Dankoe Mines Ltd.

DESIGN REVIEW OF DANKOE MINE TAILINGS DAM

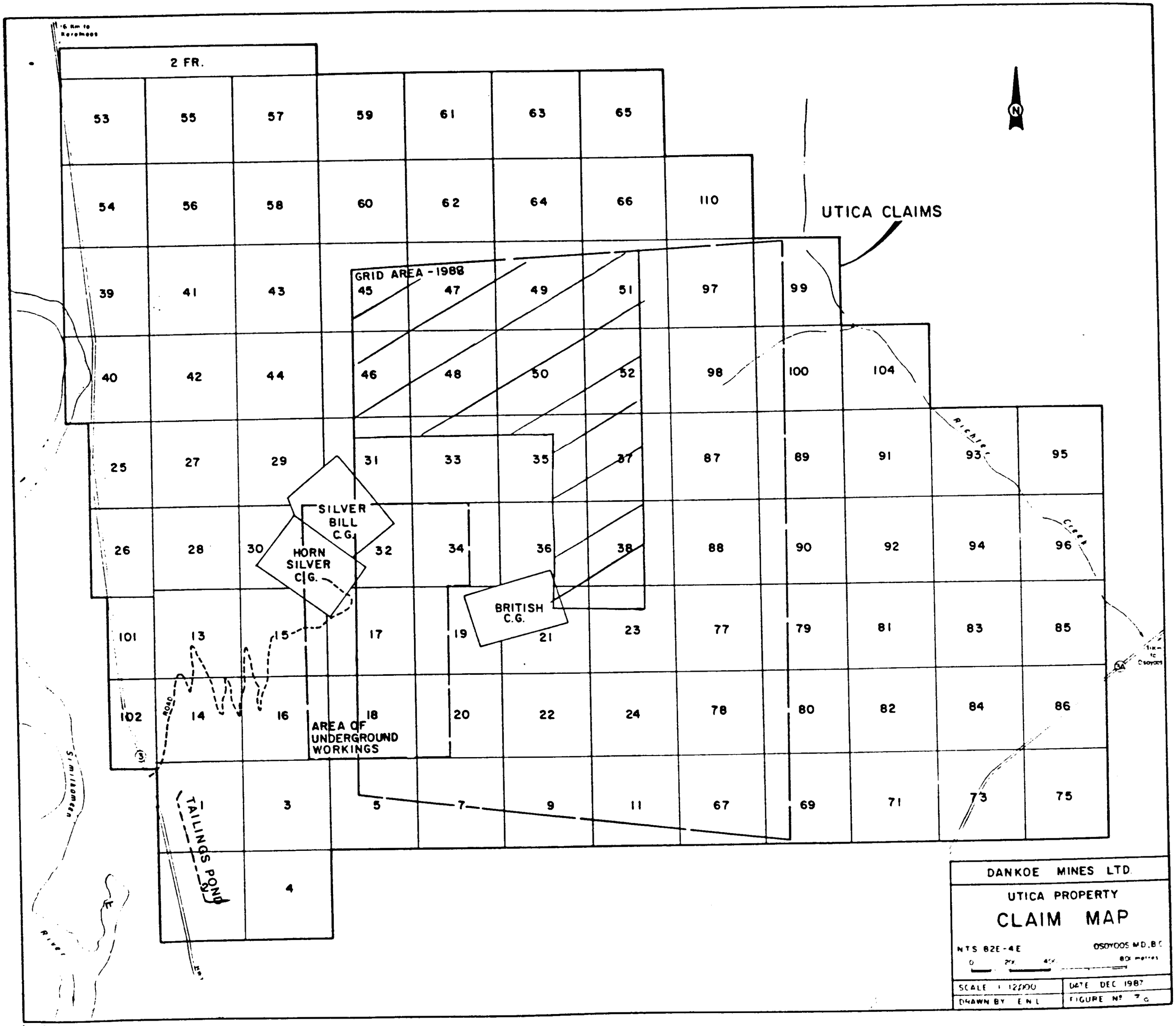
KLOHN LEONOFF
CONSULTING ENGINEERS

PB 1443 03

MAY 1990

COST STATEMENT FOR DRILLING WORK ON UTICA CLAIM GROUP, OSOYOOS MINING DIVISION OCTOBER 29, 1990

DRILLING:	
Mobilization / Demobilization	$2,275.00
Travel drill crew food and accommodations	600.00
Drilling	5,117.40
SUPERVISION:	
Engineer professional fees	$2,266.00
Travel, food & accommodations	592.71
Lab unit testing	2,459.20
Equipment rental, field supplies, telephone and courier	530.70
PROFESSIONAL SERVICES:	
Stability analysis, liquefaction assessment, drafting and preparation of Design Reports	7,163.18
Surveying, B.C. Land Surveyor	2,085.00
TOTAL	$23,089.19


UTICA CLAIMS
GRID AREA - 1988
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SILVER
BILL
C.G.
HORN
SILVER
C.G.
BRITISH
C.G.
101
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AREA OF
UNDERGROUND
WORKINGS
ROAD
TAILINGS POND
1
3
5
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11
67
69
71
73
75
4
Similkameen
River
Richter
Creek
DANKOE MINES LTD.
UTICA PROPERTY
CLAIM MAP
NTS 82E-4E
OSOYOOS M.D., B.C.
SCALE 1:12000
DATE DEC 1987
DRAWN BY E.N.L.
FIGURE Nº 7a

KLOHN LEONOFF
CONSULTING ENGINEERS

Our File: PB 1443 0301
WP 541

May 11, 1990

Dankoe Mines Ltd.
1 Ridgewood Road
Toronto, Ontario
M5P 1T4

Attention: Mrs. Alana Kotler

Re: Report on Raising Permitted Crest Elevation of Dankoe Tailings Dam

Dear Madam:

We are pleased to submit six copies of our report, dated May 11, 1990, on raising the crest level and increasing the storage capacity of the Dankoe tailings impoundment. We recommend that the maximum permitted tailings level be increased by 22 ft to elevation 1,398 ft to provide additional storage of 250,000 tons or about 5 years mill production.

This report addresses all the items requested by the British Columbia Ministry of Energy, Mines and Petroleum Resources.

The raised tailings dam will have adequate factors of safety for both static and dynamic conditions. Standpipe piezometers have been installed to allow ongoing monitoring of saturation levels within the tailings deposit.

Prior to resuming production, further construction of talus berms is required. A berm should be constructed on the existing tailings beach, stepped in about 20 ft from the existing crest to achieve the overall design slope of 2.5 horizontal to 1 vertical. A berm should also be placed on the 1,355 ft bench to flatten the existing oversteepended slope and to cover exposed tailings on the slope. It is mandatory that a Klohn Leonoff engineer be on site at the outset to confirm the construction layout and procedures, as past practices have not fully conformed with design.

Klohn Leonoff Ltd., 10200 Shellbridge Way, Richmond, B.C., Canada V6X 2W7 • Telephone (604) 273-0311 • Telex: 04-355520 • FAX: (604) 279-4300

Please advise us if we can provide any assistance in your application for approval of the increased capacity of the impoundment.

Yours very truly,

KLOHN LEONOFF LTD.

per Peter C. Lighthall, P.Eng.
Project Manager

PCL:sv
Enclosure

REPORT ON DESIGN REVIEW

OF DANKOE MINE TAILINGS DAM

FOR

DANKOE MINES LTD.

PB 1443 0301

MAY 1990

KLOHN LEONOFF

PB 1443 0301
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May 11, 1990

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DRAWINGS

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May 11, 1990

1. INTRODUCTION

This report presents a geotechnical review of the Dankoe Mines tailings dam and supports an application to the Ministry of Energy, Mines and Petroleum Resources to increase the height and capacity of the impoundment. The proposed impoundment raising provides additional tailings disposal capacity of 250,000 tons, sufficient for five years at an annual mill throughput of 50,000 tons.

The most recent approval for the tailings dam was granted in a letter from the Chief Inspector of Mines dated October 8, 1980. In that letter the maximum dam crest elevation was set at 1,380 ft. In letters dated April 27, 1989 and August 3, 1989 and an inspection report dated July 22, 1989 the Geotechnical Inspector of the Ministry of Energy, Mines and Petroleum Resources (MEMPR) pointed out to Dankoe that the tailings pond was essentially full to its permitted capacity. The District Inspector of Mines issued Dankoe a notice on November 20, 1989 that "no further milling will be permitted .. until .. the tailings impoundment meets the approval of the Chief Inspector of Mines".

Klohn Leonoff prepared an inspection report dated September 28, 1989 based on a site visit on September 12. In that report it was concluded that the tailings pond was being operated according to good practice and the recommendation was made that the crest could be raised to elevation 1,388 ft. Klohn Leonoff had not, however, been made aware of any of the above correspondence from the MEMPR.

The approval requirements for tailings ponds, either for new ponds or for raising above previously approved levels, are laid out in the MEMPR "Guidelines for the Design, Construction, Operation and Abandonment of Tailings Impoundments". In an MEMPR internal memorandum, page 2 of which was sent to us by fax, the Geotechnical Inspector listed those additional items from the Guidelines to fulfil the requirements for an approval.

Guideline Clause 1.1 - Topography - of the dam, pond and backhill.

Clause 1.5 - Hydrology - Determination of the catchment area, the design storm and the storm storage provided.

Clause 1.7 - Nature of Tailings - Grain sizes and potential for acid generation.

Clause 2.1 - Test Holes - Boreholes with blow counts, samples and moisture profiles are requested, especially towards the southern end of where the decant pond is located.

Clause 2.2 - Testing - Laboratory grain size distribution, consolidation tests and shear strength tests.

Clause 2.5 - Storage - Calculation of storage requirements for tailings and estimation of the water balance.

Clause 2.6 - Stability Analysis - Determination of the critical factor of safety.

Clause 2.7 - Instrumentation - Installation of piezometers and movement detection hubs.

This report addresses the above points in support of Dankoe's application. This review is based on a site visit and drilling program by Robert Toombs of Klohn Leonoff Ltd., March 27 to 28, 1990 in accordance with Klohn Leonoff proposal dated February 16, 1990. The program was authorized by Mrs. Alana Kotler of Dankoe Mines Ltd. in her letter dated February 28, 1990. Mr. Bob McTiernan, Mine Manager, was present at the initiation of the field program.

2. BACKGROUND

Dankoe Mine is located adjacent to British Columbia Provincial Highway No. 3, approximately midway between Keremeos to the north and Osoyoos to the south. The tailings dam is situated on the east hillside of the Similkameen River Valley, above the highway and below the mine/mill (note Drawing D-3001). The underground silver mine has been inactive since the early 1980's. However, the concentrator facility, with a maximum capacity of 500 tons/day, has been operated intermittently in recent years, either on a custom milling or lease basis.

The tailings pond structure is shown in plan and section on Drawings D-3001 and D-3002. These plans are based upon a site survey carried out on March 28, 1990 concurrent with the drilling program.

The tailings pond overlies a granular alluvial fan deposit, which in turn overlies Similkameen River deposits. Along the east end of the impoundment, at the back of the pond, the tailings abut a steeply sloping talus deposit. The dam has been built in stages using a series of talus rockfill dykes, constructed progressively upstream.

Tailings from the Dankoe concentrator are carried by pipeline to the tailings pond, where they are spigotted from discharge points located at intervals along the crest. The tailings line is either laid directly on the crest, or supported on wooden trestles just upstream of the rock fill crest. The objective of the discharge system is to vary the discharge points to form a beach of the coarse (sand) fraction of the tailings around the outer perimeter. This coarse zone provides a free-draining tailings mass. It is critical to the overall stability of the structure that this drained condition is maintained through proper tailings discharge procedures. The fine fraction and water flow into a decant pond in the eastern portion of the tailings pond, adjacent to the hillside. The fine fraction settles out in the decant pond. Throughout the life of the operation, supernatant water has infiltrated into the free-draining talus at the east abutment of the pond, with no reclaim to the mill. The mill will obtain all water from a well about 300 ft deep midway between the mill and the highway.

Klohn Leonoff has carried out periodic investigations of the tailings impoundment between 1970 and the present. At the time of our site visit in September 1988 tailings were being deposited 400 ft from the north end of the pond, contrary to good upstream practice. It was recommended at that time that the tailing pipeline be extended to allow spigotting of tailings along the entire dam crest to construct a beach of relatively free-draining sand adjacent to the crest. It was noted, during the September 1989 site visit, that the line had been extended along the entire length of the crest. During the site visit of March 1990 spigotting was not in progress, milling being last carried out in late 1989.

3. TOPOGRAPHIC SURVEY

A topographic survey was carried out by C.W. Gehue and Associates Land Surveyors of Kelowna, British Columbia, on March 28, 1990.

Spot elevations are shown on Drawing D-3003. Location, elevation and coordinates for the reference bench mark (BM 572 H) as well as two other temporary bench marks (TBM) are shown in plan. The TBMs are suitably painted points on rock boulders and may be used for future survey work.

From these spot elevations (shown on Drawing D-3003) a topographic map of the site at 10-ft contour intervals was made. Contour intervals to as close as 1 ft were interpolated locally across the surface of the pond. This result is shown in plan and section on Drawings D-3001 and D-3002.

Elevations and coordinates of current piezometer and drill hole locations, as well as surface settlement monuments were taken.

4. OBSERVATIONS - MARCH 1990

Skylark Resources has been operating the Dankoe Mill based upon an arrangement with the owners, Dankoe Mines Ltd. We understand that the production rate of the mill will be about 100 tons/day, or about 500 tons/week on a 16 hour/day, five-day/week basis. Production rates may be increased to 1,000 tons/week or 50,000 tons/year. Additional tailings storage capacity up to 250,000 tons over the next five years may be required.

At the time of our March 1990 investigation, the mill was inactive and no tailings were being discharged from the 4-inch diameter pipeline around the pond perimeter. No significant change to dyke construction was noted since our September 1989 visit. Several loads of dumped talus on the dyke opposite Piezometers A and B remain unspread. The general elevation of the crest is 1,380 to 1,382 ft. The 1,376-ft contour runs around the full perimeter of the tailings surface, from north to south, adjacent to the talus dyke, as shown on Drawing B-3001. The wet pond area noted in September 1989 when milling was active is currently dry. The pond location is identified by the 1,374-ft contour (approximately) shown in plan.

5. FIELD AND LABORATORY INVESTIGATIONS

Boreholes DH90-01 (44.5 ft), DH90-02 (55.3 ft) and Dynamic Cone Hole DC90-01 (44.5 ft), DC90-02 (19 ft) were made to depths shown in the parentheses. Standpipe piezometers were installed in all holes. The drill rig was an HT 1000 rotary drill mounted on a bombardier. Locations of these drill holes are shown in plan on Drawing D-3001.

A dynamic cone hole, DC90-01, was performed to refusal at 44.5 ft in the southwest corner of the tailings pond. Blow counts were recorded for every foot of penetration using an automatic hammer (140 lb, 30-inch drop) with a 60 mm diameter sleeved cone. Upon withdrawal of the cone, the hole caved at 19 ft, permitting installation of an open standpipe (D1) to a depth of 18.6 ft below ground surface.

Drill hole DH90-01 was made adjacent to DC90-01 to a depth of 44.5 ft where refusal was encountered by the SPT samples. Continuous sampling was made with Shelby tubes for the first 11.5 ft. Thereafter, sampling was made at 5-ft intervals with split spoons for SPT and also Shelby tubes.

The purpose was to examine the vertical tailings profile, with emphasis on the top 10 ft. Standpipe piezometers were installed at 28.9 ft (C2) and 43.0 ft (C1).

A second borehole, DH90-02, was installed, as shown in plan, equidistant from existing Piezometers A1, A2 and B1, B2. Natural ground was encountered at a depth of 55.3 ft. The Shelby samples were taken continuously to 12-ft depth. Thereafter, Shelby and SPT sampling was done alternately at 5-ft intervals. Standpipe piezometers were installed at depths of 54.5 ft (E3), 35.6 ft (E2) and 15.8 ft (E1).

Midway between Boreholes DH90-01 and DH90-02, a dynamic cone hole, DC90-02, was performed to record penetration per foot for a shallow hole (19.0 ft) by automatic hammer and allowed for installation of a standpipe piezometer (G1) at 18.7 ft.

All of the samples were returned to our Richmond laboratory for visual classification and moisture content. Sieve analysis was done on selected samples, with shear testing on two samples and Atterberg limits on one.

Borehole logs and laboratory test results are presented in Appendices I and II, respectively. The logs are summarized on Sections A, B and C of Drawing D-3002.

6. SITE AND SOIL DESCRIPTION

The Dankoe tailings dam is founded on an old fan deposit at the base of a steep mountainside. Throughout the life of the mine, tailings have been discharged to the pond by spigotting off the dam crest. One exception to this process was noted in September 1988 when spigotting was from a location 400 ft south of the north end of the pond, which promoted settlement of fines against the southern perimeter of the dam. Selective spigotting along the crest produces beaches of coarser tailings fractions near the dam with the slimes fraction and process water impounded at the back of the pond against the steep hillside. Process water leaves the pond by evaporation and by infiltration into the pervious soils underlying the base and the back of the pond.

The south abutment of the dam and the back of tailings pond contact a talus deposit which contains fine to coarse rock. The floor of the pond is seated on a fan deposit, consisting of coarse sand and gravel, with some silt, described previously in the Klohn Leonoff report of January 15, 1974. The Klohn Leonoff report of September 1980 describes clean, highly pervious gravels encountered at a depth of 50 ft below the fan deposit, probably deposited by the Similkameen River. The fan deposit and underlying river gravels form a dense, free-draining foundation.

Exploration carried out in 1970 and 1980, as well as the current (1990) program, is shown in plan and section on Drawings D-3001 and D-3002.

Drill Holes BH90-01 and 02 encountered 44.5 and 55.3 ft of tailings, respectively. The tailings encountered were similar to those encountered in TH2 (1980). The tailings are mainly fine to medium sand with some silt. Lenses of finer silt sizes (slimes) are present in the sand. As determined by sieve analysis on samples from both 1980 and 1990, the percentage of fines by weight passing the No. 200 sieve ranged from 20 to 90%. Such variation in gradation is expected in a tailings deposit developed by spigotting.

Auger Hole HA2 (1970) and Drill Hole TH3 (1980) as shown on Section C, Drawing D-3002 indicate tailings consisting of more silt than sand. This approaches the area of the free water pond, where finer, siltier fractions of the tailings slurry settle out.

Dynamic Cone Hole DC90-02, however, encountered very soft, wet silt to about 7 ft. Cone resistance varied from 0 to 2 blows/ft. This hole, midway between BH90-01 and 02 is set back from the crest approximately

25 ft. This loose condition is, in Klohn Leonoff's opinion, a local pocket of fines trapped when tailing discharged was concentrated on two conical discharge points. The presence of this pocket emphasizes the need for careful spigotting practises.

7. ACID MINE DRAINAGE

Tailings deposited to date at Dankoe have shown no signs of pyrite oxidation in the more than 20 years the mine has been operating. The majority of the tailings deposited to date have come from Dankoe underground workings and there is no visible indication of oxidation.

Future use of the Dankoe mill is expected to be custom milling with ore coming from varied sources. Prior to any material being accepted for processing, acid generation potential tests should be carried out on representative samples of the anticipated tailing. Materials identified as significantly reactive should not be processed without consideration of mitigative measures. Such mitigative measures may include exclusion of potentially acid generating tailings from the pond.

8. MONITORING

8.1 STANDPIPE PIEZOMETERS

Two piezometer groups, A and B, each containing two 3/4-inch PVC standpipes with porous tips were installed by Foundex in the tailings beach in 1983. They remain operational. However, piezometers installed in 1970 and 1980 as shown in plan and section are no longer functioning. Standpipe piezometers were installed in BH90-01 (C1, C2), DC90-01 (D1), BH90-02 (E1, E2, E3) and DC90-02 (G1). These standpipe piezometer locations are shown in plan and section on Drawings D-3001 and D-3002.

Water was added to all of the standpipes on March 28, 1990. Water levels were recorded on March 29, 1990, April 9, 1990 and April 17, 1990. This information is summarized in Table 1.

TABLE 1

STANDPIPE READINGS
MARCH - APRIL 1990

Piezo. No.	Associated Drill Hole	Date Installed	Tip Elevation (ft)	Original Ground Elevation (ft)	Remarks	
A1	--	1983	1,327.0	1,318	March 27/90 March 28/90 March 29/90 April 9/90 April 17/90	Dry, plugged at 1,331.2 Water added, at 1365.7 Water at 1362.1 Water at 1343.8 Water at 1337.5 (falling)
A2	--	1983	1,304.0	1,318	March 27/90 March 28/90 March 29/90 April 9/90	Dry at 1,308.5 Water added, at 1339.2 Water at 1315.9 No water at 1,308.5 (dry) (plugged?)
B1	--	1983	1,317.0	1,299	March 27/90 March 28/90 March 29/90 April 9/90	Dry at 1,321.2 Water added, at 1334.7 Water at 1,321.6 No water at 1,320.1 (dry) (plugged?)
B2	--	Mar. 27/90	1,291.0	1,299	March 28/90 March 28/90 March 29/90 April 9/90 April 17/90	Water at 1,307.2 Water added, at 1312.9 Water at 1,308.1 Water at 1,308.0 Water at 1,308.0 (stable)
C1	BH90-01	Mar. 27/90	1,332.9	1,331.7	March 28/90 March 29/90 April 9/90 April 17/90	Water added, at 1348.4 Water at 1,342.3 Water at 1,333.3 Water at 1332.9 (Dry)
C2	BH90-01	Mar. 27/90	1,347.3	1,331.7	March 28/90 March 28/90 April 9/90 April 17/90	Water added, at 1378.5 No water at 1,347.3 (dry) No water at 1,347.3 (dry) No water at 1,347.3 (dry)
D1	DC90-01	Mar. 27/90	1,357.6		March 28/90 March 28/90	Water added, at 1358.4 No water at 1357.6 (dry one minute later)
E1	BH90-02	Mar. 28/90	1,353.0	1,319.7	March 28/90 March 29/90 April 9/90	Water added, at 1379.7 Water at 1,366.7 No water at 1353.0 (dry)
E2	BH90-02	Mar. 28/90	1,338.7	1,319.7	March 28/90 March 29/90 April 9/90	Water added, at 1379.2 Water at 1,366.7 No water at 1,338.7 (dry)
E3	BH90-02	Mar. 28/90	1,320.5	1,319.7	March 28/90 March 29/90 April 9/90	Water added, at 1380.2 Water at 1,376.2 No water at 1,320.5 (dry)
G1	DC90-02	Mar. 28/90	1,357.4	--	March 28/90 March 29/90	Water added No water at 1,357.4 (dry)

Following addition of water, the seven new standpipe piezometers, all in tailings, showed progressively falling water levels to read dry at various times over the period March 28 to April 17, 1990.

Prior to adding water on March 28, 1990, three of the four existing piezometers were dry. B2 showed water at elevation 1,307.2 ft. Upon addition of water, B2 stabilized quickly to approximately the same elevation. Piezometer A1, still falling slowly, showed water at 1,337.5 ft. Piezometers A2 and B1, by April 17, 1990 read dry.

The permeability of the tailings within the first hundred feet of beach, formed by spigotting from the crest of the perimeter dyke, is estimated to be relatively high. Further upstream, where finer tailings are deposited, the permeability is expected to decrease. This was noted in auger hole HA2 (1970) and borehole TH3 (1980) at a distance of approximately 100 - 120 ft upstream from the point of spigotting (Section C, Drawing B-3002) at that time.

It is essential that this free draining zone be maintained, and confirmed by water level readings. The above piezometers have been read at a time when the mill was not operating, and the freewater pond dry. Further readings should be made and reviewed when the mill is operating and contributing water and solids to the pond, both under summer and winter conditions when surface freeze-up changes the water regime.

Raising of the crest by successive upstream construction will cover up the existing standpipe piezometers. To maintain use of these piezometers as long as possible, it is recommended that pneumatic piezometers be installed inside the present standpipes before they are covered up. The leads from these piezometers can be easily carried forward in advance of successive upstream construction. At present piezometers B1 and B2 are near the inside toe of the current crest. The remainder are offset 25 to 35 ft.

It is recommended that all future piezometers be of the pneumatic type, with leads that can be extended in advance of the upstream dyke construction.

8.2 MOVEMENT DETECTION HUBS

A total of 14 movement detection hubs were installed on the crest and slope of the dam. These hubs are 4-ft lengths of 19 mm rebar, which were driven 2.5 to 3 ft into the ground. Their purpose is to monitor any slope movements with time. This information is presented on Drawing D-3003.

9. STORAGE REQUIREMENTS

As the dam is raised at 2.5H:1V, it will encroach upon the east limit, the natural talus slope, which stands at about 1.5H:1V. This reduction in surface area, and hence volume, will be compensated by an increase in pond area in the northeast corner, towards the slope leading up to the mill area.

Drawing A-3004 shows a curve of additional tailings volume versus elevation, above the present tailings surface at elevation 1,376 ft. At a maximum mill throughput of 50,000 tons per year, for five years, storage requirements of 250,000 tons (dry weight) will require placement of tailings to elevation 1,398 ft.

10. WATER MANAGEMENT

10.1 POND WATER BALANCE

A pond water balance for the mill is presented on Table 2 for both operating and non-operating conditions. This is based on annual mill production of 50,000 tons per year, and an average annual precipitation of 11 inches (335 mm).

A calculated seepage outflow of 62 USgpm and 12 USgpm for operating and non-operating conditions respectively is required to maintain a balance. This is easily handled by seepage from the pond as demonstrated by more than 20 years of observation.

10.2 FLOOD STORAGE

In addition, surcharge storage is required to handle runoff from a design storm. The 200-year return period 24-hour duration storm has been selected as the design storm. This is estimated to be 2 inches (50 mm) of precipitation resulting in approximately 26 000 m^3 of storm inflow into the pond (note Table 2A). A portion of the catchment runoff would be lost to seepage through the talus resulting in an estimated net inflow to the pond of 22 000 m^3. Storm storage of 22 000 m^3 is equivalent to 3 ft of dyke freeboard. It is recommended that a minimum of 5 ft freeboard over the average water surface elevation be provided, to allow 3 ft storm surcharge storage and 2 ft of freeboard. An emergency spillway should be installed at the south end of the pond for each level of dyke crest raising. The spillway should consist of a 1 ft lower section of crest, at least 30 ft wide, adjacent to the abutment with the talus slope at the south end of the pond.

TABLE 2

ANNUAL WATER BALANCE

	Operating	Non-Operating
Inflows		
Tailings Transport Water (50,000 T/yr @ 30% solids)	106 000 m^3	0 m^3
Direct Precipitation (335 mm x 2.3 ha)	7 700	7 700
Runoff (34 mm x 65.7 ha)	22 000	22 000
Total	135 700	29 700
Losses		
Mill Reclaim	0	0
Evaporation (560 mm x 1 ha)	5 600	5 600
Void Water Retention	7 700	0
Total	13 300	5 600
Net Seepage Outflow (calculated as total inflows minus total losses)		
Volume	122 400 m^3	24 100 m^3
Rates	3.9 L/s or 62 USgpm	0.8 L/s 12 USgpm

TABLE 2A

DANKOE TAILINGS DAM
24-HOUR STORM

	200-Year Return	
Direct precipitation	50 mm x 2.3 ha	1 150 m^3
Runoff from catchment	38 mm x 65.7 ha	24 970 m^3
Total inflows		26 120 m^3
Talus seepage estimate		4 320 m^3
Net Inflow (Total Inflows - seepage)		21 800 m^3

11. STABILITY

11.1 GENERAL

Stability of the tailings dam has been reviewed both for the present structure and for the proposed raising of the tailings.

To perform this analysis, strength parameters have been reviewed for the foundation soils and the tailings. The phreatic surface, seismic activity and the potential for liquefaction have also been considered.

11.2 STRENGTH PARAMETERS

Strength parameters have been evaluated for the tailings, talus rockfill, and the underlying fan and talus slope deposits.

Direct shear testing was performed on two Shelby tube samples of tailings at in situ stress levels. The samples tested represent the sandier portion of the tailings placed by spigotting. Both samples exhibit an angle of internal friction of 33°, with no cohesion. These results are shown in Appendix II and summarized in Table 3. This sand also contains silty portions (slimes). These silty zones present in the form of bands and lenses are derived from crushed host rock rather than clay. There is little variation in angle of friction for sands and slimes. For a design strength, an angle of internal friction of 31° is chosen for the tailings sands banded with slimes.

TABLE 3

SUMMARY OF DIRECT SHEAR TESTING AND SHELBY TUBE DENSITY

Borehole no.	Sample no.	Depth (ft)	Shelby Tube Dry Density (lb/ft^3)	Shelby Tube Moisture Content (%)	Density (lbs/ft^3) Before	Density (lbs/ft^3) Consolidation	Density (lbs/ft^3) After	Test Rate of Strain (mm/min)	Peak Angle of Friction (Degrees)	Remarks
BH90-01	5	9.5 11.5	95.9	12.7	95.7	98.7	100.0	0.12	33°	Tested Saturated
BH90-01	7	19-21	88.9	25.8	-	-	-	-	-	-
BH90-02	4	8-10	91.6	10.7	-	-	-	-	-	-
BH90-02	9	25-27	86.0	25.7	84.8	87.6	88.7	0.0072	33°	Tested Saturated

The talus rockfill used for the dyke construction is placed and compacted by construction equipment. A conservative angle of internal friction of 36° is therefore chosen. The source of this rockfill, from the talus slope is assigned the same strength. The pond tailings lie directly on the dense sand gravel fan deposit. This material is assigned a strength of 36°, which is conservative. The strength properties of these soil materials are summarized in Table 4.

TABLE 4

STRENGTH OF MATERIALS

Material	Angle of Internal Friction	Cohesion (lb/ft^2)
Tailings	31°	0
Talus Rockfill	36°	0
Talus Slope	36°	0
Fan Deposit	36°	0

11.3 SEISMICITY

Dynamic stability has been reviewed to check for the following earthquake conditions:

- pseudo-static undrained loading during the earthquake;
- post-earthquake liquefaction potential.

The project area is located in Earthquake Zone 1, as defined by the National Building Code of Canada. Seismic acceleration for this site is based on a probabilistic assessment, using data from the Pacific Geoscience Centre, summarized below in Table 5 and included in Appendix III.

TABLE 5

PEAK GROUND ACCELERATION (%g) BY RETURN PERIOD

1/100 yr	1/200 yr	1/500 yr	1/1,000 yr
3	5	7	9

For purposes of design, the 1/1000 year return of 0.09 g is used. An earthquake of magnitude M6.5 has been selected for review of liquefaction potential. Magnitude 6.5 is generally considered to be the largest magnitude which will occur in south central British Columbia.

11.4 PHREATIC SURFACE

Monitoring of the standpipe piezometers indicates a very low or non-existent water table. As a conservative limit, however, the dam has been analyzed with a phreatic surface approximately 25 ft above the bottom of the tailings, as shown in section on Drawing D-3002.

11.5 LIQUEFACTION

Under sufficient earthquake loading, certain soils may liquefy. The liquefaction potential has been assessed by correlation of standard penetration test (SPT) N-values, and 60 mm cone penetration tests using Seed's method.

From the field data and our assessment, it has been determined that the talus slope, fan deposit and underlying river gravels are not subject to liquefaction. The talus fill used to construct the dyke is also not liquefiable. The tailings placed in the pond require a closer review, however.

Field sampling has been done principally on the tailings in the vicinity of the current dam crest. The analysis is based on SPT and dynamic cone penetration data, corrected from effective overburden pressure and a water table conservatively high at 35 ft below ground surface. The analysis indicates that the tailings should not liquefy and the results are summarized on Drawing A-3005.

The following comments with regard to the above analysis are made:

- Presence of fines (20 to 35%) was conservatively not accounted for in the above liquefaction analysis.
- This analysis has been undertaken with the assumption that the tailings/fan deposit contact is horizontal.

11.6 STABILITY ANALYSIS

Stability analysis has been carried out for the tailings dam in its present configuration (crest elevation 1,380 ft, tailings elevation 1,376 ft) under both static and dynamic conditions (a=0.09 g). The respective minimum factors of safety determined are 1.5 and 1.2. The surfaces analyzed are shown on Drawing D-3006.

To provide an additional 250,000 tons of storage, it is proposed to raise the tailings level by 22 ft to elevation 1,398 ft. This has been analyzed for static and dynamic stability. The factors of safety are 1.5 and 1.2, respectively. The analyzed surfaces are summarized and shown on Drawing D-3006.

12. DAM CONSTRUCTION

A typical design section for raising the tailings dam is shown on Drawing B-3007. The talus dyke between elevations 1,355 and 1,382 was raised by centreline construction rather than upstream construction, resulting in a local slope as steep as 1.5H:1V. This was contrary to Klohn Leonoff recommendations in previous reports that a slope not steeper than 2.5H:1V be maintained.

To correct the locally over-steepened slope, it is recommended that a talus berm with a nominal width of about 15 ft be placed on the elevation 1,355 bench. This will also provide cover over the exposed batterboard tailings between elevations 1,355 ft and 1,365 ft approximately.

To maintain an overall slope of 2.5H:1V above elevation 1,376 ft, it will be necessary to step the dam in. The recommended outside limit of the downstream toe at elevation 1,382 ft is a step-in of 20 ft. This will require extension of the existing standpipe piezometers as discussed in Section 8.1, with pneumatic tips, in advance of upstream construction.

Talus crest dykes should be placed in lifts no greater than 3 ft, and should be compacted by travel of hauling and spreading equipment. The dyke should be arranged to maintain an overall slope on the outside face of 2.5 horizontal to 1.0 vertical. We recommend a site visit be made by one of our engineers to lay out and inspect initial work on raising the crest.

13. CONCLUSIONS AND RECOMMENDATIONS

1. The foundation soils underlying the tailings structure are competent dense coarse grained materials, sufficiently pervious to provide good underdrainage to the tailings.

2. Monitoring of the performance of the existing and new standpipe piezometers shows that the tailings deposit continues to be well drained.

3. Examination of the tailings as sampled at BH90-01 and BH90-02 does not indicate any adverse conditions in the soil profile. Tailings were spigotted from a point on the crest 400 ft from the north end, in September 1988. A zone of very loose silt was noted at DC90-01 in the top 7 to 8 ft, suspected to be a local pocket resulting from incorrect spigotting procedures.

4. Stability analyses, shows that the dam is stable at the present tailings elevation of 1,376 ft and after raising to elevation 1,398 ft. It is essential that the coarse fraction of tailings be

placed adjacent to the crest by spigotting from successive locations along the dyke perimeter.

5. Prior to raising the tailings above 1,376 ft, we recommend that a berm of talus rockfill be added to the 1,355 ft bench to flatten the present downstream slope. The slope is locally as steep as 1.5H:1V between the present crest at 1,380-82 ft and the berm at elevation 1,355 ft approximately.

6. To maintain the overall slope of 2.5H:1V the next stage of dyke fill should be inset 20 ft from the present perimeter. Upstream construction will result in the eventual burial of the existing standpipe piezometers. We recommend that pneumatic piezometers with readout leads be installed inside the existing 3/4 inch standpipe piezometers. These leads can be buried and extended through the tailings in advance of the upstream construction, and collected at a common point for future readings.

7. We recommend that Klohn Leonoff make a site visit at the start of construction to confirm construction procedures and to supervise pneumatic piezometer installation.

8. We recommend that all piezometers be read at least on a monthly basis by the mine during deposition of tailings, and this information forwarded to Klohn Leonoff for review.

9. An estimated additional storage capacity of 250,000 tons (dry weight) may be obtained by raising the tailings to elevation 1,398 ft. A minimum crest level of 5 ft above the surface of the decant water pond is to be maintained at all times. An emergency spillway should be installed adjacent to the abutment with the talus slope at the south end of the impoundment with each level of crest raising.

10. We recommend that acid generation potential tests be carried out on all potential custom-milled ore in advance of acceptance of the work.

KLOHN LEONOFF LTD.

PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
R. G. TOOMBS

Robert G. Toombs, P.Eng.
Project Engineer

Peter C. Lighthall, P.Eng.
Project Manger

APPENDIX I

BORETHOLE LOGS

BH 90-01
BH 90-02
DC 90-01
DC 90-02

TEST HOLE LOG

SAMPLE DATA		ELEV. COLLAR	
WEIGHT HAMMER	140 lb	ELEV. GROUND	1376.2 ft
HEIGHT DROP	30 in	CO-ORD. LOCATION	3499.62 N 5628.35 E

COHESION – TONS / SQ. FT: 0.2, 0.6, 1.0, 1.4, 1.8 — ● 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 / FT	NO.
	3" SH		1
5	3" SH		2
	3" SH		3
10	3" SH		4
	3" SH		5
	2" SS	7	6
15			
20	3" SH		7
	2" SS	9	8
25	3" SH		9
	2" SS	9	10
30	2" SS	10	11
35	3" SH		12
	2" SS	12	13
40			

DESCRIPTION OF MATERIAL

TAILINGS
- loose to medium dense
- grey-brown
- fine to medium
- sand, little to some silt with silt seams

- grey clay silt, with some sandy seams

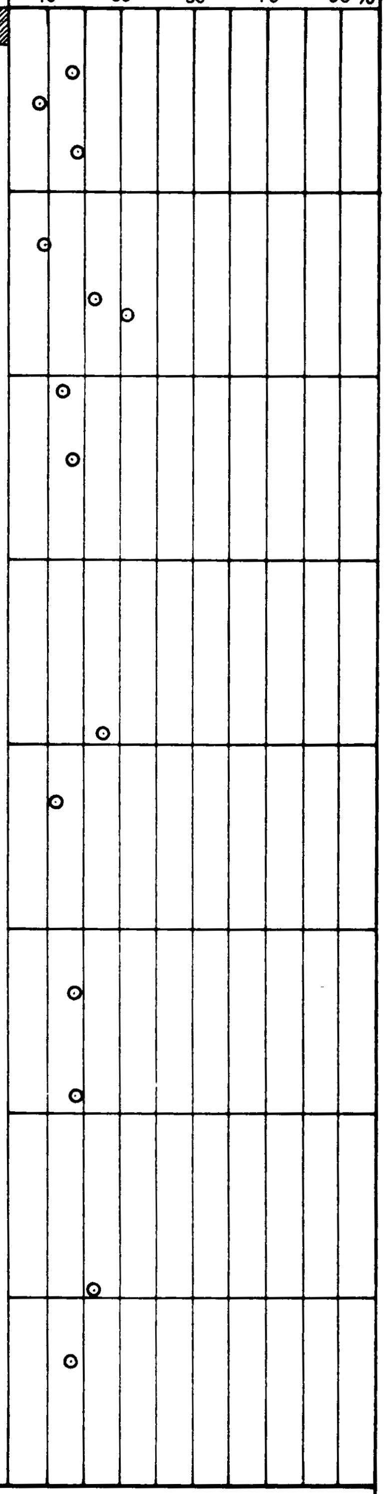
- loose to medium dense
- fine to medium sand
- little to some silt with silt seams

- light brown
- grey

- grey
- grey-brown

- grey-brown
- grey

Standpipe Piezometer C2



KLOHN LEONOFF
CONSULTING ENGINEERS

JOB No.	PB 1443 0301
PROJECT	Dankoe Mines Ltd.
LOCATION	Tailings Pond
HOLE No.	BH 90-01
DATE	March 27, 1990 — PLATE No. 1 of 2

TEST HOLE LOG

SAMPLE DATA				ELEV. COLLAR	
WEIGHT HAMMER 140 lb				ELEV. GROUND 1376.2 ft	
HEIGHT DROP 30 in				CO-ORD. LOCATION 3499.6 N 5628.4 E	

COHESION — TONS/SQ.FT: 0.2, 0.6, 1.0, 1.4, 1.8 — ● 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 / FT	NO.	SYMBOL	DESCRIPTION OF MATERIAL
	2" SS	12	14		as above Standpipe Piezometer C1
	2" SS	47	15		
45					END OF HOLE at 44.5 ft
50					

Notes:
Drill type: Bombardier HT 1000
Hammer type: Rope - Cats Head
Drill method: Rotary/Revert

Dry densities from Shelby tube samples:
a) SA5: 95.9 16/ft^3
b) SA7: 88.7 16/ft^3

KLOHN LEONOFF
CONSULTING ENGINEERS

JOB No.	PB 1443 0301
PROJECT	Dankoe Mines Ltd.
LOCATION	Tailings Pond
HOLE No.	BH 90-01
DATE	March 27, 1990
PLATE No.	2 of 2

TEST HOLE LOG

SAMPLE DATA		ELEV. COLLAR	
WEIGHT HAMMER	140 lb	ELEV. GROUND	1376.0 ft (estimated)
HEIGHT DROP	30 in	CO-ORD. LOCATION	3800 N, 5572 E (estimated)

COHESION — TONS / SQ.FT: 0.2, 0.6, 1.0, 1.4, 1.8 — ● FIELD VANE △ LAB VANE ■ UNCONF.

PLASTIC LIMIT / WATER CONTENT / LIQUID LIMIT: X — O — X, 10, 30, 50, 70, 90 %

DEPTH / ELEV.	O.D / I.D.	BLOWS / FT	NO.	DESCRIPTION OF MATERIAL
	3" SH		1	TAILINGS - loose grey layered sands and silt
5	3" SH		2	
	3" SH		3	- medium dense - fine to medium sand - little to some silt with silt - lenses - grey, light brown
10	3" SH		4	
	3" SH		5	
15	2" SS	5	6	- loose - light brown silt - some fine sand Standpipe Piezometer E1
20	3" SH		7	- medium dense - grey to grey-brown - fine to medium sand - little to some silt with silt seams
	2" SS	16	8	
25	3" SH		9	
30	2" SS	4	10	Brown sand and silt
35				Standpipe Piezometer E2
	3" SH		11	
40				

KLOHN LEONOFF
CONSULTING ENGINEERS

JOB No.	PB 1443 0301
PROJECT	Dankoe Mines Ltd.
LOCATION	Tailings Pond
HOLE No.	BH 90-02
DATE	March 28, 1990
PLATE No.	1 of 2

TEST HOLE LOG

SAMPLE DATA		ELEV. COLLAR	
WEIGHT HAMMER	140 lb	ELEV. GROUND	1376.0 (estimated)
HEIGHT DROP	30 lb	CO-ORD. LOCATION	3800 N 5572 E (estimated)

COHESION – TONS / SQ.FT: 0.2, 0.6, 1.0, 1.4, 1.8 — ● 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 / FT	NO.	SYMBOL	DESCRIPTION OF MATERIAL		
	2" SS	14	12		Brown sand and silt		
45					- medium dense - grey to grey brown sand - little to some silt with silt seams		
50							
55	2" SS		13			Piezometer E3	2 blows 2" 30 blows no penetration
					END OF HOLE at 55.3 ft		
60							
65							
70							

Notes:
Drill type: **Bombardier HT 1000**
Hammer type: Rope and Cats Head
Drill Method: Rotary/Revert
Densities from Shelby tube samples:
a) Sa.4 91.6 16/ft^3
b) Sa.9 96.0 16/ft^3

KLOHN LEONOFF
CONSULTING ENGINEERS

JOB No.	PB 1443 0301
PROJECT	Dankoe Mines Ltd.
LOCATION	Tailings Pond
HOLE No.	BH 90-02
DATE	March 28, 1990
PLATE No.	2 of 2

TEST HOLE LOG

SAMPLE DATA					
WEIGHT HAMMER	140 lb		ELEV. COLLAR		
HEIGHT DROP	30 in		ELEV. GROUND	1376.0 ft	
			CO-ORD. LOCATION	3502.6 N	5635.31 E

COHESION — TONS/SQ.FT: 0.2, 0.6, 1.0, 1.4, 1.8 — ● 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 / FT	NO.	SYMBOL	DESCRIPTION OF MATERIAL
	60 mm ∅ cone	5			
		4			
		3			
		4			
5		3			For Log, see BH90-01, located approximately 10 ft west
		4			
		6			
		9			
		9			
10		7			
		10			
		9			
		10			
		10			
15		8			
		12			Hole caved at 19.0 ft when cone was withdrawn
		12			Standpipe Piezometer D1
		13			
		12			
20		12			
		12			
		12			
		14			
		15			
25		12			
		12			
		3			
		14			
		11			
30		15			
		22			
		22			
		18			
		20			
35		24			
		26			
		19			
		24			
		16			
40		29			

KLOHN LEONOFF
CONSULTING ENGINEERS

JOB No.	PB 1443 0301
PROJECT	Dankoe Mines Ltd.
LOCATION	Tailings pond
HOLE No.	DC 90-01
DATE	March 29, 1990
PLATE No.	1 of 2

TEST HOLE LOG

SAMPLE DATA				SYMBOL	ELEV. COLLAR	COHESION — TONS/SQ.FT 0.2 0.6 1.0 1.4 1.8 ● FIELD VANE △ LAB VANE ■ UNCONF.
WEIGHT HAMMER					ELEV. GROUND 1376.0 ft	
HEIGHT DROP					CO-ORD. LOCATION 3502.6 N 5635.3 E	PLASTIC LIMIT / WATER CONTENT / LIQUID LIMIT
DEPTH / ELEV.	O.D / I.D.	BLOWS / FT	NO.		DESCRIPTION OF MATERIAL	X — O — X 10 30 50 70 90%
		28			see above	
		24				
		28				
		35				
45		90/1/2"				
					END OF HOLE at 44.5 ft	
50						

Notes:
Dynamic cone is Ø 60 mm
Drill type: Bombardier HT 1000
Hammer type: Automatic

KLOHN LEONOFF
CONSULTING ENGINEERS

JOB No. PB 1443 0301
PROJECT Dankoe Mines Ltd.
LOCATION Tailings Pond
HOLE No. DC 90-01
DATE March 27, 1990 PLATE No. 2 of 2

TEST HOLE LOG

SAMPLE DATA	
WEIGHT HAMMER	140 lb
HEIGHT DROP	30 in

ELEV. COLLAR	
ELEV. GROUND	1375.4 ft
CO-ORD. LOCATION	3634.2 N 5590.7 E

COHESION — TONS/SQ.FT: 0.2, 0.6, 1.0, 1.4, 1.8
● 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 / FT	NO.	SYMBOL	DESCRIPTION OF MATERIAL
	60 mm Ø cone	1			
		2			
		2			
		0			
5		0			
		0	1	GS	Grab Sample No. 1 - very loose - black-brown - very soft silt, wet LL = 32 PL = 25 PI = 7
		6			
		10			
		8			
10		7			
		7			
		9			
		8			
		7			
15		7			
		7			
		9			Standpipe Piezometer G1
		11			
		12			
20					END OF HOLE at 19.0 ft
25					
30					
35					
40					

Notes:
Dynamic cone is 60 mm Ø
Drill type: Bombardier HT 1000
Hammer type: Automatic

KLOHN LEONOFF
CONSULTING ENGINEERS

JOB No.	PB 1443 0301
PROJECT	Dankoe Mines Ltd.
LOCATION	Tailings Pond
HOLE No.	DC 90-02
DATE	March 28, 1990 — PLATE No. 1 of 1

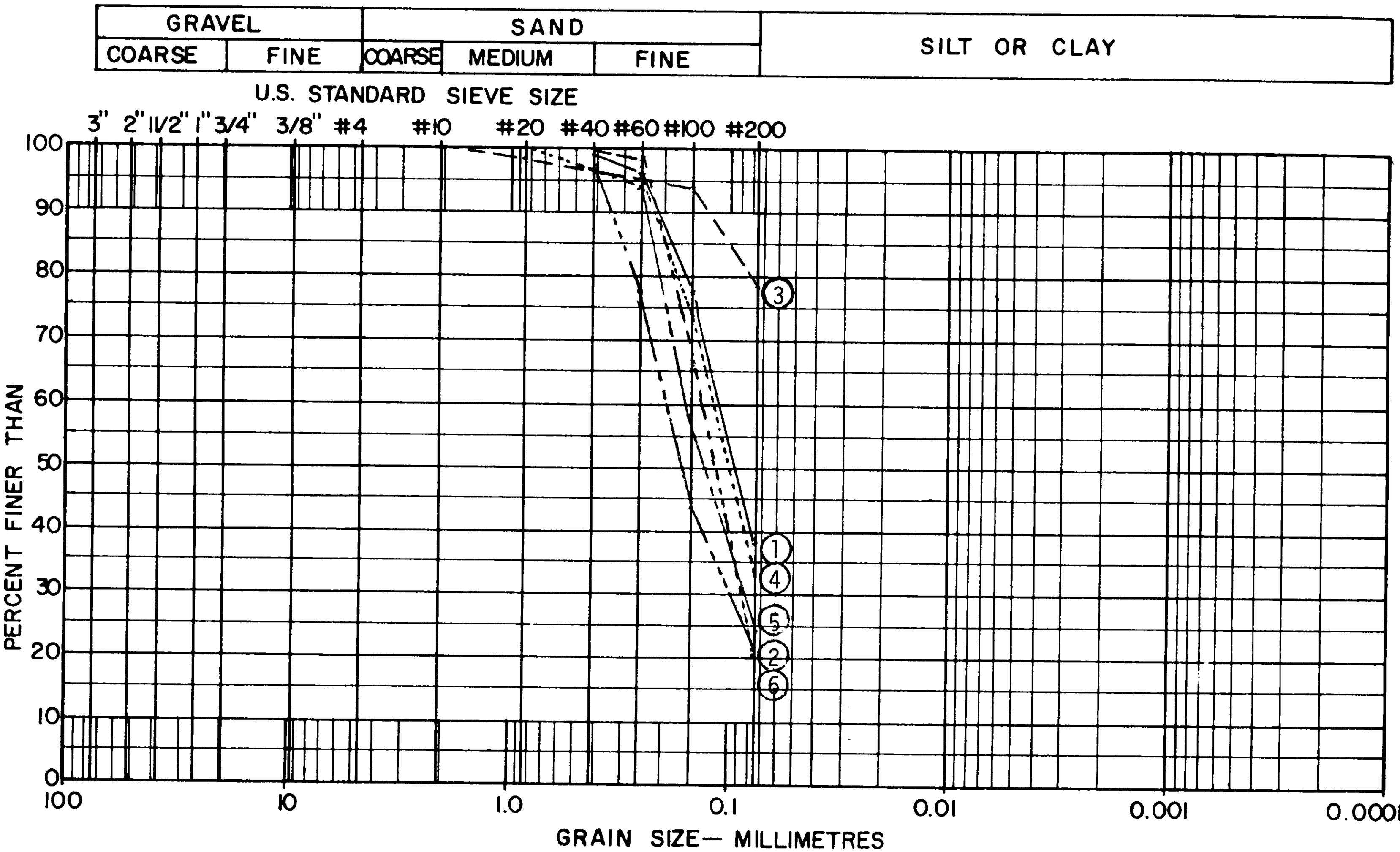
APPENDIX II

LABORATORY TEST RESULTS

GRADATIONS, BH 90-01, BH 90-02

DIRECT SHEAR TEST RESULTS, DH 90-01, SA 5

DIRECT SHEAR TEST RESULTS, DH 90-01, SA 9



GRAIN SIZE CURVE

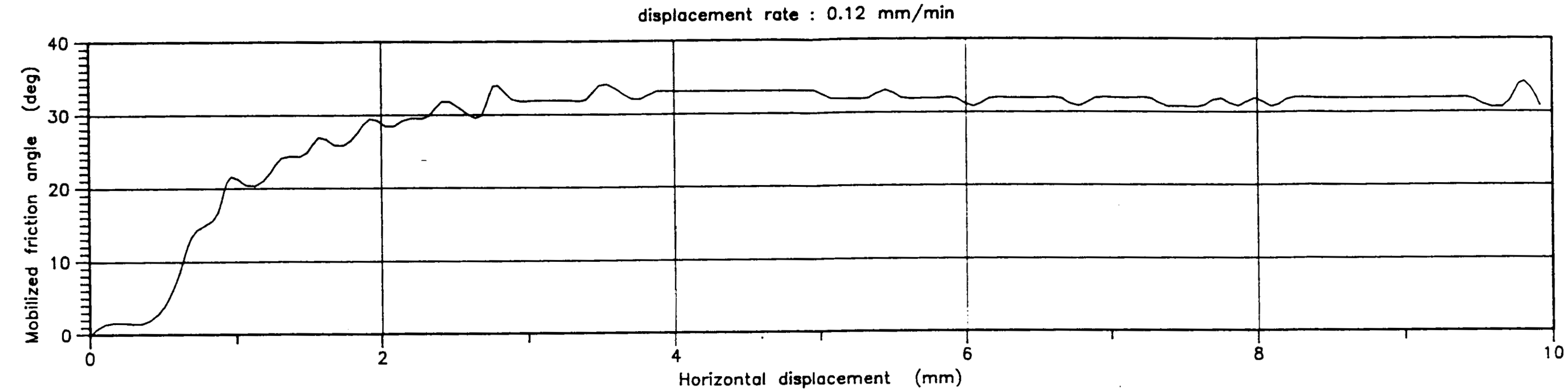
REMARKS:

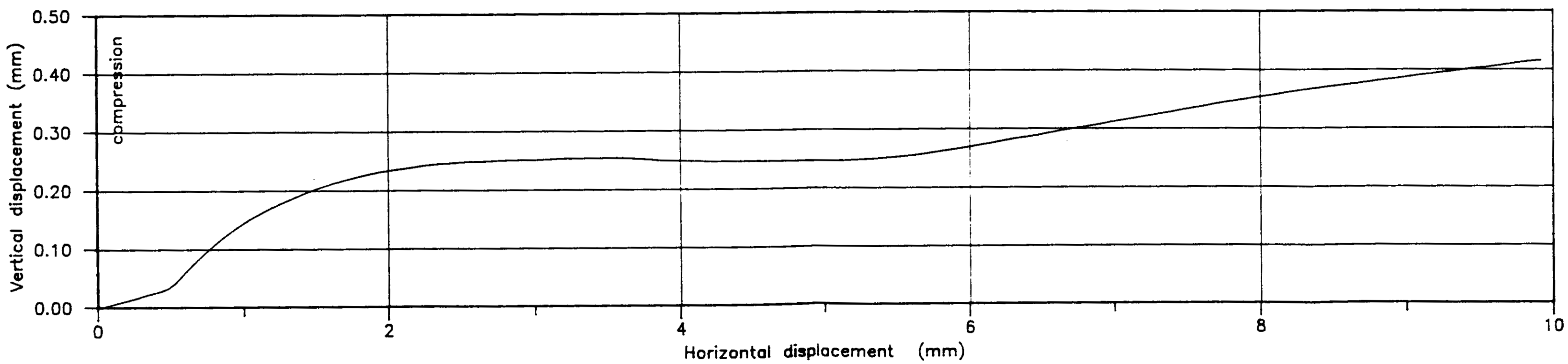
(1) BH 90-01, SA1 1.5-3.5 ft
(2) BH 90-01, SA1 1.5-3.5 ft
(3) BH 90-01, SA4 7.5-9.5 ft
(4) BH 90-02, SA1 2.0-4.0 ft
(5) BH 90-02, SA3 6.0-8.0 ft
(6) BH 90-02, SA5 10.0-12.0 ft

KLOHN LEONOFF
CONSULTING ENGINEERS

JOB No. PB 1443 0301
PROJECT Dankoe Mines Ltd.
LOCATION Tailings Pond
HOLE No. - DEPTH -
DATE March 27, 28, 1990

Normal load = 237.6 N (100 kPa)





SPECIMEN LOCATION	DH90-01 SA. 5 DEPTH 11.5 ft.
NATURAL MOISTURE CONTENT	12.7 %
SPECIMEN AREA	2376 mm2
INITIAL SPECIMEN HEIGHT	36.20 mm
CONSOLIDATED SPECIMEN HEIGHT	35.11 mm
CONSOLIDATED DRY UNIT WEIGHT	15.51 KN/m3 (98.7 lb/cu.ft)

TO BE READ WITH KLOHN LEONOFF REPORT DATED ______

SCALE

KLOHN LEONOFF LTD.
CONSULTING ENGINEERS

PROJECT: DANKOE MINE

TITLE: DIRECT SHEAR TEST RESULTS

CLIENT: DANKOE MINE

DATE OF ISSUE: APRIL 20, 1990

APPROVED

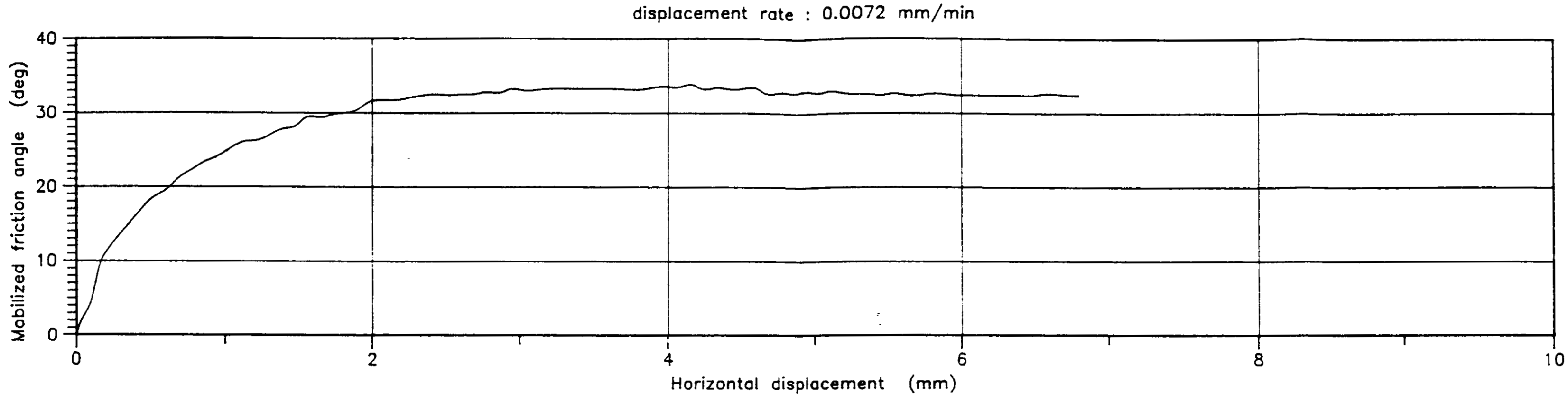
PROJECT No. PB 1443 03 01

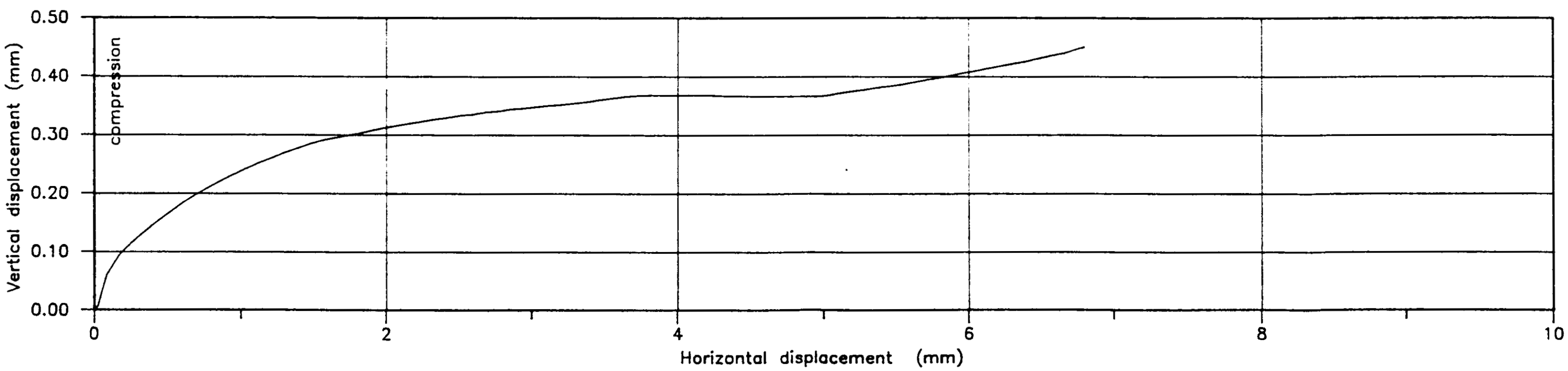
DWG. No. B 1

REV

NCI 802 KI

Normal load = 356.4 N (150 kPa)





SPECIMEN LOCATION	DH90-01 SA. 9 DEPTH 25-27 ft
NATURAL MOISTURE CONTENT	25.9 %
SPECIMEN AREA	2376 mm2
INITIAL SPECIMEN HEIGHT	36.20 mm
CONSOLIDATED SPECIMEN HEIGHT	35.04 mm
CONSOLIDATED DRY UNIT WEIGHT	13.76 KN/m3 (87.6 lb/cu.ft)

TO BE READ WITH KLOHN LEONOFF REPORT DATED ________

SCALE

KLOHN LEONOFF LTD.
CONSULTING ENGINEERS

PROJECT: DANKOE MINE

TITLE: DIRECT SHEAR TEST RESULTS

CLIENT: DANKOE MINE

DATE OF ISSUE	PROJECT No.	DWG. No.	REV.
APRIL 20 1990	PB 1443 03 01	B 2	
APPROVED			

APPENDIX III

SEISMIC DESIGN DATA

ENERGY, MINES AND RESOURCES CANADA
GEOLOGICAL SURVEY OF CANADA

ENERGIE, MINES ET RESSOURCES CANADA
COMMISSION GEOLOGIQUE DU CANADA

SEISMIC HAZARD CALCULATION * / CALCUL DE PERIL SEISMIQUE *

REQUESTED BY/ DEMANDE PAR   Robert Toombs / Klohn Leonoff Consult. Eng.

SITE   Mt. Kobau, B.C.

LOCATED AT/ SITUE AU   49.05 NORTH/NORD   119.67 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)	0.032	0.045	0.068	0.093
PEAK HORIZONTAL GROUND VELOCITY (M/SEC) / VITESSE HORIZONTALE MAXIMALE DU SOL (M/SEC)	0.040	0.054	0.081	0.110

* REFERENCES

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.

. 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.

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.

.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.

3.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.

27-MAR-90 19:26:31

SITE Mt. Kobau, B.C.

ZONING FOR ABOVE SITE/ ZONAGE DU SITE CI-DESSUS

** 1985 NBCC/CNBC: Za = 1; Zv = 2

ACCELERATION ZONE/ ZONE D'ACCELERATION Za = 1
ZONAL ACCELERATION/ ACCELERATION ZONALE a = 0.05 G

** VELOCITY ZONE/ ZONE DE VITESSE Zv = 2
** ZONAL VELOCITY/ VITESSE ZONALE v = 0.10 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, when Zv=0 and Za>0, the values of Zv and v should be taken as 1 and 0.05, respectively. See NBCC 1985, Sentence 4.1.9.1 (4).

Pour applications selon le CNBC, lorsque Zv=0 et Za>0, les valeurs Zv et v deviendraient 1 et 0.05, respectivement. Voir CNBC 1985, paragraphe 4.1.9.1 4).

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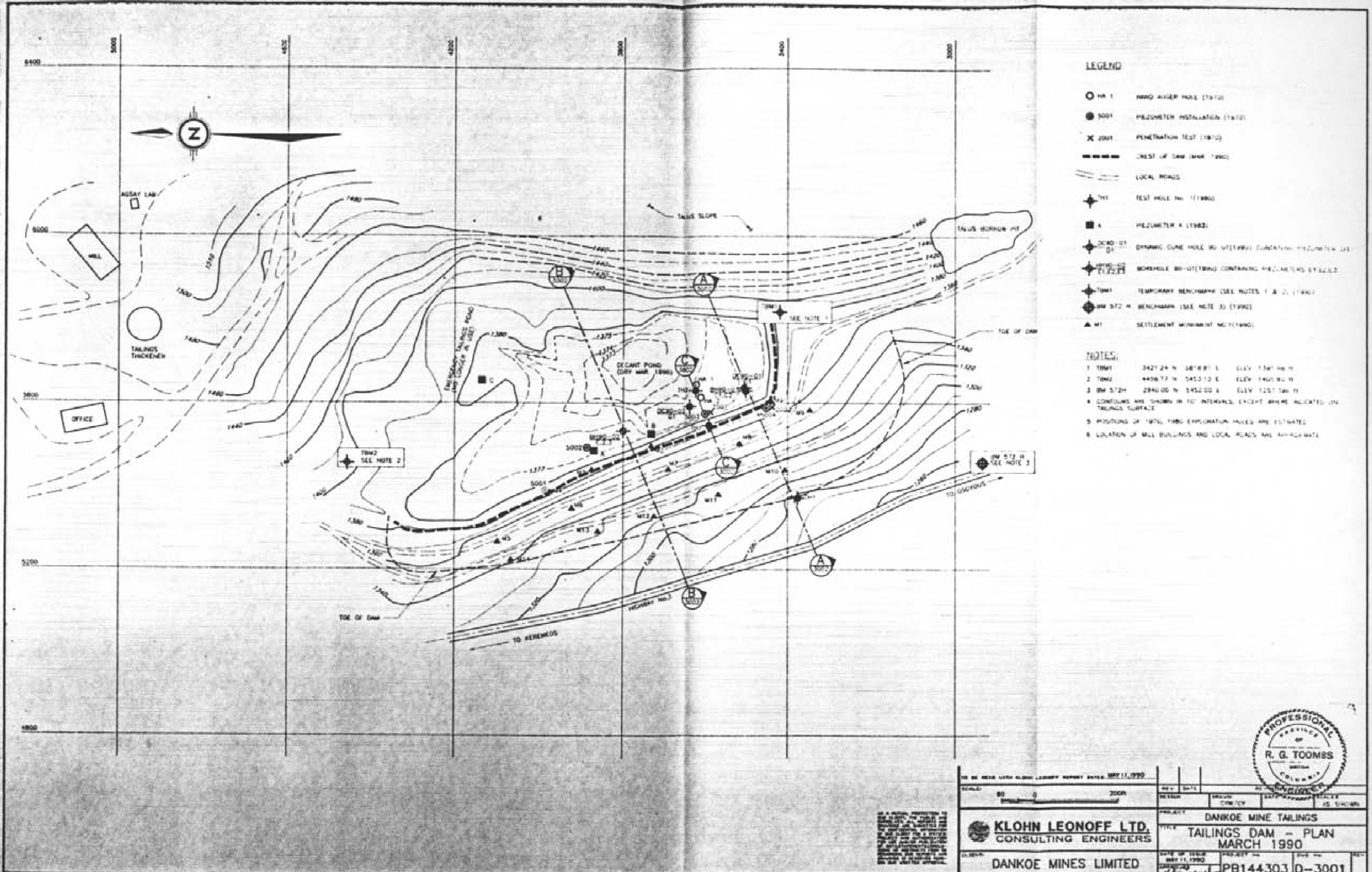
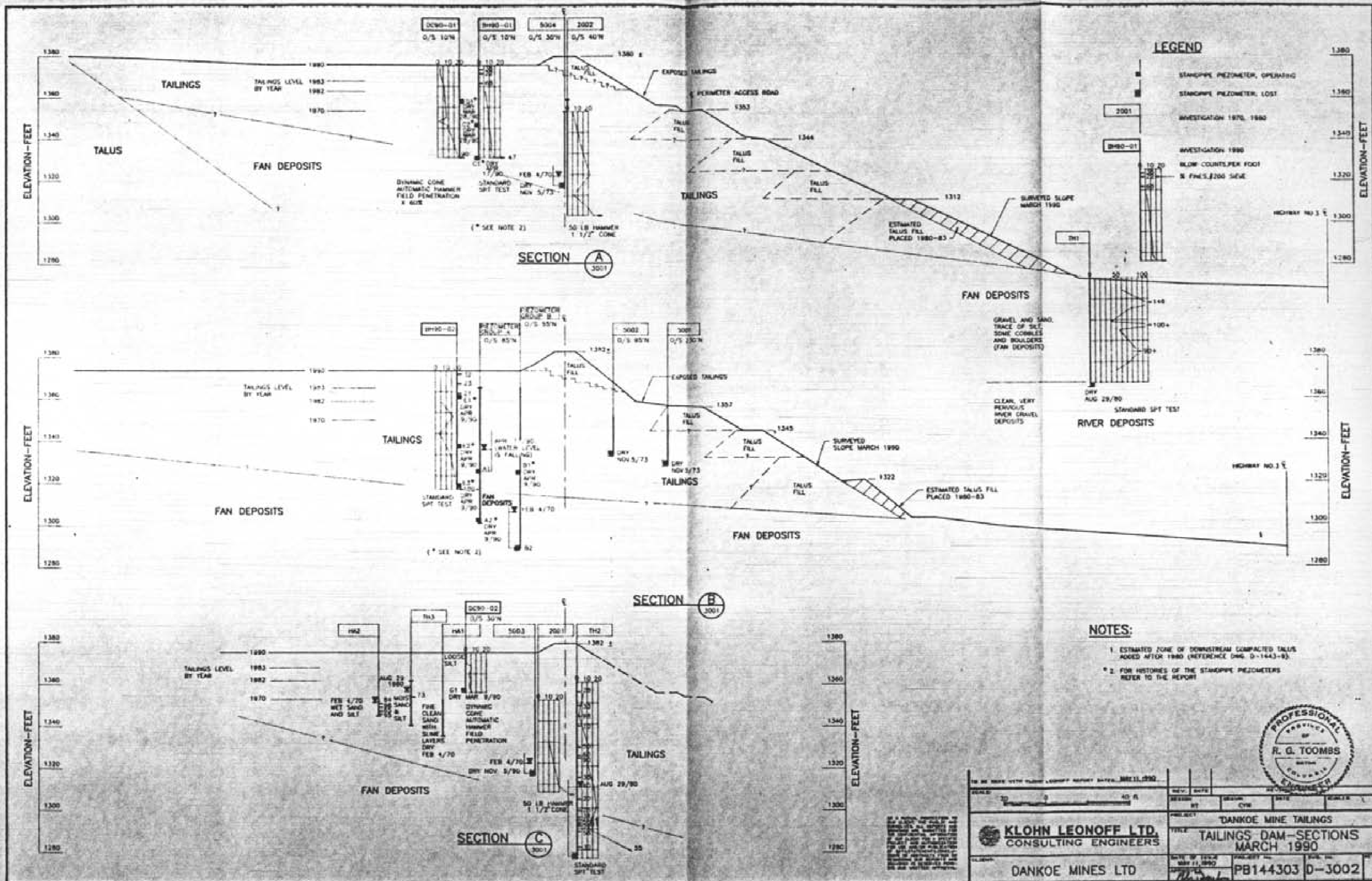
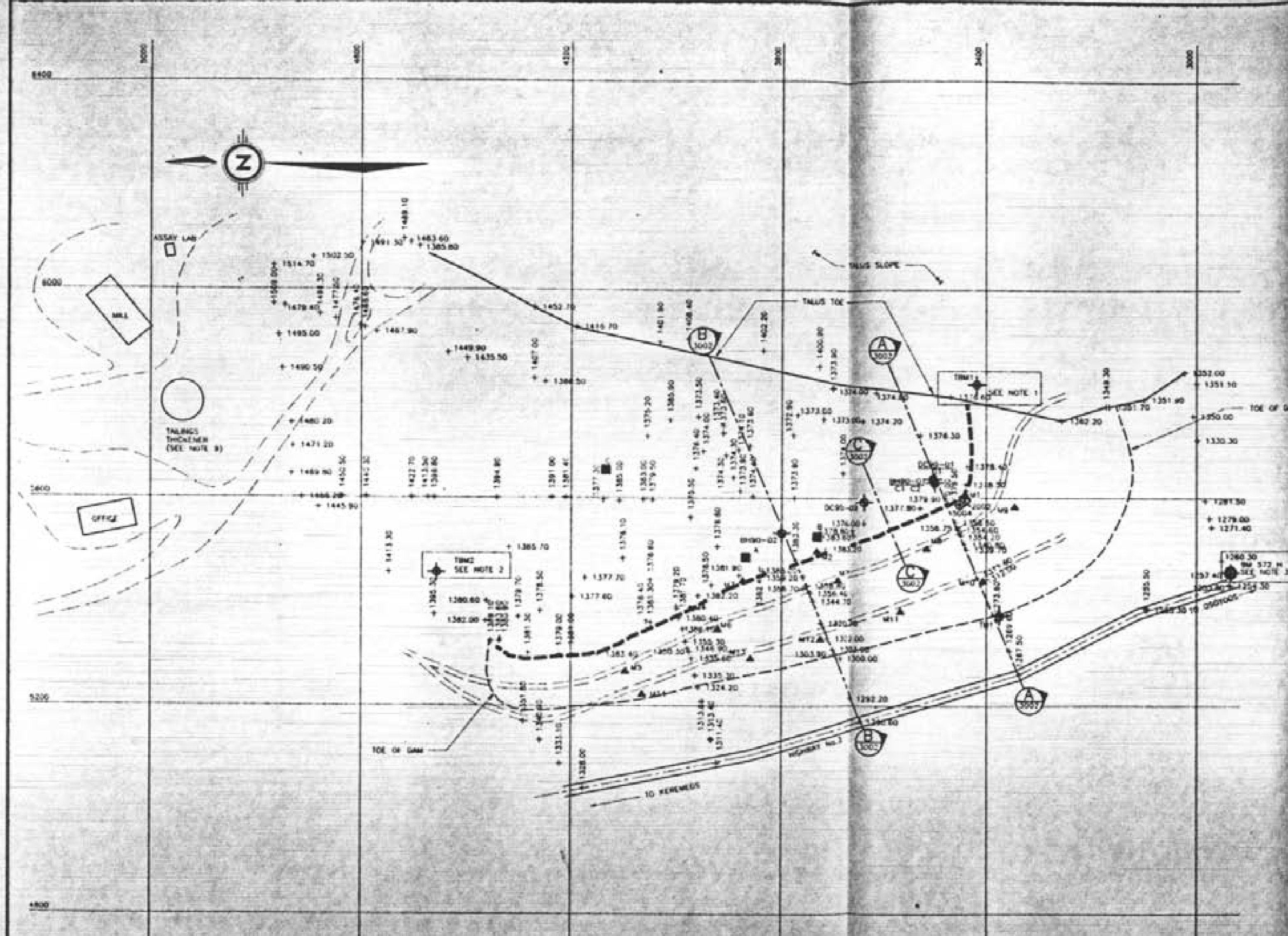


LEGEND
HAND AUGER HOLE (1970)
PIEZOMETER INSTALLATION (1970)
PENETRATION TEST (1970)
CREST OF DAM (MAR. 1990)
LOCAL ROADS
SETTLEMENT MONUMENT NO 1(1990)
NOTES:
1 TBM1
2 TBM2
3 BM 572H
TALUS SLOPE
TALUS BORROW PIT
DECANT POND (DRY MAR. 1990)
TOE OF DAM
TAILINGS THICKENER
ASSAY LAB
MILL
OFFICE
TBM2 SEE NOTE 2
BM 572 H SEE NOTE 3
SEE NOTE 1
TO OSOYOOS
TO KEREMEOS
HIGHWAY No.3
TO BE READ WITH KLOHN LEONOFF REPORT DATED MAY 11,1990
SCALE:
200m
KLOHN LEONOFF LTD.
CONSULTING ENGINEERS
DANKOE MINES LIMITED
PROJECT
DANKOE MINE TAILINGS
TITLE
TAILINGS DAM - PLAN
MARCH 1990
PROFESSIONAL
R. G. TOOMBS
ENGINEER
PB144303
D-3001


SECTION A 3001
SECTION B 3001
SECTION C 3001
ELEVATION–FEET
TAILINGS
TALUS
FAN DEPOSITS
RIVER DEPOSITS
TAILINGS LEVEL BY YEAR
1990
1983
1982
1970
EXPOSED TAILINGS
PERIMETER ACCESS ROAD
TALUS FILL
SURVEYED SLOPE MARCH 1990
ESTIMATED TALUS FILL PLACED 1980–83
DYNAMIC CONE AUTOMATIC HAMMER FIELD PENETRATION
STANDARD SPT TEST
50 LB HAMMER 1 1/2" CONE
(* SEE NOTE 2)
GRAVEL AND SAND, TRACE OF SILT, SOME COBBLES AND BOULDERS (FAN DEPOSITS)
CLEAN, VERY PERVIOUS RIVER GRAVEL DEPOSITS
HIGHWAY NO.3
LEGEND
STANDPIPE PIEZOMETER, OPERATING
STANDPIPE PIEZOMETER, LOST
INVESTIGATION 1970, 1980
INVESTIGATION 1990
BLOW COUNTS PER FOOT
% FINES #200 SIEVE
NOTES:
1. ESTIMATED ZONE OF DOWNSTREAM COMPACTED TALUS ADDED AFTER 1980 (REFERENCE DWG. D-1443-9).
* 2. FOR HISTORIES OF THE STANDPIPE PIEZOMETERS REFER TO THE REPORT
R. G. TOOMBS
KLOHN LEONOFF LTD.
CONSULTING ENGINEERS
DANKOE MINE TAILINGS
TAILINGS DAM–SECTIONS
MARCH 1990
DANKOE MINES LTD
PB144303
D-3002



LEGEND

- CREST OF DAM (MAR. 1990)
- LOCAL ROADS
- ■ A — PIEZOMETER A (1987)
- DC90-01 / D1 — DYNAMIC CONE HOLE 90-01(1990) CONTAINING PIEZOMETER D1
- BH90-02 / E1,E2,E3 — BOREHOLE 90-01(1990) CONTAINING PIEZOMETERS E1,E2,E3
- TBM1 — TEMPORARY BENCHMARK (SEE NOTES 1 & 2) (1990)
- BM 572 H — BENCHMARK (SEE NOTE 3) (1990)
- ▲ M1 — SETTLEMENT MONUMENT NO 1(1990) (SEE NOTE 5)
- + 1351.10 — TOPOGRAPHIC SURVEY POINT; ELEVATION IN FEET

NOTES:

1. TBM1 3421.24 N 5818.81 E ELEV. 1381.46 ft
2. TBM2 4456.77 N 5453.13 E ELEV. 1405.80 ft
3. BM 572H 2940.00 N 5452.00 E ELEV. 1257.396 ft
4. TBM1 AND TBM2 ARE PAINTED POINTS ON LARGE BOULDERS.
5. CO-ORDINATES OF BM 572H WERE ASSUMED BY SCALING FROM DANKOE MINES TAILING DAM MAP OF JUNE 12, 1980. TO SET THE GRID, NORTH WAS DETERMINED BY MAGNETIC BEARING AND DECLINATION. ELEVATION 1257.396 ft. OF BM 572H MAY NOT BE GEODETIC.
6. A TOTAL OF 14 MONUMENTS WERE INSTALLED ON THE BERMS OF THE DOWNSTREAM SLOPE OF THE DAM. EACH MONUMENT IS A 19mm REBAR 4' LONG DRIVEN TO A 2.5–3' DEPTH. CO-ORDINATES AND ELEVATION REFER TO THE TOP OF THE REBAR.

MONUMENT NUMBER	NORTHING	EASTING	ELEVATION
M1	3437.54	5601.58	1370.8 ft
M2	3731.46	5495.94	1385.6 ft
M3	3874.19	5438.92	1384.0 ft
M4	3973.46	5385.38	1383.9 ft
M5	4087.00	5285.18	1357.3 ft
M6	3821.35	5345.75	1357.7 ft
M7	3881.29	5439.84	1356.4 ft
M8	3514.48	5550.92	1358.2 ft
M9	3347.19	5561.89	1358.5 ft
M10	3406.68	5438.64	1314.0 ft
M11	3565.38	5379.56	1319.0 ft
M12	3725.38	5327.16	1324.8 ft
M13	3858.27	5290.39	1331.5 ft
M14	4065.45	5221.45	1342.7 ft

7. THIS SURVEY WAS PERFORMED BY C. McCLUNE AND ASSOCIATE OF KELOWNA, B.C. ON MARCH 28, 1990.
8. LOCATION OF MILL BUILDINGS AND LOCAL ROADS ARE APPROXIMATE.

PROFESSIONAL ENGINEER — R. G. TOOMBS — PROVINCE OF BRITISH COLUMBIA

SCALE: 50 0 200m

DRAWN: CYW/CY DATE: APRIL/90 SCALE: AS SHOWN

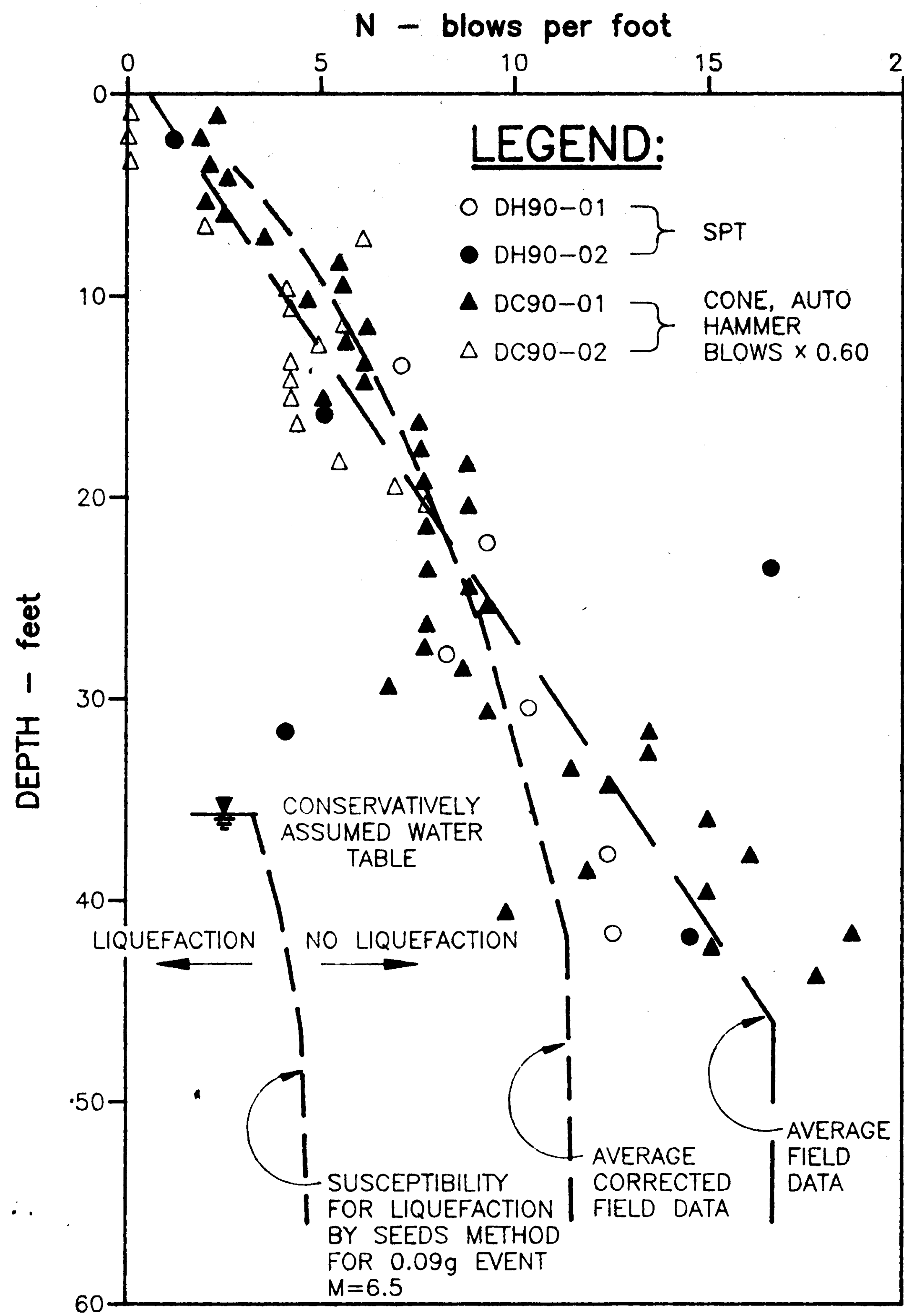
KLOHN LEONOFF LTD.
CONSULTING ENGINEERS

CLIENT: DANKOE MINES LIMITED

PROJECT: DANKOE MINE TAILINGS

TITLE: TAILINGS DAM – SURVEY MARCH 1990

PROJECT No. PB144303 DWG No. D-3003

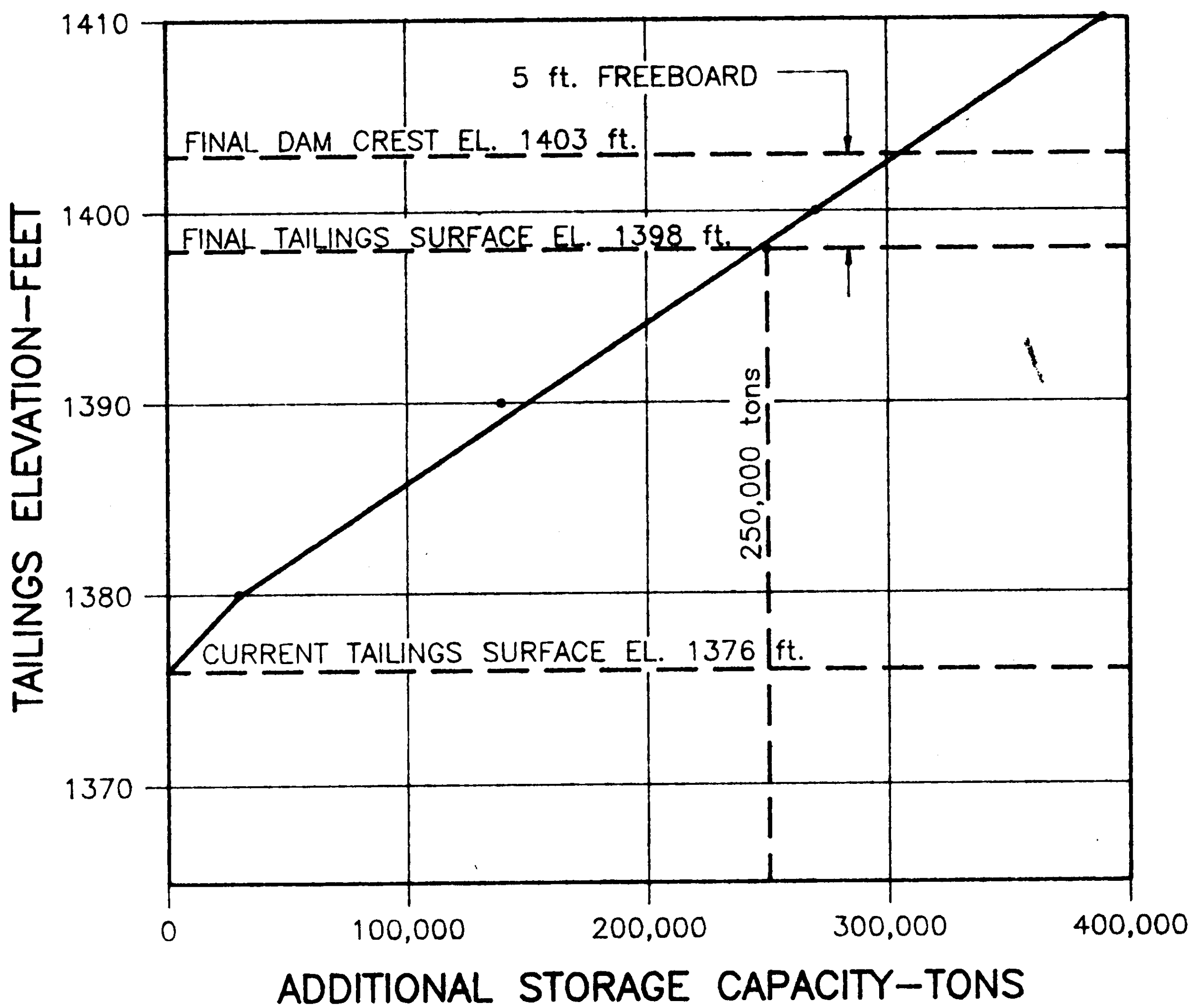


PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — R. G. TOOMBS

SCALE

KLOHN LEONOFF LTD.
CONSULTING ENGINEERS

PROJECT	DANKOE MINE TAILINGS
TITLE	PENETRATION RESISTANCE vs. DEPTH AND LIQUEFACTION SUSCEPTIBILITY
CLIENT:	DANKOE MINES LTD.
DATE OF ISSUE	MAY 11, 1990
APPROVED	[signature]
PROJECT No.	PB144303
DWG. No.	A-3005
REV.	

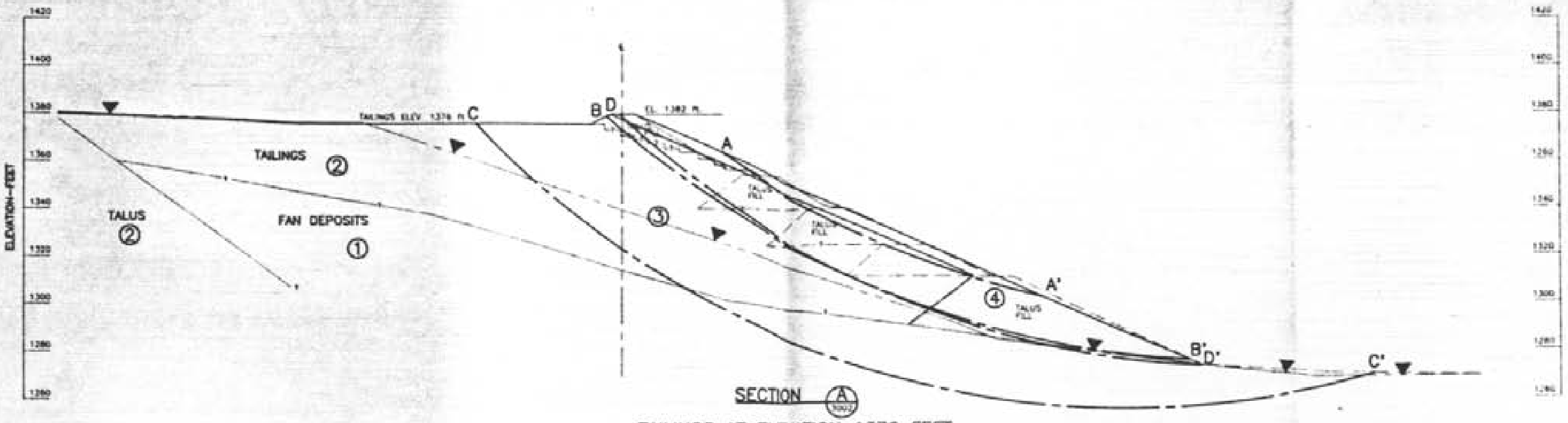


NOTES:

1. STORAGE CAPACITY IS BASED ON CONTOURS DERIVED FROM MARCH 1990 SURVEY.
2. DRY DENSITY OF STORED TAILINGS IS ASSUMED TO BE 90 lbs/ft^3.

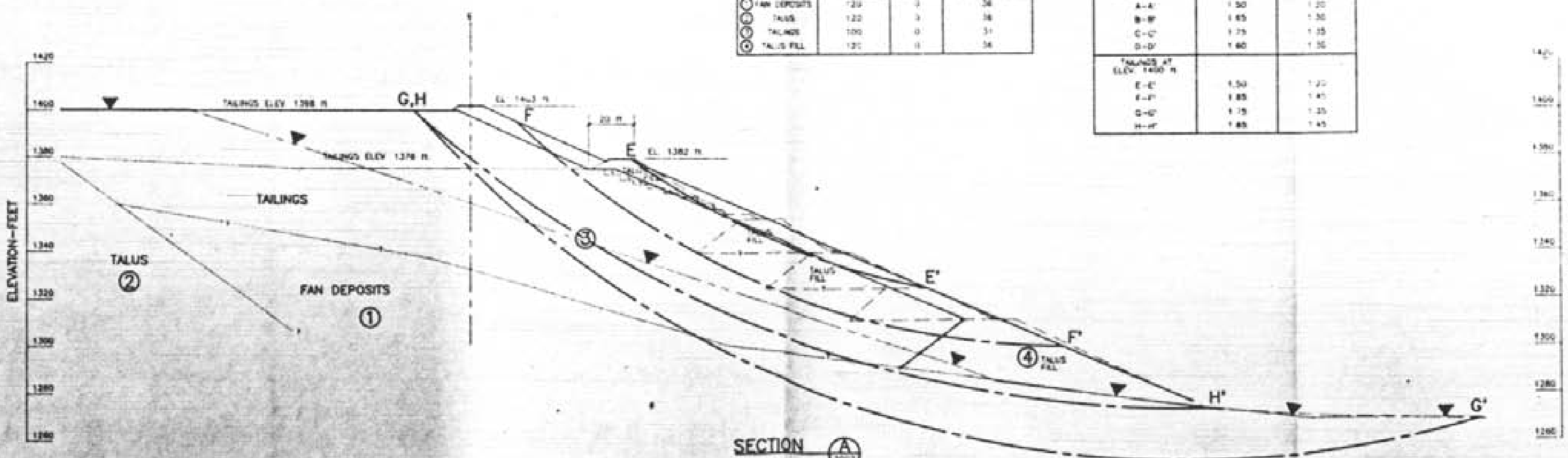
PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — R. G. TOOMBS

KLOHN LEONOFF LTD. CONSULTING ENGINEERS	SCALE	PROJECT: DANKOE MINE TAILINGS	
		TITLE: POND STORAGE ADDITIONAL CAPACITY vs. TAILINGS ELEVATION	
CLIENT: DANKOE MINES LTD.	DATE OF ISSUE: MAY 11, 1990 APPROVED: [signature]	PROJECT No.: PB144303	DWG. No.: A–3004 REV.



SECTION (A / 3002)

TAILINGS AT ELEVATION 1376 FEET



SECTION (A / 3002)

TAILINGS AT ELEVATION 1398 FEET

SUMMARY OF SOIL PROPERTIES

MATERIAL	MOIST DENSITY lbs/ft³	SOIL STRENGTH STATIC & DYNAMIC	
		COHESION lbs/ft²	FRICTION ANGLE degrees
① FAN DEPOSITS	120	0	38
② TALUS	122	0	38
③ TAILINGS	100	0	31
④ TALUS FILL	120	0	38

SUMMARY OF STABILITY ANALYSIS

DESCRIPTION	FACTOR OF SAFETY	
	STATIC	DYNAMIC a=0.09g
TAILINGS AT ELEV. 1376 ft		
A-A'	1.50	1.20
B-B'	1.65	1.30
C-C'	1.75	1.35
D-D'	1.60	1.30
TAILINGS AT ELEV. 1400 ft		
E-E'	1.50	1.20
F-F'	1.85	1.45
G-G'	1.75	1.35
H-H'	1.85	1.45

NOTES:

1. STABILITY ANALYSES ARE BASED ON BISHOP'S METHOD OF SLICES LIMIT EQUILIBRIUM ANALYSIS

TO BE READ WITH KLOHN LEONOFF REPORT DATED MAY 11, 1990

SCALE 20 ft 0 80 ft

KLOHN LEONOFF LTD.
CONSULTING ENGINEERS

CLIENT: DANKOE MINES LTD.

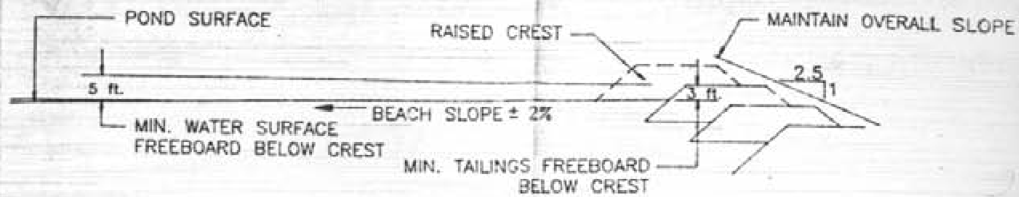
DESIGN RT | DRAWN DT

PROJECT: DANKOE MINE TAILINGS

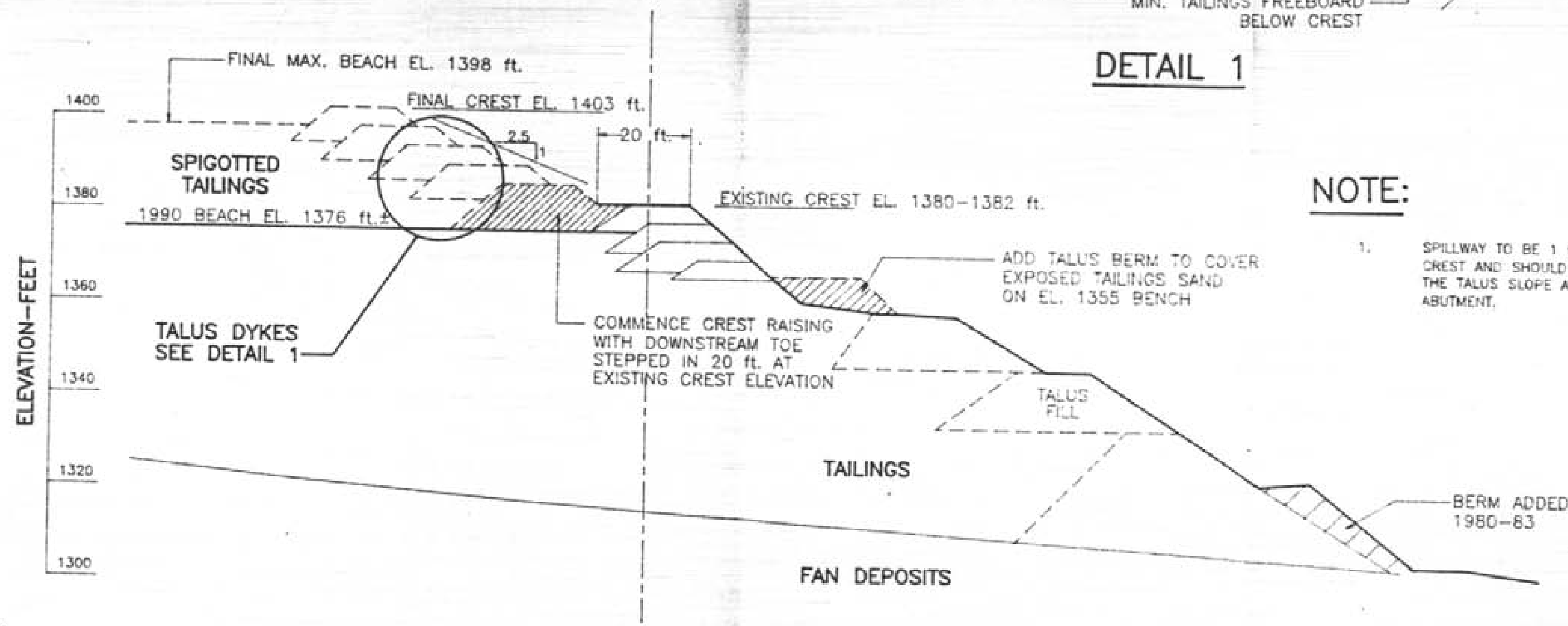
TITLE: TAILINGS DAM STABILITY ANALYSIS

DATE OF ISSUE MAY 11, 1990 | PROJECT No. PB144303 | DWG No. D-3006

PROFESSIONAL ENGINEER — R. G. TOOMBS



DETAIL 1



TYPICAL DESIGN SECTION

NOTE:

1. SPILLWAY TO BE 1 ft. LOWER THAN CREST AND SHOULD BE CUT INTO THE TALUS SLOPE AT THE SOUTH ABUTMENT.

TO BE READ WITH KLOHN LEONOFF REPORT DATED MAY 11, 1990

SCALE 1" = 20'

KLOHN LEONOFF LTD.
CONSULTING ENGINEERS

CLIENT: DANKOE MINES LTD.

PROJECT: DANKOE MINE TAILINGS

TITLE: TYPICAL TAILINGS DAM SECTION & DETAIL

DATE OF ISSUE	PROJECT No.	DWG. No.	REV.
MAY 11, 1990	PB144303	D–3007	

APPROVED –

PROFESSIONAL ENGINEER – R. G. TOOMBS – BRITISH COLUMBIA