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# DEPARTMENT OF MINERALS AND ENERGY

# BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Record 1976/19

054990

# TUGGERANONG SEWERAGE TUNNEL CONNECTION: GEOLOGICAL INVESTIGATION, 1975

by

R.C.M. Goldsmith

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## SUMMARY

The site of the proposed Tuggeranong sewerage tunnel connection at Tuggeranong Creek, A.C.T., has been investigated by geological mapping, seismic refraction surveying, and diamond drilling.

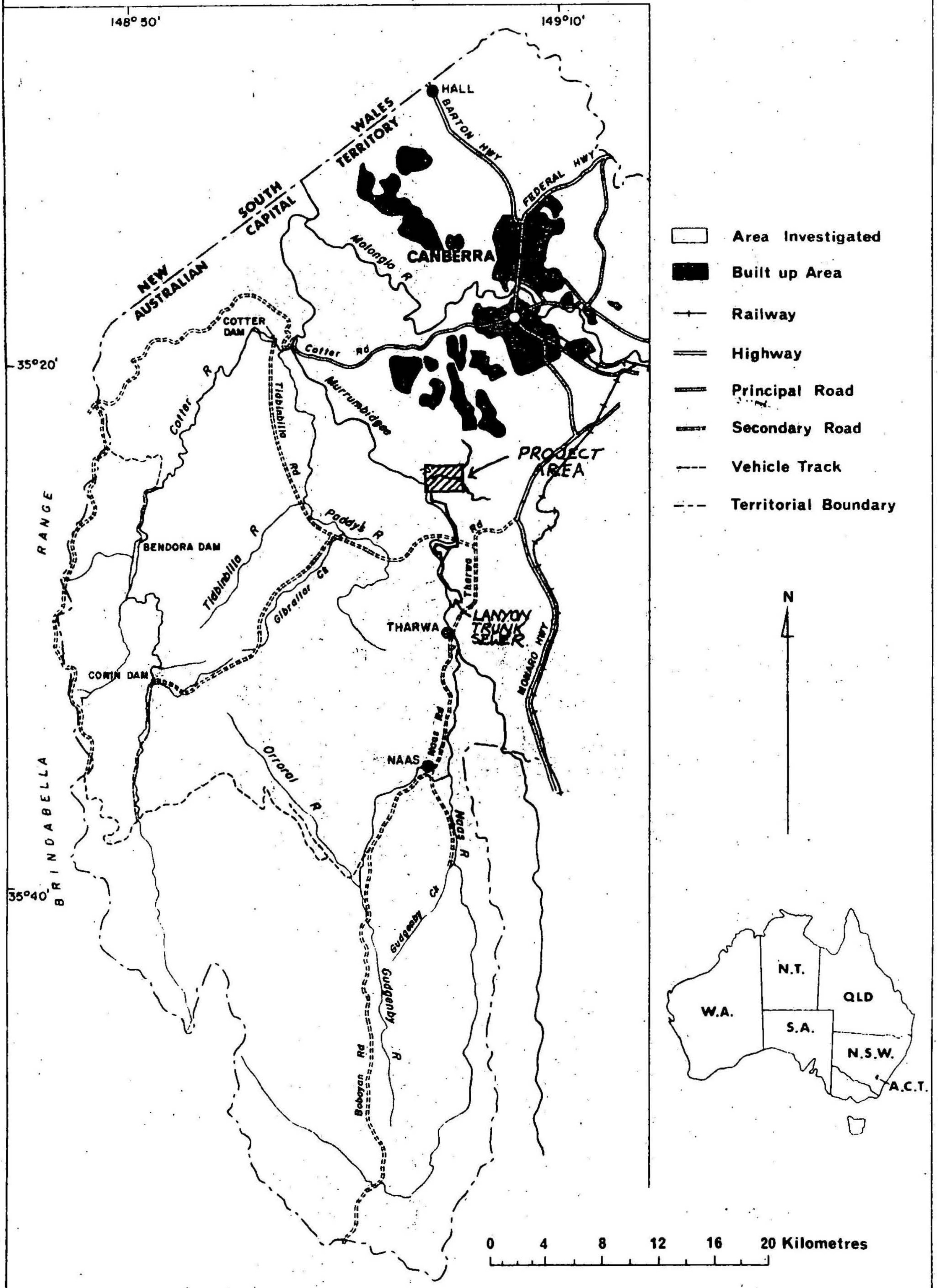
Abundant outcrop of moderately weathered to fresh dacite occurs on the steeper slopes north of the creek and along the creek bed. Jointing is moderately spaced and fits into a regional stress pattern, with maximum stress orientation of 066°.

The sewer connection includes two drop structures of 15 m and 18 m depth respectively and 1955 m of buried pipeline. Trenches will be excavated through the extremely weathered rock and soil, which are up to 10 m deep, but the moderately weathered to fresh rock below will have to be blasted.

Two joint sets and seven joint intersections are considered unstable in the proposed excavations, and support will be necessary in the drop structures and the deeper sections of the benches, particularly where joints are undercut by the rock slope. The unstable joint orientations may occur singly or in groups.

FIGURE 1

# TUGGERANONG SEWERAGE TUNNEL CONNECTION
## LOCATION MAP



*Record 1976/19*

155/A16/1527 from 155/A16/954

P.B.

## INTRODUCTION

The Department of Housing and Construction (DHC) requested the Bureau of Mineral Resources (BMR) to carry out a geological investigation of the site of the proposed Tuggeranong sewerage tunnel connection. For location see Figure 1.

A 1350-mm diameter buried pipeline along Tuggeranong Creek will connect a 900-mm sewer from the east and a 1200-mm sewer from the southeast to Tuggeranong tunnel (see Plate 2); the incoming sewer lines will be reduced to the level of the 1350-mm diameter pipeline through 15 m and 18 m drop structures respectively. The Lanyon trunk sewer, 1350 mm diameter, will join the system near the tunnel portal.

A diamond-drill hole was drilled by DHC at each of the two drop structure sites. A seismic survey was carried out by the Commonwealth Testing and Research Laboratory (CTRL) along sections of the pipeline (Makarucha, 1975), and the depths below which blasting will be required were estimated by BMR.

Previous geological investigations of the Tuggeranong water feature (Purcell & Goldsmith, 1975; Michail, 1975), the Village Creek and Tuggeranong sewers (Michail, 1974), and the Tuggeranong sewer tunnel (Purcell, 1974) provided additional subsurface information.

## GENERAL GEOLOGY

The area between Tuggeranong tunnel inlet portal and the proposed dam across Tuggeranong Creek has been geologically mapped at a scale of 1:2500 (Plate 1). The rock is a grey dacite with phenocrysts of quartz and plagioclase 2-8 mm in diameter. Rhyodacite is present in small localized zones, with orthoclase phenocrysts 1-3 mm in diameter.

Abundant outcrop of moderately weathered to fresh rock (Appendix 1) occurs on the steeper slopes north of the creek, and along the creek bed where much of the more highly weathered rock has been eroded from the gullies, but on some banks of the creek large areas of highly weathered rock are exposed.

Jointing is generally moderately spaced (See Appendix 1) and tight, and open-fractured zones and closely spaced joints are localized; there are marked changes in joint patterns over 20 m in some outcrops. A joint stereogram of the general area (Fig. 2) shows four steeply dipping joint sets that indicate a stress pattern with the maximum principal stress parallel to 066°; joint set 4 is tensional, set 2 compressional, and sets 1 and 3 are conjugate 'shear' joints (Price, 1966). Also present are three shallow-dipping sets which are probably the result of unloading subparallel to the surface owing to the downcutting of the Murrumbidgee River. Epidote and calcite veins are parallel to the closely spaced joints and are probably related to localized shear zones.

No major faults are known to intersect the project area, but airphoto-lineaments along Tuggeranong tunnel were found to represent either a joint pattern, sheared zones, or concealed faults. Airphoto-lineaments are shown in Plate 1.

## ENGINEERING GEOLOGY

### Method of investigation

The diamond-drill holes at the sites of the two drop structures were completed by DHC in September 1975. The geological logs of the two holes form Appendix 2 of this report.

A seismic refraction survey was carried out by CTRL along 1100 m of the proposed sewer routes. Spreads of 30 m were surveyed using hammer impact and a Bison receiver. The seismic profiles are shown in Plates 2-4.

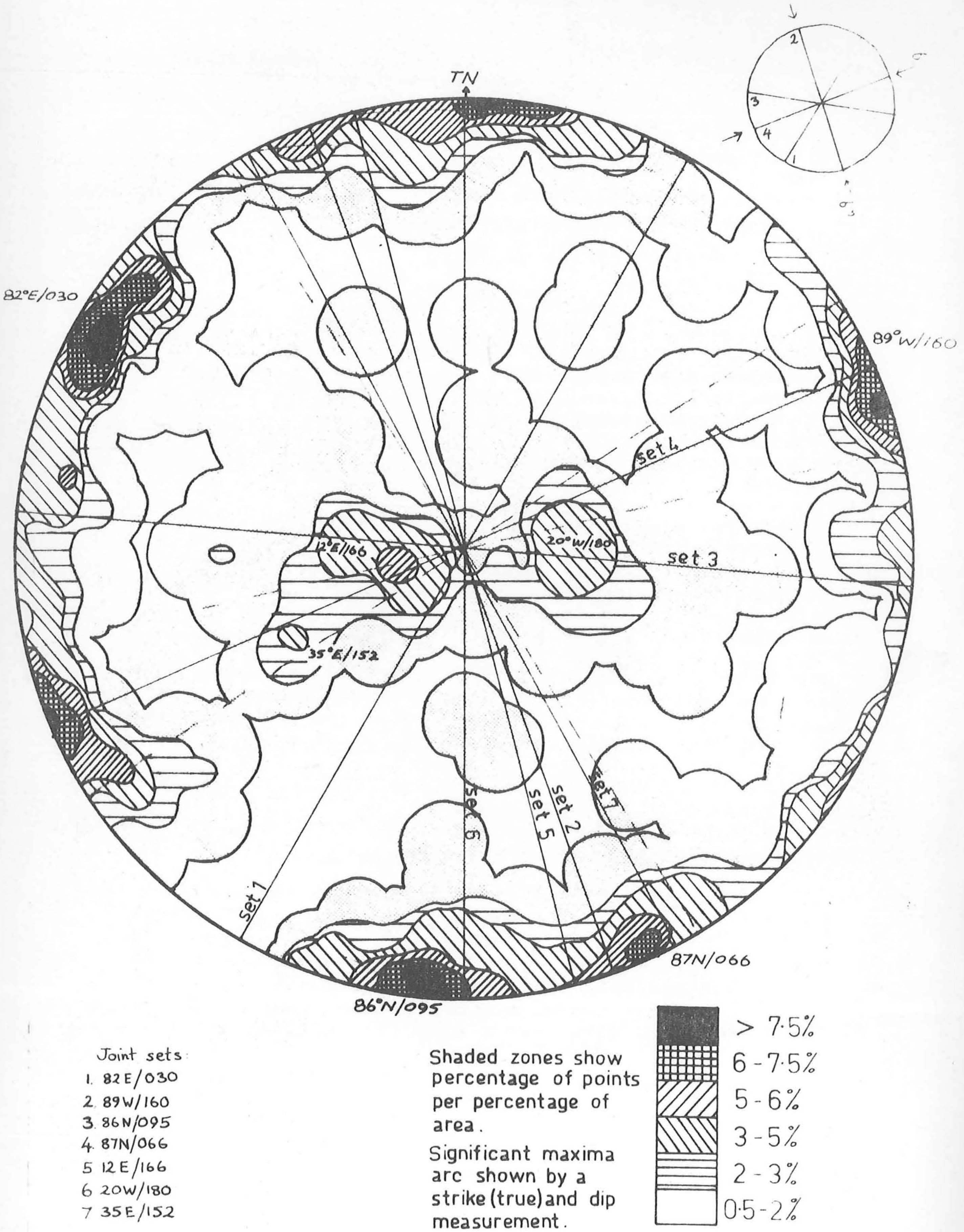
Reinterpretations of the seismic results for traverses E and I show a closer correlation with the drilling results (see Plates 3 & 4). The seismic results of the other traverses were not reinterpreted because there are no drilling results with which to correlate them.

The bedrock refractor at the western end of traverse L (2700 m/s) is at 10 m, but the same location intersected by a traverse shot for the Tuggeranong water feature (Michail, 1975) shows bedrock (4500 m/s) at 17.5 m. The discrepancy may be due to different refractors having been observed, and to the possibly misleading nature of average velocities. The 1150 m/s refractor (Michail, 1975) may represent an average of the 700, 1000, and 2700 m/s refractors of traverse L, and the 4500 m/s refractor too deep to be picked up by the CTRL survey.

For excavations down to about 10 m the seismic survey should be reasonably accurate.

The following table shows the correlation between seismic velocity and weathering condition based on previous experience in the same rock type in the A.C.T.

# TUGGERANONG CREEK-JOINT STEREOGRAM



Joint sets:
1. 82E/030
2. 89W/160
3. 86N/095
4. 87N/066
5. 12E/166
6. 20W/180
7. 35E/152

Shaded zones show percentage of points per percentage of area.

Significant maxima arc shown by a strike (true) and dip measurement.

| | |
|---|---|
| ■ | > 7·5% |
| ▦ | 6 - 7·5% |
| ▨ | 5 - 6% |
| ▧ | 3 - 5% |
| ▤ | 2 - 3% |
| □ | 0·5 - 2% |

243 poles to joints measured in area shown by Plate 1, including –
a) 100 readings from Tuggeranong tunnel south heading (Purcell, in prep)
b) 90 readings from Tuggeranong water feature embankment area (Purcell & Goldsmith, 1975)
c) 53 readings from present investigation.

FIGURE 2.

| Seismic velocity m/s | Description |
|---|---|
| 300-1000 | Soil and slopewash, dry |
| 1500 | Soil and slopewash, saturated |
| 1000-1500 | Extremely weathered rock |
| 1000-2000 | Highly weathered rock |
| 1200-3500 | Moderately weathered rock |
| 3000-4500 | Slightly weathered rock |
| ⩾ 4100 | Fresh rock |

## Pipelines

**Excavation conditions.** Excavation by a mechanical shovel (e.g., a large Kato) should be possible in material with a seismic velocity of up to 1200 m/s. Higher-velocity material will generally require blasting. Excavation conditions at invert are summarized in the following table.

| | Section | Seismic velocity (a) 200-1200 m/s | (b) 1200-1900 m/s | (c) 2700-6000 m/s |
|---|---|---|---|---|
| Eastern pipeline (900 mm) | 515 m | 45% | 40% | 15% |
| Southeast pipeline (1200 mm) and eastern connector to tunnel (1350 mm) | 1250 m | 40% | 50% | 10% |
| Lanyon trunk sewer (1350 mm) (section) | 190 m | 90% | 20% | - |
| Total | 1955 m | 45% | 45% | 10% |

(a) should be excavated by mechanical means only

(b) will generally require blasting

(c) hard rock, requiring blasting

Much of the lengths requiring blasting near invert are less than 2 m thick (based on DHC seismic results). The thickest section to be blasted will be 8 m near drop structure B (Plate 3).

**Stability.** A considerable proportion of the pipeline will require excavation down to 8 m or more, especially on the western side of the drop structures. Stability of the open excavations depends on:

(1) the depth of excavation

(2) the length of time the excavation is exposed

(3) the degree of rock weathering

(4) the orientation of joints and other defects with respect to the direction of the trench walls

(5) the condition of joint surfaces, e.g., the incidence of clay seams and the degree of water saturation.

Most of the deeper excavations are within material with a seismic velocity of 1100 m/s or less, except adjacent to the drop structures. Any unsafe exposures in the trenches wil therefore fail along weathered open joints in highly to moderately weathered rock overlain by a varying mass of soil, slopewash, and decomposed rock. This condition is particularly applicable along the eastern connector, and sections of the eastern and southeast pipelines that lie at the foot of natural hill slopes. Precautions should be taken to prevent the failure of walls along these sections of the trench, particularly if any of the walls are saturated.

The safe angle of batters for the trench walls is difficult to predict owing to the irregular weathering. However, in highly weathered rock, stability should generally be attained with batter angles of 70-80°, except along the southwest pipeline which is parallel to the strike of joint set 7 (dip 35°, strike 150°). If this joint set is intersected, batters should be safe at about 50°, and only extremely unfavourable conditions would require battering to 35°. The selection of a batter angle to reduce the incidence of failure will be facilitated by geological mapping of the excavations. If the time between excavation and back filling of the trenches is kept to a minimum during construction, the problems of instability in trench walls will be greatly reduced.

## Drop structure A

Excavation conditions and stability. Excavation will be nearly 15 m deep, with blasting required below about 10 m. Drill hole A intersected 10.2 m of extremely weathered dacite and soil with residual zones of highly to moderately weathered rock (Plate 4).

From 10-15 m the rock is slightly weathered to fresh-stained and is generally tight. Joints are either shallow-dipping or near-vertical, as indicated by the joint stereogram (Fig. 2). Numerous veins of sericite and epidote parallel the joints.

Figure 3 lists the joint faces and joint intersections likely to fail in a slope at 80°. The angle of friction of the dacite has not been measured, but is likely to be steeper than

$20^{o}$, so that only set 6 and three joint intersections would be kinematically and kinetically unstable.

Precautions should be taken to prevent failure in the exposed soil and extremely weathered rock. The most likely causes of failure would be narrow clay seams or shears not necessarily along joint trends; for example, 75 m south of drill hole A, narrow clay-coated shear zones at a number of orientations are more likely to fail than closely spaced joints and associated epidote veins dipping $25^{o}$ west-northwest.

Any stability problems in this excavation will be remedied by correct application of shoring or rock bolts, or both.

Drop structure B

Excavation conditions and stability. Excavation will be about 17 m deep, with blasting required below about 10 m. Drill hole B (Plate 3) intersected 8.5 m (9.2 m below ground) of extremely weathered dacite and soil, even though rubbly outcrop lies at the surface. It is therefore likely that residual boulders of moderately weathered to fresh dacite lie within this weathered mantle.

The stability of the 9.2 m of soil and weathered rock depends on its moisture content, and this section will need to be supported to prevent failure, even if it is dry during excavation.

Below 10 m the rock is slightly weathered to fresh. Joint set 6 is unfavourably oriented in the south and east faces, as is set 7 in the west face. Six unsafe joint intersections could lead to wedge failure (Fig. 3). Narrow clayey seams along joints also contribute to instability, and they may be found on joints that have not been located by this investigation. Drill hole B intersected four narrow shear and crush zones. Defects in the drill core mostly dip $0-30^{o}$ with some up to $45^{o}$; but the stereogram (Fig. 2) shows no major joint sets dipping between $35^{o}$ and $82^{o}$. The discrepancy indicates that irregular localized joints are superimposed on the regional pattern, and that reassessments of stability in excavations should be made from the geological mapping of rock defects during construction.

## CONCLUSIONS AND RECOMMENDATIONS

1. Excavation of a trench for the sewer pipeline is geologically feasible. Blasting near or within 2 m of invert level will be necessary over 55 percent of the route, based on the seismic survey and drilling. The trench walls will have to be supported in the deeply weathered sections, and along the southeast pipeline where joint set 7 will be undercut in the excavation.

2. Depth to fresh dacite, ranging from 3 to 17 m, is based on the results of the seismic survey. The maximum thickness of rock requiring blasting is about 8 m, near drop structure B.

3. The drop structures have similar geological features, based on the two drill holes. Extremely weathered rock and soil, 8-10 m thick, will require support. Moderately weathered to fresh rock 4-8 m below this will be stable in slopes up to 80° although some rock bolts may be required.

4. The regional joint pattern indicates two joint gaces and six joint intersections are kinematically and kinetically unsafe in the proposed cuts if the angle of joint friction is over 20° (see Fig. 3). The joint orientations may occur singly or in groups on any one face. Clay seams in the exposures will cause the greatest stability problems, but their location cannot be predicted.

5. During excavation, joints and shear zones, particularly clay-lined zones, should be mapped to assess slope stability and the support requirements, especially in the deeper sections.

6. The time interval between excavation and backfilling of trenches should be kept to a minimum to reduce the incidence of slope failure.

## REFERENCES

MAKARUCHA, L.J., 1975 - Tuggeranong sewerage tunnel connection, seismic survey. Central Testing Res. Labs. Tech. Rep. 152.

MICHAIL, F.N., 1974 - Tuggeranong sewer pipeline, seismic refraction survey. Bur. Miner. Resour. Aust. Rec. 1974/190 (unpubl.).

MICHAIL, F.N., 1975 - Tuggeranong town centre water feature, seismic refraction survey. Bur. Miner. Resour. Aust. Rec. 1975/5 (unpubl.).

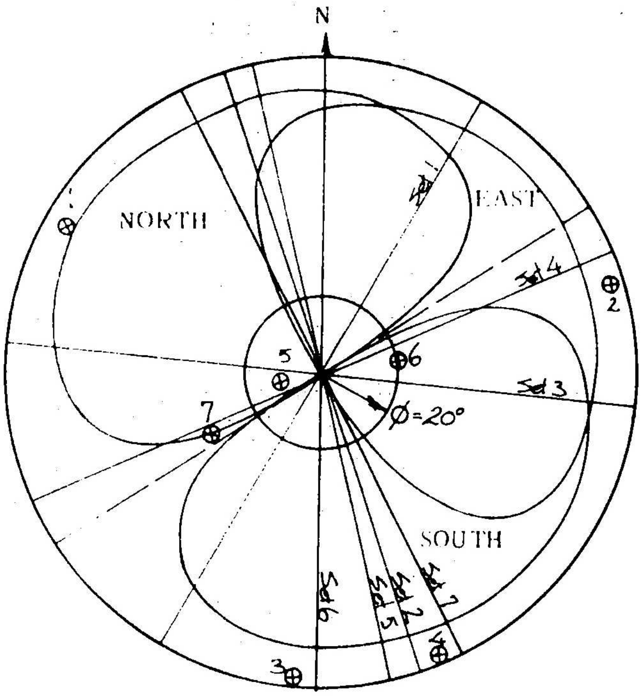
PRICE, N.J., 1966 - FAULT AND JOINT DEVELOPMENT IN BRITTLE AND SEMI-BRITTLE ROCK. London, Pergamon.

PURCELL, D.C., 1974 - Tuggeranong-Weston Creek sewer tunnel, A.C.T.: geological investigations, 1971. Bur. Miner. Resour. Aust. Rec. 1974/11 (unpubl.).

# STEREOGRAMS SHOWING STABILITY OF JOINTS IN EXCAVATIONS

Joints and joint intersections indicated are both kinematically and kinetically unstable in the indicated face. Joint sets will induce planar failure and joint intersections will induce wedge failure.

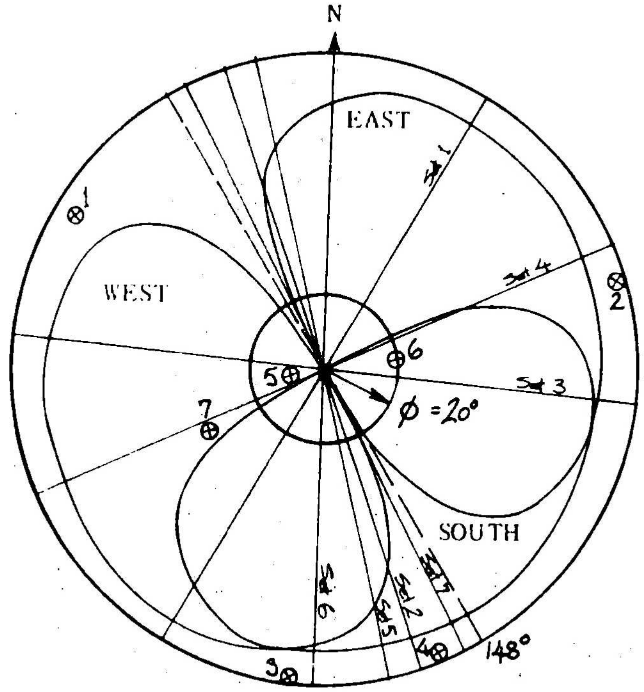
DROP STRUCTURE A



Unsafe joint sets:
South face Set 6 (20W/180)
East face Set 6 (20W/180)

Unsafe joint intersections
South face Set 1/Set 7 (35/036)
North face Set 1/set 2 (81/160)
Set 3/Set 7 (31/092)

DROP STRUCTURE B



Unsafe joint sets:
South face Set 6 (20W/180)
East face Set 6 (20W/180)
West face Set 7 (35E/180)

Unsafe joint intersections
South face Set 1/Set 7 (35/036)
West face Set 1/Set 7 (35/036)
Set 4/Set 7 (35/063)
Set 3/Set 7 (31/092)
Set 1/Set 3 (79/072)
Set 1/Set 4 (72/052)

Closed curves enclose the loci of the poles of all joint planes kinematically unsafe for a given slope of 80°. The small circle represents the angle of friction ($\phi$ = 20°).

155/A16/1529

Figure 3

PURCELL, D.C., in prep. - Tuggeranong-Weston Creek sewer tunnel, A.C.T.: completion report. Bur. Miner. Resour. Aust. Rec. (unpubl.).

PURCELL, D.C., and GOLDSMITH, R.C.M., 1975 - Tuggeranong town centre water feature, A.C.T.: preliminary geological investigations (1973-75). Bur. Miner. Resour. Aust. Rec. 1975/55 (unpubl.).

# APPENDIX 1

## GLOSSARY OF ENGINEERING GEOLOGY TERMS

### GRAINSIZE

| | |
|---|---|
| Coarse-grained | - 1 mm to 4 mm in diameter |
| Medium-grained | - ¼ mm to 1 mm in diameter |
| Fine-grained | - less than ¼ mm in diameter |

### BEDDING

| | |
|---|---|
| Laminated | - less than 10 mm thick |
| Thinly bedded | - 10 mm to 100 mm thick |
| Thickly bedded | - greater than 100 mm thick |

### HARDNESS

| | |
|---|---|
| Hard to very hard | - impossible to scratch with knife blade |
| Moderately hard | - shallow scratches with knife blade |
| Soft | - deep scratches with knife blade |

### PERCUSSIVE STRENGTH

| | |
|---|---|
| Strong to very strong | - cannot be broken by repeated blows with a hammer |
| Moderately strong | - rock breaks after 3 or 4 heavy blows with a hammer |
| Weak | - rocks break after 1 blow with hammer (includes brittle, fissile, friable, plastic, and flaky rocks) |

### JOINT SPACING

| | |
|---|---|
| Closely spaced | - joints spaced less than 15 cm apart |
| Moderately spaced | - joints spaced 15 cm to 91 cm apart |
| Broadly spaced | - joints spaced more than 91 cm apart |

## JOINT APERTURE

This describes the amount of separation of the joint surfaces. Joints are open or tight. If two joint faces fit perfectly, the joint in the rock mass was probably tight (or closed); however, if they do not fit, the joint was probably open, or possibly filled with clay that has been washed away during drilling.

## WEATHERING OF ROCK

| | |
|---|---|
| Fresh | - No discolouration or loss in strength |
| Fresh stained | - Limonitic staining along fractures, rock otherwise fresh and shows no loss of strength. |
| Slightly weathered | - Rock is slightly discoloured, but not noticeably lower in strength than the fresh rock. |
| Moderately weathered | - Rock is discoloured and noticeably weakened; N-size drill core generally cannot be broken by hand across the rock fabric. |
| Highly weathered | - Rock is discoloured and weakened; N-size drill core can generally be broken by hand across the rock fabric. |
| Extremely weathered | - Rock is decomposed to a soil, but the original rock fabric is mostly preserved. |

## APPENDIX 2

## GEOLOGICAL LOGS OF DRILL CORES

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# GEOLOGICAL LOG OF DRILL HOLE

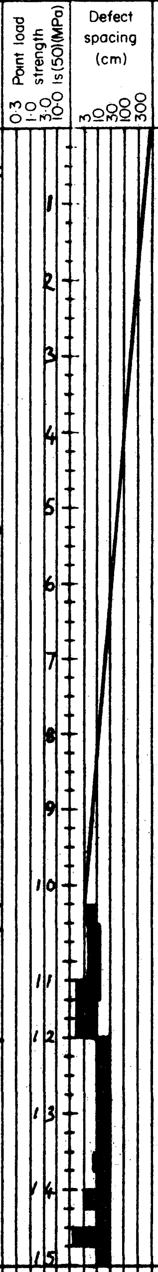
PROJECT TUGGERANONG SEWER CONNECTION
LOCATION North side of Tuggeranong Creek, A.C.T.
ANGLE FROM HORIZONTAL (θ) 90°
DIRECTION —
CO-ORDINATES 589953 N / 204 587 E
R.L. OF COLLAR 565·5 m

HOLE NO. A
SHEET 1 OF 1

Drilling Information | Rock Substance | Rock Mass Defects

Method: ROCK ROLL (0–0.5 m); NMLC
Casing: to c. 10.8 m
Water: 18/9/75 (at c. 9.5 m)
Pressure test * (lugeons): NOT TESTED

| Lift & % core recovery | Substance description rock type grain characteristics colour, structure, minor components | Weathering | Defect description thickness, type, inclination, planarity roughness, coating, strength |
|---|---|---|---|
| | Floater | Fr | |
| 80 | Compact EW dacite, clayey, red-orange. | | |
| 100 | Loose and friable, gravelly sand texture, with fragments of rock. | | Defects indicate it is undisturbed weathored mantle, joint planes visible in sand and gravel. |
| 45 | | | |
| 10 | | EW (some HW frags) | |
| 100 | Completely decomposed rock, with many fragments of MW-HW dacite in core lengths up to 6cm. | | HW core pieces show moderataly closely spaced joints are claycoated. |
| 90 | | | |
| 50 | Crumbly, red-orange, EW dacite, some more resistent HW rock in core lengths up to 25cm, but can be broken by hand. | | Any defects in HW rock are generally clay coated, few crushed zones. |
| 100 | | | |
| 85 | | | sharp contact |
| 100 | DACITE Moderately hard and strong Groundmass pink and grey, showing much alteration to sericite and cherty material. Quartz phenocrysts up to 4mm. | MW<br>SW | Rock mass generally mod. tight, joints 10cm apart 0-35°dip, some 90°. Many close fractures healed with epidote and sericite Little or no clay on joints. |
| 100 | | | |
| 100 | DACITE Hard and strong, dark grey and pink, phenocrysts of quartz and plagioclase 2-5mm, minor orthoclase 1-3mm. Groundmass pink-orange. Network of epidote and calcite veins, one vein vertical between 14-15 m (has epidote crystals 1-4mm). | FS | Rock mass tight, joints 15-20 cm apart, dip 0-80°, iron oxide stains on surface some breakages follow epidote veins. Veins are numerous and drilling water has eroded sections of them away - mainly the epidote. |
| 100 | | | Crushed zone 10cm. |



Depth (metres): 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

R Q D

Rock Condition No. (subjective)

END OF HOLE 15·0 m.

Drill type MOLE PIONEER
Feed CROWD PRESSURE
Core barrel type NMLC
Driller DHC (W. HART)
Commenced 5-9-75
Completed 11-9-75
Logged by R. Goldsmith
Vertical scale 1cm = 1m.

Weathering
Fr – Fresh
FS – Fresh stained
SW – Slightly weathered
MW – Moderately weathered
HW – Highly weathered
EW – Extremely weathered

Water
▼ 10 Oct. '73 water level date shown
▶ Water inflow
◁ Partial drilling water loss
◀ Complete drilling water loss

Notes
Bedding & Joint Planes — Angles are measured relative to a plane normal to the core axis.
* Water Pressure Tests — Values in lugeons should be read in conjunction with computation sheets.

Core Photograph Negative No

| Depth (m) | Black & White | Colour |
|---|---|---|
| | | |

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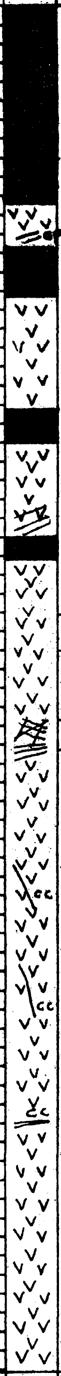
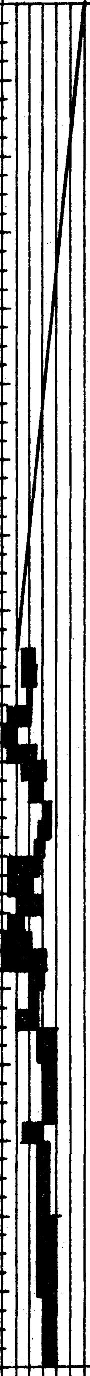
# GEOLOGICAL LOG OF DRILL HOLE

PROJECT TUGGERANONG TUNNEL SEWER CONNECTION
LOCATION 100m. south of Tuggeranong Creek, A.C.T.
ANGLE FROM HORIZONTAL (θ) 90° DIRECTION —
CO-ORDINATES 589733·73N/204674·62E R.L. OF COLLAR 566·836m

HOLE NO. 15
SHEET 1 OF 1


Graphic log & core loss


Defect spacing (cm) 3 10 30 100 300

| Method | Drilling rate | Casing | Water | Pressure test * (lugeons) | Lift & % core recovery | Depth (metres) | Substance description: rock type, grain characteristics, colour, structure, minor components | Weathering | Point load strength 0·3 1·0 3·0 10·0 Is(50)(MPa) | R Q D | Defect description (thickness, type, inclination, planarity, roughness, coating, strength): Particular | General | Rock condition (interpreted) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ROCK ROLLER | | | 28-8-75 | | | 1 | | | | | | Rock completely broken down, no defects visible. | |
| NMLC | | | | | | 2 | Dacite<br>Orange-brown, soft and friable, breaks in hands. Generally has a gravelly sand texture with quartz fragments 1-5mm and clayey feldspar (white-yellow). Some HW-MW epidote veins within the EW material. Some core pieces of clay-bonded gravelly sand 15-20cm long. | EW | | | | | |
| | | | 29-8 | | 55<br>0 | 3 | | | | | 10cm thick epidote vein. | | |
| | | | 15-9 | | 85 | 4 | | | | | | | |
| | | | 29-8 | | 100 | 5 | | HW | | | | | |
| | | | | | 75 | 6 | | EW | | | | | |
| | | | | | 80 | 7 | | | | | | | |
| | | | | | | 8 | Compact clayey layer | | | | Compact clay | | |
| | | | 1-9-75 | NOT TESTED | 100<br>100 | 9 | Dacite<br>Light tan, horizontal foliation plag and quartz 1-4mm.<br>Grey dacite - Iron oxide veins | HW<br>MW | | | Closely fractured zone, clay coated faces.<br>Fractured zone, some EW infill in joints | Horizontal crushed joints and // veins spaced at 10cm some clay on joint faces | |
| | | | | | 100 | 10 | Dacite.<br>Dark grey-blue, tuffaceous texture, hard and strong. Contains phenocrysts of quartz 1-5mm, plagioclase 1-3mm and some biotite and chlorite. Crystal grains are sub-hedral and partly rounded. Many very thin epidote and calcite veins. | SW | | | | joints generally tight dip 10-30°, some 45°. calcite and epidote infillings, no clay visible. Rock mass moderately strong but open excavation may need support | |
| | | | | | 100 | 11 | | FS | | | | | |
| | | | | | 100<br>[illegible] | 12 | | SW | | | 1cm crushed zone<br>calcite vein, dip 80°<br>Breakages drill induced due to jumping of bit. | | |
| | | | | | 100 | 13 | | FS | | | calcite/limonite vein dips 70°. | Joints generally dip 0-20° healed with epidote and calcite. Some Fe oxide stains and SW in places, 80% of breakages probably machine induced. Rock mass hard and strong, defects tight no clay, should stand up in excavation. | |
| | | | | | 100 | 14 | | | | | | | |
| | | | | | 100 | 15 | | | | | horizontal calcite/epidote vein, 1cm. | | |
| | | | | | 100<br>[illegible] | 16 | | Fr | | | | | |
| | | | | | 100 | 17 | | | | | | | |
| | | | | | 100 | 18 | END OF HOLE 18·0 M. | | | | | | |

Drill type MOLE PIONEER
Feed CROWD PRESSURE
Core barrel type NMLC
Driller DHC (W.HART)
Commenced 28/8/75
Completed 3/9/75
Logged by R. Goldsmith
Vertical scale 1m. = 1cm.

Weathering
Fr - Fresh
FS - Fresh stained
SW - Slightly weathered
MW - Moderately weathered
HW - Highly weathered
EW - Extremely weathered

Water
▼ 10 Oct '73 water level date shown
▶ Water inflow
◁ Partial drilling water loss
◀ Complete drilling water loss

Notes
Bedding & Joint Planes — Angles are measured relative to a plane normal to the core axis
* Water Pressure Tests — Values in lugeons should be read in conjunction with computation sheets

Core Photograph Negative No

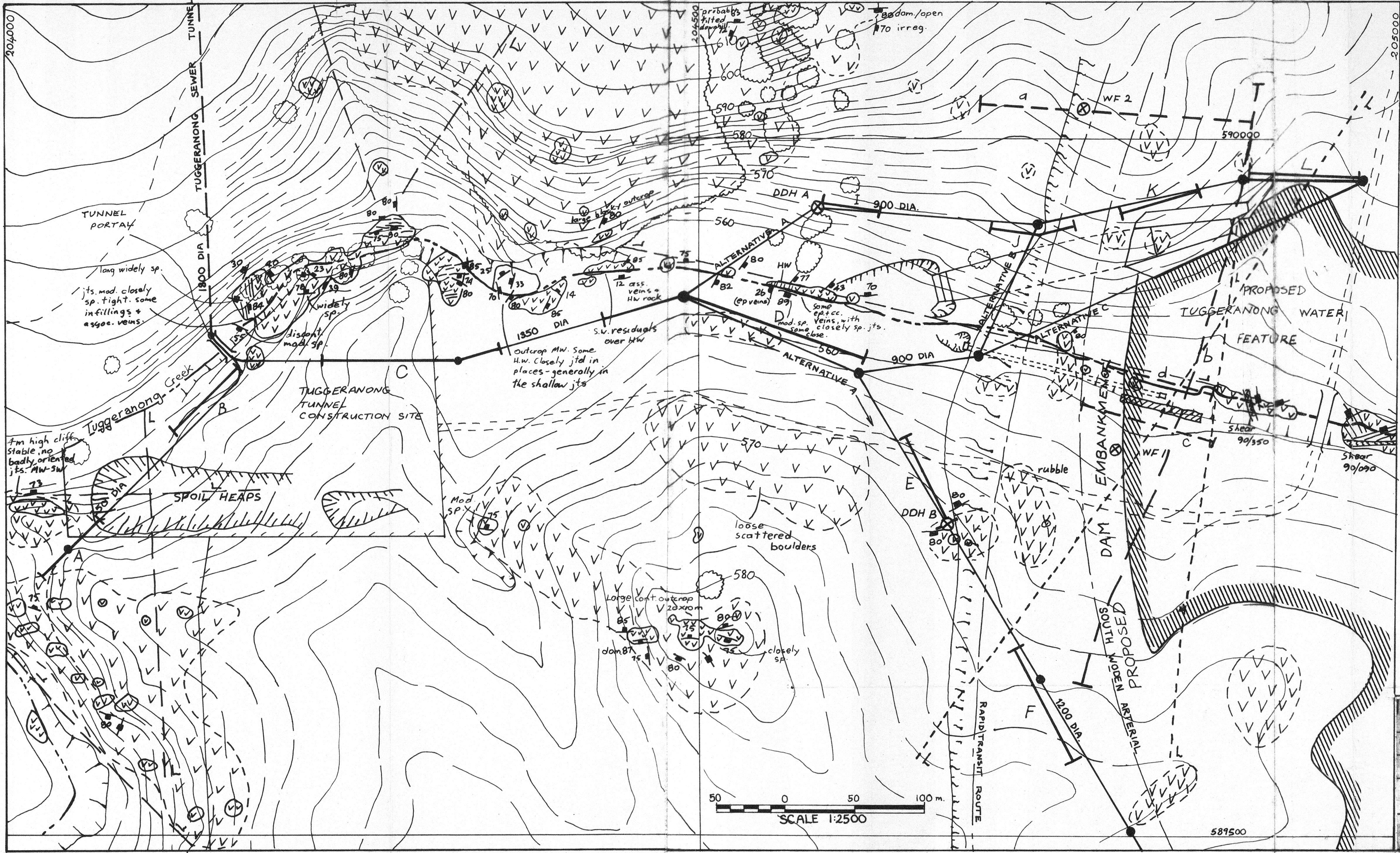
| Depth m | Black & White | Colour |
|---|---|---|
| | | |

Record 1976/19

155/A16/1535 M(Pf)180

# TUGGERANONG SEWERAGE TUNNEL CONNECTION

## Geology of Project Site, Tuggeranong Creek, A.C.T.



(V V V) Areas of generally continuous outcrop
(V V) Loose boulders at surface some isolated outcrops
━■ Joint, vertical
━■ 70 Joint, showing dip
▨ Sheared zone
⊗ DDH A Diamond drillhole, this project
⊗ WF1 Diamond drillhole, Water Feature Proj.
├ A ┤ Seismic traverse, this project.
├ a ┤ Seismic traverse, Water Feature Proj.
▨ Costean
- - - - Road
●━● Pipeline route
L - - - L Lineament

TN MN

Rock weathering

EW - Extremely weathered
HW - Highly "
MW - Moderately "
SW - Slightly "
Fr - Fresh

Contour interval: 2 metres

SCALE
0 50 100m

Base map/survey A.C.T. Detail series No. 811 A.

Geology by R.C.M. Goldsmith.

| Compiled and checked | Checked and approved |
|---|---|
| R.C.M.G. | D.C.P. |
| Project geologist | Senior geologist |

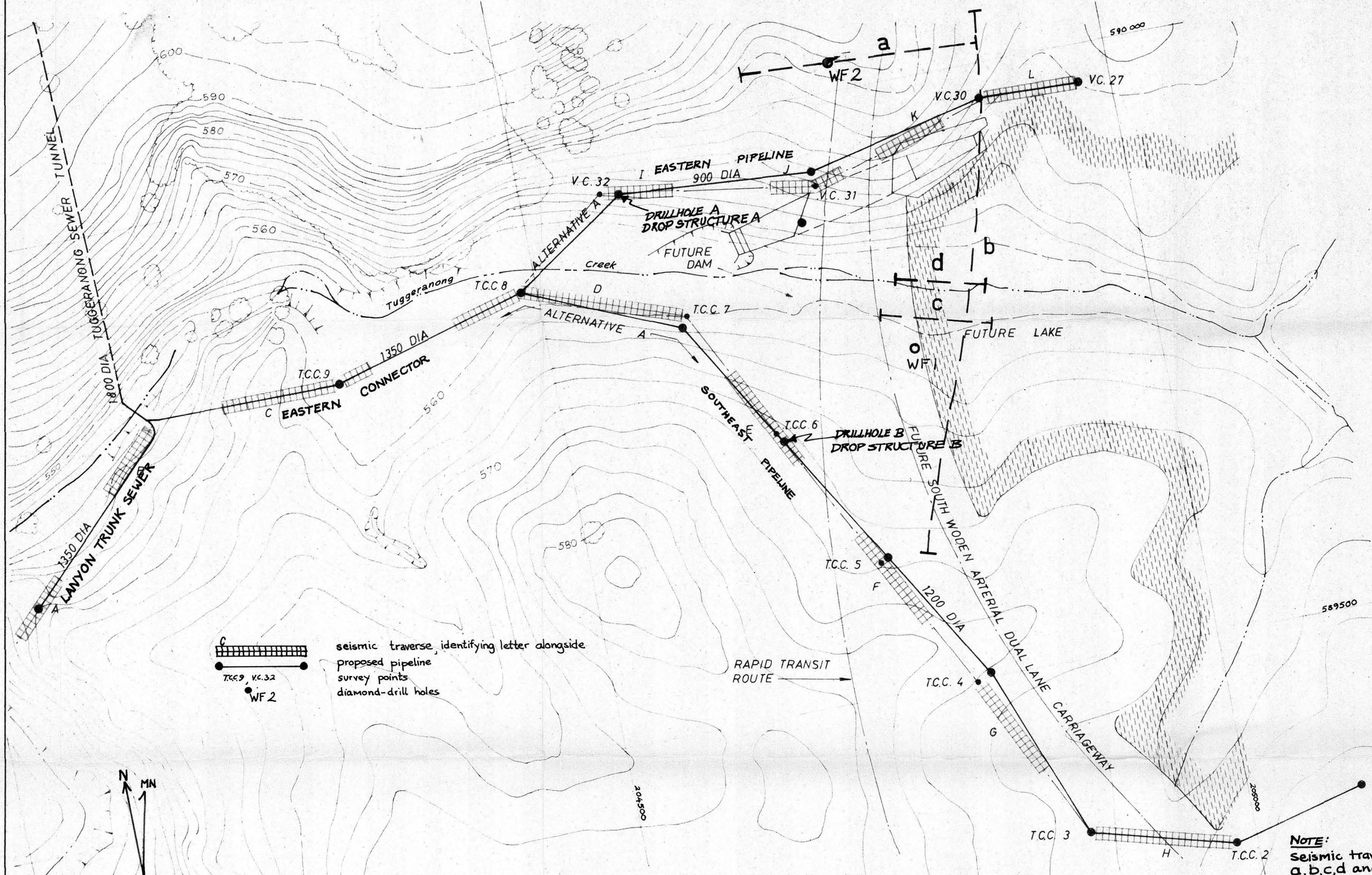
E.G.W
Supervising geologist

COMMONWEALTH OF AUSTRALIA
BUREAU OF MINERAL RESOURCES
CANBERRA, A.C.T.

TITLE Geology of project site.

PROJECT Tuggeranong sewerage tunnel connection.

| To accompany | Drawn by | Drawing No. |
|---|---|---|
| Record 1976/19 | R.G. | 155/A16/1530 |

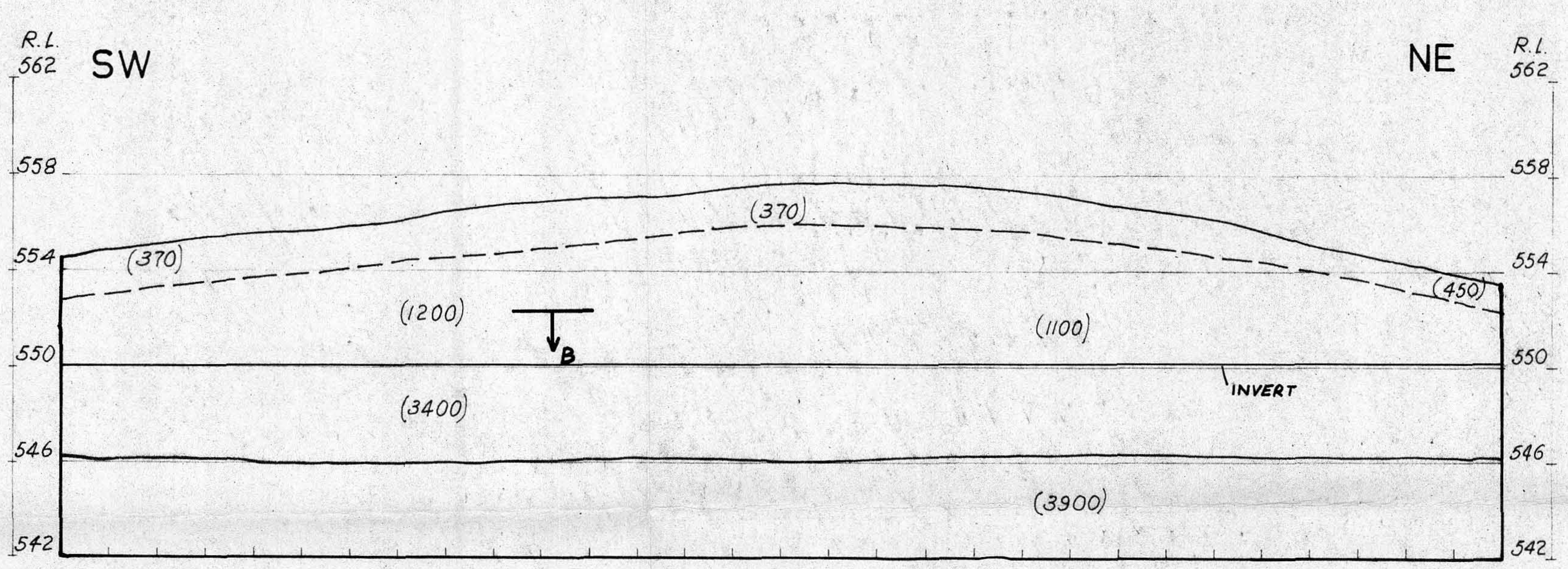


## TUGGERANONG SEWERAGE TUNNEL CONNECTION
## SEISMIC TRAVERSES LOCATIONS

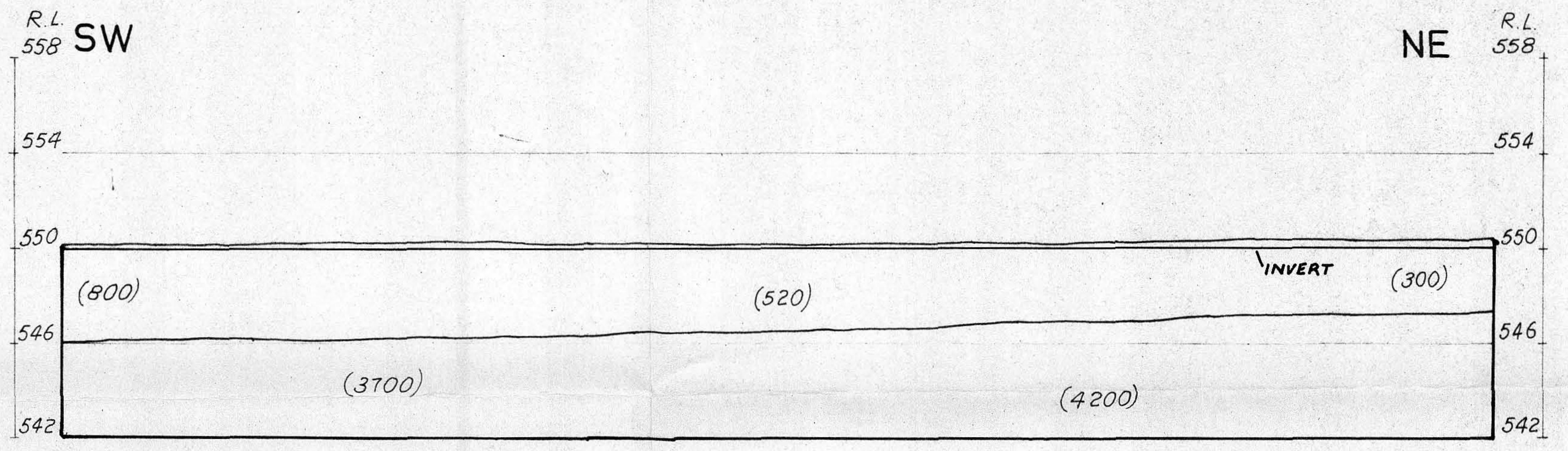
SCALE 1:2500

0 50 100 200
m.

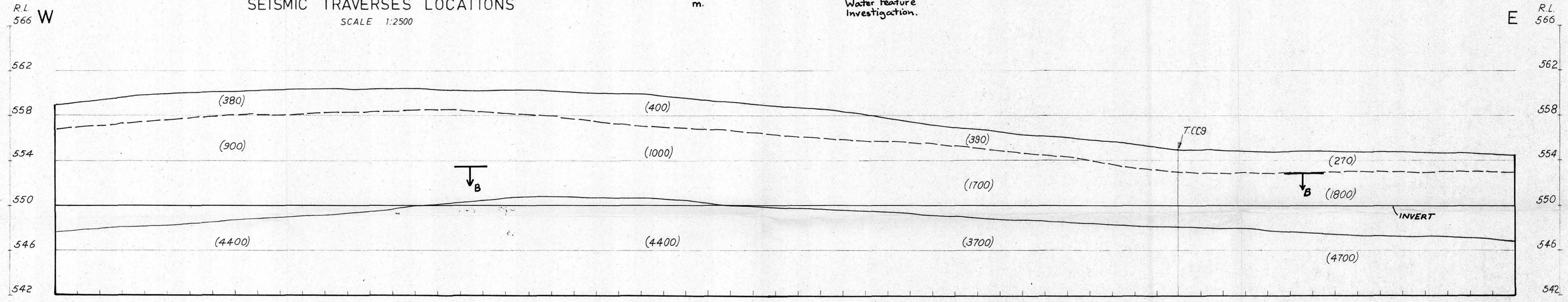
NOTE: Seismic traverses a, b, c, d and drill-holes WF1 and WF2 from Tuggeranong Water Feature Investigation.



TRAVERSE A



TRAVERSE B



TRAVERSE C

0 5 10 20
m

155/A16/1531

PLATE 2

AMEND. No. | AMENDMENTS | DATE | INITL. | DRAWING No. | ASSOCIATED DRAWINGS

B Depth below which blasting will be required.

According to Bureau of Mineral Resources

All dimensions must be verified on the job before commencing any work or making any shop drawings.

This drawing to be read in conjunction with the specification.

DESIGNED
DRAWN
CHECKED
DES. PROJ. OFFICER
SUPERVIS.
PRINCIPAL
DIRECTOR OF WORKS

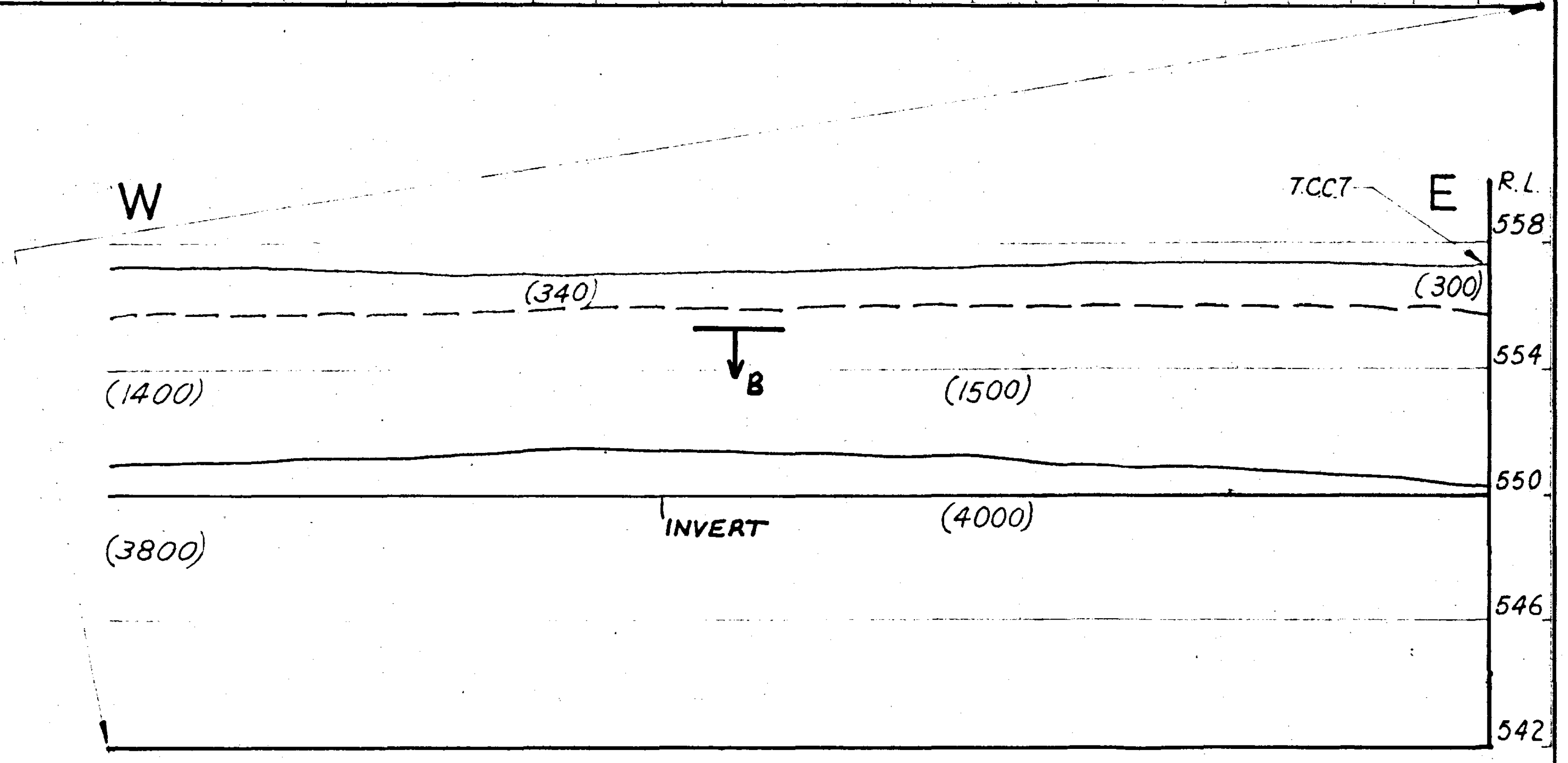
**COMMONWEALTH OF AUSTRALIA**
**DEPARTMENT OF WORKS**
**CANBERRA A.C.T.**
FOR AND ON BEHALF OF THE
NATIONAL CAPITAL DEVELOPMENT COMMISSION

Canberra Sewerage
TRUNK SEWERS – TUGGERANONG
TUGGERANONG TUNNEL
SEWER CONNECTION
SEISMIC SURVEY - TRAVERSES A,B,C.

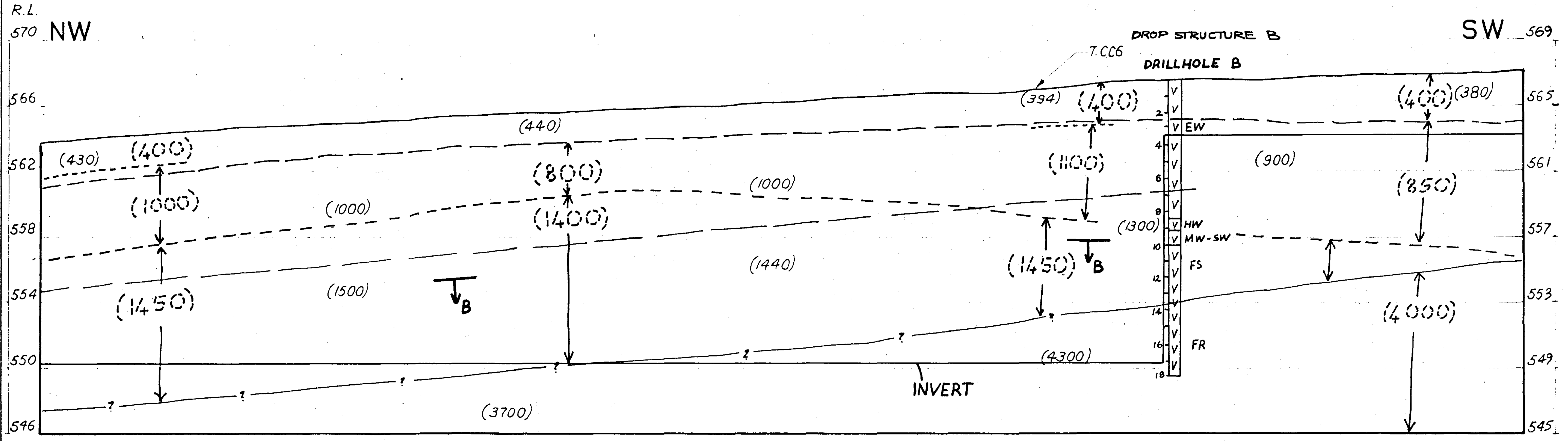
SHEET No.
SCALE 1:200
FILE
STANDARD DRAWING YES/NO
CDW/SfB
DRG. No. C
AMEND.
1

Record 1976/19

TRAVERSE D

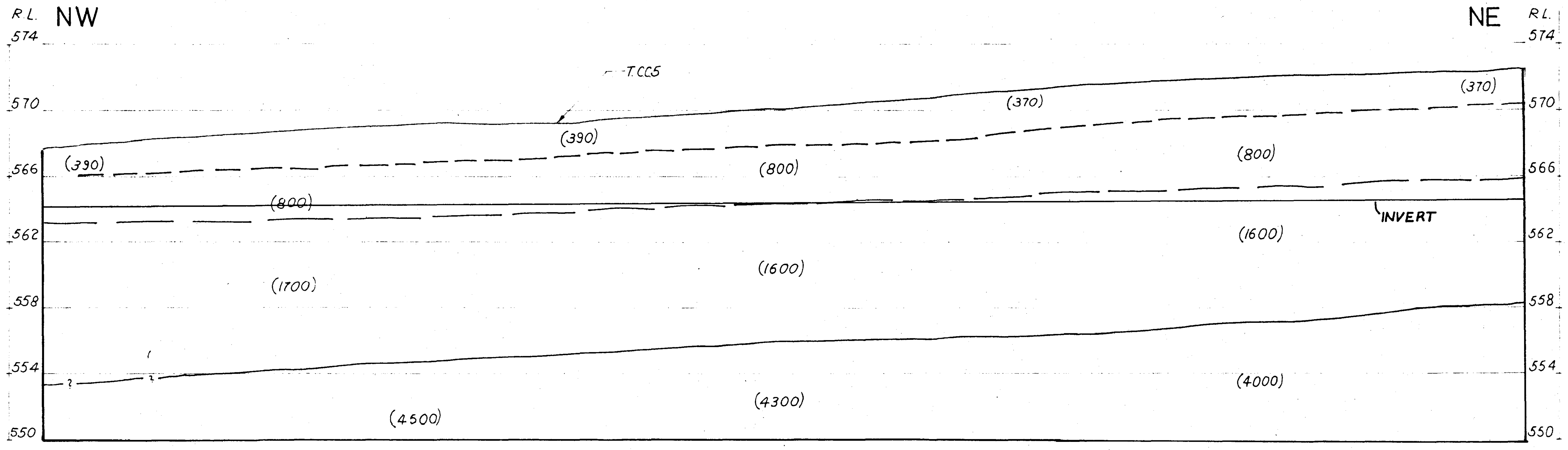


TRAVERSE D

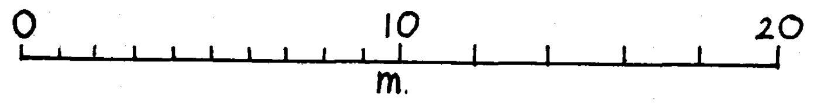


TRAVERSE E

Figures dashed thus (400) and small-dash lines is a re-interpretation of the seismic data by D.C. Purcell of BMR.



TRAVERSE F



FOR LOCATION OF SEISMIC TRAVERSES SEE PLATE 2.

155/A16/1532

PLATE 3

Record 1976/19

| AMEND. No. | AMENDMENTS | DATE | INITL | DRAWING No. | ASSOCIATED DRAWINGS |
|---|---|---|---|---|---|

B Depth below which blasting will be required.

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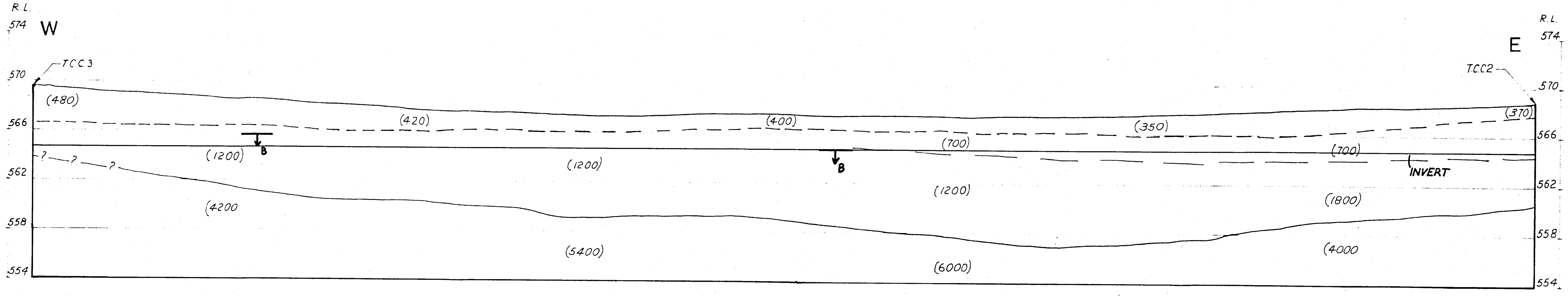
Canberra Sewerage
TRUNK SEWERS — TUGGERANONG

TUGGERANONG TUNNEL
SEWER CONNECTION

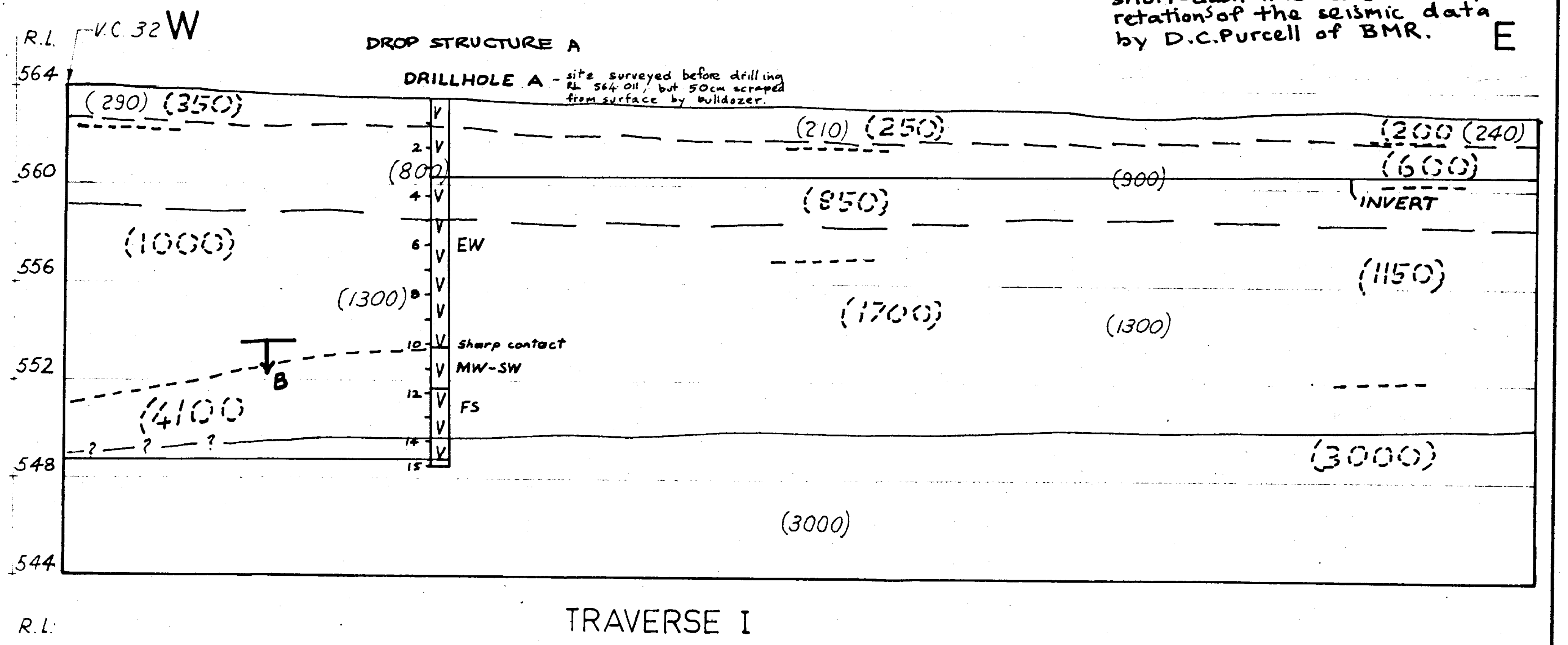
SEISMIC SURVEY — TRAVERSES D, E, F.

SHEET No.
SCALE 1:200
FILE
STANDARD DRAWING YES/NO
CDW/STB
DRG. No. C
AMEND.
1

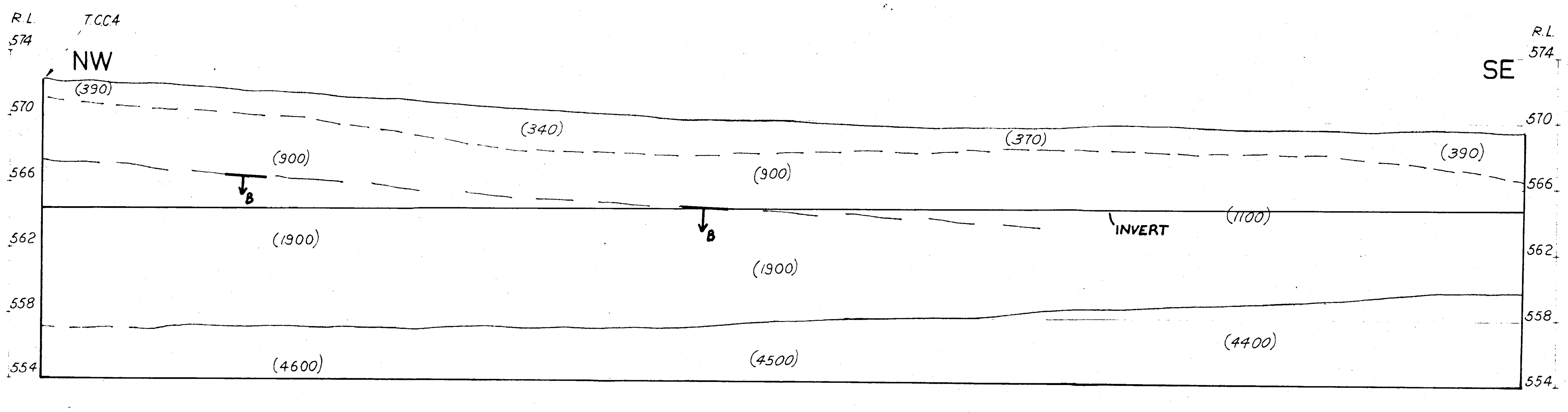


TRAVERSE H

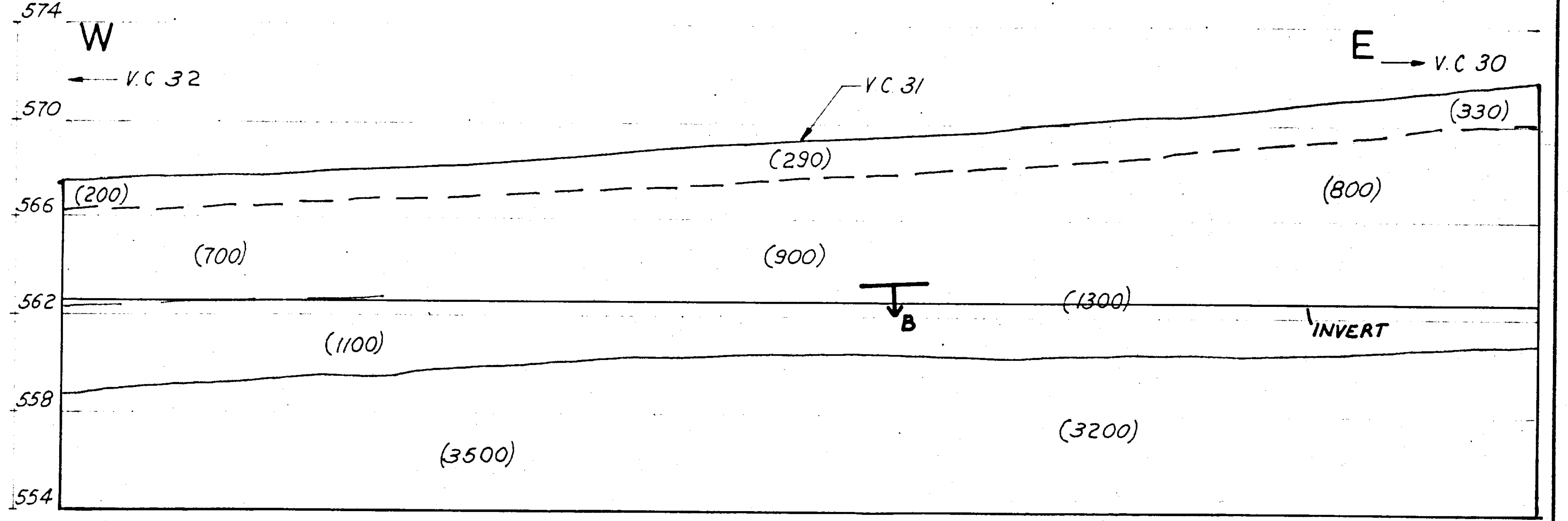
**NOTE:**
Figures dashed thus (250) and short-dash lines are re-interpretations of the seismic data by D.C.Purcell of BMR.



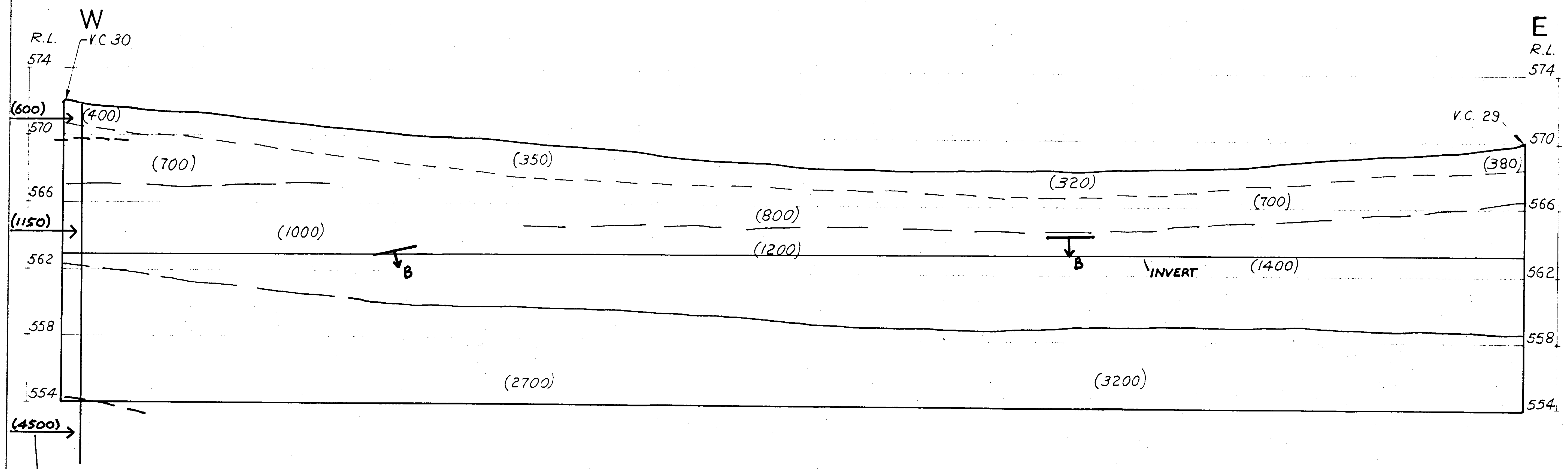
TRAVERSE I



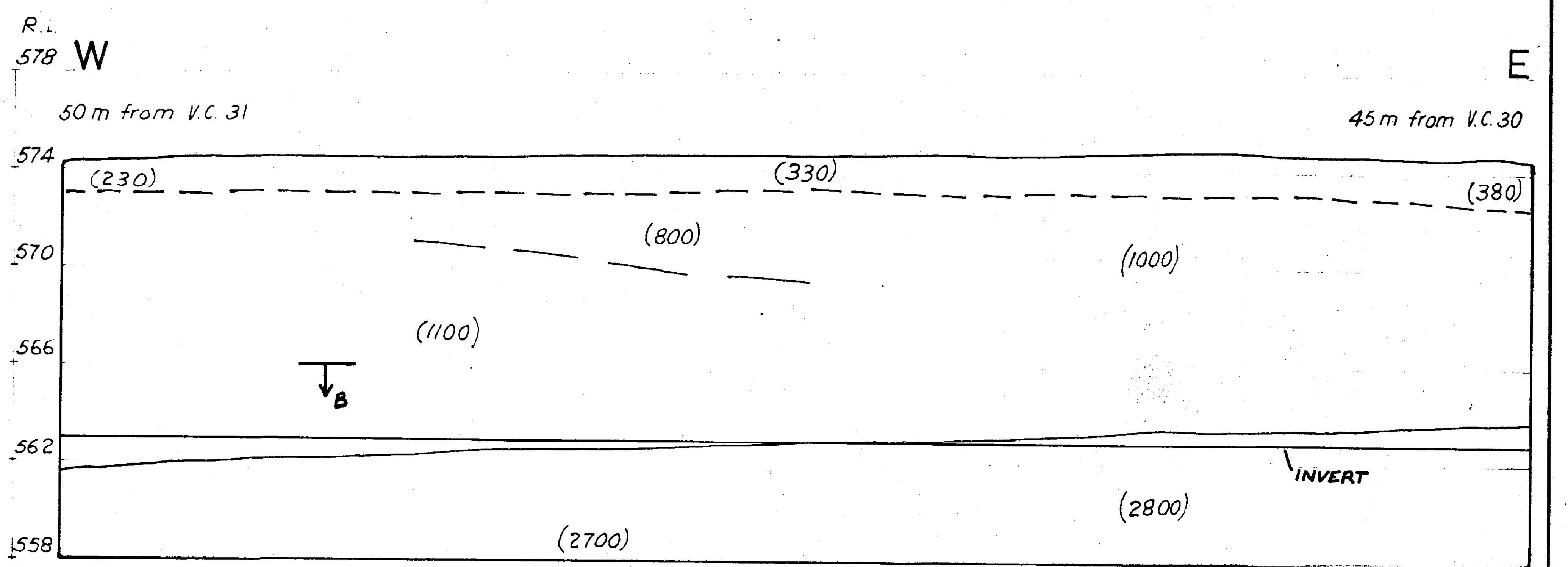
TRAVERSE G



TRAVERSE J

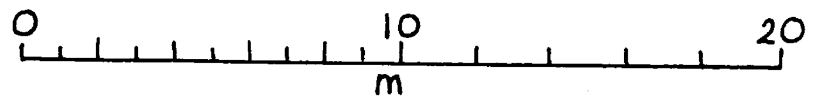


TRAVERSE L



TRAVERSE K

TRAVERSE b AT 18660m OF TUGGERANONG WATER FEATURE INVESTIGATION (PURCELL & GOLDSMITH, 1975).



FOR LOCATION OF SEISMIC TRAVERSES SEE PLATE 2.

155/A16/1533

PLATE 4

B Depth below which blasting will be required.
According to Bureau of Mineral Resources.

| AMEND. No. | AMENDMENTS | DATE | INITL. | DRAWING No. | ASSOCIATED DRAWINGS |
|---|---|---|---|---|---|

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TRUNK SEWERS – TUGGERANONG
TUGGERANONG TUNNEL
SEWER CONNECTION
SEISMIC SURVEY-TRAVERSES G,H,I,J,K,L.

SHEET No.
SCALE 1:200
FILE
STANDARD DRAWING YES/NO
CDW/SfB
DRG. No. C
AMEND. B1

Record 1976/19