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RISDON BROOK DAM SITE SEISMIC SURVEY AND DETERMINATION OF ROCK CONSTANTS,

TASMANIA 1965

by

P.E. MANN

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ILLUSTRATIONS

Note. This Record supersedes Record No. 1965/135.

1968/19

SUMMARY

A seismic refraction survey to determine the overburden thickness and the quality of the bedrock at a dam site, saddle, and borrow pit at Risdon Brook, was carried out at the request of the Department of Mines, Tasmania. At the dam site the overburden is thinnest about 70 ft upstream of the proposed axis. A shear zone intersects the saddle and brook about 200 ft upstream of the axis.

The rock at the dam site is almost horizontally bedded, and its elastic constants are different in the vertical and horizontal directions (transversely anisotropic). Approximate values for the five parameters needed to describe these properties were obtained near drill hole DH2, but the results are not reliable for all parameters. Near DH5, three of the parameters could not be determined with any certainty.

1. INTRODUCTION

To improve the domestic water supply on the eastern shore residential area of Hobart, the Metropolitan Water Board is considering either constructing a small dam at Risdon Brook or duplicating the existing main from New Norfolk. The approximate co-ordinates of the dam site is 519730 on the Hobart sheet of the Australia 1:250,000 map series.

Investigation of the dam site is being carried out for the Water Board by Gutheridge, Haskins, and Davey, consulting engineers and the Department of Mines, Tasmania. The Department of Mines requested the Bureau of Mineral Resources, Geology and Geophysics to carry out a geophysical survey to determine the depth and nature of the bedrock at the dam site, a low saddle of the pondage area, and a quarry and a clay borrow pit site for construction material. Also they requested a determination of the elastic constants of the foundation rock in situ, by using seismic methods. These tests are to supplement elastic constant determinations by a dynamic method on cores from the dam site (Jesson, 1964). The work was done between the 4th and 13th February by a party consisting of P.E. Mann (party leader), J.P. Piggott (geophysical assistant), and four field-hands supplied by the Water Board.

2. GEOLOGY

The geology of the area (Plate 1) has been described by Jennings (1964) and is shown on maps and borehole sections by Moore (1964 a & b). At the dam site the bedrock is the Permain Ferntree Formation consisting of siltstone with some sandy beds, limestone, and muddy limestone beds. The dip of the bedding is 6 ± 2 degrees towards west to south-west, i.e. the beds are nearly horizontal. The Ferntree Formation has strongly developed partings parallel to the bedding planes, with a joint system dividing the rock in rectangular blocks banded with thin 'clay' seams. The rock itself is tough and competent.

A rock like the Ferntree Formation, with pronounced horizontal bedding planes, may be transversely anisotropic i.e. the rock may have elastic properties symmetrical about one fixed direction (here nearly the vertical axis $x = y = 0$).

Apart from a thin soil layer, the rock is only slightly weathered along partings parallel to bedding planes and joints. The change from subsurface, slightly-weathered rock to unweathered rock at depth is possibly fairly gradual.

Triassic sandstone interbedded with mudstone and shale crop out about 350 ft upstream of the proposed axis. At the north-eastern end of the saddle the sandstone crops out but at the south-western end Ferntree mudstone boulders are scattered over the ground.

Regional mapping and a study of bedrock exposure in two trenches on the left bank indicates that a major fault with a south-easterly trend (the Lindisfarne Fault) probably intersects the leftbank saddle. This fault probably also crosses the creek about 200 ft upstream from the dam axis. A small fault interpreted from drilling results crosses the creek about 450 ft downstream of the axis, but the trend is not firmly established.

Seven diamond-drill holes have been put down at the site; three along the proposed axis of the dam, and two upstream and two downstream from the axis. Drill hole logs are shown in Plate 5. Three costeans have been excavated in the creek bed and several long exploratory trenches about 2 ft wide and 3 ft deep have been excavated on the left and right banks.

At the time of the survey about 3 ft of soil had been stripped away by a bulldozer exposing a hard rock surface as parts of traverses A, B, E, F, G, H, and J (Plate 2). The excavated surface forms gently dipping hard rock'benches'.

At the borrow pit sites the bedrock is Jurassic dolerite. Investigation of the quality of the bedrock and clay was being carried out at the time of the survey by drilling, and samples were taken from shallow test pits. Seismic traverses are located there on the scree slopes on each side of Risdon Brook.

3. METHODS

To determine the thickness of the weathered layer the seismic refraction method was used (Polak and Moss, 1959; Polak, 1960). Seismic geophone spreads were 250 or 500 ft long, with geophones at 25 or 50-ft intervals, and shot distances 25(or 50) and 200 ft from each end of the spread and in line with it. In a weathering spread the geophones were 10 ft apart and shots were fired 10, 50, and 200 ft from each end of the spread and in line with it.

The seismic method was also used to determine in situ the elastic constants of the transversely anisotropic rock. The advantage of this dynamic method is that the rock is not disturbed or changed by sampling, and that the determination applies to a large body, or sample, of rocks. In this method it is necessary to detonate charges at different levels in boreholes.

A 200-ft spread approximately parallel to the creek bed was laid out along the costean west of DH2 (Plate 2). Vertical geophones were placed 33 ft apart between two three-component geophones at each end of the spread. A vertical geophone was placed on alluvium 45 ft from the three-component geophone at the downstream end of the spread. Charges were detonated 184 ft and 143 ft from the northern (upstream) and southern (downstream) three-component geophone, respectively. This combination of vertical and three-component geophones allows the velocities of longitudinal and transverse waves along the refractor at DH2 in a direction approximately parallel to the ground surface and the bedding to be calculated.

To measure the velocities of longitudinal and transverse waves in a vertical or oblique direction near DH2, vertical geophones were spaced 15 ft apart between two three-component geophones at each end of the spread, located on the rock surface of the costean through DH2. The closest three-component geophone was 15 ft from DH2; the furthest 75 ft. A three-component geophone was placed on the ground 10 ft above the costean floor and 98 ft from the drill hole. Small charges were detonated at depths of 102, 70, 35, and 15 ft in the drill hole.

Similarly near DH5, velocities along oblique paths were measured by detonating small charges at depths of 84, 54, and 24 ft in the drill hole, the ground motion being recorded by geophones placed near the drill hole. A vertical geophone was placed at the drill hole; two vertical geophones and a three-component geophone were placed at 15-ft intervals in line from the drill hole. The geophones were planted on the excavated rock 'bench', collinear and approximately level with the top of the drill hole. A three-component geophone was placed at stations A850 and A900, i.e. along a line approximately perpendicular to the other geophone array.

Velocities of longitudinal and shear waves in oblique directions were obtained by firing charges at a depth of 100 ft in DH2 and recording ground motion with vertical and three-component geophones in turn at DH4 and DH5.

A three-component geophone was placed at the bottom of the drillhole: 80 ft deep in DH4 and 84 ft in DH5. A three-component geophone was placed at each drill collar. From DH4 three vertical geophones and a three-component geophone were placed by sight in succession 24 ft apart approximately along the line joining DH2 and DH4. A similar geophone layout was adopted near DH5. The array was not aligned with DH2.

The equipment used was a SIE refraction seismograph, TIC geophones of natural frequency about 20 c/s, three-component Hall-Sears geophones model HS-1-LP 3D of natural frequency about 14 c/s, and one miniature three-component Hall-Sears geophone model HS-1-LPJ 3D of natural frequency about $7\frac{1}{2}$ c/s.

To improve the accuracy of timing, the photographic paper in the oscillograph was fed at maximum speed (about 17 inches/second). Furthermore, charges were fired with one shot box, but this instrument although checked did not always give a sharp shot instant break on the seismogram. Two shots had to be fired with another shot box.

For the theory of elastic wave propagation in a medium with elastic properties symmetrical about one fixed direction (the vertical axis $x = y = 0$ in the instance of the Risdon Brook dam site) reference is made to Wiebenga, Mann, and Dooley (1964), Stoneley (1949), and Love (1927).

4. RESULTS

Computation of the elastic constants

Area near borehole DH2. Jesson (1964) determined densities ranging from 2.20 to 2.44 g/cm^3 for dry samples, and 2.35 to 2.52 g/cm^3 for wet samples. A density of 2.44 g/cm^3 was adopted for the present computations.

The velocity of longitudinal waves approximately horizontal and parallel to the bedding could not be measured with the geophones in the east-west costean because of practical difficulties. The longitudinal velocity measured with geophones in the north-south costean is 10,500 ft/s and on Traverse A, 10,300 ft/s. The difference in velocity is not considered significant and the value 10,300 ft/s is adopted. Substitution of these values in equation (4) of Wiebenga et al (1964) gives

$$A = 241 \times 10^9 \text{ dyne/cm}^2$$

The seismic velocities of longitudinal and transverse waves approximately vertical and perpendicular to the bedding were measured by firing charges at different depths in DH2 and recording the arrival of the different wave types at geophones on the costean floor. Plate 6A is the velocity log of the drill hole. The velocities measured were 7000 ft/s for the P wave and 3400 ft/s for the S wave. From equations (6) and (7) of Wiebenga et al, weget

$$C = 111 \times 10^9 \text{ dyne/cm}^2$$

$$L = 26 \times 10^9 \text{ dyne/cm}^2$$

N is most directly obtained from the horizontal velocity of horizontally polarised transverse waves. In this case a reliable measurement of this could not be made, and a value for N was obtained from oblique paths shown in Plate 6B using equation (9) of Wiebenga et al, and substituting the value of L obtained above. The travel time in the weathering layer was estimated by using two paths. The value of N obtained was

$$N \approx 80 \times 10^9 \text{ dyne/cm}^2$$

Because of the small difference between the length of these two paths, this must be regarded as a rough estimate only.

The elastic constant F was determined by measuring the velocity of longitudinal waves along oblique paths to the geophones for shots at different depths in the borehole and substituting appropriate values of l, n, A, C, L, and c in equation (11) of Wiebenga et al. Plate 6C shows the arrangement of shot-points and geophones, and the experimental time/distance curves.

For waves travelling at an angle of 45^{o} the average measured velocity is 8200 ft/s, and for 30^{o} it is 7400 ft/s. Substituting these and the above values for A, C, and L in equation (11), we get F = 52 and 62 x 10^{9} dyne/cm^{2}, respectively. We take the mean value

$$F = 57 \times 10^{9} \text{ dyne/cm}^{2}$$

Using equations (18) to (23) of Wiebenga et al, we calculate for Young's moduli and Poisson's ratios for the rock in this area:

$$E_1 = E_2 = 198 \times 10^{9} \text{ dyne/cm}^{2}$$

$$E_3 = 91 \times 10^{9} \text{ dyne/cm}^{2}$$

$$\sigma_1 = 0.25$$

$$\sigma_2 = 0.38$$

$$\sigma_3 = 0.18$$

Area near borehole DH5. The velocity of horizontal longitudinal waves was assumed to be the velocity recorded for the bedrock on traverses near DH5, i.e. 13,500 ft/s. Substituting in equation (4) gives:

$$A = 414 \times 10^{9} \text{ dyne/cm}^{2}$$

Longitudinal and transverse wave velocities were measured by firing charges at different depths in DH5 and recording the arrival at geophones laid out near the drill hole. Plate 6D shows the velocity log of the drill hole. Vertical velocity of the longitudinal wave is 10,000 ft/s. Substituting in equation (6) gives

$$C = 227 \times 10^{9} \text{ dynes/cm}^{2}$$

A satisfactory value could not be obtained for either vertical or horizontal SH velocities in this case. Estimates for L and N obtained from equation (11) using four oblique paths for SH waves gives

$$L \approx N \approx 40 \times 10^{9} \text{ dyne/cm}^{2}$$

As with N near DH2, these values cannot be regarded as reliable.

For oblique paths, a longitudinal velocity of about 8000 ft/s was measured (Plate 6E). Using the above values of A, C, and L, this leads to a negative value for F. This gives more reason to suspect the values obtained for L and N above.

Because of the doubt about values of F, L, and N, it is not possible to make reasonable estimates of Young's moduli or Poisson's ratios for this rock.

Wiebenga and Manganwidjoyo (1960) give an empirical relation between longitudinal seismic velocity and rock strength, measured as compressive strength in a standard compression test, viz:

$$c_s = 2.5V - 5 \pm 35\%$$

where c_s is rock strength in units of 1000 lb/in^2 and V the seismic velocity in kilo-ft/s.

Taking the lowest seismic velocities in the anisotropic rock as a measure, the compressive strength for the siltstone near DH2 with 7000 ft/s seismic velocity is estimated at 12,500 lb/in^2 or 5.6 ton/in^2 and near DH5 with 8000 ft/s seismic velocity at 15,000 lb/in^2 or 6.8 ton/in^2.

In laboratory tests on samples from Risdon Brook, Jesson (1964) had difficulties in making reliable measurements of bar velocity, and hence of Young's modulus. This was attributed to fracture planes in the samples.

<u>Cross-sections and bedrock contour plan</u>

Table 1 gives the interpretation of the seismic velocities at the dam site and saddle area in geological terms. The interpretation is based on geological mapping, logs of drill hole cores, and experience in other areas.

TABLE 1

Seismic velocity (ft/s)	Rock type
1000	Soil
3500 to 5500	Highly weathered to weathered bedrock (Ferntree Formation or Triassic sandstone)
6500 to 8700	Moderately weathered bedrock or bedrock in shear zone.
9500 to 10,000	Unweathered bedrock - Triassic sandstone.
10,000 to 20,000	Unweathered bedrock - Ferntree Formation.

The seismic results are shown as cross-sections in Plate 3. On the dam site traverses the seismic velocity of the deepest refractor is interpreted as bedrock, for the purpose of foundation rock for a dam. On Traverse J the time/distance curves indicate a deeper refractor with seismic velocity about 18,000 ft/s. This refractor may be too deep to be used for the dam foundations. On the northern end of Traverses B and J the bedrock velocities (respectively about 7000 and 6500 ft/s) probably indicate shear zones. Both traverses do not extend far enough to give the seismic velocity or width of the shear zone.

On Traverse S the seismic velocity of the bedrock changes from 7100 to 9500 ft/s and the thickness of overburden increases near S200. These two factors suggest the presence of a shear zone intersecting Traverse 5. However, on Traverse X, the seismic velocity of the bedrock and the overburden thickness are approximately constant. This suggests that the wide shear zone intersecting Traverse S does not intersect Traverse X. A major shear zone interpreted to intersect Traverse S and part of Traverses B and J has approximately the same strike as the Lindisfarne Fault interpreted from geological work (Plate 1).

Plate 4 shows the contours of the depth of bedrock based on the seismic cross-sections (Plate 3). On the left bank the contours are approximately parallel to the ground contours. On the right bank there is a ridge of high bedrock approximately in the triangle formed by Traverses A, D, and J. This structural feature may be useful for the dam foundations.

Table 2 gives the interpretation of the seismic velocities at the quarry and clay borrow pit sites.

TABLE 2.

Seismic velocity (ft/s)	Rock type
1000	Soil and talus material
3750 to 4000	Stiff or compacted clay
5000 to 6000	Weathered, jointed dolerite
9500	Dolerite bedrock in shear zone
10,000	Partly weathered, jointed dolerite
14,000 to 20,000	Unweathered dolerite bedrock

The seismic cross-section of Traverse V (Plate 3) shows that the unweathered bedrock with seismic velocity greater than 14,000 ft/s is deeper at the south-east than at the north-west end of the traverse. The log of drill hole Q9 (Plate 5), about 6 ft from V300, shows fresh dolerite below about 25 ft. Rock with seismic velocity 10,000 ft/s is probably suitable for construction material.

On Traverse P the seismic cross-section (Plate 3) suggests that clay with velocity about 4000 ft/s lenses out or is too thin to be detected by seismic methods near P0. On cross-traverses P, Q, and R the overburden thickness is approximately constant on the hillside.

5. CONCLUSIONS

The most important elastic constants to be considered in relation to horizontal stresses acting on a horizontally layered medium are the constants L and N. For the siltstone, N is about three times greater than L at DH2, but at DH5 the results suggest that N is about the same order of magnitude as L, but smaller than at DH2.

The estimates of the elastic constants cannot be regarded as reliable because their accuracy depends on timing waves over short distances in vertical and oblique directions. Practical steps taken to improve the accuracy of timing in this survey were not completely successful.

On the right bank, rock probably suitable for the dam foundations is shallowest about 70 ft upstream of the proposed axis.

A wide shear zone intersects Traverse S in the saddle area and probably strikes across the brook about 200 ft upstream of the axis.

6. REFERENCES

JENNINGS, I.L.B.	1964	Geological report on the Risdon Brook damsite. Dept. of Mines, Tasmania (Unpublished internal report).
JESSON, E.E.	1964	Measurements of dynamic elastic constants of rock samples from Risdon Brook damsite, Tasmania, Bur. Min. Resour.Aust.Rec. 1964/165.
LOVE, A.E.H.	1927	MATHEMATICAL THEORY OF ELASTICITY. Cambridge University Press.
MOORE, W.R.	1964a	Geological map Risdon Vale - Geilston Bay Area, Map No. 2491, Dept. of Mines, Tasmania.
	1964b	Bore logs 1-8, Risdon Brook damsite, Plan No. 2436-82, Dept. of Mines, Tasmania.

POLAK, E.J. & MOSS, F.J. 1959 Geophysical survey at the Cluny damsite, Derwent River, Tasmania, Bur.Min.Resour.Aust.Rec. 1959/87.

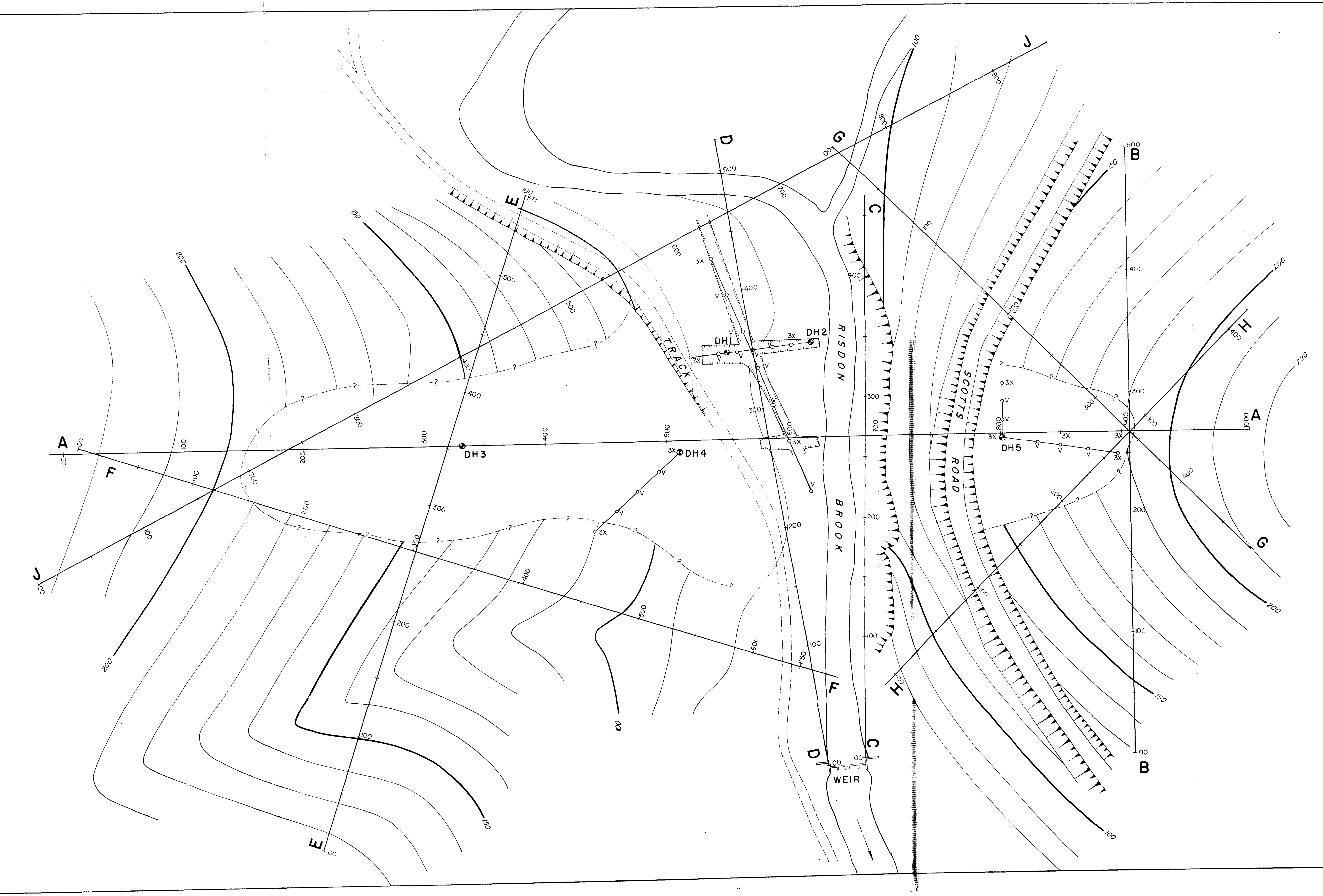
POLAK, E.J. 1960 Railton geophysical survey, Tasmania, 1959 - 1960, Bur.Min.Resour.Aust.Rec. 1962/181.

STONELEY 1949 The seismological implications of aelotropy in continental structure. Mon.Not.R.Astr.Soc. Geophys. Suppl. 5, 343.

WIEBENGA, W.A. MANN, P.E. and DOOLEY, J.C. 1964 Meadowbanks damsite, seismic determination of rock constants, Tasmania 1963, Bur.Min.Resour.Aust.Rec. 1964/114.

WIEBENGA, W.A. and MANGANWIDJOYO, A. 1960 Some correlations between rock parameters, derived from Wuerkers annotated tables of strength and elastic properties, 1956. Am. Inst. Min. Engrs. Trans. 271, 7.


PLATE I
RICHMOND
Mt Direction
SURVEY AREA
Risdon Vale
LINDISFARNE
HOBART
BELLERIVE
River Derwent
Ralphs Bay
0 1 2 3 4 MILES
42°45'
43°00'
147°15'
147°30'
BURNIE
LAUNCESTON
TASMANIA
QUEENSTOWN
OATLANDS
PORT DAVEY
HOBART
REFERENCE TO AUSTRALIA 1:250,000 STANDARD MAP SERIES: HOBART
SCOTTS ROAD
RISDON BROOK
LINDISFARNE
DHQ9
JURASSIC DOLERITE
ALLUVIAL GRAVELS AND FINE SAND
TRIASSIC SANDSTONE
FERNTREE SILTSTONE
APPROXIMATE POSITION OF LINDISFARNE FAULT
FAULT INFERRED
APPROXIMATE GEOLOGICAL BOUNDARY
SEISMIC TRAVERSE
ELEVATION CONTOUR (FEET)
PROBABLE SHEAR ZONE FROM SEISMIC DATA
MN
TN
GEOPHYSICAL SURVEY, RISDON BROOK DAM SITE
TASMANIA, 1965
LOCALITY MAP, GEOLOGY, AND SEISMIC TRAVERSES
SCALE
200 0 200 400 600 FEET
TO ACCOMPANY RECORD No. 1966/19
Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics
K55/B5-82



SEISMIC TRAVERSES AT THE DAM SITE

LEGEND

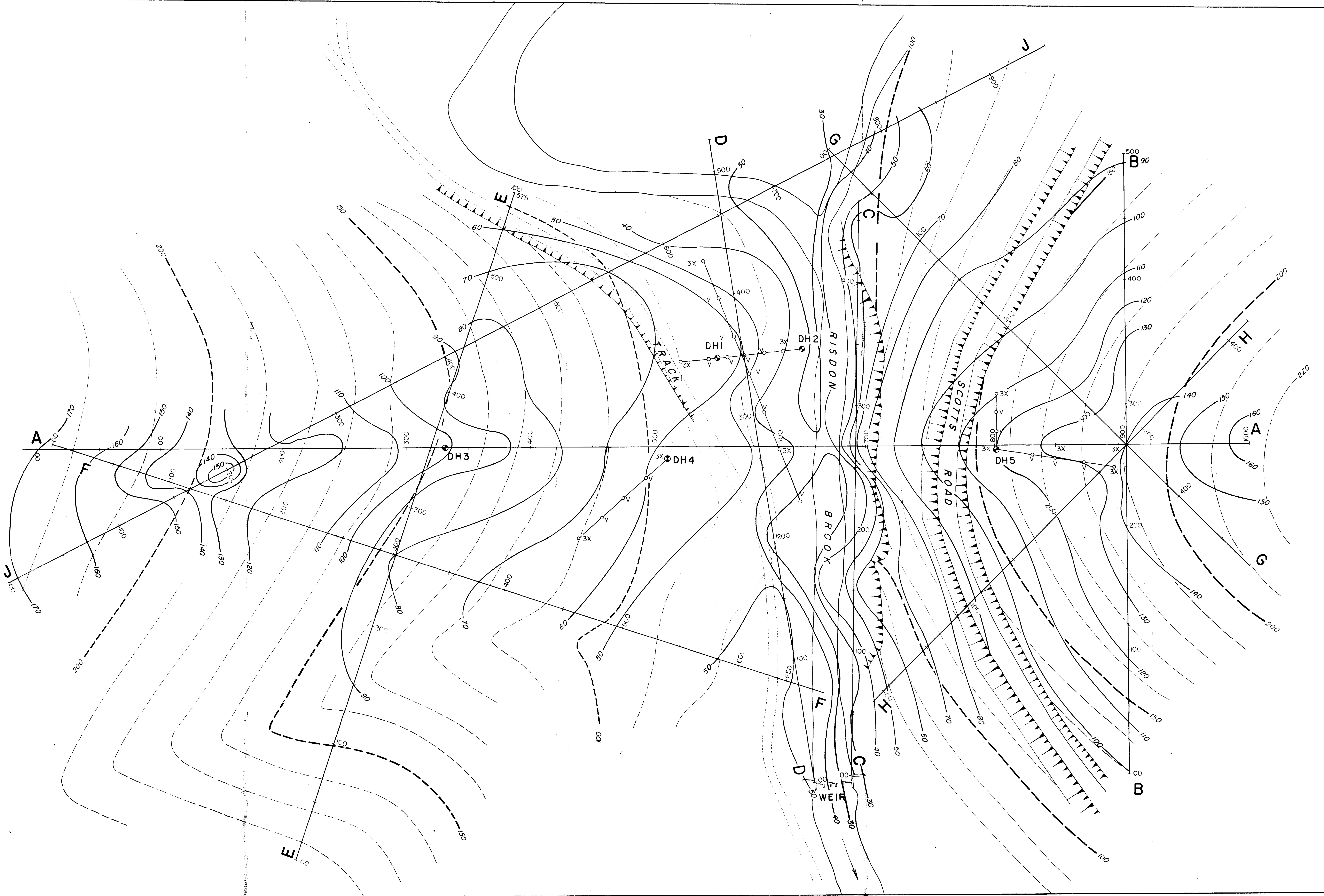
- Geophysical traverse with station number
- Geophysical traverse with vertical and three component geophones
- Elevation contours
- Approximate boundary excavated area
- Drill hole
- Costean
- Near – Vertical face

FEET
40 0 40 80 120

Based on Gutteridge, Haskins & Davey Plan 1810-2-22
and Department of Mines, Plan 2434-82

TO ACCOMPANY RECORD No 1968/19
GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS K55/B5-83


PLATE 3
TRAVERSE A
WEST
EAST
TRAVERSE J
SOUTH-WEST
NORTH-EAST
TRAVERSE S
SOUTH-WEST
NORTH-EAST
TRAVERSE P
NORTH-WEST
SOUTH-EAST
TRAVERSE B
SOUTH
NORTH
TRAVERSE C
SOUTH
NORTH
TRAVERSE D
SOUTH
NORTH
TRAVERSE X
SOUTH-EAST
NORTH-WEST
TRAVERSE Q
NORTH-EAST
SOUTH-WEST
TRAVERSE R
NORTH-EAST
SOUTH-WEST
TRAVERSE T
NORTH-EAST
SOUTH-WEST
TRAVERSE E
SOUTH-WEST
NORTH-EAST
TRAVERSE F
NORTH-WEST
SOUTH-EAST
TRAVERSE G
NORTH-WEST
SOUTH-EAST
TRAVERSE H
SOUTH-WEST
NORTH-EAST
TRAVERSE V
SOUTH-EAST
ELEVATION (FEET)
Datum 00
STATION NUMBER
STATION ELEVATION
DEPTH TO BEDROCK
LEGEND
(10,000) Seismic velocity (ft/s) in formation
Depth to formation with different seismic velocity
I Pt Intersection point
Top of deepest refractor
DDH Diamond drill hole
Based on Gutteridge, Haskins & Davey Plan 1810-2-24
FEET
(Horizontal and Vertical)
SEISMIC CROSS-SECTIONS
TO ACCOMPANY RECORD No 1968/19
GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS
K55/B5-84



BEDROCK ELEVATION CONTOURS AT THE DAM SITE

LEGEND

Geophysical traverse with station number

Geophysical traverse with vertical and three component geophones

Elevation contours

Bedrock elevation contours

DH5 Drill hole

Near - Vertical face

FEET
40 0 40 80 120

Based on Gutteridge, Haskins & Davey Plan 1810-2 -22
and Department of Mines Plan 2434-82

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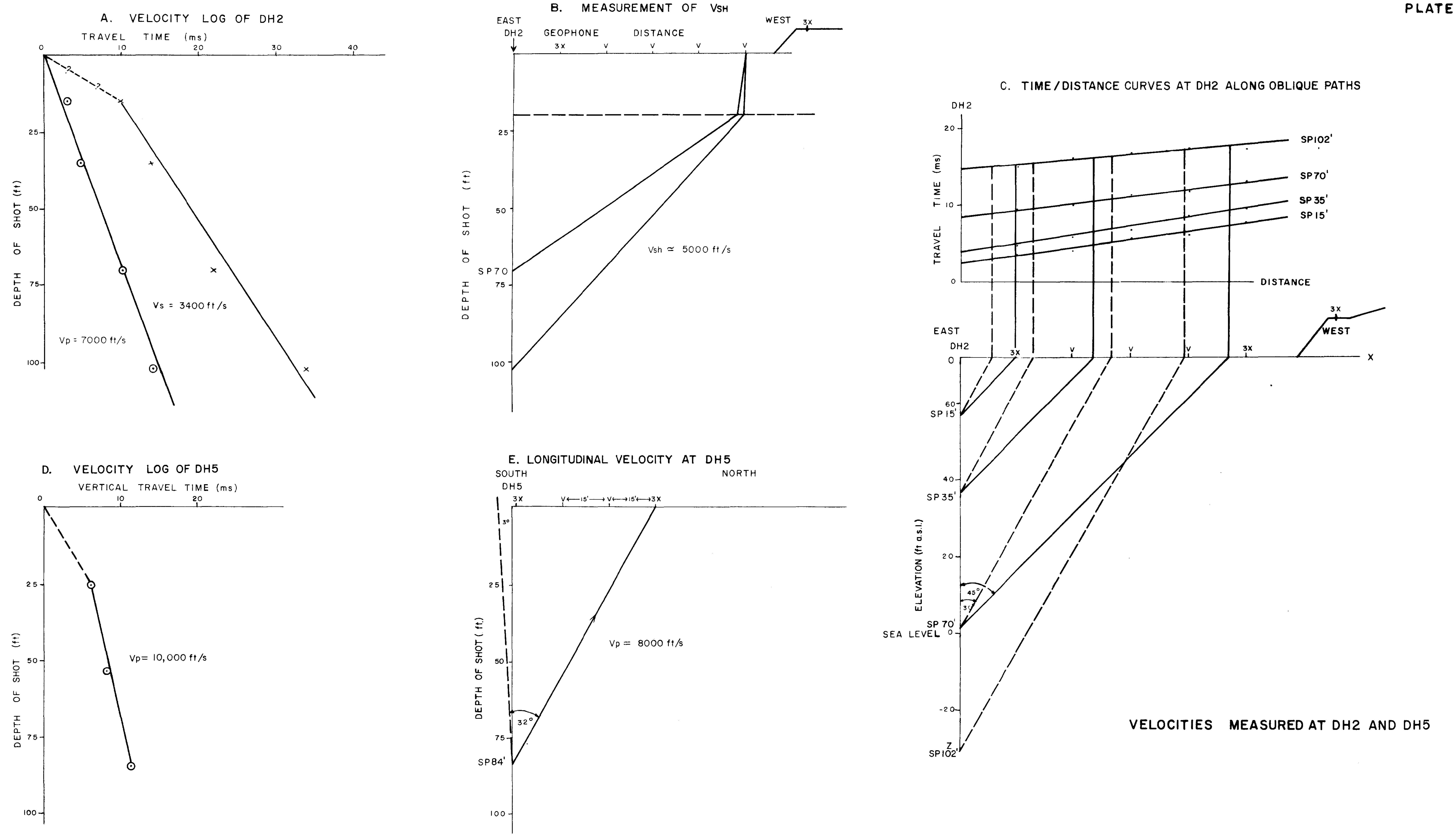
PLATE 5
DRILLHOLE 3
DATUM 156 ft
1 1/2" BRECCIATED PUGGY BAND
1' QUARTZ FELDSPATHIC SANDSTONE
THIN VENEER OF OXIDISED CLAY
5" ZONE OF DARK MUDSTONE IN SILTSTONE
1/2" BRECCIATED PUG BAND
1" COARSE SANDSTONE WITH ROCK FRAGMENTS
3' MED-FINE CREAMY MASSIVE SANDSTONE
3/4" CLAY BAND REPORTED
Pf
DRILLHOLE 4
DATUM 92 ft
< 1/16" MUDSTONE BAND
Pf
3" CREAMY SILTY LIMESTONE
< 1/16" BLACK MUDSTONE BAND
2 LAMELLAE BLACK MUDSTONE BEDS WITH PYRITE
THINPYRITE VEINS ALONG BEDDING PLANE EVERY 1/2" FOR 18" ZONE
SHEAR POLISH ON DARK MUDSTONE
DRILLHOLE 1
DATUM 73 ft
2" CLAY BAND POSSIBLY JOINT INFILL CLAY
SUBVERTICAL JOINTING PRESENT
15'4" OXIDATION OF SILTSTONE ALONG BEDDING PLANE CEASED
28" GREY COLOUR FINE GRAINED MUDDY CALCAREOUS SANDSTONE
9" FINE GRAINED MUDDY DARK LIMESTONE
4" CREAMY GREY GREEN CONCRETIONARY LIMESTONE BAND
3" LIGHT GREY SILTY SANDSTONE AND SANDY SILTSTONE
Pf
LEGEND
FINE SANDSTONE
SANDY SILTSTONE - SILTY SANSTONE
SILTSTONE
CLAY OR MUDSTONE
LIMESTONE
FAULT PUG AND/OR BRECCIA
SHEAR ZONE
DOLERITE
Pf FERNTREE FORMATION - PERMIAN
FIGURES BESIDE COLUMNS REFER TO:
1) DEPTH CORE PULLED
2) PERCENT CORE RECOVERED
DRILLHOLE 2
DATUM 72 ft
19" GREY MUDDY FINE GRAINED LIMESTONE
3" ZONE DARK MUDSTONE: PYRITE ALONG BEDDING
3" GREY GREEN CONCRETIONARY LIMESTONE
7" FINE MUDDY S.S. WITH PYRITE GRAINS
3" SILTSTONE
28" FINE SILTY S.S. AND SANDY SILTSTONE
Pf
9" LIGHT GREY CALCAREOUS MUDSTONE
DRILLHOLE 5
DATUM 155 ft
5' SANDY SILTSTONE
6" GREY SILTY SANSTONE
12" SANDY SILTSTONE
3/4" PUGGY CLAY BED
5' FINE MASSIVE GREY SANDSTONE GRADING UP AND DOWN TO GREY SANDY SILTSTONE
2' MOTTLED GREY RUSTY SILTSTONE
2' BED OF SANDY SILTSTONE
10' BED OF SANDY SILTSTONE
SURFACE OXIDATION CEASES
Pf
BEDDING PLANE AND JOINT
BLACK PUGGY MUDSTONE
DRILLHOLE Q9
RISDON BROOK QUARRY SITE
DATUM 280 ft
SOIL AND TALUS MATERIAL
FRESH DOLERITE - WEATHERED JOINTS
FRESH DOLERITE
DRILL HOLE LOGS
VERTICAL SCALE
10 5 0 10 20 30 FEET
TO ACCOMPANY RECORD No 1968/19
Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics.
K55/B5-86



VELOCITIES MEASURED AT DH2 AND DH5