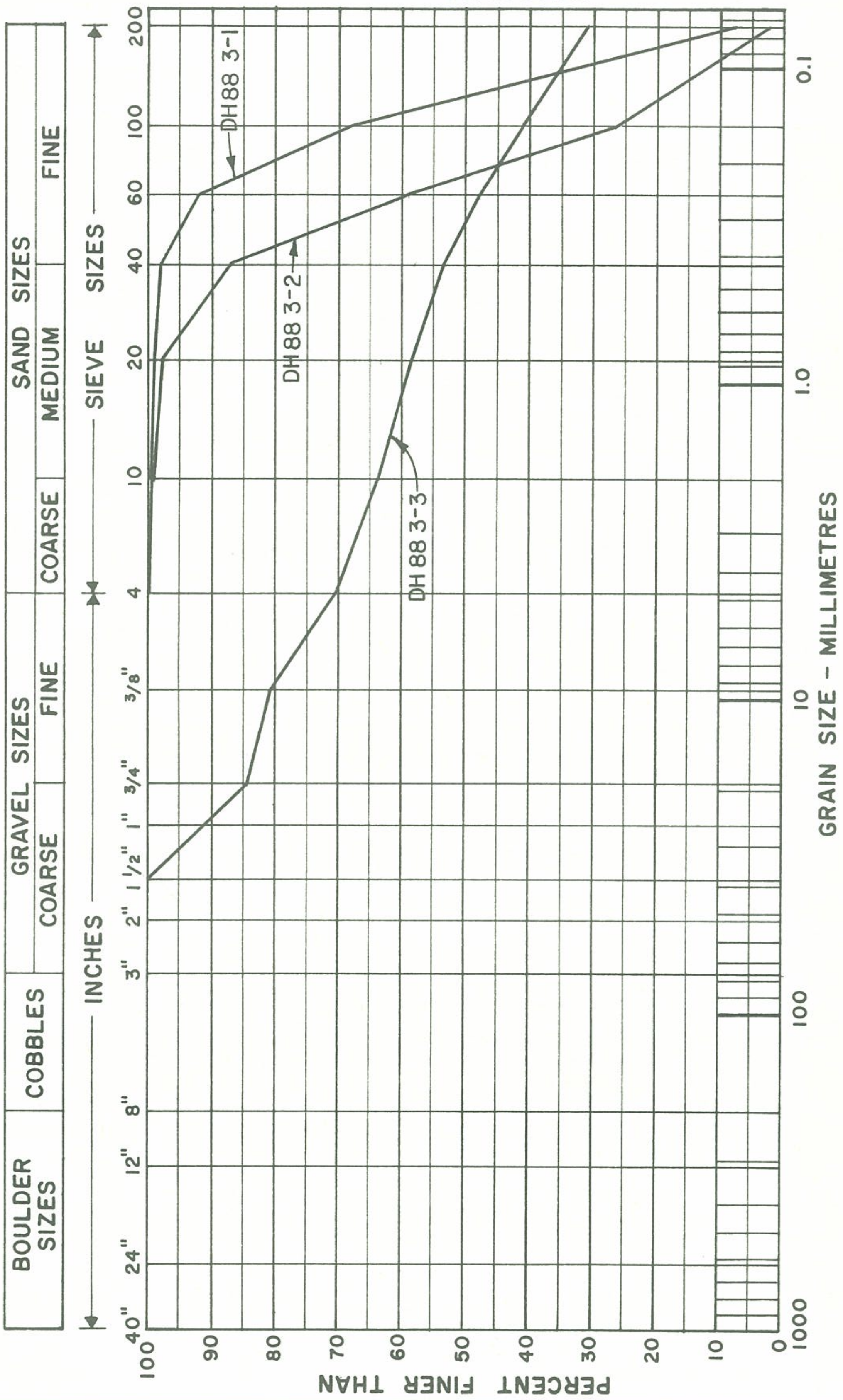
PROJECT Mt. Nansen Gold Mine

LOCATION Yukon Territory

HOLE No. DH 88-4 **DEPTH** 1.8 m

DATE November 7, 1988

GRAIN SIZE CURVE
GRANULAR SOILS



REMARKS: Drillhole DH 88-3 S.P.T. Samples

Sa-1 Depth 0.4 m

Sa-2 Depth 3.4 m

Sa-3 Depth 15.5 m

KLOHN LEONOFF
CONSULTING ENGINEERS

JOB No.	PB 3574 0301
PROJECT	Mt. Nansen Gold Mine
LOCATION	Yukon Territory
HOLE No.	DH 88-3 DEPTH
DATE	November 7, 1988

KLOHN LEONOFF

APPENDIX III

SEISMIC EVALUATION

ENERGY, MINES AND
RESOURCES CANADA
GEOLOGICAL SURVEY OF CANADA

ENERGIE, MINES ET
RESSOURCES CANADA
COMMISSION GEOLOGIQUE DU CANADA

SEISMIC RISK CALCULATION * CALCUL DE RISQUE SEISMIQUE *

REQUESTED BY/ DEMANDE PAR IAN BRUCE / KLOHN LEONOFF CONSULTANTS MJG

SITE MT. NANSEN, YUKON

LOCATED AT/ SITUE AU 62.05 NORTH/NORD 137.17 WEST/OUEST

PROBABILITY OF EXCEEDENCE PER ANNUM/ PROBABILITE DE DEPASSEMENT PAR ANNEE	0.010	0.005	0.0021	0.001
PROBABILITY OF EXCEEDENCE IN 50 YEARS/ PROBABILITE DE DEPASSEMENT EN 50 ANS	40 %	22 %	10 %	5 %
PEAK HORIZONTAL GROUND ACCELERATION (G) ACCELERATION HORIZONTALE MAXIMALE DU SOL (G)	0.057	0.074	0.095	0.117
PEAK HORIZONTAL GROUND VELOCITY (M/SEC) VITESSE HORIZONTALE MAXIMALE DU SOL (M/SEC)	0.126	0.163	0.217	0.262

* REFERENCES

1. NEW PROBABILISTIC STRONG SEISMIC GROUND MOTION MAPS OF CANADA: A COMPILATION OF EARTHQUAKE SOURCE ZONES, METHODS AND RESULTS. P.W. BASHAM, D.H. WEICHERT, F.M. ANGLIN, AND M.J. BERRY EARTH PHYSICS BRANCH OPEN FILE NUMBER 82-33, OTTAWA, CANADA 1982.

2. ENGINEERING APPLICATIONS OF NEW PROBABILISTIC SEISMIC GROUND-MOTION MAPS OF CANADA A.C. HEIDEBRECHT, P.W. BASHAM, J.H. RAINER, AND M.J. BERRY CANADIAN JOURNAL OF CIVIL ENGINEERING, VOL. 10, NO. 4, P. 670-680, 1983.

3. NEW PROBABILISTIC STRONG GROUND MOTION MAPS OF CANADA. P.W. BASHAM, D.H. WEICHERT, F.M. ANGLIN, AND M.J. BERRY, BULLETIN OF THE SEISMOLOGICAL SOCIETY OF AMERICA, VOL. 75, NO. 2, P. 563-595, 1985.

4A. SUPPLEMENT TO THE NATIONAL BUILDING CODE OF CANADA 1985, NRCC NO. 23178.
CHAPTER 1: CLIMATIC INFORMATION FOR BUILDING DESIGN IN CANADA.
CHAPTER 4: COMMENTARY J: EFFECTS OF EARTHQUAKES.

4B. SUPPLEMENT DU CODE NATIONAL DU BATIMENT DU CANADA 1985, CNRC NO 23178F.
CHAPITRE 1: DONNEES CLIMATIQUES POUR LE CALCUL DES BATIMENTS AU CANADA.
CHAPITRE 4: COMMENTAIRE J: EFFETS DES SEISMES.

19-OCT-88 18:57:40

SITE MT. ANSEN, YUKON

ZONING FOR ABOVE SITE/ ZONAGE DU SITE CI-DESSUS

1985 NBCC/CNBC: ZA = 2; ZV = 4; V = 0.20 M/S

ACCELERATION ZONE/ ZONE D'ACCELERATION ZA=2
ZONAL ACCELERATION/ ACCELERATION ZONALE 0.10 G

VELOCITY ZONE/ ZONE DE VITESSE ZV=4
ZONAL VELOCITY/ VITESSE ZONALE 0.20 M/S

1985 NBCC/CNBC **
SEISMIC ZONING MAPS/ CARTES DU ZONAGE SEISMIQUE

PROBABILITY LEVEL: 10% IN 50 YEARS
NIVEAU DE PROBABILITE: 10% EN 50 ANNEES

G OR M/S	ZONE	ZONAL VALUE/ VALEUR ZONALE
0.00		
	0	0.00
0.04		
	1	0.05
0.08		
	2	0.10
0.11		
	3	0.15
0.16		
	4	0.20
0.23		
	5	0.30
0.32		
	6*	0.40

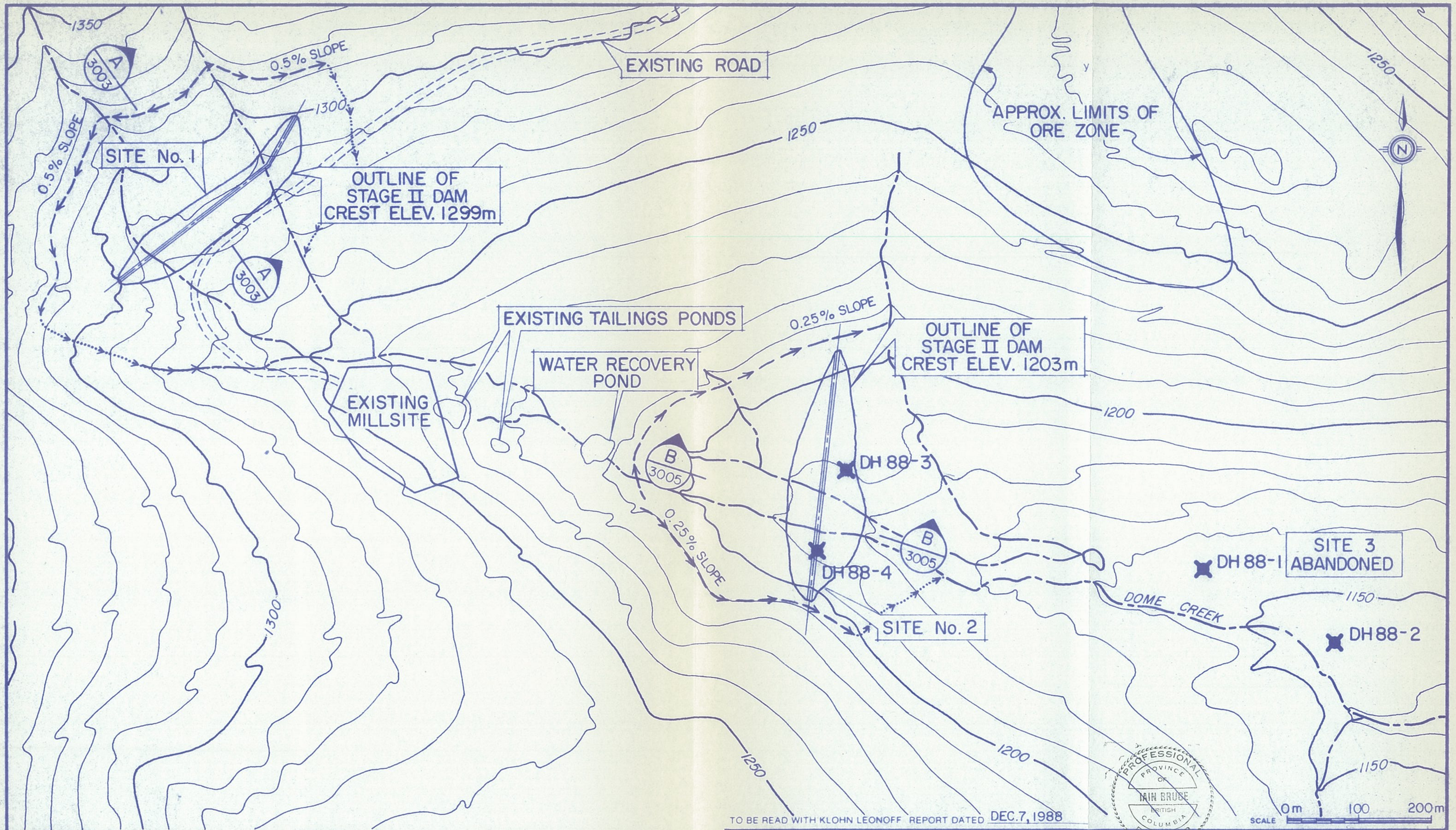
* ZONE 6: NOMINAL VALUE/ VALEUR NOMINALE 0.40;
SITE-SPECIFIC STUDIES SUGGESTED FOR IMPORTANT PROJECTS/
ETUDES COMPLEMENTAIRES SUGGEREES POUR DES PROJETS D'IMPORTANCE.

** FOR NBCC APPLICATIONS, CALCULATED ZONE VALUES AT A SITE SHOULD BE REPLACED BY EFFECTIVE ZONE VALUES [ZA(EFF) OR ZV(EFF)] AS SHOWN BELOW/ POUR APPLICATIONS SELON LE CNBC, ON DOIT REMPLACER LES VALEURS ZONALES CALCULEES POUR UN SITE PAR LES VALEURS EFFECTIVES [ZA(EFF) OU ZV(EFF)] COMME MONTRE CI-DESSOUS:

1. IF/SI (ZA - ZV) > 1, ===> ZA(EFF) = ZV + 1.
OR/OU
2. IF/SI (ZA - ZV) < 1, ===> ZA(EFF) = ZV - 1.
OR/OU
3. IF/SI ZV=0 AND/ET ZA > 0, ===> ZV(EFF) = 1.

(SEE REFERENCE 2 CITED ABOVE, PAGE 677)
(VOIR PAGE 677 DE LA REFERENCE 2 CI-DESSUS)

19-OCT-88 18:57:40



TO BE READ WITH KLOHN LEONOFF REPORT DATED DEC. 7, 1988

LEGEND:

— — → — — →	DIVERSION DITCH
········→········→	LINED DIVERSION DITCH (TO BE DESIGNED LATER)
✖	DRILL HOLE LOCATION (NOT SURVEYED)

NOTE:

1. SEE DRAWING A-3007 FOR MINIMUM DIVERSION DITCH DIMENSIONS.
2. CONTOURS OBTAINED FROM ORTHO-PHOTO SUPPLIED BY ARCHER CATHRO ASSOCIATES AT SCALE OF 1:5000

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CONSULTING ENGINEERS

CLIENT:
CHEVRON RESOURCES CANADA LTD.

PROJECT
MOUNT NANSEN GOLD PROJECT

TITLE
LOCATION OF BOREHOLES AND DAM OUTLINES

DATE OF ISSUE
DEC. 7, 1988

APPROVED
I Bruce

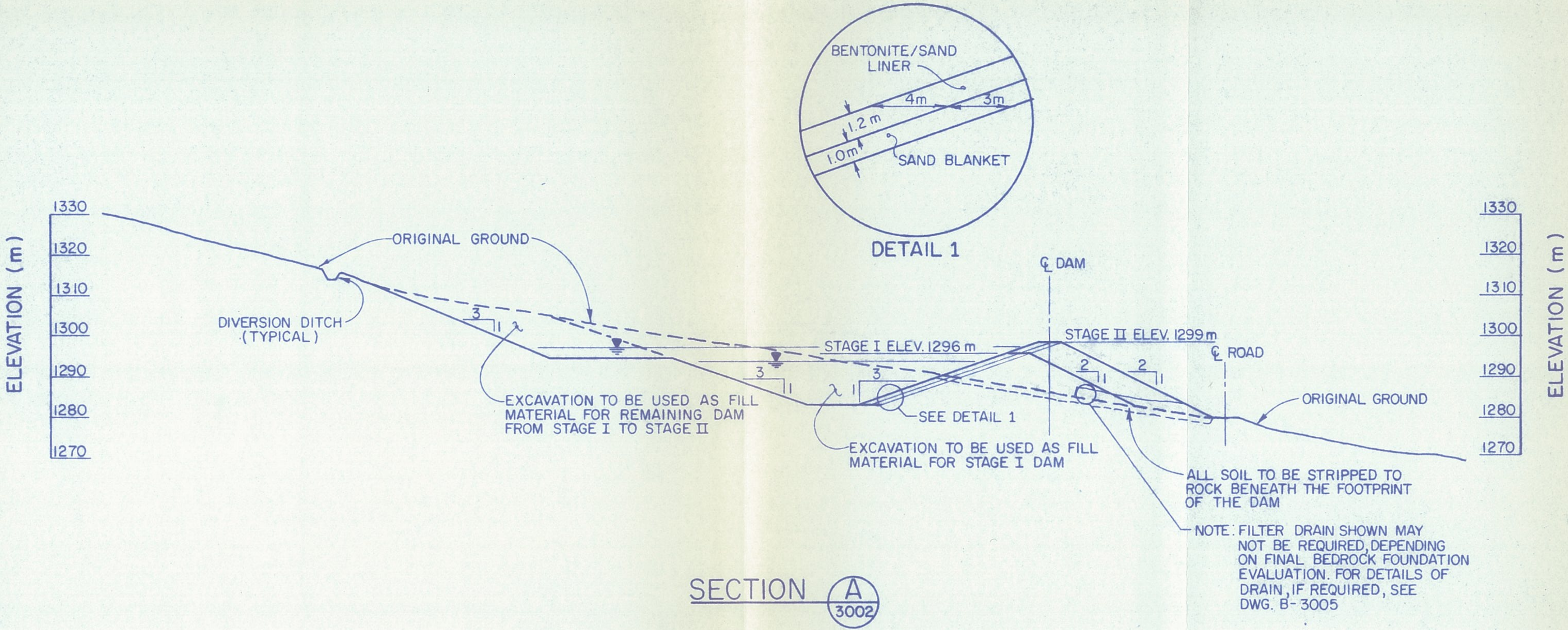
PROJECT No.
PB 3574 03

DWG. No.
B-3002

REV.

IAIN BRUCE

NCI - 802 - KL



SECTION A/3002

TAILINGS DAM FOUNDED ON "THAWED" BEDROCK

NOTE:

THE SECTION SHOWN ASSUMES THAT STAGE II FILL IS OBTAINED FROM WITHIN THE PROPOSED POND. IF ROCK FILL IS OBTAINED FROM THE OPEN PIT, THE FINAL DESIGN CREST ELEVATION WILL BE RAISED 2m TO 1301 m.

TO BE READ WITH KLOHN LEONOFF REPORT DATED DEC. 7, 1988

SCALE 0m 10 20 30 40m

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CLIENT: CHEVRON RESOURCES CANADA LTD.

PROJECT: MOUNT NANSEN GOLD PROJECT

TITLE: SITE No. 1
CROSS SECTION

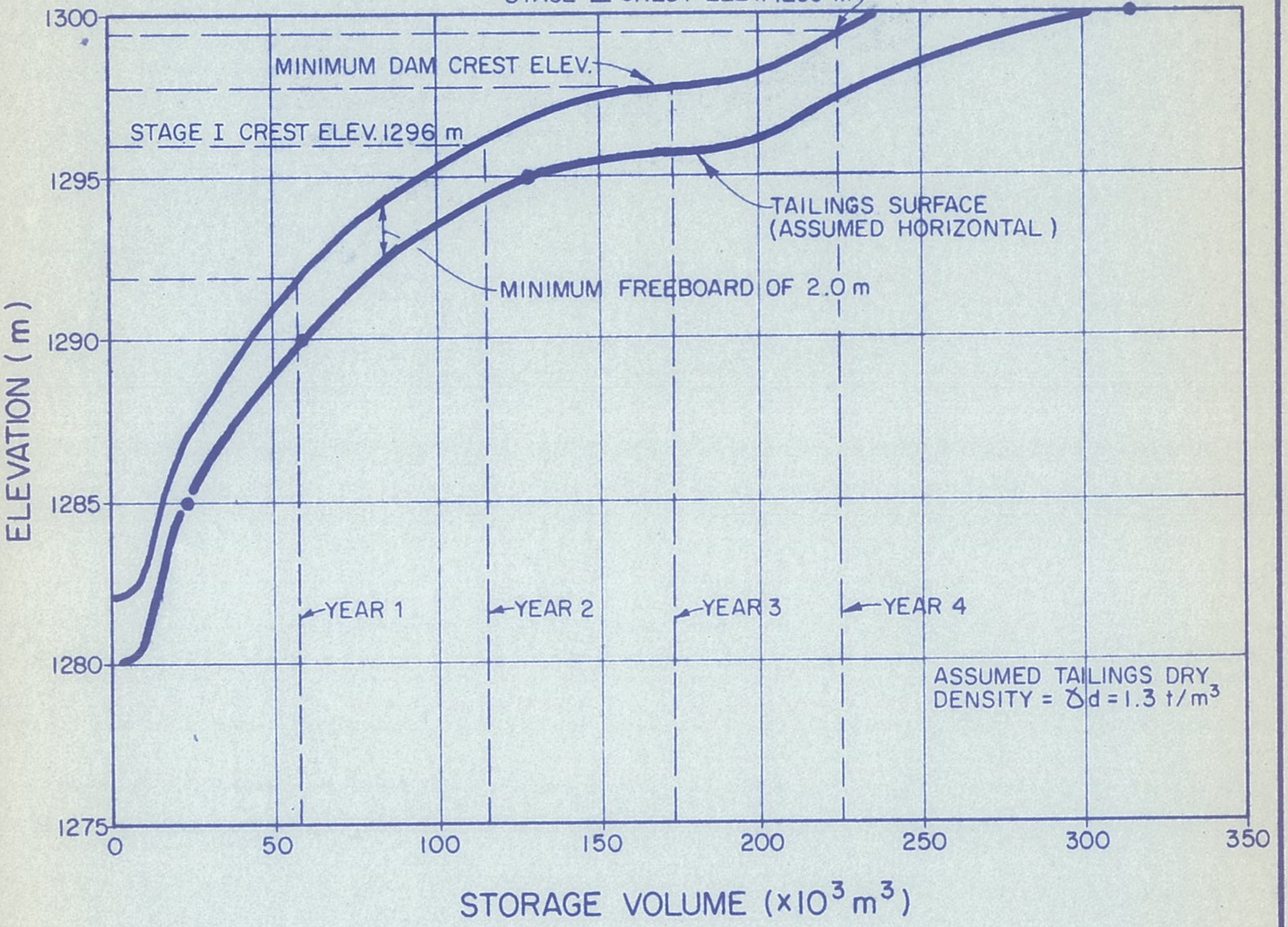
IAIN BRUCE

DATE OF ISSUE: DEC. 7, 1988
APPROVED:
PROJECT No.: PB 3574 03
DWG. No.: B-3003
REV.:

NCI-802-KL

SITE No. 1

MILLSITE TAILINGS DAM



NOTE:

CREST ELEVATIONS SHOWN ASSUME THAT ROCK FILL OBTAINED FOR THE DYKE COMES FROM WITHIN THE POND AREA.

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SCALE

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PROJECT
MOUNT NANSEN GOLD PROJECT

TITLE
SITE No. 1
STORAGE / ELEVATION CURVE

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PB 3574 03

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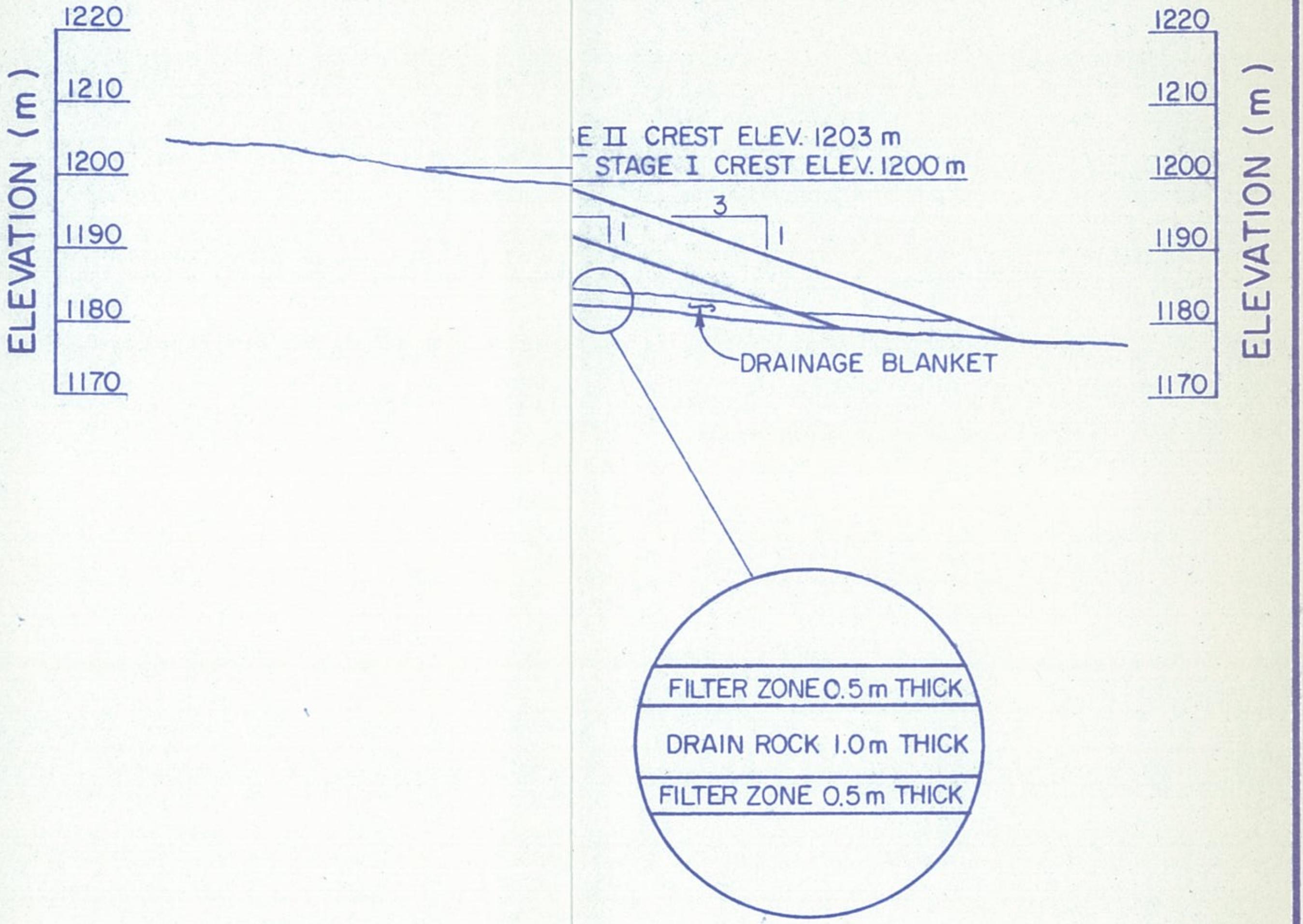
A-3004

REV.

NCI-760



PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
IAIN BRUCE

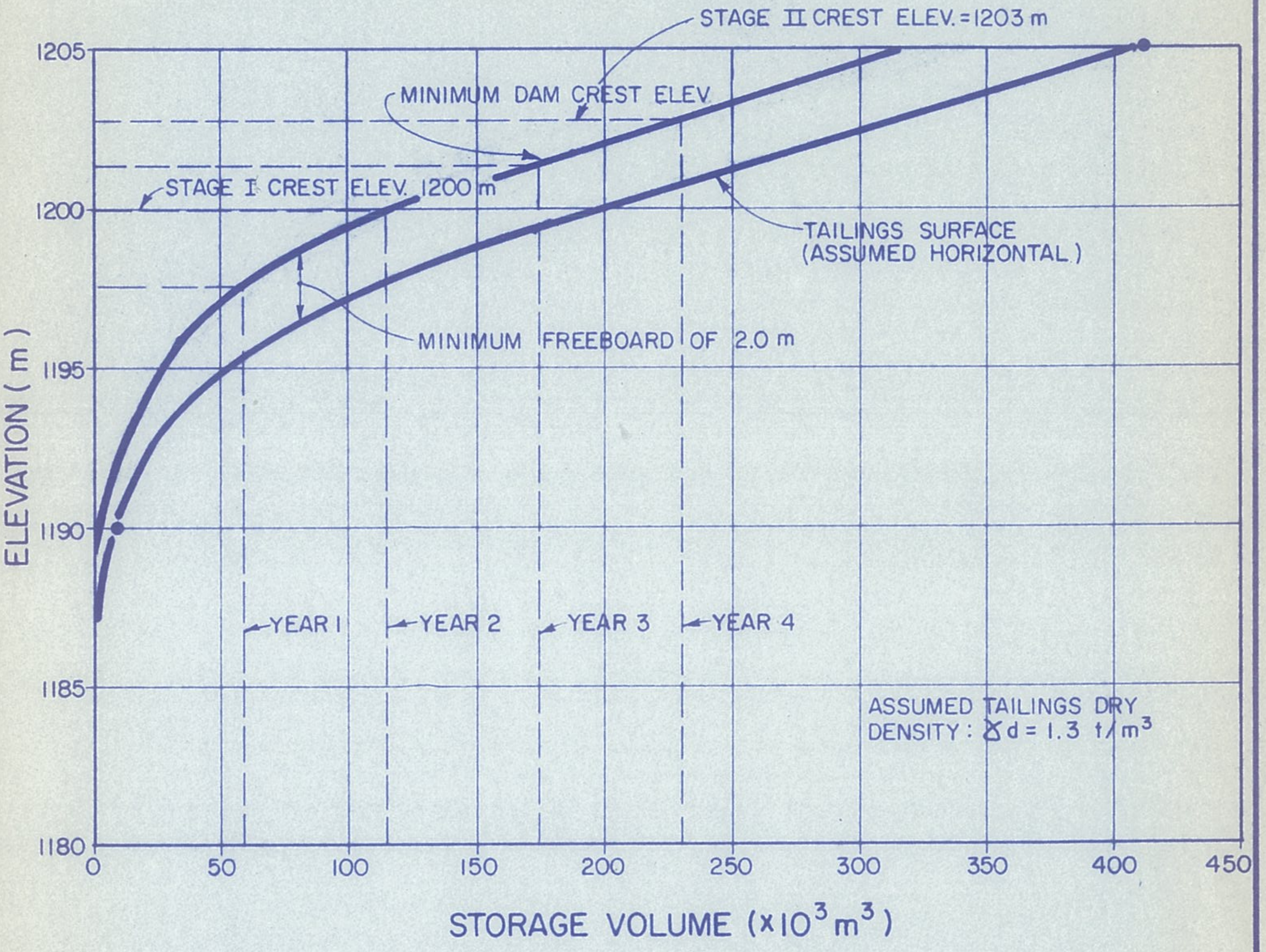
SCALE 0m 10 20 30 40m

PROJECT
MOUNT NANSEN GOLD PROJECT

TITLE
SITE No. 2
CROSS SECTION

DATE OF ISSUE	PROJECT No.	DWG. No.	REV.
DEC. 7, 1988	PB 3574 03	B-3005	
APPROVED			

SITE No. 2
CROSS VALLEY TAILINGS DAM



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TITLE
SITE No. 2
STORAGE / ELEVATION CURVE

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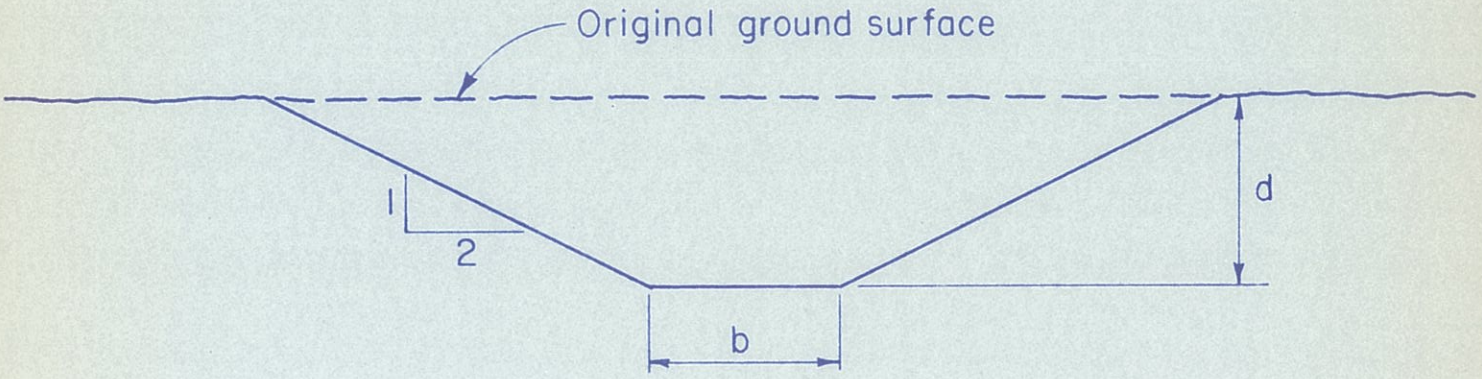
DWG. No.
A-3006

REV.



TYPICAL DIVERSION DITCH SECTION

MINIMUM DIVERSION DITCH DIMENSIONS			
	b (m)	d (m)	slope (%)
SITE No. 1	1.0	1.0	0.50
SITE No. 2	3.0	1.6	0.25

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MOUNT NANSEN GOLD PROJECT

TITLE
MINIMUM DIVERSION
DITCH DIMENSIONS

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PROJECT No.
PB 3574 03

DWG. No.
A - 3007

REV.