DEPARTMENT OF
MINERALS AND ENERGY

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Record 1976/44

GEOLOGICAL INVESTIGATIONS FOR THE GINNINDERRA SEWER TUNNEL BELCONNEN, A.C.T., 1975

by

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CONTENTS

SUMMARY

In 1974 the then Department of Housing and Construction requested the Bureau of Mineral Resources to carry out geological design investigations of the proposed Ginninderra sewer tunnel, extending about 5.2 km from Ginninderra Creek southwards to the Lower Molonglo Water Quality Control Centre.

A continuous seismic refraction profile was obtained (and also some cross traverses) along the route, which was mapped at scales of 1:2400 and 1:9600. 14 diamond-drill holes and 9 groundwater observation bores were drilled, by the Department of Housing and Construction and Bureau of Mineral Resources respectively, and several mechanical rock parameters were determined by the Bureau of Mineral Resources.

The tunnels will be driven through an Upper Silurian sequence of acid volcanics, tuffaceous sediments, and a granite porphyry intrusion. Some units in the sequence are gently to moderately folded. Five major faults have been detected, and many small fractured or sheared zones are indicated by airphoto-lineaments and zones of low seismic velocity. Seismic risk to the tunnel, its lining, shafts, or other appurtenant works is very low.

The engineering, geological, and excavation properties of the different rock types have been determined. The rocks to be excavated are generally very hard and strong, and mostly good tunnelling conditions can be expected. Poor tunnelling conditions will generally be confined to faulted, fractured, or sheared zones, and about 16 percent of the tunnel will require support.

Shafts and portals are favourably located with respect to geology, and no serious geotechnical problems are expected.

1. INTRODUCTION

1.1 BACKGROUND

Wastewater from the Ginninderra catchment (i.e., the Belconnen and future Gungahlin development areas) is currently treated at the Belconnen Water Pollution Control Centre (BWPCC). Conventional treatment is followed by lagooning before discharge of effluent to Ginninderra Creek, which flows via the Murrumbidgee River to Burrinjuck Reservoir. The BWPCC has an effective capacity to serve about 70 000 persons; this number is expected to be exceeded in 1977-78, so that the plant must be augmented or wastewater diverted to the Lower Molonglo Water Quality Control Centre (LMWQCC) about 5.3 km away.

An augmented plant at Belconnen would require nutrient removal facilities to avoid stimulating excessive aquatic growths in the receiving waters, and an economic study indicated substantial economies in both capital and operating costs by diverting wastewater to the LMWQCC. A tunnel was preferred to a trench sewer because the shorter tunnel route results in a lower capital cost, and also because construction difficulties and environmental impact are substantially less.

The tunnel will have sufficient capacity to divert future wastewater flows from the neighbouring Gooromon Ponds and Jeir catchements because of the economies of treating all wastewater at the LMWQCC and the small additional cost for a larger tunnel.

1.2 ENGINEERING DETAILS

The Ginninderra sewer tunnel (GST) will join the existing BWPCC near Ginninderra Creek, to the LMWQCC near the confluence of the Molonglo and Murrumbidgee Rivers (Fig. 1).

The design details are shown in Figures 2 and 3.

This scheme will consist of two 2130 mm diameter concrete-lined tunnels about 4240 m and 860 m long, joined at Window Bend by about 150 m of pipe which will be buried in an embankment of spoil excavated from the tunnels. The sewer will fall 8.8 m from RL 523.7 at the base of shaft 1 to RL 514.9 at the outlet portal at LMWQCC - a gradient of 1:600. Two 2600 mm diameter concrete-lined ventilation shafts (shafts 2 and 3) 41 m and 46 m deep will be excavated 4 m west of the centre line of the tunnel at Stn 17+12 and Stn 33+15 (Plate 1).

The GST will be connected to the existing Belconnen trunk sewer by a 210 m section of 1500 mm diameter concrete pipe in an open-cut trench, a tunnel about 148 m long lined with 1350 mm diameter concrete pipes, and a 61 m section of 2130 mm diameter concrete pipe in an open-cut trench.

Two concrete-lined shafts - shaft C and shaft 1 of 2600 mm and 4500 mm diameter, respectively, incorporating vortex drop structures - will drop the sewerage from the Belconnen trunk sewer (RL 555) to the GST (RL 523.7).

The design provides for connection to future sewers from Gooromon Ponds at point E (RL 536) and from Jeir at the bottom of shaft 1 (RL 523.7).

1.3 REQUEST FOR GEOLOGICAL INVESTIGATION

In April 1974 the then Department of Housing and Construction (DHC), who were to design the sewer on behalf of the National Capital Development Commission (NCDC), asked the Bureau of Mineral Resources (BMR) to carry out a feasibility investigation along the proposed route.

In late 1974, NCDC decided that the sewer was to be completed in 1978. DHC then requested BMR to:

(a) carry out a geological design investigation along the adopted route;

(b) provide geological information for the design of the tunnel; and

(c) prepare a report for inclusion in the 'Information for Tenderers' document.

1.4 SCOPE OF INVESTIGATION

During the feasibility stage, geological information was made available to assist in determining:

(a) the feasibility of constructing a tunnel from BWPCC to the LMWQCC;

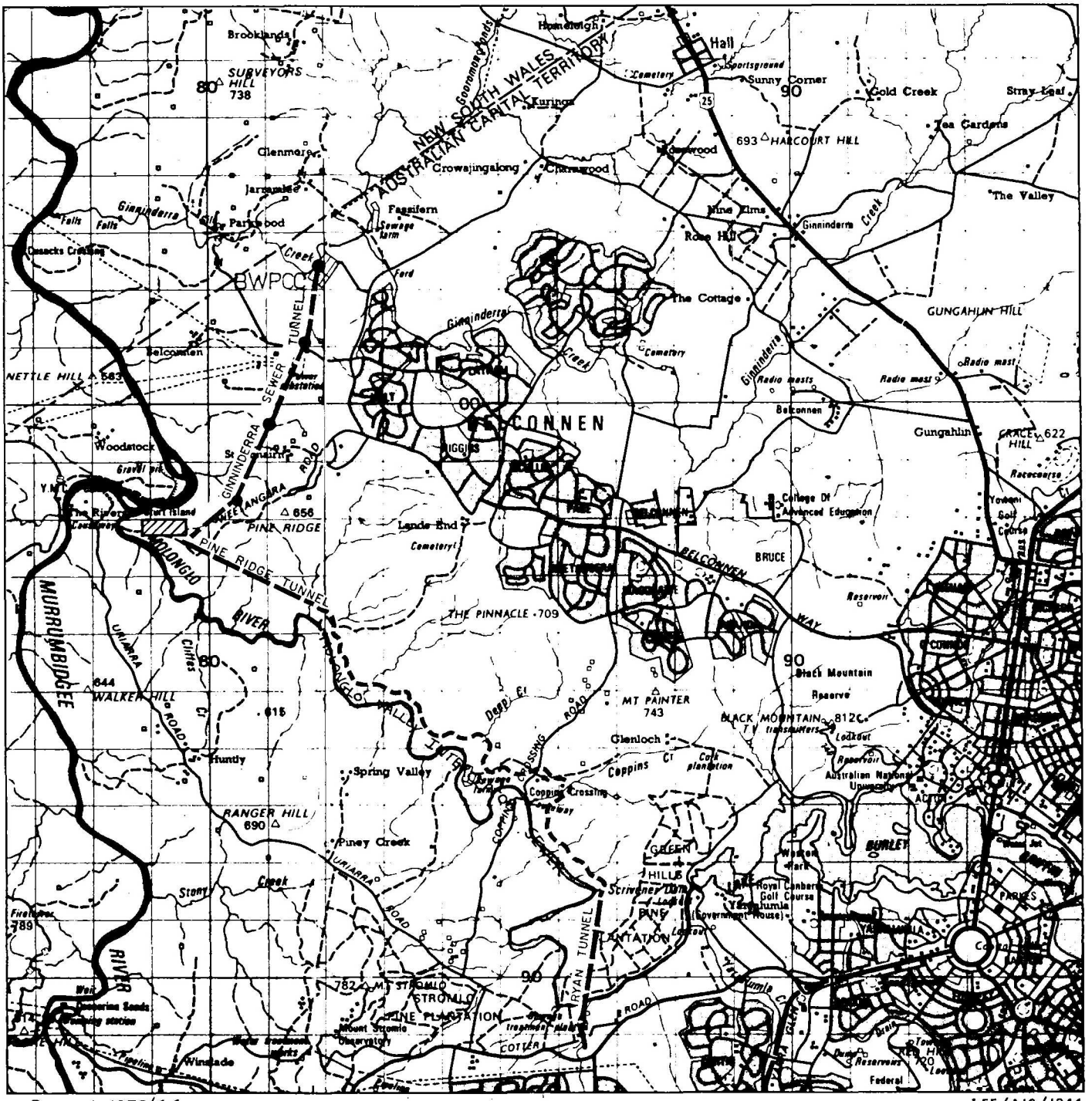
(b) the most practical route and elevation for the tunnel, taking into account cost and environmental aspects; and

(c) the best positions for the shafts.

During the design stage and for the 'Information for Tenderers' document, information was made available about the geology of the route and the effect it will have on the design and construction of the tunnel, shafts, portals, and the connection from the north end of the tunnel to the existing Belconnen trunk sewer; in particular to predict the effect of geology on:

(d) choice of tunnelling method

LOCATION MAP
GINNINDERA SEWER TUNNEL
MOLONGLO VALLEY INTERCEPTOR SEWER
LOWER MOLONGLO WATER QUALITY CONTROL CENTRE
CANBERRA A.C.T.



BWPCC Belconnen Water Pollution Control Centre

Lower Molonglo Water Quality Control Centre

Tunnel

Bu ried pipeline

Shaft

GINNINDERRA SEWER TUNNEL DESIGN DETAILS

FIGURE 2

CHAINAGE 00
COORDS N612801
E199427

SHAFT N° 1
CHAINAGE 498·711
COORDS N612424
E198948
DEPTH 22·826 m
DIA. 4·500 m
R.L. OF INVERT 523·716

SEE DETAIL 1

103° 54' 37"

189° 03' 23"
1213·556

ORIGINAL DESIGN ROUTE

SHAFT N° 2
CHAINAGE 1712·267
COORDS N611225
E198757
DEPTH 40·717 m
DIAMETER 2·600 m
R.L. OF INVERT 521·693

203° 01' 50"
1602·433

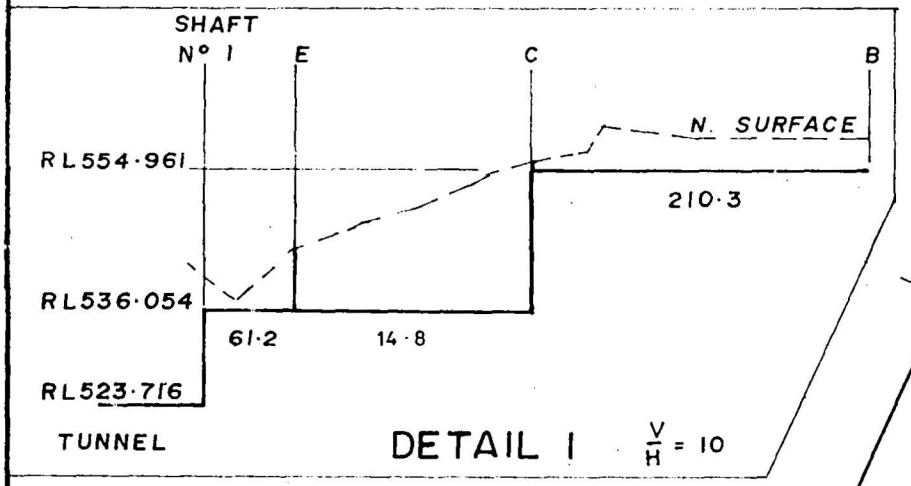
SHAFT N° 3
CHAINAGE 3314·694
COORDS N609751
E198130
DEPTH 46·0 m
DIAMETER 2·600 m
R.L. OF INVERT 519·020

1480·500

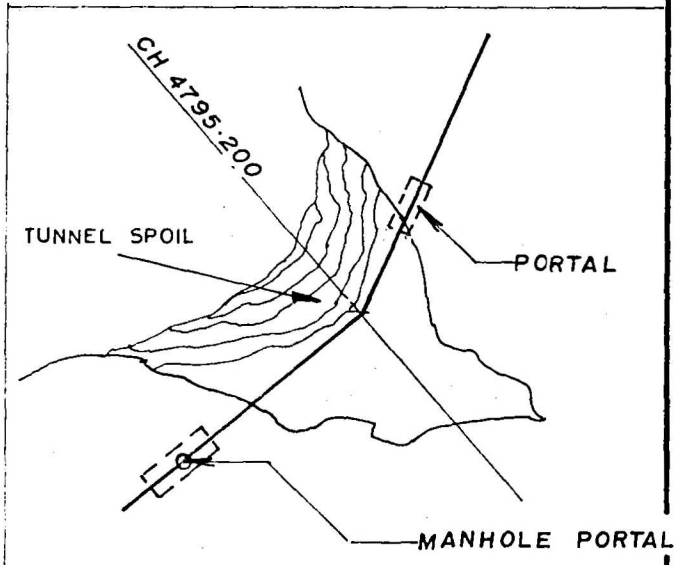
WINDOW BEND - (SEE DETAIL 2).
CHAINAGE 4795·20
COORDS N608388
E197551
R.L. OF INVERT 516·555

229° 24' 33"
993·254

OUTLET PORTAL
CHAINAGE 5788·454
COORDS N607740
E196798
R.L. OF INVERT 514·900



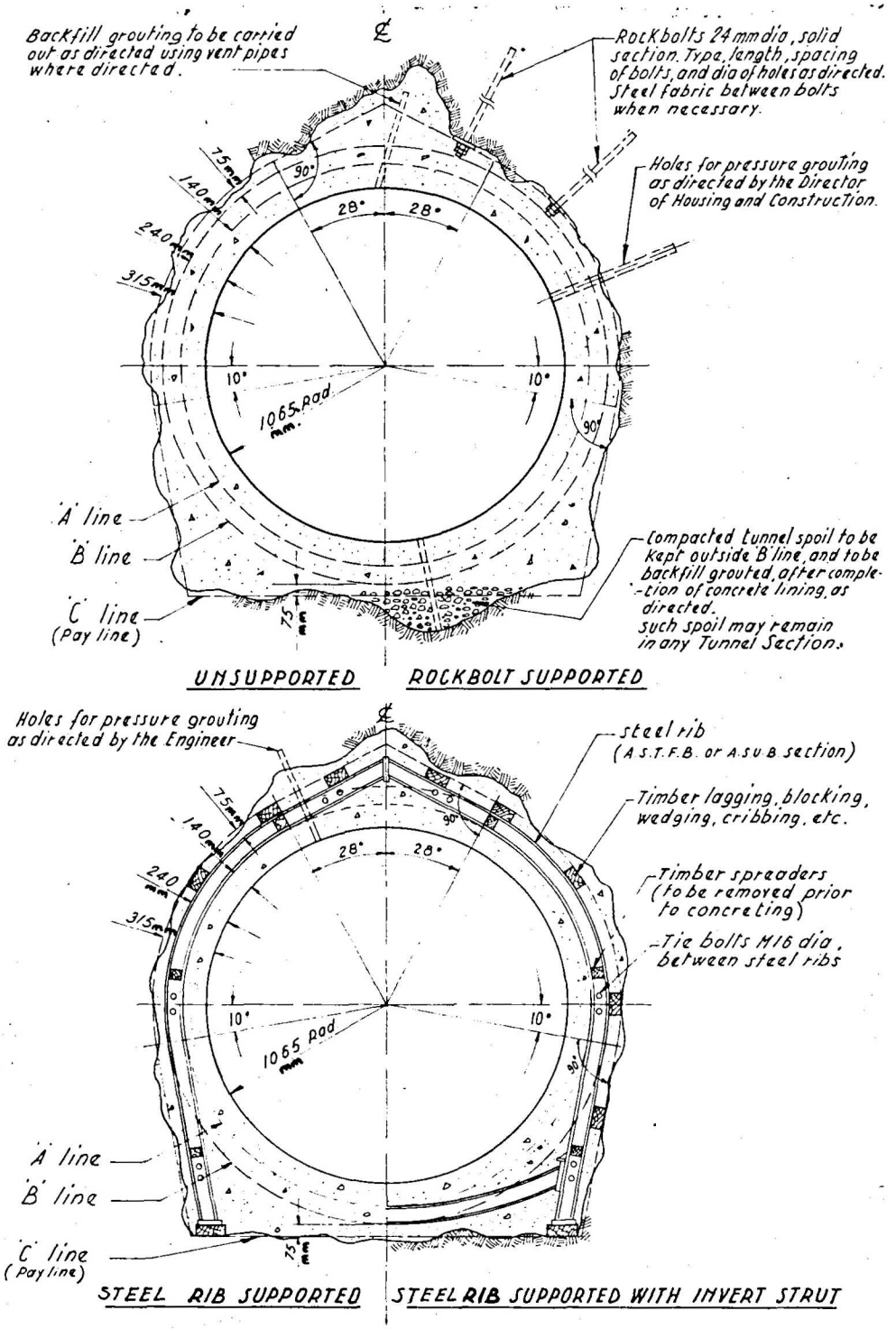
DETAIL 1 $\frac{V}{H}$ = 10



DETAIL 2

FIGURE 3

GINNINDERRA SEWER TUNNEL
TYPICAL TUNNEL CROSS — SECTIONS



SCALE 400 0 500 1000 mm

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(e) excavation conditions - rate of advance
- wear rate of drills
- explosive quantities

(f) overbreak

(g) support - type
- amount

(h) groundwater inflows - quantities
- duration of flow
- effect on excavation rate
- effect on concrete placement
- long-term effect on concrete lining.

All these parameters have been studied and this report lists and describes the results of the investigations carried out by the BMR Engineering Geology Subsection for DHC.

2. GENERAL GEOLOGY

2.1 REGIONAL GEOLOGY

The regional geology of the area is described in the Canberra 1:250 000 Geological Series map and explanatory notes (Strusz, 1971), and the area was more recently mapped for the Brindabella Sheet of the 1:100 000 Geological Series (Owen & Wyborn, 1975).

The interpretative solid geology of the proposed tunnel area is shown in Plate 1. The tunnels will be driven through an Upper Silurian sequence of acid volcanics, tuffaceous sediments, and a granite intrusion.*

The rocks are faulted, gently folded, and are tilted about 20°-30° southwest.

2.2 PHYSIOGRAPHY AND WEATHERING

The area south of Stn 40+00 (Plate 1) is generally steep and dissected by tributary creeks of the Murrumbidgee River. Downcutting of the Murrumbidgee River and its tributaries has caused rapid erosion of weathered rock, and a shallow weathering profile remains.

The area north of Stn 40+00 is undulating plateau, with depths of weathered overburden ranging from 10 to 35 m.

* Chemical analyses and petrographic description of rocks samples are set out in Appendix 5.

2.3 GROUNDWATER

The water-table is 0 to 20 m below ground surface (i.e., generally 30 to 45 m above tunnel level) on the plateau area, and 0 to 45 m below ground surface (i.e., 0 to 20 m above tunnel level) in the dissected area.

Permeability of the rock substance in the granites, dacites, and shales are almost zero, and groundwater is contained in open joints and fractures in the rock mass. No large water-filled cavities are present in these rock types. Permeabilities of the rock mass are expected to be less than 30 m/day and generally less than 10 m/day.

Chemical analyses of five water samples from Pine Ridge tunnel are presented in Appendix 6. Water samples from drill holes along the GST tunnel line will be collected and analysed, and results will be available in 1976. See Appendix 1 for investigation methods.

2.4 ROCK TYPES AND STRATIGRAPHY

2.4.1 Purple rhyodacite and green rhyolite

Generally the purple rhyodacite is weathered or partly altered. No fresh samples have been obtained from outcrops, road-cuts, or drill core. It is generally soft and weak, or crumbly. Phenocrysts of quartz, pink feldspar, and epidote are common in a fine-grained purple groundmass. In some places it appears to be a bedded tuff with a sharp contact against the green rhyolite; more commonly it appears to grade upwards into the green rhyolite.

At Pine Ridge Hill (locality C1; Plate 1) the purple rhyodacite appears to grade up through a medium-grained highly weathered and crumbly green rhyolite, into a fine-grained very siliceous green rhyolite at the top.

The relationship of these two rock types to the rocks in the rest of the area is not known, because most of the contacts are either faulted or their nature is not determinable. No definite conformable contacts have been seen. The rocks may be extrusive or intrusive. If intrusive they may be an offshoot of the granite porphyry. If extrusive they probably underlie the volcanics and sediments mapped as the lower part of the Walker Volcanics.

The evidence for an intrusive origin is as follows:

(a) A dyke of green rhyolite intrudes the upper part of the Walker Volcanics (locality D2; Plate 1); however, the dyke-rock may be younger than the other green rhyolites in the area.

(b) Near the east end of Pine Ridge tunnel, exposures in creeks and in the Molonglo River show green rhyolite intruding purple dacites (locality D3; Plate 1).

(c) The irregular contact between the green rhyolite and purple rhyodacite near Window Bend does not appear to be conformable.

(d) The position of the contact in drill hole GST 16 (Plate 8) did not coincide with its predicted position assuming the beds were conformable (see Appendix 8 for logs of holes, and Appendix 7 for photographs of drill-core).

(e) Possible intrusive contact against shales near Belconnen Golf Course (locality D5; Plate 1).

The evidence for an extrusive origin is as follows:

(a) In Pine Ridge tunnel, the green rhyolite is welded and massive at depth and grades up into a coarse agglomerate, then into black shale. The transition zone has blocks of green rhyolite up to 50 cm diameter surrounded by black shale.

(b) On, and west of Pine Ridge Hill (locality D6; Plate 1), the outcrop pattern suggests the rhyolite is bedded and dips about 20° SW, and is overlain by the shales and tuffaceous sediments (locality G1) in the valley south of Pine Ridge Hill.

(c) At Belconnen Golf Course (locality D4), the rhyolite crops out to the east of the southwest-dipping Walker Volcanics which suggests that the latter overlies the rhyolite. This would mean that the shales in Pine Ridge tunnel and at locality G1 are within the lower part of the Walker Volcanics.

A chemical analysis of a sample of green rhyolite from a road-cut on Weetangera Road (locality D1), and, for comparison, two analyses from a similar green rhyolite in Tuggeranong tunnel, are tabled in Appendix 5.

2.4.2 Walker Volcanics, lower sequence

A sequence of dacitic welded tuff and agglomerates, pyroclastic flows, and sills and dykes of dacitic composition with interbedded tuffaceous shale, siltstone, and sandstone

comprises the lower part of the Walker Volcanics. In some places there is complete gradation from the welded tuff through to the tuffaceous sandstone. Drill core from GST 7 shows several beds of massive welded tuff grading up into reworked tuffaceous sandstone with scour-and-fill structures near the top of each bed. Intraclasts of contorted shale up to 10 cm thick and 1 m long are incorporated in the tuff in drill core GST 7 and in outcrops to the west of Parkwood Road (locality E2).

Most of the sediments are near the base of the sequence. Above these most of the rock is welded dacitic agglomerate and tuff, and intrusive rock. Most of the extrusive rocks are massive, but in places they show a strong flow-banding/bedding due to flattening of dark grey, fine-grained rock fragments. In some places they grade up through reworked tuff into sandstone lenses.

The intrusive rocks are similar in appearance to the welded tuff, but are massive and slightly coarser-grained. Intrusive contacts against well bedded tuffs and tuffaceous sediments have been seen in several locations (E3 and E4). The intrusions are probably high-level sills and dykes.

The extrusive rocks in hand specimen are similar in appearance to outcrops of extrusive Mount Painter Porphyry* near Coppins Crossing, and have the following features in common.

(a) both have interbedded sediments

(b) both contain garnet

(c) both have a fragmental texture, e.g., contain angular quartz

(d) both contain biotite which is often fresh

(e) composition of plagioclase is similar

(f) both contain rare potash feldspar phenocrysts

(g) chemical analysis of sample 75840019 is similar to five analyses of Mount Painter Porphyry particularly Rb, Sr, Ba, Zr (see Appendix 5). Sample 75840018 shows some differences; it is an agglomerate and some changes in chemistry probably occurred at the time of eruption.

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* The Mount Painter Porphyry was the name given by Öpik (1958) to a porphyritic rock of dacitic composition to the southwest of Canberra that he regarded as a sill. Subsequent mapping to the west of Canberra has indicated that rock with apparent continuity with the Mount Painter Porphyry exhibits primary structures attributable to an extrusive origin.

The lower sequence of the Walker Volcanics is faulted against the upper part of the Walker Volcanics to the south; against purple rhyodacite and green rhyolite to the east; and against Willow Bridge Tuff to the north. It is intruded by a granite porphyry sill (Plate 1).

2.4.3 Walker Volcanics, upper part

The upper part of the Walker Volcanics is at least 1500 m thick (Malcolm, 1954). It is thought to be the same age as the Hawkins Volcanics in the Yass Basin, but the units cannot be correlated lithologically (Wyborn, pers. comm.). It is a sequence of dacitic densely welded pyroclastic flows and tuffs with some lenses of shale and limestone.

In Pine Ridge tunnel the upper part of the Walker Volcanics consists of densely welded pyroclastic flows and tuffs, mostly massive but with some thin-bedded welded tuffs and some thin lenses of water-deposited shales and tuffaceous sandstones. The massive welded rocks grade up into well-bedded crystal tuffs near the west portal of Pine Ridge tunnel; in the LMWQCC, well bedded tuffs are ubiquitous. The general dip is 20°SW, but the tuffs are moderately folded in the LMWQCC area.

The rocks are generally blue-grey to purple, but green-grey rocks are also common. Chemical analyses of five samples collected in Pine Ridge tunnel are presented in Appendix 5. Chemistry of the five samples is fairly similar except for FeO/Fe_2O_3 ratios which are high in the green varieties and low in the purple varieties. Total Fe as FeO ranges from 4 percent to 6 percent; FeO/Fe_2O_3 ranges from 4.3 to 0.45.

The purple colour appears to be due to secondary oxidation which has permeated into the rock from permeable defects in the rock mass. The oxidation is more complete in the more permeable rock (close jointed and fractured) than in the very tight, wide-jointed zones. Calcite veins are common in the blue grey to purple zones, but rare in the green grey zones.

2.4.4 Willow Bridge Tuff (previously Laidlaw Volcanics)

The Willow Bridge Tuff unconformably overlies the Yass Subgroup in the Yass Basin (Link, 1970) and unconformably overlies sediments (thought to be Yass Subgroup), purple rhyodacite and purple rhyolite at Gooramon Ponds (Henderson, 1975). Near the BWPCC, it either unconformably overlies or is faulted against purple rhyodacite and pink rhyolite. The sequence is about 500 m thick 1 km west of Yass (Link, 1971).

In the area of the BWPCC, the Willow Bridge Tuff is a sequence of densely welded pyroclastic flows of dacitic composition. It is generally pale grey with phenocrysts (approximately 25%) of quartz feldspar and biotite up to 5 mm in a fine-grained groundmass; there is a dark grey bed about 70 m thick at the base of the sequence which crops out along the eastern edge near the BWPCC; this bed has fewer phenocrysts and a finer-grained, darker groundmass.

Flow banding/bedding (dip about 35°SW/135°) can be seen in some drill core and in exposures of extremely weathered rock in creek beds (locality J2). Zones of quartz-epidote veining, and pink calcite veining, are seen in GST 2 and 4 and in some outcrops. Where this veining occurs the felspars and much of the groundmass is stained pink.

2.4.5 Granite porphyry (Ginninderra Porphyry)

This is a sill of granite porphyry which has intruded along the bedding planes of the shales and sandstones within the Walker Volcanics.

Intrusive contacts have been seen in exposures in creeks near the Murrumbidgee River (locality L1) and in drill core from GST 1 and GST 22.

The granite porphyry was probably emplaced in Ludlovian times (Upper Silurian). The granite porphyry is regarded as part of the Ginninderra Porphyry, which intrudes the Willow Bridge Tuff to the west and north.

2.5 STRUCTURE

2.5.1 Folding

Walker Volcanics. Some gentle folding is present in the lower part of the Walker Volcanics; and some strong folding occurs in the shales near the granite porphyry intrusion (location G2). No cleavage is apparent in the shales. The sequence is tilted about 20°SW.

Gentle to moderate folding is present in the upper part of the Walker Volcanics in Pine Ridge tunnel and in the LMWQCC excavations. Most of the upper part of the Walker Volcanics is also tilted about 20°SW.

Willow Bridge Tuff. The Willow Bridge Tuff is a very competent unit. No folding is apparent, and the unit is tilted about 35°SW.

2.5.2 Faults

Seven major faults have been located during the mapping; however, only five of them intersect the GST line (Plates 1 to 5). Many minor fractured or sheared zones are indicated by airphoto-lineaments (Plates 2 to 5). Zones of low bedrock velocity, and defect zones are shown on the seismic profiles (Plates 6 to 8).

The major fault zones range in width from a few metres to several hundred metres; they generally consist of one or more clay-filled crushed and sheared zones from 3 to 30 m wide, with adjacent fractured rock. All the major faults extend beyond the area mapped or are truncated by other major faults.

The upthrown and downthrown sides of the faults have been deduced from stratigraphic relationships and are shown in Plate 1. The faults were active during Silurian and Devonian time, with probably some reactivation during the Late Tertiary to Quaternary Kosciuskan uplift. Significant displacement across the faults is unlikely to have taken place during the last million years.

Some of the faults may still be active (i.e., causing earth tremors), but relative movement along a fault producing a measurable displacement at or near the ground surface would be extremely unlikely and prediction of the site of such a displacement is not possible. See also Seismicity.

Fault 1 crosses the northwest corner of the mapped area and does not intersect the tunnel line (Plate 1). It is roughly parallel to fault 5 and the Winslade Fault, a major fault crossing the Molonglo valley about 6 km to the southeast. It is also subparallel to one of the prominent photo-lineament directions in the area.

In February 1975 an earth tremor of magnitude 3 on the Richter scale originated from an epicentre on this fault at a depth of about 1.6 km. There was no displacement along the fault at the ground surface.

Fault 2 is an east-west-trending fault which crosses the tunnel line near stn 13+00. There is no rock outcrop near the tunnel line from which width or condition of the fault can be estimated. Between the tunnel line and the Murrumbidgee River the fault can be traced on aerial photographs, and appears to divide into several fault zones. Near the Murrumbidgee River the fault can be seen in creeks and in outcrops as sheared and fractured zones up to 100 m wide. Drill holes GST 6 and 8 intersected sections of crushed and sheared granite porphyry. The extent of the fault to the east is not known.

The northside of the fault is thought to be the downthrown block since it contains the Willow Bridge Tuff which is thought to be younger than the lower part of the Walker Volcanics, which occurs south of the fault.

Fault 3 intersects the tunnel at stn 40+20. Where fault 3 is exposed in creek beds to the west of the tunnel line the crushed and sheared zone ranges from 25 to 50 m wide. Where fault 3 crosses the Murrumbidgee River, there is 3 m of sheared and crushed rock with 10 m of strongly fractured rock and up to 100 m of moderately fractured rock on the south side of the fault. The rocks on the north side of the fault have not been affected. Drill hole GST 12 revealed a 3 m wide crushed zone with sheared and fractured rock on the south side.

The south side of the fault is considered to be the downthrown block; this interpretation requires a much smaller displacement than if the south side were the upthrown block. East of the tunnel line, fault 3 may be truncated by fault 6 and probably by fault 5, although fault 3 may diverge and merge with fault 5.

Fault 4 intersects the tunnel line at stn 47+50; it trends southeast, subparallel to the Deakin Fault - a major fault 6 km to the northeast through Belconnen - and to the second major photo-lineament and joint direction in the area. It is truncated at its northwestern end by fault 5, and at the southeastern end, it is possibly truncated by fault 7. Fault 4 is probably a continuation of fault 3 that has been displaced by dextral transcurrent movement along fault 5.

Fault 4 is exposed in several places in the creek near Window Bend. The zone of crushed and sheared rock appears to range from less than 1 m to about 15 m wide. Drill hole GST17 revealed that it consists of sheared and crushed shale and volcanic fragments in a heavy clay matrix with 20 m of sheared and fractured rhyolite on the northern side. The condition of the rock on the southern side is probably similar to that on the south side of fault 3, but will not have any effect on the construction of the GST as the rock will be under the spoil heap at Willow Bend.

The fault is an impermeable barrier and has held back water in the fractured rhyolite to the northeast. Drill hole GST17 went through this fault into the fractured rhyolite, and water has flowed from the collar of the hole continuously since it was drilled.

The south side of the fault is considered to be the downthrown block for the same stratigraphic reason that applied to fault 3.

Fault 5 appears to divide into several faults in some areas. The fault zone is about 30 m wide near Pine Ridge homestead (locality Z; Plate 1) but widens out to about 200 m and becomes hard to trace in the upper part of the Walker Volcanics (locality Y; Plate 1). Aerial photographs show the fault continues south of Uriarra Crossing.

Fault 5 is subparallel to Fault 1, to the Winslade Fault, and to the prominent photo-lineament and joint direction (060^{o}) in the area.

Fault 6 is a branch of Fault 5. It was intersected by drill hole GST13; it appears to have been intersected near the surface in GST15, and it must lie between GST14 and GST21 as the rock types in these two holes are on the opposite sides of the fault. The trace of the fault on the ground surface is fairly irregular (Plates 1 and 5).

Where intersected by GST13, the fault zone consisted of 0.5 m of crushed and sheared shale and rhyolite, with about 6 m of sheared and fractured rhyolite on the eastern side. Drill holes GST14 and GST15 revealed that in these areas there is at least 20 m of slicksided, seamy, and fractured rock on each side of the crushed zone.

The wedge between faults 4 and 5 is very complex and appears to be extensively faulted and the detailed structure has not been worked out.

2.5.3 Photo-lineaments

Photo-lineaments are plotted on Plates 2 to 5 (see Investigation Methods, Appendix 1). These probably represent sheared and fractured zones. There are two main directions of lineaments and several random lineaments. The main joint set directions are probably parallel to the main photo-lineament directions.

Photo-lineaments plotted during the design investigation of Tuggeranong tunnel correlated well with defect zones encountered during its construction.

2.5.4 Joints

No detailed joint study has been done in the area. The main joint sets in Pine Ridge tunnel are $90^{o}/060^{o}$, $90^{o}/160^{o}$, and a third set parallel to bedding. The sets $90^{o}/060^{o}$ and $90^{o}/160^{o}$ are subparallel to the major fault directions (including the Deakin and Winslade faults) and to the most common photo-lineament directions in the area. These will probably be the most common joint sets in the tunnel but joints are controlled by

folding and faulting and vary according to structural domain. Therefore, the main joint sets are likely to vary several times along the tunnel line.

2.6 SEISMICITY

Recorded seismic data for the last 13 years show a number of epicentres within a few kilometres of the tunnel line, indicating the possibility that some of the faults are active (i.e., causing seismic tremors). A tremor of magnitude 3 on the Richter scale originating from an epicentre 1.6 km depth on fault 1 was recorded in February 1975. Data are insufficient to predict either frequency or magnitude of future tremors.

An earthquake producing measurable displacement at the ground surface would be extremely unlikely, and prediction of the site of such a displacement is impossible.

3. ENGINEERING GEOLOGY

3.1 ENGINEERING, GEOLOGICAL AND EXCAVATION PROPERTIES OF THE ROCK TYPES

3.1.1 DACITE: WALKER VOLCANICS, UPPER PART

(Stn 47+60 to 57+88. Drill holes GST17 GST18, GST20, MV7)
(Stn 40+20 to 43+80. Drill holes GST12, GST13, GST14)

Tunnelling conditions in these sections of Ginninderra sewer tunnel are expected to be similar to those encountered in the western 1800 m of Pine Ridge tunnel, which passes through the same rock unit. Within this part of the text, references to Pine Ridge tunnel refer only to the section within 1800 m of its west portal (see note on 'Correlation with Pine Ridge tunnel', Appendix 1).

3.1.1.1 ENGINEERING PROPERTIES OF THE ROCK SUBSTANCE

The methods for determining the mechanical rock parameters, and the results of testing, are set out in Appendix 4.

Most samples tested were of the purple or green varieties of the dacite. The fresh blue grey dacite is expected to give higher values for both UCS and Shore Hardness.

Sample location	UCS (MPa)		Point Load Strength (MPa)					
	No. of samples	Range	Average	Samples successfully tested	Is(50)**		UCS equiv.*	Mean hardness (Shore units)
					Range	Average		
GST 13	-	-	-	6	4.2-9.9	7.0	170	
GST 18	3	96-145	120	7	2.9-7.8	5.1	120	68
GST 20	3	141-255	206	10	4.9-7.5	6.2	150	89
MV 7	3	187-239	213	-	-	-	-	91
Mv 11	4	177-262	222	-	-	-	-	88
Pine Ridge Tunnel	-	-	-	65	4.3-12.0	7.9	200	-

* Values in the 'UCS equivalent' column were obtained from Brock & Branklin (1972).

** Point Load Strength Index; see Appendix 4.

3.1.1.2 TUNNEL SECTION STN 47+60 TO 57+88
(Drill holes GST17, GST18, GST20, MV7)

3.1.1.2.1 Geological properties of the rock mass at tunnel level (Plate 8)

Weathering. This section of the tunnel will be excavated through fresh dacite, except for about 40 m of moderately weathered to fresh rock near the south portal at Window Bend. The highest-velocity seismic refractor indicates that the base of the zone of weathering is more than 10 m above tunnel crown along 700 m (about 95%) of this section.

Seismic velocities*. Bedrock** velocities range from 3500 to 4400 m/sec, similar to the 3400 to 4800 m/sec for the same rock type in Pine Ridge tunnel.

Defects. No major faults have been detected by surface mapping or seismic refraction along the tunnel line.

In Pine Ridge tunnel, long sections (up to 700 m) of competent rock (RCN < 4) are broken by shorter sections (generally 40-100 m, but up to 200 m) of less competent rock (RCN ≥ 4). In the competent rock (about 75% of Pine Ridge tunnel) joints are mostly spaced 0.3 to 1 m and are slightly open to very tight. There are four main joint sets in Pine Ridge tunnel:

J1	80°/W/170°	Spaced 0.6 - 2 m
J2	90°/060°	" 0.3 - 1 m
J3	20° -40°/N/070° (bedding)	" 0.1 - 0.6 m
J4	80°/S/100°-140°	occur intermittently

The above joints vary in prominence from area to area, and in many places some or all sets are not present. There are many random discontinuous joints, and in some areas joints sets other than those listed above are more prominent.

In competent sections of Pine Ridge tunnel, crushed and sheared zones, generally 0.1 to 0.3 m wide, associated with thin clay seams and close jointed and fractured zones up to 1 m wide, are spaced about 10 to 200 m apart. Most are oriented parallel to J1 or J3.

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* Time-distance curves for the seismic profiling are available at BMR for inspection by tenderers.

** The term 'bedrock' as used in this report refers to the deepest seismic refractor detected, and the term 'overburden' refers to the soil, colluvium, and weathered rock above that refractor.

The less competent rock (about 25% of Pine Ridge tunnel) is more closely jointed (0.1-0.3 m), with joints slightly open or with some clay on surfaces. Crushed and sheared zones (less than 2% of Pine Ridge tunnel) are generally 0.3 to 1 m wide, with 3 to 30 m of associated close jointed and/or fractured and seamy rock.

Defects in GST are expected to be similar in width, spacing, and condition to those in Pine Ridge tunnel, except that, along the GST line, joints parallel to bedding dip about 20°SW/130°. Spacing is variable from 10 to 30 cm between the Window Bend south portal and stn 51+00, to greater than 60 cm for most of the rest of the section.

3.1.1.2.2 Groundwater inflows*

Water outflowed from each portal of Pine Ridge tunnel at about 10 m^3/hr during excavation. Outflows from this section of the Ginninderra sewer tunnel are expected to be less than those from Pine Ridge tunnel because groundwater in the area has been substantially drained by the deeply incised nearby Murrumbidgee River and its deep tributary creeks. The maximum height of the water-table above tunnel level is about 10 m. The porosity and permeability of this rock mass is expected to be similar to that at Pine Ridge tunnel, so it is unlikely that there is much water stored in the rock above tunnel level.

Based on experience at Pine Ridge tunnel, when water-bearing defects were intersected during excavation, water inflows, generally less than 1 m^3/hr but possibly up to 10 m^3/hr in a few zones, will enter the tunnel initially but will decrease rapidly after excavation.

3.1.1.2.3 Excavation properties

Effect of engineering properties. The rock is very strong and very hard. Drill penetration is slow and drill wear rate is high. In the hardest blue-grey dacite in Pine Ridge tunnel one drill steel was worn out for about every 5 m of drilling.

In Pine Ridge tunnel the average weight of explosive (AN60 and ANFO in varying proportions) per cubic metre of rock excavated (including overbreak**, which was calculated from concrete quantities) ranged from 2.6 to 3.6 kg/m^3. However, over-

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* Water-pressure test computation sheets are available at BMR for inspection by tenderers (see also Appendix 3).

** The term "overbreak" in this report refers to the depth measured normal to the C-line (see Fig. 3) of the space produced when a block or blocks of rock fall from outside the line of the perimeter drill holes. Predictions of overbreak in this report assume a well designed and loaded drilling pattern suitable for the rock conditions encountered. Overbreak due to poor drilling and blasting procedures cannot be predicted. The overbreak figures quoted do not refer to the average overbreak which could be expected for that particular tunnel section.

break in Pine Ridge tunnel was excessive for such competent rock and much of it is attributed to inaccurate drilling and overblasting. A neat tunnel profile with less overbreak could be produced in this section of the GST with more accurate drilling and slightly smaller explosive quantities.

Effect of geological properties of the rock mass. Using the same excavation techniques, overbreak would be slightly greater in GST than in Pine Ridge tunnel because of the prominent joint set J2 (strike 040° to 070° in GST line), which is subparallel to the tunnel line.

Joint set 20°SW/130° (parallel to the bedding) will dip with tunnel drive and should not cause extra overbreak if the tunnel is driven from Window Bend.

Intersection of major joints spaced 0.3 to 1 m will cause blocky ground in areas where the joints are open or clay-coated, and random rock bolts** may be needed to pin some blocks.

The narrow sheared and fractured zones in the competent sections (RCN < 4) will generally not need support. In the less competent sections (RCN ≥ 4), low angle shears, seams, and fractured zones will occur at random orientations and will cause some overbreak; some of these defects will need support. Defect zones > 10 m wide will need support irrespective of orientation.

Excluding the portals, 3 percent of the upper part of the Walker Volcanics in Pine Ridge tunnel had steel-set support in irregularly spaced sections 6 to 15 m long. A similar percentage is expected in this section of GST; however, it could be higher if any major defects oriented parallel to the tunnel line run along the tunnel crown for any distance.

In Pine Ridge tunnel the following percentages of each rock condition number were mapped in this section of the Walker Volcanics. See Appendix 2 for definition of Rock Condition Number (RCN).

RCN 2	20%
TCN 3	55%
RCN 4	23%
RCN 5	2%

Similar percentages are expected in this section of GST.

Effect of groundwater inflows. No major groundwater inflows that could significantly slow excavation progress are expected.

** The term 'random rockbolts' is used by tunnel engineers for the placing of rockbolts as required by the rock conditions, as distinct from 'pattern rockbolts' where rockbolts are placed in a regular pattern along a section of tunnel.

Combined effects of all parameters:

(a) Geologically there is no reason why the excavation rate should differ from that maintained in the same unit in Pine Ridge tunnel.

(b) The blue grey dacite is very hard, and drill penetration will be slow and drill wear rate high.

(c) Less overbreak can be expected in this section of GST than in Pine Ridge tunnel if drilling is more accurate and slightly less explosive is used.

(d) Excluding portals, about 3 percent of this section is expected to need steel-set support.

(e) No major groundwater inflows which could significantly slow excavation progress are expected.

(f) Within this section, the percentages of tunnel assigned to each rock condition number are expected to approximate those logged in Pine Ridge tunnel which are set out below.

RCN 2	20%
RCN 3	55%
RCN 4	23%
RCN 5	2%

3.1.1.2.4 Contact, stn 47+50: fault 4 (drill holes GST 17)

The contact between dacite of the upper part of the Walker Volcanics and the green rhyolite is fault 4. This will affect the Window Bend north portal and its engineering significance is described in that section.

3.1.1.3 TUNNEL SECTION STN 40+20 TO 43+80
(Drill holes GST 12, GST 13, GST 24)

3.1.1.3.1 Geological properties of the rock mass at tunnel level (Plate 8)

Weathering. This section of the tunnel will be in fresh dacite of the upper part of the Walker Volcanics.

Seismic velocities. Seismic velocities of 3600 to 4600 m/sec indicate that the rock mass is fairly tight.

Defects. This part of the tunnel passes through a wedge of rock between faults 3 and 6. Fault 6 runs close to the tunnel line for most of the length of this section and has probably caused some shearing and fracturing in the rock mass. Drill holes GST12 and GST13 reveal that the rock has been partly stressed and sheared, but most defects have been healed with chlorite. Joint spacing is variable from 20 cm to 1 m. Joint surfaces are slickensided and coated with chlorite and are fairly tight. Many small fractured zones from 10 cm to 1 m wide, spaced 30 cm to 5 m, were intersected in drill holes GST12 and GST13. Crushed seams up to 10 cm wide with clay are also common. Most sheared and fractured zones probably strike parallel to fault 6, i.e., at a small angle to the tunnel.

3.1.1.3.2 Groundwater inflows

The water table ranges from 20 to 40 m above tunnel level. Water-pressure test losses in drill holes GST12 and GST13 were up to 10 lugeons, but most were less than 1 lugeon, indicating that permeability of the rock mass is generally fairly low.

Most of this section will be damp, with persistent seepages and drips from some fractured zones. Most open joints and fractured zones will yield initial inflows less than 1 m^3/hr, but a few may yield up to 10 m^3/hr.

3.1.1.3.3 Excavation properties

Effect of engineering properties: similar to stn 47+60 to 57+88, except that shearing and formation of chlorite throughout the rock has probably reduced the strength of this rock slightly. Drill penetration should be marginally faster and drill wear rate slightly lower.

Effect of geological properties of the rock mass. The variable joint spacing from 20 cm to 1 m will mean that, when blasted, much of the rock mass will break into fragments less than 30 cm diameter, but in some sections some larger blocks will remain.

The fracturing, shearing, and close jointing resulting from the nearby faults will mean that there is more loose ground in this section than in the section from stn 47+60 to 57+88. Many of the crushed, sheared, and fractured zones are expected to be parallel to fault 6 (about 20° to tunnel line) resulting in longer sections of support and more overbreak. About 20 percent of the section from 40+20 to 43+00 is expected to need steel-set support.

In competent rock some blocks generally less than 30 cm will fall out from beyond the C-line. Crushed, sheared, and fractured zones parallel to fault 6 will probably cause up to 1 m overbreak in the east wall and crown in places. Clay-coated defects with dips up to 45° against tunnel drive could cause in excess of 1 m overbreak (rare).

Effect of groundwater inflows. The water inflows expected should not cause any delay in excavation progress. The action of groundwater on the clay-filled defects, especially near fault 6, will reduce the stand-up time of the rockmass.

Combined effects of all parameters:

(a) Rock condition number is expected to be mainly 3, with some 4 and possibly some 5.

(b) About 20 percent of the section from stn 40+20 to 42+30 is expected to need steel-set support with timber logging.

(c) Generally less than 30 cm but in places up to 1 m overbreak in the crown and east wall may result from defects oriented parallel to fault 6. Other unfavourably oriented defects may cause in excess of 1 m overbreak (rare).

(d) Drill penetration will be slightly faster and drill wear rate slightly lower than section stn 47+60 to 57+88.

3.1.1.3.4 Contact, stn 40+20: fault 3 (Drill hole GST12)

The contact between the upper and lower parts of the Walker Volcanics is fault 3. Drill hole GST12 revealed a 5 m wide crushed zone of soft and weak clayey gravel with fragments less than 2 cm in a sandy clay matrix. On the southern side of the fault the rock is closely jointed and slickensided for 20 m from the fault zone, and to the north of the fault the rock is widely jointed and tight (i.e., little affected by the fault).

3.1.2 GREEN RHYOLITE: STN 46+10 (APPROX.) TO STN 47+45. (DRILL HOLES GST 16, GST 17)

3.1.2.1 Engineering properties of the rock substance

Sample location	UCS (MPa)			Point load strength (MPa)				
	No. of samples	Range	Average	Samples successfully tested	Is(50) Range	Is(50) Average	UCS equiv.	Mean hardness (Shore units)
GST 16	NOT TESTED			9	6.1-11.4	9.0	220	NOT TESTED
GST 17	3	247-322	283	11	5.9-10.2	8.4	200	96
Road cut D1				9	6.1-11.4	9.8	240	-

3.1.2.2 Geological properties of the rock mass at tunnel level (Plate 8)

Weathering. This section of tunnel will be excavated through fresh green rhyolite.

Seismic velocities. Bedrock velocities range from 3400 to 4400 m/sec. 4400 m/sec probably represents fairly tight rock; 3400 m/sec probably represents closely jointed rock, with joint surfaces partly separated and rock mass moderately loose.

Defects. This section of tunnel will be excavated through rock which is in a wedge between faults 4 and 5. Movement on the two faults during the Siluro-Devonian and Tertiary times has probably broken this wedge of rock into a closely jointed and fractured mass; the movement has probably caused the rock mass to be strained and the joint surfaces to be partly separated. However many of the joints in the drill core from GST 16 and GST 17 have been partly cemented with silica. Where the cementing is incomplete, cavities up to 70 mm but generally less than 5 mm diameter have been formed (drill hole GST 16).

Most of the rock mass is expected to be closely jointed (10-30 cm) and fairly loose with some fractured zones. Areas where joints have been cemented will effectively be wider jointed (30-60 cm) and tight. Clay seams and 'greasy backs' are not expected in the rhyolite although there may be some, especially approaching the contact with the purple rhyodacite.

3.1.2.3 Groundwater inflows

The rock mass is very permeable. Water-pressure test losses in GST 17 were up to 25 lugeons and GST 16 lost all drilling water at one level. GST 17 flowed initially at 1.6 m^3/hr and decreased to about 0.5 m^3/hr. When GST 17 was drilled, the water-level in GST 16 fell 7 m in one week.

Water is contained in open joints and fractured zones and in the small cavities mentioned above. When these are intersected during excavation, water inflows generally less than 5 m^3/hr, but possibly up to 20 m^3/hr in a few zones, will enter the tunnel initially.

3.1.2.4 Excavation properties

Effect of engineering properties. The Shore Hardness and the UCS of the green rhyolite are higher than for the dacites in the upper part of the Walker Volcanics. This suggests that drill penetration will be slower and drill wear rate higher.

Explosive quantities per volume will probably be similar to or less than for dacites in the upper part of the Walker Volcanics because the close spacing of joints will offset the higher UCS of the rhyolite.

Effect of geological properties of the rock mass. The closely spaced joints will cause the rock mass the break into fragments generally less than 30 cm diameter when blasted.

Areas where the rock is closely jointed and loose will require steel-set support with timber lagging. About 40 percent of this section is expected to need steel-set support.

In loose sections, overbreak will depend mainly on tunnelling methods (explosive quantities, drilling accuracy), and how quickly support is erected to retain the loose rock.

In the sections where joints are cemented, blocks generally less than 60 cm may fall, in, leaving voids beyond the C-line. Rockbolts may be more efficient and economical than steel sets in supporting rock of this nature.

Effect of groundwater inflows. The water inflows expected should not cause any delay in excavation progress.

This section of tunnel is expected to yield the largest water inflows. Special attention should be given to making a watertight concrete lining in this section. As this section only extends 150 m from the portal some consideration should be given to providing a drain below the tunnel lining.

Combined effect of all parameters:

(a) Rock condition number will be mostly 4, with some 3.

(b) About 40 percent of this section is expected to need steel-set support with partial timber lagging.

(c) Amount of overbreak could vary greatly in this section, but will depend mainly on tunnelling method.

(d) Advance rate will be slowed by (i) jamming of drill stems in loose rock, and (ii) necessity to erect steel-set support.

3.1.2.5 Contact, stn 46+10 (drill hole GST 16)

The contact between the green rhyolite and purple rhyodacite in the core from GST 16 could be either intrusive or conformably extrusive. No major defect is known to exist at the contact. Water inflows, overbreak and support are not expected to be significantly different at the contact than in the rocks on either side of the contact.

3.1.3 PURPLE RHYODACITE: STN 43+80 TO APPROX. STN 46+10 (DRILL HOLES GST 15, GST 16)

3.1.3.1 Engineering properties of the rock substance

Sample location	UCS (MPa)		Point Load Strength (MPa)				Mean hardness (Shore units)
	No. of samples	Range Average	Samples successfully tested	Is(50) Range	Is(50) Average	UCS equivalent	
GST 15	CORE TOO FRACTURED		NOT TESTED				
GST 16	3	all samples failed prematurely on joints	6	2.9-6.1	4.6	110	78

The rock was too fractured and seamy to enable samples of required size to be collected for testing although 6 successful point load and three Shore Hardness tests were carried out on GST 16 core.

3.1.3.2 Geological properties of the rock mass at tunnel level (Plate 8)

Weathering. The rockmass at tunnel level is below the zone of weathering, but the rock has been altered by moving groundwaters. Degree of alteration is probably variable; much of the rock is probably equivalent to highly to moderately weathered dacite, with zones of slightly weathered and seams of extremely weathered material.

Seismic velocity. The seismic velocity of 3700 m/sec for this material indicates that although the rock is moderately weak the bulk density is high because there are few voids or open joints; most joints are clay-filled.

Defects. The purple dacite is part of the wedge between faults 4 and 5. Movement of the faults during Siluro-Devonian and Tertiary times has caused the rock mass to be strained and the joint surfaces to be partly separated, allowing water to penetrate the rock mass and cause alteration.

The rock mass is expected to be closely jointed (10-30 cm), with most joints clay-filled. Clay-filled, crushed, sheared, and fractured zones are likely.

3.1.3.3 Groundwater inflows

Water pressure tests in GST 15 and in the purple rhyodacite in GST16 showed negligible water losses. Most of the rock mass is expected to be relatively impermeable because most of the defects are clay-filled.

Any water inflows are expected to be small (probably less than 3 m^3/hr). Water will seep and drip from clay-filled fractured and sheared zones.

3.1.3.4 Excavation properties

Effect of engineering properties. The UCS tests of the purple rhyodacite suggests that much of the rock has the strength of highly to moderately weathered rock. Drill penetration will be rapid and drill wear rate low.

Effect of geological properties of the rock mass. Blasting will break the rock into fragments generally less than 20 cm diameter because the rock is weak and closely jointed.

Probably 70-100 percent of this section will need steel-set support with timber lagging. In some places considerable weight may be imposed on the sets, and spacing less than 1 m may be required.

Overbreak will depend mainly on efficiency in installing support. Clay-coated defects with dips up to 45° against tunnel drive could cause several metres of overbreak in a few places. Generally overbreak will be less than 60 cm.

Effect of groundwater inflows. Groundwater inflows are expected to be small. However the action of the groundwater on the clay-filled defects will reduce the stand-up time of the rock mass.

Combined effects of all parameters:

(a) This is expected to be the most difficult section of the tunnel to excavate and support.

(b) Rock condition number will be mainly 4, but long sections of 5 are possible.

(c) Expect 70 to 100 percent steel-set support is expected, which sets spaced less than 1 m in some zones.

(d) Overbreak will generally be less than 60 cm, but could be in excess of 1 m in some zones where poorly oriented defects occur.

(e) Advance rate will be slowed by necessity to erect support and sometimes to fill large overbreak with timber lagging. It may be more economical to use hand-held machines for tunnelling some sections.

3.1.3.5 Contact, stn 43+80; faults 5 and 6 (drill hole GST14)

The contact between the purple rhyodacite and the dacite of the upper part of the Walker Volcanics is a fault zone (faults 5 and 6) which probably extends for about 150 m along tunnel line. Drill hole GST14 reveals that the dacite in the fault zone is closely jointed and fractured. Joints are generally spaced less than 10 cm, and are coated with calcite and chlorite and are slickensided. Most joint surfaces are greasy, having from 1 to 10 mm of clay. Clay seams up to 10 cm thick are spaced less than 30 cm in places in GST14.

Rock condition in the tunnel is expected to be 4 to 5.

When blasted the rock will mostly break up into a coarse gravel with few fragments larger than 20 cm diameter.

80 to 100 percent of this section is expected to need steel-set support.

Water inflows are expected to be similar to the remainder of the section from 43+00 to 40+20.

3.1.4 WALKER VOLCANICS, LOWER SEQUENCE

3.1.4.1 DACITE AND TUFFACEOUS SANDSTONE
(Stn 37+30 to 40+20: Drillholes GST 11 and 12)
(Stn 15+20 to 25+00: Drillholes GST 7 and 1)

The rock in these sections consists of dacitic welded tuffs and agglomerates, with sills and dykes of dacitic composition. The northern section (15+20 to 25+00) also contains interbeds of tuffaceous sandstone and some minor shales. The main section of shale in the Walker Volcanics is discussed in the following section.

Samples of reworked tuff give lower strength results than the welded tuff and agglomerates. This accounts for the larger range of values and the lower mean on GST11 and GST 12. UCS of welded tuffs is greater than 200 MPa. UCS of reworked tuff is less than 120 MPa. There is a complete gradation between these rock types, so UCS of the volcanics in this section is expected to range from about 100 to 250 MPa.

3.1.4.1.1 Engineering properties of the rock substance

Sample location	UCS (MPa)			Point load strength (MPa)				
	No. of samples	Range	Average	Samples successfully tested	Is(50)		UCS equivalent	Mean hardness (Shore units)
					Range	Average		
GST7 (reworked tuff)	-	-	-	13	3.2-5.3	4.4	110	
GST7 (welded tuff)	3	203-205	204	11	6.5-15.8	9.8	220	73
GST 11	3	152-164	157	10	4.1-7.4	6.2	150	74
GST 12	3	97-105	102	12	3.4-10.6	7.2	170	70
Locality E1	-	-	-	10	7.1-14.0	10.5	250	

3.1.4.1.2 Geological properties of the rock mass at tunnel level (Plates 6 and 7)

Weathering. These sections of tunnel will be excavated through fresh rock.

Seismic velocities. Bedrock velocities of 4400 to 5100 m/sec were recorded in this rock type except for 80 m of 3300 to 3400 m/sec between stn 39+40 to 40+20. The higher velocities represent tight rock. The 3300 to 3400 m/sec velocities lie close to fault 3 and probably represent partly fractured and sheared rock.

Defects. Most of the rock mass is expected to be tight. Joints are generally spaced 0.3 to 1 m but are wider in some places and are commonly cemented with calcite. Many joint surfaces are coated with chlorite and slickensided. Flow-banding is apparent in some places but this is not expected to be a weakness. Some narrow fractured and/or sheared and crushed zones can be expected.

In the section from 37+30 to 40+20, GST12 revealed good sound rock and GST11 revealed slightly weaker and more jointed rock with some crushed seams (clayey gravel) generally less than 20 cm wide and spaced 1 to 6 m in the drill core.

3.1.4.1.3 Groundwater inflows

The water-table is about 30 m above tunnel level. Water-pressure test losses in drill holes GST12, GST11, and GST7 were insignificant, which indicates that the permeability of the rock mass is low.

Most of this section will be dry or damp. Most open joints and fractured zones will drip or seep but some will yield initial inflows less than 1 m^3/hr. Flows up to 10 m^3/hr are possible but unlikely.

3.1.4.1.4 Excavation properties

Effect of engineering properties. The Shore Hardness of this dacite is less (i.e., softer) than the Walker Member dacite. UCS values range from about 100 MPa for the reworked tuffs, up to values similar to those from the dacite of the upper part of the Walker Volcanics (200 MPa) for the densely welded tuffs. Drill penetration, drill wear rate, and explosive quantities for dacites with UCS near 200 MPa will be similar to the dacite in the upper part of the Walker Volcanics; the softer dacite will be more easily and economically excavated.

Effect of geological properties of the rock mass. When blasted, the reworked (softer) dacite is expected to break across the rock fabric more readily than the harder dacite and the dacite in the upper part of the Walker Volcanics. Away from prominent defect zones, joints will be tight and spaced generally 0.3 to 1 m.

About 10-15 percent of the dacite in these tunnel sections is expected to need steel-set support. In most of this rock type overbreak will generally be less than 30 cm beyond C-line; up to 60 cm may occur in blocky zones. Overbreak in sheared or fractured rock will generally be less than 1 m, but may be greater than 1 m (rare).

Effect of groundwater inflows. No major groundwater inflows that could significantly slow excavation are expected.

Combined effects of all parameters:

(a) Drill penetration and wear rate, and explosive quantities for dacites with UCS near 200 MPa, will be similar to those for the Walker dacite; the softer dacite (reworked tuffs) will be more easily and economically excavated.

(b) About 10-15 percent of the dacite in these sections is expected to need steel-set support.

(c) No major groundwater inflows that could significantly slow excavation progress are expected.

(d) Rock condition will be mostly 2 to 3, with some 4.

(e) Average excavation rate is expected to be slightly faster than in the Walker dacite.

(f) Overbreak is expected to be minor along most of this section; a good tunnel profile.

3.1.4.1.5 Contact with granite porphyry, stn 37+30

The contact with the granite porphyry (stn 37+30 approx.) is possibly intrusive or possibly faulted. Drill core from GST24 revealed that the granite porphyry is closely jointed, and joints are strongly slickensided. GST11 revealed that the rock is closely jointed and that there are some crushed seams.

The contact is expected to be closely jointed and fractured. Joints will be strongly slickensided, and coated with chlorite and calcite. There may be some clay seams and zones of clay-coated joints. Parts of the rock mass will be moderately loose.

3.1.4.2 SHALES: STN 25+00 TO 26+20 (DRILL HOLES GST7, GST1)

3.1.4.2.1 Engineering properties of the rock substance

Sample location	UCS (MPa)			Point load strength (MPa)			UCS equiv.	Mean hardness (Shore units)
	No. of samples	Range	Average	Samples successfully tested	Is(50) Range	Is(50) Average		
GST7	3	>111 - >197	>144	9	1.6-3.7	2.3	55	68
				NOT TESTED				

All UCS samples of shale failed prematurely along an incipient fracture in the test sample.

3.1.4.2.2 Geological properties of the rock mass at tunnel level (Plate 7)

Weathering. The shales at tunnel level are expected to be fresh. However, thin interbeds - beds of tuffaceous sandstone or siltstone - may be decomposed to clay seams in some areas.

Seismic velocities. Bedrock velocities in the sequence of rocks containing the shales are 4200-4400 m/sec, but it is not possible to determine if these velocities are in the shale or in the interbedded dacites since the seismic refraction method cannot pick up a lower velocity below a higher velocity.

No seismic refraction profiling was done in the NSW Electricity Commission Substation (stn 18+20 to 24+20).

Defects. Joint spacing in most of the shale is expected to be tight. However, some tight folding has been seen in surface outcrops; tightly folded shales at tunnel level may be very closely jointed.

GST7 revealed that the bedding planes were very tight and were not a weakness in the rock. However, it is expected that in places the shale will tend to part on the bedding planes. In some places there may be clay seams on bedding planes and in joints. In some places, thin beds (0.1-0.3 m thick) of tuffaceous sandstone or siltstone may be decomposed to clay.

The general dip of the shale is $20^{o}W/160^{o}$, but this is likely to be variable owing to small-scale folding.

No major faults or defect zones have been detected, but some may be present where the Electricity Substation prevented investigation.

3.1.4.2.3 Groundwater inflows

The shale is expected to be mostly tight and impermeable. There may be some open joints or fractured zones - especially near contacts - that will yield some initial inflows but these are expected to be generally less than 3 m^3/hr, although larger inflows are possible.

3.1.4.2.4 Excavation properties

Effect of engineering properties. Drill penetration will be faster and drill wear rate less than in the dacites, and is expected to be about average for hard shale.

Effect of geological properties of the rock mass. The shale will generally fragment into pieces less than 10 cm diameter. Most of the shale will be tight and a good tunnel profile could be produced. In areas where the rock parts easily on bedding planes, 'slabby' conditions may result, producing overbreak generally less than 50 cm. Regular barring-down of flaking slabs will generally be sufficient in these areas but some zones may need rockbolts.

Some badly oriented defects may cause in excess of 1 m overbreak (rare).

Any fractured or sheared zones that dip unfavourably or that are wider than a few metres will need steel-set support. In folded zones with decomposed thin sandstone beds or clay seams on bedding planes, some steel-sets may be required, especially where the dip is against the direction of tunnel drive.

Effect of groundwater inflows. No major groundwater inflows that could significantly slow excavation progress are expected.

Combined effects of all parameters:

(a) Drill penetration will be fast and drill wear rate low.

(b) Explosive quantities will be low.

(c) Rock condition will be mainly 2 to 3, with some 4.

(d) About 15 percent steel-set support and about 5 percent rock-bolts are expected in the shale.

(e) Overbreak will be minor in most of the section.

(f) No groundwater inflows that could significantly slow excavation progress are expected.

3.1.4.2.5 Granite-shale contact between stn 26+00 and 28+00

The contact could cross the tunnel anywhere between stn 26+00 and stn 28+00. It is possible that the contact could follow the tunnel for up to 200 m, but this is considered very unlikely.

Drill hole GST1 revealed that the contact was fractured, open-jointed, and limonite-stained; clay seams are possible. Rock condition at the contact is expected to be 4 to 5. Steel-set support will probably be required if the contact occurs in the tunnel for more than about 3 m.

3.1.4.2.6 Granite contact, stn 15+20 approx.

The contact between the granite porphyry and the lower part of the Walker Volcanics has not been intersected by any drill hole and cannot be seen at the surface. Its exact position, orientation, width, and condition are therefore not known. Rock condition at this contact will probably be similar to conditions at the granite-shale contact.

3.1.5 GRANITE PORPHYRY
(Stn approx. 13+00 to 15+20: Drillholes GST8, GST6)
(Stn approx. 26+20 to 37+30: Drillholes GST1, GST23, GST9, GST22, GST24)

3.1.5.1 Engineering properties of the rock substance

Sample location		UCS (MPa)		Point load strength (MPa)				Mean hardness (Shore units)
	No. of samples	Range	Average	Samples successfully tested	Is(50)		UCS equivalent	
					Range	Average		
GST23	3	188-263	232	10	5.8-9.7	8.4	200	98
GST9	3	125-237	177	7	5.5-10.1	7.6	180	93
GST24	2	178-201	190	11	2.4-8.4	5.6	130	85

3.1.5.2 Geological properties of the rock mass at tunnel level

Weathering. These sections of the tunnel will be excavated through fresh granite porphyry.

Seismic velocities. Bedrock velocities range from 2000 to 5800 m/sec, but along most of the section range from 4000 to 5000 m/sec. Narrow sections with velocities less than 3000 m/sec, mainly between stns 30+50 and 32+00, coincide with three sets of intersecting photo-lineaments (Plates 4 and 7). These probably represent zones of sheared and fractured rock.

Defects. Most of the rock mass will be tight. Joints are generally spaced 0.3 m to 1 m and often wider. Along most of the section, joints will be tight and often cemented with calcite. There will be some sections where joints are open and not cemented. Photo-lineaments and seismic profile indicate that some fractured and/or sheared and crushed zones can be expected. Most of these will be less than 20 m wide.

3.1.5.3 Groundwater inflows

The water-table is generally 30 to 40 m above tunnel crown. Most of these sections of tunnel will be dry to damp. Most open joints and fractured zones will seep or drip, but some may produce initial inflows less than 3 m^3/hr; flows up to 10 m^3/hr are possible.

3.1.5.4 Excavation properties

Effect of engineering properties. UCS values are about the same as for the dacite from the upper part of the Walker Volcanics; Shore hardness values of the granite are slightly higher. Unlike the dacites, the granite porphyry does not have the fine-grained siliceous groundmass which is considered responsible for the high wear rate of the drill steels. Balancing these factors it is considered that drill penetration and wear rate will be about the same as for the dacite from the upper part of the Walker Volcanics.

Effect of geological properties of the rock mass. Slightly more explosives may be needed in the granite porphyry than in the dacite from the upper part of the Walker Volcanics because the granite is more widely and tightly jointed.

About 10 percent of the granite porphyry will need steel-set support, and probably most will be confined to individual sections 6 to 20 m long between stns 30+50 and 32+00.

Along most of this section a good tunnel profile could be produced with overbreak generally less than 30 cm beyond the C-line. Where joints are open, blocky conditions may result with generally less than 60 cm of overbreak. Overbreak in sheared or fractured rock will generally be less than 1 m but may be greater than 1 m (rare).

Effect of groundwater inflows. No major groundwater inflows that could significantly slow excavation are expected.

Combined effects of all parameters:

(a) Excavation rate is expected to be the same as for the dacite in the upper part of the Walker Volcanics.

(b) Drill penetration and wear rate is expected to be similar to the dacite in the upper part of the Walker Volcanics.

(c) Rock condition will be mainly 2 to 3, with some 4.

(d) About 10 percent of this section is expected to require steel-set support.

(e) Overbreak is expected to be minor over most of this section, resulting in a good tunnel profile.

(f) No groundwater inflows that could significantly slow excavation progress are expected.

3.1.5.5 Contact, fault 2, stn 13+00 approx.

Fault 2 crosses the tunnel line at about 90°. The exact width, orientation, and condition of the faulted contact is not known. Core recovered from drill holes GST 6 and GST 8 was generally closely jointed, fractured, and sheared. It appears as if fault 2 is comprised of several sheared and fractured zones, separated by zones of harder, less weathered and fractured rock, but nevertheless rock that would require support. Information available suggests that the faulted contact could extend for up to 100 m along tunnel line (stn 13+00 to 14+00) and probably all of this would require steel-set support. Moderate initial water inflows can also be expected (heavy limonite staining of fractures was observed in the core recovered from GST 6 and GST 8).

3.1.6 WILLOW BRIDGE TUFF: STN 1+70 TO 13+00 (DRILLHOLES GST5, GST 3, GST4, GST2)

3.1.6.1 Engineering properties of the rock substance

Sample location	UCS (MPa)			Point load Strength (MPa)				Mean hardness (Shore units)
	No. of samples	Range	Average	Samples successfully tested	Is(50)		UCS equiv.	
					Range	Average		
GST5	3	185-291	245	16	8.7-15.7	11.2	270	100
GST3	2	294-492	393	10	9.5-15.4	12.1	290	102
GST4	2	173-273	223	10	5.8-8.8	7.4	180	98
GST2	-	-	-	21	9.0-11.3	9.9	240	-
Locality J1	-	-	-	10	8.6-16.5	12.6	300	-
Locality K1	-	-	-	10	11.0-14.0	12.9	310	-
Locality K2	-	-	-	10	10.0-13.5	12.0	290	-
Locality K3	-	-	-	6	10.0-16.0	12.3	300	-

3.1.6.2 Geological properties of the rock mass at tunnel level

Weathering. Most of this section is expected to be tunnelled through fresh dacites. The seismic profile (Plate 6) suggests that the zone of weathering may extend down to near tunnel level from stn 8+00 to 9+00; however the correlation of seismic results with drill core indicates that the seismic interpretation may have placed the refractor too deep; if this is so, then the rock at tunnel level will be fresh.

Seismic velocities. Bedrock velocities of 4500-5600 m/sec were recorded for most of this section. Velocities down to 2600 m/sec were recorded between 10+10 and 11+30. The lower velocities probably indicate the presence of zones of fractured and/or sheared and crushed rock.

Defects. Drill holes GST3 and GST5 and the bedrock velocities of 4500-5600 m/sec indicate that the rock mass along most of this section of tunnel will be very tight; joints are expected to be spaced greater than 1 m and tightly closed or cemented with calcite.

Drill holes GST2 and GST4 revealed that in some sections the joint spacing is commonly 10-30 cm, and in some places the rock mass is fractured. Calcite and epidote veins are prolific; as they generally broke during investigation drilling, they would probably break when blasted.

No major faulted zones were detected during investigation drilling, but the seismic and photo lineaments (Plates 2 and 3) indicate that some narrow zones of very closely jointed and/or sheared and crushed rock will probably be intersected. They are expected to be generally less than 5 m wide, but a few may be up to 20 m wide. These zones will have various orientations but the most common ones will probably be near-vertical and strike parallel to the two major photo-lineament directions, i.e., 055° and 145°.

In places there may be joints or narrow sheared and fractured zones parallel to bedding (35°SW/135°).

3.1.6.3 Groundwater inflows

The water-table is about 20-30 m above tunnel level. Water-pressure test losses in drill hole GST3 were zero, and in GST4 and GST5 the results were unreliable. The permeability of most of the rock mass is low.

3.1.6.4 Excavation properties

Effect of engineering properties. This is the hardest and strongest rock type that will be encountered. UCS values range up to 492 MPa and average about 290 MPa. During investigation drilling wear rate of diamond-drill bits was extremely high (some lasting for only 45 cm), and drill penetration extremely slow (1½ hours to drill 70 cm with a new diamond bit). During excavation, drill penetration is expected to be extremely slow, drill wear rate very high, and explosive quantities per cubic metre of rock removed also very high.

Effect of geological properties of the rock mass. The rock hardness and strength and the wide spacing and tightness of joints will require the use of larger quantities of explosive to fragment the rock satisfactorily.

The photo lineaments (Plates 2 & 3) indicate that most of the sheared and fractured zones and the major joints will be vertical and will intersect the tunnel at about 45°. These defects should not require support except for a few that may be more than 3 m wide. About 10 percent of this section is expected to need steel-set support, and this will be mainly in fractured and sheared zones from 6 to 20 m wide.

Joints and fractured zones parallel to bedding, dip with tunnel drive and should not cause much overbreak or require support.

Along most of this section a good tunnel profile could be produced with overbreak generally less than 30 cm. Where joints are open, blocky conditions may result with generally less than 60 cm of overbreak. Overbreak is sheared, and fractured rock will generally be less than 1 m, but may be greater than 1 m (rare) where clay-coated defects are unfavourably oriented.

Effect of groundwater inflows. Most of this section will be dry to damp, with seepages and drips in places. Some open joints and fractured zones will yield initial inflows generally less than 3 m^3/hr. Flows in excess of 10 m^3/hr are possible but unlikely.

Combined effects of all parameters:

(a) Excavation rate is expected to be slow.

(b) Drill penetration will be slow and drill wear rate high.

(c) Explosive quantities will be high.

(d) Rock condition will be mainly 2 to 3, with some 4.

(e) About 10 percent of this section is expected to need steel-set support.

(f) Overbreak is expected to be minor over most of this section, resulting in good tunnel profile.

(g) No groundwater inflows that could significantly slow excavation progress are expected.

3.2 PORTALS

3.2.1 WINDOW BEND, NORTH PORTAL: STN 47+40. DRILL HOLE GST 17

3.2.1.1 Suggested portal position

Stn 47+40: this location would avoid the main fault zone of fault 4, which intersects tunnel line between stn 47+60 and stn 47+45.

3.2.1.2 Conditions at portal face

Fresh to fresh stained closely jointed (10-20 cm) and loose green rhyolite will occur from invert to about 3 m above portal crown, and grade into loose variably weathered rock and rubble towards the ground surface, which is 11 m above portal crown. The rock face above portal crown will need to be battered and stabilized with rockbolts and mesh.

In the tunnel, closely jointed and loose ground requiring discontinuous sections of steel-set support with timber lagging can be expected to stn 46+00.

3.2.1.3 Conditions of open cut

The open cut will be in water-saturated loose scree and slopewash overlying fractured and sheared rock; heavy clay will occur in the central section of the fault zone. A low batter slope will be required to restrict slumping especially on the eastern wall of the open cut.

3.2.1.4 Groundwater inflows

Near the portal and for the first 100 m of tunnel, water inflows initially up to 20 m^3/hour during excavation, but decreasing to less than 3 m^3/hour within a few weeks, can be expected.

3.2.2 WINDOW BEND, SOUTH PORTAL: STN 48+90. DRILLHOLE GST 18

3.2.2.1 Suggested portal position

Stn 48+90

3.2.2.2 Conditions in the open cut

Rock conditions in the open cut should be similar to those in the existing open cut at Pine Ridge west portal if similar excavation procedures are used. Mapping, seismic results, and diamond drilling indicate that there is about 3 m of highly weathered dacite overlying moderately to slightly weathered dacite.

The rock mass is closely jointed. Many joints are coated with 1-10 mm of clay. Some crushed seams and/or weathered seams up to 20 cm thick are expected. The most prominent joint direction is $20^{\circ}S/110^{\circ}$ - 130° (spaced 10-30 cms), which is a favourable orientation for stability in the portal face and the walls of the open cut, but there are probably other joint orientations (spaced generally > 30 cm) that may produce a few unstable blocks of rock; these may need to be bolted or barred down. With the exception of the few unstable blocks mentioned above, near-vertical slopes should be stable in moderately weathered rock below about 4 m if the cut is carefully pre-split.

3.2.2.3 Conditions at the portal

At stn 48+90, the tunnel crown is about 9 m below the surface. The portal will be in moderately to slightly weathered closely jointed dacite with defects as described above.

Rockbolts and mesh will probably be required to stabilize the face above the portal.

In the tunnel, blocky and seamy ground requiring discontinuous sections of steel support with timber lagging can be expected to about stn 49+90.

3.2.2.4 Groundwater inflows

Only minor seepages of groundwater are expected in the open cut and portal areas.

3.2.3 SOUTH PORTAL (LMWQCC): STN 57+55. DRILL HOLE MV7

3.2.3.1 Suggested portal position

Stn 57+55. On geological grounds there is no reason to shift the location of the portal face inwards (northwards) from the existing northeast side of the access road-cut to Pine Ridge tunnel.

3.2.3.2 Conditions in the open cut

If the portal is at stn 57+55 then the only open-cut excavation necessary will be deepening of the existing Pine Ridge access road down to invert level, and removal of rock between the portal and the connection to the LMWQCC.

In the area of the portal the existing cut shows about 2.5 m of extremely to highly weathered dacite overlying moderately to slightly weathered dacite.

There are four prominent sets of continuous joints commonly coated with 1-20 mm of clay:

1.	60°-70°SW/110°-130°	spaced up to 4 m
2.	80°-90°S/065°-085°	" "
3.	60°W/015°-045°	" "
4.	20°N/070 (bedding)	" 0.3-0.6 m.

Stability of the portal face and northeast wall of the open cut will be affected by Set 1 which dips out of the rock face. A batter slope of about 60° and some rockbolts will probably be required to stabilize the face.

If the open cut is extended north of stn 57+55 along tunnel line, then joint sets 2, 3, and 4 may cause failure of blocks of rock on the resulting southeast wall of the cut unless the slope is battered or stabilized with rockbolts.

3.2.3.3 Conditions at the portal

At stn 57+55 the tunnel crown is about 11 m below the natural surface. The portal will be in slightly weathered to fresh dacite with defects as described above. Rockbolting of the portal face in a direction normal to joint set 1 should provide a stable portal. Steel mesh may be required above the portal to stabilize any loose rubble.

In the tunnel the four joint sets will intersect to form blocks that may fall out of the crown and walls. Steel sets will be required near the portal. Northwards beyond the steel sets, rockbolts will probably be needed to secure some blocks from falling out.

3.2.3.4 Groundwater inflows

Only minor seepages or very small inflows are expected from the portal face and the first 50 m of tunnel.

SHAFT C GEOLOGY (STN 2+90, DRILL HOLE G.S.T. 5)

FIGURE 4

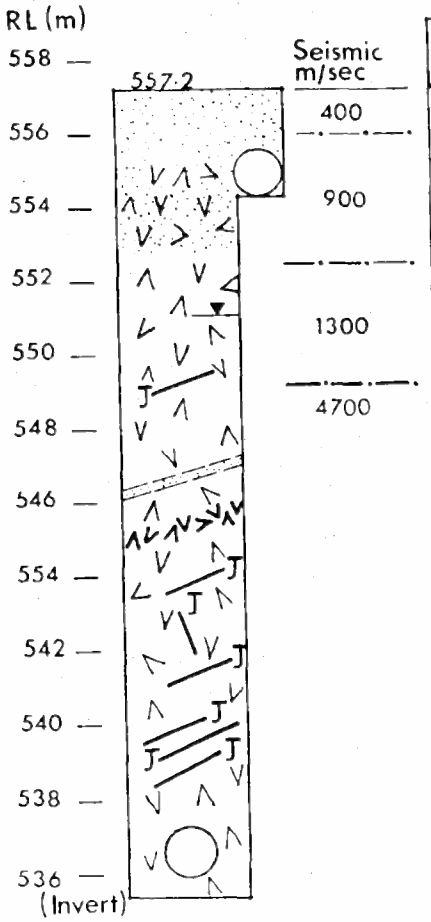
Sandy clay fill
EW Dacite
Light grey dacite } WILLOW GREEN TUFF
Dark grey dacite }

Scale $\frac{V}{H} = 1$ 2 1 0 2 4

300 Seismic Velocity m/sec
—•— Seismic refractor

▼ Water level in drill hole
—J Major joint orientation

Note detailed geology shown on log of drill hole GST 5



GEOLOGY	EXCAVATION CONDITIONS	PREDICTED SUPPORT	GROUNDWATER INFLOWS
Sandy clay fill	Excavation by large back-hoe. Any boulders may need to be blasted.	Slopes will need to be battered to about 1:1 Vertical slopes will need steel ring support with continuous timber lagging.	None expected Some seepages after heavy rain.
EW Dacite (soil properties) Possibly some SW-FS boulders.			
MW-FS Dacite. Some HW seams. Joints mostly dip 30° and 60°, spaced 30-50 cm. Most are limonite stained or slightly weathered. Some are slightly open.	The rock is hard and strong	Probably some support. Random rockbolts and/or rockbolts and mesh may be sufficient.	Probably some seepages and/or minor inflows initially; decreasing after excavation.
Mainly FS Dacite; possibly some EW-HW seams near top. Rock substance very hard and very strong. Joints oriented as above mostly spaced 30 cm - 2 m. Joint surfaces mostly rough and tight. Some weakly cemented with calcite. Some are open and limonite stained.	No major defects that could cause instability are known. Drill penetration slow. Drill wear rate high. Explosive quantities high.	Probably none necessary, but some random rock bolts possible.	Similar to above but inflows up to 10 m^3/hr are possible but unlikely. Some minor inflows near invert may persist throughout construction.

SHAFT 1 GEOLOGY - STN 498·711

Scale V/H = 1 : 2 0 2 4m

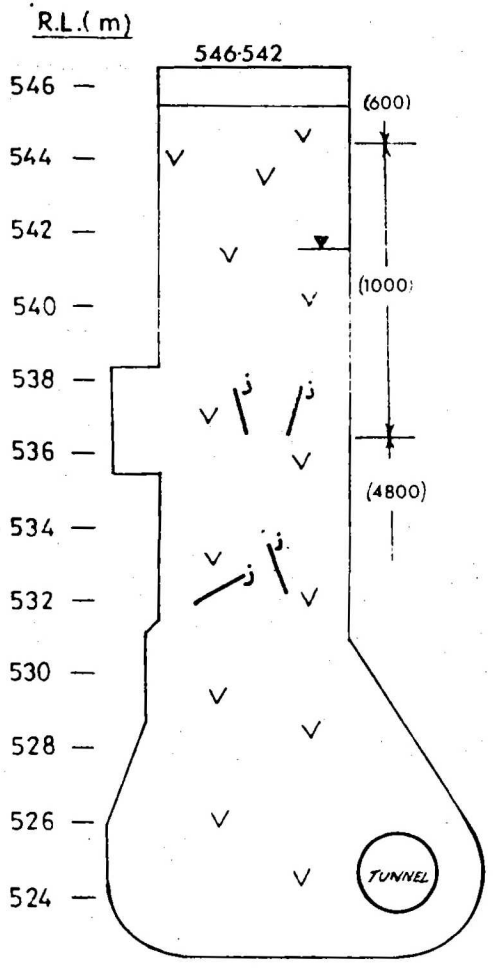
(300) Seismic velocity (m/s)

— Velocity boundary

▼ Water table

j— Major joint orientation

NOTE: Detailed geology shown on log of drill hole GST 3



INVERT 523·716

GEOLOGY	SHAFT CONDITIONS	PREDICTED SUPPORT
SOIL DACITE Extremely weathered. Water table at 5m below present ground surface.	Rock mass very soft and weak. Easily excavated by backhoe. Minor water inflows possible especially following rain.	Steel rings at 1m. centres with complete timber lagging below top structure.
DACITE - Mainly Fresh stained. Fresh from R.L. 525·5. Light grey with some quartz epidote veins.	Rock mass is very hard and strong. Widely jointed and tight. Weathered seams 7-10cm wide at R.L. 530 and at R.L. 526·5. Minor water seepage only. Shaft - tunnel junction in competent rock.	NO SUPPORT REQUIRED Shaft - tunnel junction should not need support.

FIGURE 5

FIGURE 6

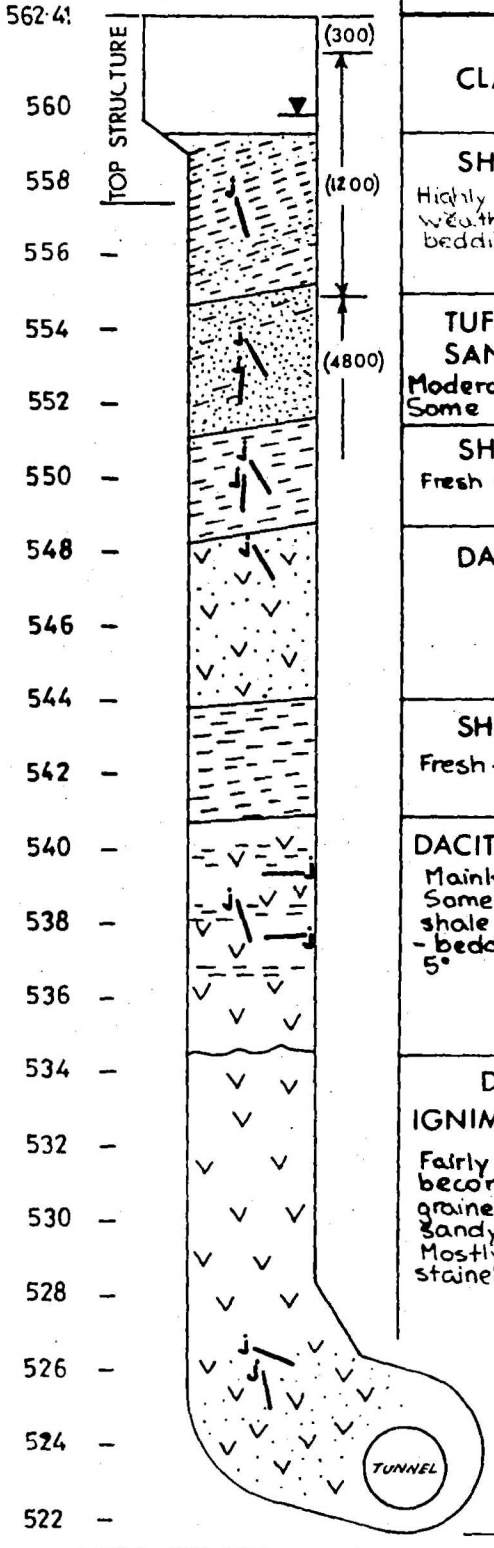
SHAFT 2 GEOLOGY - STN 1712·267

Scale V/H=1 2 0 2 4m

(300) Seismic velocity (m/s)
—— Velocity boundary

▼ Water table
Major joint orientation

NOTE: Detailed geology shown on log of drill hole GST 7



GEOLOGY	SHAFT CONDITIONS	PREDICTED SUPPORT
CLAYEY SOIL		Steel rings spaced 1m. with timber lagging required below top structure.
SHALE Highly to moderately weathered - bedding at 10°	Rock mass weak but fairly tight - main defect is bedding planes spaced 0·5 cm to 2 cm. Bedding and steeply dipping joints may cause some overbreak on blasting. Some clay seams occur.	
TUFFACEOUS SANDSTONE Moderately weathered Some minor shale.	Rock mass stronger than above and improves with increasing depth. Bedding planes in sandstone stronger than shale. Joints at 60°-90° could cause some overbreak. Occasional clay seams (< 5cm wide) spaced 20cm to 1m.	
SHALE Fresh - bedding at 5°		Steel ring support may be required.
DACITE	Rock mass is very strong. Widely jointed - bedding planes in shale are tight and strong. Above R.L. 550 minor groundwater seepage is expected; any inflows will be negligible. Shaft dry - damp below R.L. 550.	NO SUPPORT REQUIRED
SHALE Fresh - bedding at 5°.		
DACITE TUFF Mainly fresh. Some thin beds of shale and sandstone - bedded at about 5°	Rock mass generally tight and strong. Joints in tuff dip mostly 60°-80°, spaced 20cm to 1m and often tightly cemented by calcite. Beds of shale generally fractured along bedding planes.	
DACITE IGNIMBRITE TUFF Fairly massive - becomes finer-grained and more sandy near R.L. 526. Mostly fresh but stained near R.L. 526	Rock mass very strong and tight. No natural fractures between R.L. 534 and R.L. 527.	
	Rock fractured - some clay seams. Joints at 20° and 70°-80°; may cause minor overbreak.	
	Very few natural fractures below R.L. 527·5.	Shaft - tunnel junction will be located in competent rock.

INVERT 521·693

SHAFT 3 GEOLOGY - STN 3314·694

FIGURE 7

Scale V/H = 1 2 0 2 4m

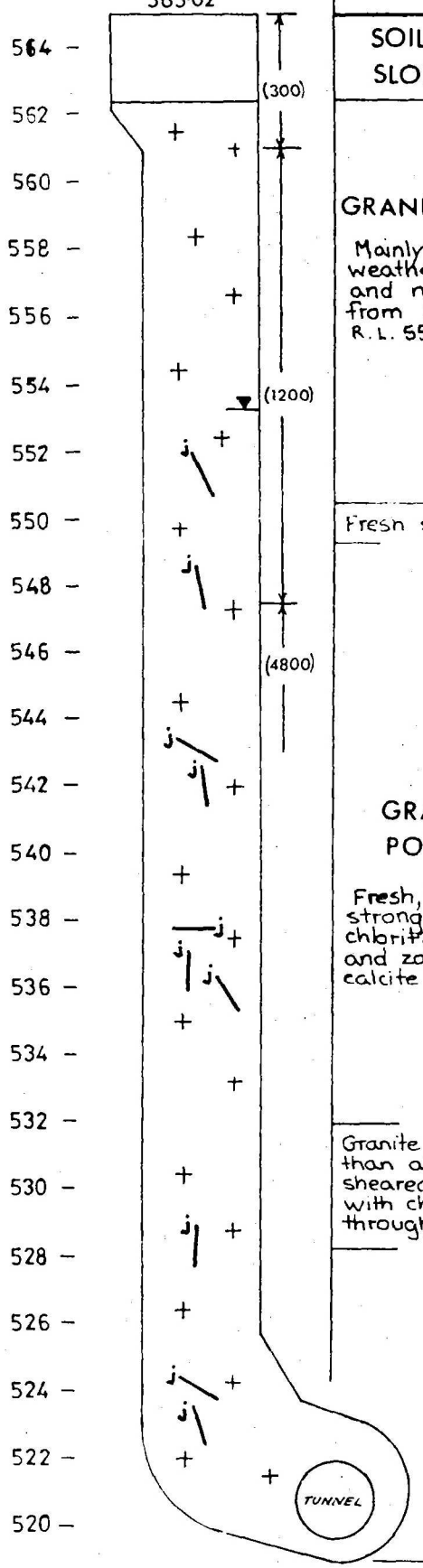
(300) Seismic velocity (m/s)

—— Velocity boundary

▼ Water table

j —— Major joint orientation

NOTE: Detailed geology shown on log of drillhole GST 9



GEOLOGY	SHAFT CONDITIONS	PREDICTED SUPPORT
SOIL AND SLOPEWASH	Rock mass soft and weak. If wet, stand-up time measured in hours. Could be excavated by large back-hoe to base of top structure and then jack-picking to about R.L. 551. Any moderate to steeply dipping defects (joints, seams etc.) may cause considerable overbreak in places.	STEEL RING & TIMBER LAGGING FROM BASE OF TOP-STRUCTURE TO ABOUT RL 550
GRANITE PORPHYRY Mainly extremely weathered. Highy and moderately from R.L. 553 to R.L. 550·5.		
Fresh stained		
GRANITE PORPHYRY Fresh, hard, and strong. Some slightly chloritized zones, and zones where calcite veins common.	Rock strong and generally very competent. Joints generally very tight - and most cemented by calcite. Most joints are at 0°-30°; some at 60° and 80°-90°. Joint surfaces generally rough. This section of shaft should be mainly dry except for minor seepage in places.	NO SUPPORT REQUIRED
Granite slightly softer than above. Partly sheared, and healed with chlorite veins throughout		
	Tunnel-shaft junction will be excavated in competent rock.	

INVERT 519·020

3.3 SHAFTS

3.3.1 SHAFT C: STN 2+90 (DRILL HOLE GST5, FIGURE 4)

3.3.1.1 Geology

4.5 m of sandy clay fill and extremely weathered rock (to RL 553) overlies moderately weathered to fresh-stained dacite with some highly weathered seams to RL 549. Below RL 549 the rock is mainly fresh-stained light to dark grey welded dacite (Willow Bridge Tuff).

3.3.1.2 Excavation conditions

Excavation by mechanical shovel without preblasting should be possible to RL 553; if any fresh boulders are encountered they may need to be blasted.

Below RL 553 the rock is hard and strong. UCS values obtained from GST5 core averaged 245 MPa (range 185 to 291 MPa). UCS values up to 492 MPa have been recorded in the same rock type from nearby drill holes. Average hardness is 100 Shore units. During investigation diamond drilling, drill penetration in the fresh dacite was very slow and drill bit wear rate very high. The same is expected with construction drilling. Explosive quantities will need to be high to fragment the rock satisfactorily.

Minor inflows can be expected below about RL 552, but will rapidly decrease to drips or seepage (which may increase after heavy rain). Below about RL 549, inflows up to 10 m^3/hr are possible but will decrease fairly rapidly. Some minor inflows near invert may persist but will not be large enough to significantly slow construction.

3.3.1.3 Shaft support

Above RL 553 vertical slopes will need steel-ring support. Between RL 553 and RL 546, some steel-ring support may be required but rockbolts and mesh may be adequate to hold blocks formed by unfavourably oriented joints (possibly dipping at 30° and 60°). Below RL 549, support should not be required although any unstable blocks will require pinning with rock bolts.

3.3.2 SHAFT 1: STN 4+98.7 (DRILL HOLE GST3, FIGURE 5)

3.3.2.1 Geology

This shaft will be excavated in light grey dacite, which is extremely weathered to RL 537. Below RL 537 the dacite is mainly fresh. For engineering properties of the rock substance see section 3.1.6.1.

3.3.2.2 Excavation conditions

The rock mass is very hard and strong below RL 537, with UCS up to 490 MPa; no prominent defects that would cause excessive overbreak or shaft instability are known to occur.

Above RL 537 the extremely weathered dacite is soft and weak, and water inflows or seepages could result in slumping of the shaft walls unless quickly supported. The rock in this section of shaft would be soft enough to be excavated by a large backhoe.

Some groundwater inflow or seepage can be expected from the sharp contact between weathered and fresh dacite at RL 537. This section may need to be panned before the concrete lining is laid. Groundwater seepage may occur elsewhere from open joints or weathered seams.

3.3.2.3 Shaft support

Steel rings and complete timber lagging will be required from base of top structure to RL 537. Below RL 537, support will not be required unless any steeply dipping seams occur; rockbolts would provide adequate support.

3.3.3 SHAFT 2: STN 17+12.3 (DRILL HOLE GST7, FIGURE 6)

3.3.3.1 Geology

The shaft will be excavated through dacite (60%), shale (30%) and sandstone (10%). About 3 m of clayey soil overlies weathered shale bedrock.

3.3.3.2 Excavation conditions

Shale and sandstone. Bedding planes - the main defects - are nearly horizontal, and little overbreak or instability is expected to result from them. However, where the bedding planes are cut by prominent joints dipping into the shaft, some instability will result; rockbolts may be required to pin back loose blocks.

Dacite. Joints in the dacite are generally tight, and little overbreak or instability is expected.

Minor initial groundwater inflows may occur above about RL 550, but the shaft is expected to be generally dry. Panning groundwater inflows or seepages before concrete is laid may be necessary in places, although this is unlikely.

3.3.3.3 Shaft support

Steel-ring support (spaced 1 m to 1.5 m) with timber lagging is expected from base of top structure to about RL 552 m (10 m below ground surface) and possibly to 548 m. Poorly oriented joints producing unstable blocks of rock may need to be pinned with rockbolts.

3.3.4 SHAFT 3: STN 33+15 (DRILL HOLE GST 9, FIGURE 7)

3.3.4.1 Geology

The shaft will be excavated through granite porphyry; 2.5 m of soil and slopewash overlies weathered bedrock. The granite is fresh below RL 550 (14 m below ground surface).

3.3.4.2 Excavation conditions

The rock mass is soft and weak to RL 550. The shaft walls may become unstable in areas of groundwater seepage and along unfavourably oriented joints or clay seams. The rock is expected to become progressively harder and stronger below about RL 553.

Below about RL 550 the granite is essentially fresh and the contact with the weathered rock above is sharp. Shaft stability in the fresh granite will depend on the orientation and frequency of clay-coated joints and seams; no major defects are known to occur and no major wall instability is therefore expected. Overbreak is expected to be negligible in fresh rock.

The shaft will be damp below about RL 553. Any water inflow will be small and will be mainly confined to the weathering contact at RL 550. Panning water inflows or seepages before concrete is laid may only be necessary near RL 550. Water inflows through contraction cracks in the concrete lining should be confined to the crack closest to RL 550.

3.3.4.3 Shaft support

Steel-ring support will be required from base of top structure to about RL 551 (11 m). Support is not expected to be required below RL 551; however, if any unfavourably oriented defect occurs, rockbolts may be required to pin back the defect.

3.4 CONNECTION, SHAFT 1 TO EXISTING BELCONNEN TRUNK SEWER

3.4.1 OPEN-CUT EXCAVATION: STN 0+79 TO 2+90 (SHAFT C)

400-1100 m/sec material (probably extremely to highly weathered dacite) extends from the surface to below the bottom of the excavation along most this section; this can probably be excavated by a large backhoe without preblasting. However, the seismic profile indicates that 1500 m/sec material (probably moderately weathered dacite) extends above invert between stn 1+90 and 2+40, and some blasting or jack-picking will be necessary. Boulders of fresh dacite (generally less than 1 m but up to 3 m in diameter) surrounded by extremely weathered dacite occur in the area; if encountered in the trench they may have to be blasted or jack-picked.

Groundwater inflows. No water inflows are expected.

3.4.2 TUNNEL: STN 2+90 (SHAFT C) TO AT LEAST STN 3+30

At stn 3+30 the tunnel crown is 16 m below ground surface. From stn 2+90 to at least stn 3+30 the rock at tunnel level is expected to be slightly weathered to fresh stained welded dacite. It is extremely strong (UCS av. 290 MPa)* and very hard to drill (abrasive and resistant to penetration).

The rock mass is expected to be strong and fairly tight. Joints mostly dipping about 30^{o} and generally spaced 0.3 m to 1 m are rough and tight, and sometimes with up to 5 mm of flaky pink calcite cement (weak). The refractor between the 800 m/sec and 4700 m/sec layers (probably extremely to highly weathered and slightly weathered to fresh dacite respectively) is shown (Plate 6) to cross the tunnel at stn 3+30. However seismic-drill hole correlations (see Plates 6-8) show that the seismic interpretation may have placed the refractor too deep; if this is so the tunnel could be continued in hard rock (4700 m/sec) beyond stn 3+30.

Support. Steel-set support will probably be needed from the selected portal to stn 3+20.

Groundwater inflows. Water-pressure tests in drill hole GST 5 showed large water losses, but results are thought to be unreliable. There are probably some open joints and weathered seams, but any water inflows are expected to be less than 5 m^3/hr and of short duration.

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* An approximate value obtained from 9 UCS tests and Point Load tests on rock from drill holes GST 3, 4, and 5, and from Point Load tests on cubes from surface outcrops. Maximum value was UCS 492 MPa from GST 3. See Appendix 4 for results.

3.4.3 OPEN CUT OR TUNNEL: STN 3+30 TO 4+38

The contractor has the option whether to open-cut or tunnel this section.

The seismic profile shows that 800 to 1200 m/sec material (probably extremely to moderately weathered dacite) extends from the surface to below invert level in this section. However, as noted previously, the bedrock refractor may be shallower than this interpretation shows.

Excavation Alternative. The excavation will be at least 9 m and up to 18 m deep depending on the position of the tunnel portal. Most of the excavation will be in extremely to highly weathered dacite which can be excavated by bulldozer and ripper without blasting. If the bedrock refractor is shallower than shown in Plate 6, then some blasting will be needed in the bottom of the trench along at least part of this section. There may be some large boulders of fresh dacite sitting in extremely weathered dacite; these may need to be blasted. The excavation will need to be battered or shored to prevent collapse.

Tunnelling Alternative. The portal crown will be at least 7 m (at stn 4+38) and up to 16 m (at stn 3+30) below the surface. This section of the tunnel will be mainly in extremely to moderately weathered rock. There may be some slightly weathered to fresh rock encountered if the bedrock refractor is shallower than shown in Plate 6. Steel-set support with timber lagging will be required throughout. Any areas of saturated extremely weathered rock will need continuous timber lagging.

Groundwater inflows. Some water is expected to drain into the tunnel or open cut through open joints and/or weathered seams and especially from the interface between extremely weathered and fresh rock. If any open joints are connected to Ginninderra Creek, these inflows could become large especially if 'piping' has developed in the extremely weathered dacite.

3.4.4 OPEN CUT EXCAVATION: STN 4+38 TO 4+99

Plate 6 shows that material of up to 1200 m/sec velocity (probably extremely to moderately weathered dacite) extends from the surface to invert level. However, drill hole GST 3 entered fresh rock 1 m above invert level, which suggests that the refractor is shallower than marked on the profile.

Most of the rock can probably be excavated by bulldozer with ripper, but some blasting will be necessary near invert.

Battered or supported slopes will be necessary.

Groundwater inflows. As for stn 3+30 to 4+38.

4. CONCLUSIONS AND RECOMMENDATIONS

4.1 CONCLUSIONS

1. Geologically, construction of the tunnel is feasible.

2. The tunnel will be driven through dacite, rhyodacite, and rhyolite units (67%), granite porphyry (25%) and tuffaceous sediments (8%). (Percentages are approximate.)

3. Most of the rock excavated will be fresh. Weathered rock will occur at portals, top sections of shafts, most of the section connecting this tunnel to the existing Belconnel Trunk sewer (stn 0+79 to stn 5+00) and in wide defect (faults, etc.) zones.

4. Unconfined compressive strengths for the acid volcanic units mostly range from 200 to 300 MPa (but up to 400 MPa); granite about 200 MPa; and shales 145 MPa. Shore hardness values were between 70 and 100 (average about 90) for the acid volcanics and the granite; value for the shale was about 68.

5. The contact between different rock types is generally a defect zone. Deterioration in rock condition, increased water inflows, overbreak and support requirements can generally be expected.

6. Five major faults have been detected and many small fractured or sheared zones are indicated by airphoto-lineaments and zones of low seismic velocity. Four of the major faults occur between stns. 40+00 and 48+00, and generally poor tunnelling conditions are expected in this section.

7. All rock units along the route are jointed. Joint spacing will generally be in the range 0.3 to 1 m.

8. Overbreak will generally be less than 50 cm beyond C-line, although overbreak in excess of 1 m can be expected in and near some wide defect zones or in blocky and seamy ground.

9. Tunnelling condition will generally be very good in the dacites of the Walker Volcanics, granite porphyry, tuffaceous sediments, and the Willow Bridge Tuff. Just north of the Window Bend area (stn 40+00 to 44+00), the green rhyolite, purple rhyodacite, and that section of dacite of the Walker Volcanics, will generally yield poor tunnelling conditions, mainly because several major fault zones are present.

10. From the outlet portal (stn 57+88) to shaft 1 (stn 5+00), about 16 percent of the tunnel (850 m) will need to be supported with steel sets and timber lagging during construction (see also 'Recommendations').

11. No large underground cavities containing large quantities of groundwater are expected in the area. Water inflows ranging from seepage to inflows not exceeding 20 m^3/hr can be expected. Very few inflows in excess of 5 m^3/hr are expected and most will be less than 1 m^3/hr; most will be reduced to dripping a few weeks after excavation. Some water will continue to enter the tunnel from open defects mostly near invert level. In areas of shallow cover some defects will seep or drip again after heavy rain.

12. An earthquake producing measurable displacement at the ground surface is unlikely. Seismic risk to the tunnel, its lining, shafts, or other appurtenant works is low.

13. Owing to the variability of the rock units encountered, the extreme strength and hardness of the rock material, and the presence of at least five major fault zones, the use of a tunnel boring machine is not considered practical.

14. At Window Bend, the north portal open cut will be located in fault zone material, soil, and slopewash; the portal face will be in loose green rhyolite. The south portal at Window Bend and the south portal (LMWQCC) will be located in generally sound rock with no known major defects.

15. No known major defects occur at any of the shaft sites. Shafts 1 and C will be located in dacite, shaft 2 in interbedded sediments and dacite, and shaft 3 in granite porphyry.

16. The open-cut excavation, stns 0+79 to 2+90 (shaft C), will mostly be in extremely to highly weathered dacite.

17. The tunnel section between stns 2+90 and 3+30 will probably not need steel-set support.

18. The section from stn 3+30 to 5+00 will be located mainly in extremely weathered to moderately weathered dacite, although fresh rock may occur between invert and springline in some places.

4.2 RECOMMENDATIONS

1. A permanent drain should be installed at Window Bend north portal near tunnel invert. (The purpose of this drain is to release groundwater from the highly permeable open jointed green rhyolite that occurs behind fault 4, which acts as an impermeable groundwater barrier. Drill hole GST 17 penetrated the green rhyolite behind the fault zone and is flowing at a constant rate of 1200 to 1400 l/hr.)

2. Total groundwater outflows from the tunnel (and shafts) should be measured accurately, using appropriate automatic recorders, and an accurate record should be kept of all groundwater inflows into the tunnel, including initial inflow quantity, location of flow and duration. (Such records will help in locating areas requiring panning before concrete is laid.)

3. Greater use of rockbolts (instead of steel sets) should be made, particularly in blocky ground or slabby ground associated with shallow dipping sediments.

4. The lining of invert and walls up to only maximum design flow should be considered for sections of tunnel where the standard (specified full 360°) concrete lining could be dispensed with. The sections for consideration are:

   (a) Essentially self-supporting and free of steel-set support, but including areas of rockbolt, gunite, or shotcrete support. (Narrow sections, such as fault zones, within essentially self-supporting sections may require steel support and full lining, but these cannot be predicted accurately.)

   (b) Essentially dry sections of tunnel that never produced water inflows even when first excavated. (Narrow sections, such as narrow faults, etc., as described above, may need to be grouted to reduce water inflows to an acceptable level.)

Tunnel Sections	Length (m)
Stn 5+00 to 8+00	300
Stn 9+00 to 10+00	100
Stn 10+30 to 13+00	270
Stn 14+00 to 25+60	1160
Stn 26+50 to 42+30	1580
Stn 50+00 to 57+00	700
TOTAL	4110 (80% of tunnel between 5+00 and 57+88)

5. ACKNOWLEDGEMENTS

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The BMR Engineering Geophysics group carried out the seismic refraction survey of the tunnel route. Mechanical properties of rock samples from surface outcrops and drill core were determined by N. Wise (Engineering Geology) and M. Idnurm (Rock Testing Group, Geophysical Branch). The petrographic descriptions were done by C. Gardner (Geological Branch).

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APPENDIX 1

INVESTIGATION METHODS

Correlation with Pine Ridge tunnel

The information obtained during construction of the nearby Pine Ridge tunnel has been used as an aid in assessing conditions in the GST. Pine Ridge tunnel and its portals were photographed and geologically mapped at a scale of 1:240; geochemical, petrographic, and water samples were collected and tested, and the results studied; groundwater inflows were measured; observation bores monitored; overbreak calculated from concrete quantities; explosive quantities, drilling pattern, advance rate, support, and overbreak were correlated; and all the results were correlated with the predictions made from mapping, seismic refraction profiling, and diamond drilling during the design investigation for that tunnel.

Airphoto-interpretation

Airphoto-interpretation of photos taken from 760 m (1968 black and white), 427 m (1968 colour), and 214 m (1973 colour) was done by P. Lang throughout the investigations.

Geological mapping

Geological mapping at a scale of 1:2400 and 1:9600 was carried out by P. Lang and field hand D. Broome between April 1974 and September 1975. The maps were reduced to 1:2500 and 1:10 000 respectively, and metric coordinates added (see Plates 1 to 5).

Geophysical methods

A continuous seismic refraction profile was obtained by the BMR Engineering Geophysics Group (Taylor, 1975) along most of the route from stn 00+50 (on the preliminary tunnel line) to stn 55+20. The traverse consisted of 53 spreads, and fieldwork was done in November and December 1974.

The following sections were omitted:

(a) from stn 18+20 to stn 24+20 (Belconnen Electricity substation)

(b) from stn 41+60 to stn 42+30

(c) from stn 47+70 to stn 47+95

(d) stn 55+20 to stn 57+88 because of its proximity to the Pine Ridge tunnel operations.

During March 1975, eight additional traverses were done to investigate the altered route at the north end (stn 4+99 to stn 17+12), the connection from shaft 1 to the existing Belconnen trunk sewer (stn 0+79 to stn 4+99), and to further investigate the faulted zone from stn 40+00 to stn 45+00.

Each spread was 88 m long, with 23 geophones spaced 4 m and with a reciprocal geophone 60 m from each end of the spread. Five shots were fired for each spread at -

geophone 1	-60 m
geophone 1	- 2 m
geophone 12	+ 2m
geophone 23	+ 2 m
geophone 23	+60 m

Time-distance curves were made available at BMR for inspection by Tenderers.

Drilling

From April to October 1975, 15 diamond-drill holes totalling 665 m were drilled by DHC using three drill rigs. NMLC triple-tube core barrels with split inner tube were used. Water-pressure testing was done on each hole. Geological logs of drill core showing water-pressure testing results are in Appendix 8. Water-pressure test computation sheets are available at BMR for inspection by Tenderers.

From December 1974 to October 1975, nine 125 mm diameter observation bores were drilled by BMR. The holes were partly cored but were not water-pressure tested. Geological logs of drill core are in Appendix 8.

Locations of drill holes are plotted in Plates 1 to 5, and summary logs are plotted on the profiles (Plates 6 to 8).

Drill core is stored at the Department of Construction Core Shed at Kingston, A.C.T. Photographs of the drillcore comprise Appendix 7.

Rock testing

Several mechanical rock parameters were determined by BMR. Point load induced tensile strength tests were carried out on rock samples collected from surface outcrops at seven localities (see Plates 2 and 3 for sample locations), and from 35 localities in Pine Ridge tunnel within 1800 m of the west portal.

The parameters measured on drill core were uniaxial compressive strength, specific gravity, modulus of elasticity, Poisson's ratio, Shore hardness, compressional velocity, and point load induced tensile strength. Detailed results are in Appendix 4.

Petrology

Petrographic descriptions and chemical analyses were done on rocks from drill core and surface outcrops (see Appendix 5).

Water analyses

Water samples from drill holes and from Pine Ridge tunnel were analysed for components aggressive to concrete lining (see Appendix 6).

APPENDIX 2

GLOSSARY OF TERMS

ROCK CONDITION NUMBERS

1. Descriptions of the Rock Condition Numbers (RCN) have been modified here by one of us (D.C.P.) after Terzaghi (1946) and Deere, Merritt, & Coon (1969) to suite geological conditions actually encountered in tunnelling operations carried out in the A.C.T. since 1971. To date these tunnels have passed mainly through acid volcanics and sedimentary rocks derived from them.

2. The predicted support requirements for each RCN should only be used as a guide, as very narrow but poorly oriented defects in an otherwise long section of competent rock (e.g., RCN 2) may require 2 or 3 steel sets or a few rockbolts for stabilization. The predictions of support assume an excavated tunnel diameter of up to 4 m.

3. It should also be noted that RCN 7 and 8 have not been recorded to date in the A.C.T.

ROCK CONDITION NUMBER	DESCRIPTION OF THE ROCK MASS
1.	HARD INTACT ROCK: Rock massive, very hard and very strong, with no significant joints or other defects. Breaks across sound rock when blasted. No support necessary.
2.	HARD WIDELY JOINTED ROCK: As above, but may be foliated or bedded with a fairly high resistance to separation of surfaces. Prominent continuous joints spaced 1-3 m are tight; joints usually not continuous for more than a few metres. No support required.
3.	MASSIVE, MODERATELY JOINTED: Rock mostly hard and strong. Continuous joints generally spaced 0.5 m - 1 m are usually fairly tight, but some water seepage along joints may occur. Rock may be partly blocky in places, and generally breaks along joint surfaces when blasted. Steel or rockbolt supports generally not required in 3 m diameter tunnel; in a 4 m tunnel, some rockbolts may be required where blocky or poorly oriented defects cross the tunnel.

4. MASSIVE, MODERATELY JOINTED, SEAMY: As above but defect surfaces generally clay-coated and loose. Clay seams and sheared or fractured rock with clay common. Rock may be moderately weathered or altered and soft in parts. Steel-set support (1-1.3 m spacing) sometimes required in tunnels up to 3 m diameter; more often in 4 m tunnel. Rockbolts may be preferable in places.

5. CLOSELY JOINTED AND SEAMY: Closely jointed, seamy, and fractured rock; joints and fractures are loose and open (where not clay-filled), and may result in large water inflows into the excavation; includes highly and extremely weathered (or altered) rock. May exert considerable weight on steel-set supports; steel supports spaced at 1 m (or less) with heavy timber lagging. Rockbolts not usually effective.

6. SEAMY AND CRUSHED ROCK: Includes unconsolidated sand, slopewash, etc. Refers to fault zone material (gouge) or shattered rock where clay and gravel sized fragments makes up the greater percentage of the material mass. If water content is high, these materials may run or flow and exert significant side pressures. Stand-up time near zero. Rockbolting not effective. Steel sets <0.5 m centres, invert struts, and possibly linear plates. Shotcrete or gunite often effective in containing running ground.

7. SQUEEZING GROUND: Slow movement of rock into the tunnel without perceptible volume increase (rock with clay minerals with low swelling characteristics).

8. SWELLING GROUND: Material expands in volume upon exposure to water (e.g. montmorillonite clay, serpentinite, anhydrite, etc.).

DEGREES OF ROCK WEATHERING

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 (54 mm) drill core generally cannot be broken by hand across the rock fabric.

HIGHLY WEATHERED : Rock is discoloured and weakened; N-size (54 mm) drill can generally be broken by hand across the rock fabric.

EXTREMELY WEATHERED : Rock is decomposed to soil, but the original rock fabric is mostly preserved.

ROCK SUBSTANCE

This is defined as intact, effectively (for engineering purposes) homogenous rock. Repeated mechanical tests on the material would give acceptable coefficients of variations (e.g., uniform results).

ROCK MASS

Rock mass is a body of material which is not effectively homogenous, that is, the rock substance is crossed by natural defects such as joints, faults, seams etc.

SHEARED ROCK

Consists of rock intersected by close (<1 cm), slightly curving intersecting fracture planes; the fracture surface may be smooth, polished, slickensided, or coated with clay.

CRUSHED ROCK

Consists of rock which is mechanically disintegrated but not obviously chemically decomposed.

FRACTURED ROCK

Consists of rock which is intensively jointed in several directions. Fracture surfaces are often clay-coated.

FAULTED ROCK

Faults can be sheared, crushed, or fractured rock, and where relative displacement of rock can be seen. Unless evidence for faulting is quite definite the term should not be used.

JOINT SPACING

Very close - joints spaced <5 cm

Close - joints spaced 5 cm to 30 cm

Moderately close - joints spaced 30 cm to 1 m

Wide - joints spaced 1 m to 3 m

Very wide - joints spaced >3 m

JOINT APERTURE

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

BEDDING

Laminated	-	< 10 mm thick
Thinly bedded	-	10 mm to 100 mm thick
Thickly bedded	-	> 100 mm thick

GRAINSIZE

Coarse-grained	-	1 mm to 4 mm in diameter
Medium-grained	-	¼ mm to 1 mm in diameter
Fine-grained	-	< ¼ mm in diameter.

ROCK QUALITY DESIGNATION (RQD)

RQD is the ratio (expressed as a percentage) of length of core recovered to the total length of core run, counting only those pieces of hard and sound rock 10 cm in length or longer.

APPENDIX 3

DRILL HOLE WATER-PRESSURE TESTS

Water-pressure tests were carried out on NMLC diamond-drill holes along the route. Standard test procedures were used.

Permeabilities have been calculated for each test section and have been plotted on the geological logs (Appendix 3) in lugeon units. The lugeon is defined as:

> 'the rate of loss of water from a drill hole 46 to 76 mm diameter, of 1 litre per minute per metre of drill hole at a pressure of 10 bars, the test being applied for ten minutes over a test length of 2 metres.'

Computation sheets for every test carried out are not presented here but can be examined at the Bureau of Mineral Resources.

APPENDIX 4

MECHANICAL PROPERTIES OF ROCK SAMPLES

Appendix 4 describes the measurement of mechanical properties of NMLC and Treifus 2½" drill core samples from the proposed tunnel line. Point Load Strengths were determined by N. Wise of the BMR Engineering Geology Section. The other measurements were carried out by M. Idnurm and R. Eaton of the Rock Measurements Group.

The rocks tested were dacites, rhyodacites, granite, rhyolite, and shales. All samples were classified as fresh rock.

MEASUREMENT TECHNIQUES

Elastic properties

The elastic properties are measured on drill core samples 10 to 13 cm long in a laboratory-dry condition.

Compressional sound velocity. The compressional sound velocities were determined from the transmission times of a sound pulse using a Cawkell ultrasonic instrument type UCT2. The pulse consisted of a damped sine wave of frequency 150 kHz.

Modulus of Elasticity and Poisson's Ratio. The Modulus of Elasticity and Poisson's ratio were calculated from the compressional velocity and the resonance frequency of the drill core sample. A Cawkell instrument type SCT4 was used for the resonance measurements. The elastic moduli consequently represent the dynamic rather than the static values. The experimental errors in the velocity are estimated to be within 5 percent, and in the elastic moduli within 15 percent.

The elastic properties, specific gravity, and hardness of the drill core samples are shown in Table A together with the drill log data. The gaps in the table denote lack of reliable elastic property data owing to high sonic attenuation.

Hardness

The hardnesses were determined by the Shore scleroscope, which measures the height of rebound of a diamond-tipped weight from a flat test surface. A total of 64 readings was obtained from the end faces of each sample, and the average of these was taken as the Shore Hardness. The samples were tested in a laboratory-dry condition.

Table B lists for comparison the values of Shore Hardness for several common rock types. This table is compiled from

the information given in the US Bureau of Mines report on their Investigation No. 4727.

Uniaxial compressive strength (UCS)

The length to diameter ratio of the samples for the compressive strength tests was 2:1. The specimen ends were surface-ground to a flatness within 25 μm (highest to lowest point). The ends were parallel within $\frac{1}{2}^{o}$. No lubricant was used on the end faces. The samples were tested in a laboratory-dry condition. A Baldwin testing machine Model 400 CT was used. The loading rate was 500 KN/m^2/sec.

Table C lists the uniaxial compression test results. The samples tested represent the least jointed sections of the drill core. Defect free samples were not available from some of the drill cores. Where the failure occurred prematurely on pre-existing fracture planes only the lower limit of uniaxial compressive strength is given. The shale samples were tested normal to their bedding planes.

Point Load Strength Index: Is(50)

The Point Load Strength (PLS) test was devised as a quick means of determining the rock strength. The tests were carried out using a technique developed by Brock & Franklin (1972).

Where possible at least 10 tests were carried out on a sample 'unit'. A 'unit' is a sample of rock considered on inspection to have uniform strength. In some cases it was not always possible to obtain 10 suitable rock samples.

Failure of a sample was considered satisfactory if it occurred across the rock substance. Where failure occurred along fractures, joints, or bedding planes, the results were discounted.

Tests of shale samples were carried out perpendicular to the bedding planes. The length of the drill core shale samples tested was roughly equal to the diameter.

Drill-core samples and surface samples were tested in a laboratory-dry condition.

Drillcore samples

Tests were carried out on core samples having a length to diameter ratio greater than 1.4. The samples were tested through a core diameter at a distance 0.7 diameter between the contact point of the platen and the nearest free end.

All tests were carried out in the field using core samples taken from the boxed drill core.

The PLS test results for the drill core are included in Table D.

Surface samples

The PLS test results for surface samples from GST and tunnel samples from Pine Ridge tunnel are included in Tables E and F. The samples tested were the form of irregular lumps collected from surface outcrops and from the tunnel-walls. With one exception the testing procedures have followed those recommended by Brock & Franklin (1972). The exception is in the shape factor for which the lower limit has been reduced from 1.0 to 0.9. This should not introduce any serious errors and has enabled a large number of samples to be retained, which would have otherwise been unsuitable for the tests.

The following should be noted about the tests:

1. The test samples were roughly cubical in shape with an average edge length of 6 cm. The final trimming to produce the cubical shape was done with a diamond-disc saw.

2. The shape factor ranged from 0.9 to 1.3.

Correlation of Point Load Strength Index, Is(50), with Uniaxial Compressive Strength (UCS).

From the Is(50) a corresponding UCS can be predicted from the correlation curve of Brock & Franklin (op. cit.). The correlation is:

$$UCS \approx 24\ Is(50)$$

A comparison between Is(50) and UCS has been carried out by M. Idnurm of the BMR Rock Measurements Group. The correlation coefficient between Is(50) and UCS found here was 0.84, which compares with values of 0.88 obtained by Brock & Franklin, and 0.95 obtained by D'Andrea et al. (1965).

The results obtained by M. Indurm agree reasonably well with those of Brock & Franklin at low and intermediate compressive strengths, but deviate at high strengths. For example the average Is(50) for fresh dacite from Pine Ridge tunnel is 7.9 MPa, and the corresponding UCS predicted from the correlation curve of Brock & Franklin is 190 MPa; however, measurements by M. Idnurm indicate a UCS of 210 MPa. These results indicate a possible non-linear relationship between Is(50) and UCS at high stress levels, and departures from the Brock & Franklin curve start from about 160 MPa.

TABLE A. GENERAL RESULTS OF ROCK TESTS

Drill hole	Depth (m)	Geological description	Sample no.	Specific gravity	Compressional velocity (m/s)	Modulus of elasticity (E) ($10^3 MN/m^2$)	Poissons Ratio (r)	Hardness (Shore units)
GST. 3	17.90	Dacite	75/529	2.67	5660	76	0.22	-
GST. 3	24.70	"	75/530	2.65	5560	72	0.23	-
GST. 3	35.60	"	75/531	2.64	4420	45	0.24	-
GST. 3	17.95	"	75/532		Shore Hardness test only			102
GST. 3	24.65	"	75/533		Shore Hardness test only			102
GST. 3	19.80	"	75/534		Shore Hardness test only			101
GST. 4	29.10	Dacite	75/535	2.66	5930	81	0.25	-
GST. 4	29.30	"	75/536	2.65	5650	74	0.24	-
GST. 4	32.40	"	75/537	2.66	5750	77	0.24	-
GST. 4	29.30	"	75/538		Shore Hardness test only			100
GST. 4	32.05	"	75/539		Shore Hardness test only			98
GST. 4	32.30	"	75/540		Shore Hardness test only			96
GST. 5	12.50	Dacite	75/541	2.66	5490	67	0.26	-
GST. 5	12.60	"	75/542	2.65	5740	65	0.31	-
GST. 5	12.80	"	75/543	2.67	5630	73	0.24	-
GST. 5	12.45	"	75/544		Shore Hardness test only			102
GST. 5	12.70	"	75/545		Shore Hardness test only			101
GST. 5	12.87	"	75/546		Shore Hardness test only			96
GST. 7	19.10	Shale	75/547	2.68	4400	-	-	-
GST. 7	19.63	"	75/548	2.68	4650	-	-	-
GST. 7	19.95	"	75/549	2.68	5020	-	-	-
GST. 7	19.05	"	75/550		Shore Hardness test only			72
GST. 7	19.50	"	75/551		Shore Hardness test only			64
GST. 7	19.80	"	75/552		Shore Hardness test only			67
GST. 7	35.76	Dacite	75/553	2.61	3850	-	-	-
GST. 7	39.70	"	75/554	2.63	4790	52	0.25	-
GST. 7	40.35	"	75/555	2.65	3900	-	-	-
GST. 7	35.85	"	75/556		Shore Hardness test only			81
GST. 7	40.40	"	75/557		Shore Hardness test only			68
GST. 7	59.80	"	75/558		Shore Hardness test only			71
GST. 9	44.10	Granite	75/487	2.68	5770	71	0.29	
GST. 9	45.90	"	75/488	2.67	5720	71	0.28	
GST. 9	46.50	"	75/489	2.68	5650	60	0.33	-
GST. 9	44.50	"	75/491		Shore Hardness test only			91
GST. 9	46.00	"	75/490		Shore Hardness test only			92
GST. 9	47.50	"	75/492		Shore Hardness test only			97
GST. 11	31.80	Dacite	75/493	2.71	5070	61	0.24	-
GST. 11	38.60	"	75/494	2.74	5450	67	0.27	-
GST. 11	58.20	"	75/495	2.69	5500	70	0.25	-
GST. 11	31.68	"	75/496		Shore Hardness test only			71
GST. 11	38.65	"	75/497		Shore Hardness test only			75
GST. 11	58.05	"	75/498		Shore Hardness test only			75
GST. 12	70.30	Dacite	75/499	2.70	5330	59	0.30	-
GST. 12	71.50	"	75/500	2.67	5580	69	0.27	-
GST. 12	71.60	"	75/501	2.67	5310	59	0.29	-
GST. 12	70.20	"	75/502		Shore Hardness test only			71
GST. 12	71.42	"	75/503		Shore Hardness test only			82
GST. 12	77.70	"	75/504		Shore Hardness test only			57

TABLE A. (contd.)

Drill hole	Depth (m)	Geological description	Sample no.	Specific gravity	Compressional velocity (m/s)	Modulus of elasticity (E) ($10^3 MN/m^2$)	Poissons Ratio (r)	Hardness (Shore units)
GST. 16	37.30	Rhyodacite	75/559	2.63	4560	49	0.22	-
GST. 16	37.40	"	75/560	2.61	5030	61	0.20	-
GST. 16	39.50	"	75/561	2.58	4600	45	0.26	-
GST. 16	27.45	"	75/562		Shore Hardness test only			90
GST. 16	37.20	"	75/563		Shore Hardness test only			81
GST. 16	39.60	"	75/564		Shore Hardness test only			63
GST. 17	20.00	Rhyolite	75/505	2.74	5710	75	0.26	-
GST. 17	21.80	"	75/506	2.66	5680	73	0.26	-
GST. 17	21.80	"	75/507	2.60	5560	62	0.30	-
GST. 17	20.10	"	75/508		Shore Hardness test only			98
GST. 17	20.14	"	75/509		Shore Hardness test only			93
GST. 17	21.92	"	75/510		Shore Hardness test only			97
GST. 18	18.60	Dacite	75/565	2.70	4540	42	0.31	-
GST. 18	18.70	"	75/566	2.70	4740	49	0.28	-
GST. 18	18.90	"	75/567	2.71	4390	-	-	-
GST. 18	18.50	"	75/568		Shore Hardness test only			63
GST. 18	18.75	"	75/569		Shore Hardness test only			69
GST. 18	18.85	"	75/570		Shore Hardness test only			71
GST. 20	56.60	Dacite	75/511	2.72	4600	40	0.33	-
GST. 20	57.80	"	75/512	2.68	5650	70	0.27	-
GST. 20	58.00	"	75/513	2.69	5520	68	0.26	-
GST. 20	57.61	"	75/515		Shore Hardness test only			90
GST. 20	58.00	"	75/514		Shore Hardness test only			89
GST. 20	60.00	"	75/516		Shore Hardness test only			87
GST. 23	48.50	Granite	75/517	2.68	5880	75	0.28	-
GST. 23	59.90	"	75/518	2.68	5840	75	0.27	-
GST. 23	61.30	"	75/519	2.68	5870	76	0.27	-
GST. 23	48.35	"	75/520		Shore Hardness test only			100
GST. 23	59.90	"	75/521		Shore Hardness test only			97
GST. 23	61.35	"	75/522		Shore Hardness test only			97
GST. 24	43.90	Granite	75/523	2.66	5600	67	0.28	-
GST. 24	44.10	"	75/524	2.66	5600	67	0.28	-
GST. 24	34.10	"	75/525	2.67	5440	65	0.27	-
GST. 24	43.60	"	75/526		Shore Hardness test only			82
GST. 24	43.90	"	75/527		Shore Hardness test only			87
GST. 24	43.64	"	75/528		Shore Hardness test only			86
MV 7	11.9	Dacite	71/229	2.67	5660	70	0.28	99
MV 7	18.8	"	71/230	2.70	5450	66	0.28	89
MV 7	19.2	"	71/231	2.68	5600	69	0.28	90
MV 7	19.5	"	71/232	2.68	5500	67	0.28	86
MV 11	33.6	"	71/233	2.67	5850	75	0.28	96
MV 11	34.5	"	71/234	2.68	5640	64	0.31	93
MV 11	35.6	"	71/235	2.69	5630	69	0.23	94
MV 11	48.5	"	71/236	2.69	4250	32	0.36	69

TABLE B. SHORE HARDNESS RANGE IN COMMON ROCK TYPES*

Rock type	Shore Hardness	No. of localities of sample collection
Granite	90 - 100	5
Basalt	69 - 84	1
Quartzite	81 (one value only)	1
Limestone	27 - 66	4
Sandstone	31 - 65	3
Shale	34 - 58	2

* From US Bureau of Mines Report on Investigation 4727

TABLE C. UNIAXIAL COMPRESSIVE STRENGTHS (UCS)

Drill hole	Depth (m)	Diam (cm)	Geological description	Sample no.	Compressive strength MPa	Mode of failure
GST. 3	17.90	5.2	Dacite	75/529	294	Fractured into numerous small pieces
GST. 3	24.70	5.2	"	75/530	492	Longitudinal failure through length
GST. 3	35.60	5.2	"	75/531	> 110	Premature failure through joint plane
GST. 4	29.10	5.2	Dacite	75/535	>101	Premature failure through joint plane
GST. 4	29.30	5.2	"	75/536	273	Fracture into numerous small pieces
GST. 4	32.40	5.2	"	75/537	173	Longitudinal failure through length
GST. 5	12.50	5.2	Dacite	75/541	291	Fracture into numerous small pieces
GST. 5	12.60	5.2	"	75/524	258	Fracture into numerous small pieces
GST. 5	12.80	5.2	"	75/543	234	Longitudinal failure through lengths
GST. 7	19.10	5.2	Shale	75/547	> 245	Premature failure through joint plane
GST. 7	19.63	5.2	"	75/548	>124	Premature failure through joint plane
GST. 7	19.95	5.2	"	75/549	>197	Premature failure through joint plane
GST. 7	35.76	5.2	Dacite	75/553	203	Conical
GST. 7	39.70	5.2	"	75/554	204	Fracture into numerous small pieces
GST. 7	40.35	5.2	"	75/555	205	Conical
GST. 9	44.10	5.2	Granite	75/487	170	Fracture into numerous small pieces
GST. 9	45.90	5.2	"	75/488	237	Fracture into numerous small pieces
GST. 9	46.50	5.2	"	75/489	125	Longitudinal failure through length
GST. 11	31.80	5.2	Dacite	75/493	154	Fracture into numerous small pieces
GST. 11	38.60	5.2	"	75/494	152	Fracture into numerous small pieces
GST. 11	58.20	5.2	"	75/495	164	Fracture into numerous small pieces
GST. 12	70.30	5.2	Dacite	75/499	104	Semiconical failure
GST. 12	71.50	5.2	"	75/500	97	Semiconical failure
GST. 12	71.60	5.2	"	75/501	105	Longitudinal failure through length
GST. 16	37.30	5.2	Rhyodacite	75/559	> 52	Premature failure through joint plane
GST. 16	37.40	5.2	"	75/560	> 89	Premature failure through joint plane
GST. 16	39.50	5.2	"	75/561	> 38	Premature failure through joint plane
GST. 17	20.00	5.2	Rhyolite	75/505	279	Fracture into numerous small pieces
GST. 17	21.80	5.2	"	75/506	322	Fracture into numerous small pieces
GST. 17	21.80	5.2	"	75/507	247	Conical
GST. 18	18.60	5.2	Dacite	75/565	145	Longitudinal failure through length
GST. 18	18.70	5.2	"	75/566	119	Longitudinal failure through length
GST. 18	18.90	5.2	"	75/567	96	Conical
GST. 20	56.60	6.3	Dacite	75/511	141	Conical
GST. 20	57.80	6.3	"	75/512	255	Longitudinal failure through length
GST. 20	58.00	6.3	"	75/513	223	Longitudinal failure through length
GST. 23	48.50	6.3	Granite	75/517	188	Longitudinal failure through length
GST. 23	59.90	6.3	"	75/518	246	Fracture into numerous small pieces
GST. 23	61.30	6.3	"	75/519	263	Fracture into numerous small pieces
GST. 24	43.90	6.3	Granite	75/523	178	Longitudinal failure through length
GST. 24	44.10	6.3	"	75/524	201	Fracture into numerous small pieces
GST. 24	34.10	6.3	"	75/525	> 110	Premature failure through joint plane
MV 7	11.9	5.2	Dacite	71/229	239	Not available
MV 7	18.8	5.2	"	71/230	214	Not avilable
MV 7	19.2	5.2	"	71/231	187	Not available
MV 7	19.5	5.2	"	71/232	-	Not available
MV 11	33.6	5.2	"	71/233	257	Not available
MV 11	34.6	5.2	"	71/234	262	Not available
MV 11	48.5	5.2	"	71/235	192	Not available
			"	71/236	177	Not available

TABLE D. POINT LOAD STRENGTH TESTS ON DRILL CORE

Hole no.	Depth approx. (m)	No. samples tested	Formation	No. successful tests	Mean Is(50) MPa	Standard deviation	Geological description
GST. 2	43.0	9	Willow Bridge Tuff	7	9.8	0.65	)FR - Dacite, light grey to
	56.0	11		10	9.9	1.01	) dark grey to pink with
	60.0	7		5	9.4	0.94	) zones of alteration.
GST. 3	17.0	10		10	12.1	1.65	FS - Dacite, light grey
GST. 4	28.0	10		10	7.4	1.06	FS - Dacite, pale grey
GST. 5	10.0	10		7	11.2	1.78	)FS - Dacite, welded, mostly
	20.0	10		9	11.1	3.08	) pale grey
GST. 7	16.0	10	Walker Volcanics Lower Sequence	8	7.3	1.44	FR - Dacite, crystal tuff arenite
	16.0	3		3	2.4	0.93	Black shale intraclasts
	19.0	2		2	2.6	0.02	FR - Black shale
	25.0	4		4	2.2	0.21	Black shale intraclasts
	25.0	10		8	7.9	3.92	FR - Dacite tuff
	36.0	11		8	4.3	0.95	FR - Dacite ignimbrite tuff, med. grey
GST. 9	15.0	10	Ginninderra Porphyry	8	1.5	0.67	MW-FS Granite porphyry, light grey
	20.0	18		8	6.1	2.00	)FR - Granite porphyry
	30.0	14		3	8.4	3.24	) light grey
GST. 9	35.0	8		4	2.9	1.46	FR - Granite porphyry, but slightly altered and chloritized.
	44.0	14		7	7.6	2.22	FR - Granite porphyry
GST. 11	30.0	14	Walker Volcanics Upper Sequence lower sequence	6	6.3	0.82	FR - Dacite ignimbrite tuff
	44.0	11		4	6.0	1.10	FR - Dacite ignimbrite tuff
GST. 12	38.0	10		4	5.1	0.82	FS - FR Dacite, mostly sheared but healed with chlorite and limonite
	72.0	10		8	7.2	2.51	FR - Dacite ignimbrite tuff
GST. 13	63.0	10		6	7.0	1.91	FR - Dacite
	80.0	14		5	4.1	0.95	)FR - Rhyolite, green mottled
	82.0	9		3	2.0	0.54	)Silicious with black chlorite
GST. 14	23.0	10		2	6.4	0.10	)FR - Rhyolite, purple with
	32.0	8		3	4.5	0.62	)chlorite veins throughout
GST. 16	20.0	10	Green rhyolite	7	6.5	1.32	SW-FS Rhyolite, pale green
	24.0	10		9	9.1	1.67	SW-FS Rhyolite, blue green
	37.0	12	Purple rhyodacite	6	4.6	1.00	FS - Rhyodacite, purple
GST. 17	20.0	15	Green rhyolite	11	8.4	1.07	FR - Rhyolite, green
GST. 18	19.0	10	Walker Volcs Upper Sequence	7	5.1	2.00	FR - Dacite, welded, stained purple
GST. 20	55.0	13		10	6.2	0.94	FR - Dacite, blue grey
GST. 23	46.0	10	Ginninderra Porphyry	10	8.4	1.19	)FR - Granite porphyry pale grey
	60.0	11		6	7.9	0.93	
GST. 24	28.0	12		10	5.6	1.79	FS - FR Granite porphyry green grey

TABLE E. POINT LOAD STRENGTH TESTS ON SURFACE SAMPLES

Map locality and thin-section numbers	Grid position	No. samples tested	Mean Is(50) MPa	Standard deviation	Geological description
J1 75360026	198750 E 612590 N	10	12.6	2.34	Light grey dacite, SW - FR
74360060	199180 E 612710 N	10	12.9	0.92	Dark grey dacite, FS - FR
74360061	199210 E 612100 N	10	12.0	1.07	Dark grey dacite, FS- FR
K3 75360023	199177 E 612310 N	6	12.3	2.44	Dark grey dacite, SW - FS
75360021	199940 E 612340 N	9	9.8	2.16	Purple dacite, SW
E1	196710 E 610390 N	10	10.5	1.83	Dacite agglomerate, SW - FS
D1 75360031	198810 E 608690 N	9	9.8	1.85	Green rhyolite, SW- FS

TABLE F. PINE RIDGE TUNNEL POINT LOAD STRENGTH TESTS

All samples consisted of fresh dacite containing cemented fractures.

Location chainage (ft)	No. of samples	Mean Is(50) MPa
200 (w)	4	7.8
300 (w)	3	8.4
400 (w)	2	8.0
500 (w)	3	8.2
600 (w)	3	6.7
700 (w)	2	9.0
800 (w)	2	10.7
900 (w)	3	8.5
1000 (w)	2	8.1
1100 (w)	2	5.9
1200 (w)	2	7.3
1300 (w)	3	8.3
1400 (w)	3	7.4
1500 (w)	2	9.6
1600 (w)	2	7.5
1700 (w)	3	7.1
1800 (w)	2	7.1
1900 (w)	3	5.9
2000 (w)	3	8.0
2100 (w)	3	7.3
2200 (w)	3	8.9
2300 (w)	2	7.1
2400 (w)	2	8.0
2500 (w)	2	7.3
2600 (w)	2	6.4
2700(w)	3	10.4
		Mean 7.9

APPENDIX 5
PETROLOGY

THIN SECTION DESCRIPTIONS
(by C. Gardner)

SUMMARY

All the samples described are porphyritic dacites (62-68% SiO_2) or rhyolites (SiO_2 68%) with between 30 and 50 percent phenocrysts. These generally include unbroken phenocrysts, fragments of broken phenocrysts (fragmentation is a distinctive feature of these rocks), and microphenocrysts. Quartz is the dominant porphyritic mineral in all of the samples, in terms of abundance and grainsize; it occurs as rounded or hexagonal embayed crystals and always shows complete extinction.

Plagioclase (albite-?andesine) is always present, usually as subhedral, partly sericitized, irregularly twinned, zoned laths. Euhedral microphenocrysts of magnetite also occur in all the samples.

Mafic phenocrysts were originally biotite ± hornblende ± clinopyroxene, orthopyroxene was found in one sample. In almost all the samples, the mafics have been completely altered, usually to chlorite + opaque oxides or sericite. Calcite, tremolite, sphene are also common alteration products. Low-grade greenschist metamorphism is inferred from these alteration products.

The groundmass is usually composed of quartz, plagioclase, K-feldspar, chlorite, sericite, and opaque oxides in many stages of devitrification. Strong flow-banding is evident in some samples, the flow enveloping deformed biotite pseudomorphs.

Accessories include apatite, zircon, and epidote.

THIN SECTION DESCRIPTIONS

Purple rhyodacite

(No. 75360021)

Phenocrysts: (35%) Most of these are clear (i.e., not undulose) quartz, up to 5 mm, cracked but not displaced. Sericitized albite and biotite partly replaced by chlorite + opaques make up the remainder of the phenocrysts. Microphenocrysts of biotite, chlorite, opaques and magnetite occur. (3%)

Groundmass: Partly devitrified quartz-feldspar-opaques. Feldspar is clouded with inclusions of opaque oxides.

Green rhyolite

(No. 75360031) Extensively altered. Large areas of the matrix are recrystallized - these may be of sedimentary origin. Quartz phenocrysts (20%) cracked but not displaced, and feldspars (10%) sericitized. Rare original biotite and hornblende has been replaced by opaques + sericite or opaques + chlorite.

Groundmass is poorly crystalline.

Accessory zircon, magnetite microphenocrysts.

Walker Volcanics, lower sequence (Dacite)

(No. 74360064) Phenocrysts: (60%) composed of rounded fragments of clear quartz, sericitized subhedral feldspar, and pseudomorphs after biotite and hornblende. The pseudomorphs are aggregates of quartz-calcite-tremolite-epidote, calcite-chlorite, or Fe-rich chlorite. Former biotite laths are deformed.

Groundmass: is structureless cryptocrystalline quartz-chlorite-plagioclase-K-feldspar.

Accessory: zircon, sphene, opaques.

(No. 74360065) ?Phenocrysts: (60%) Comprised of fragmented irregularly-shaped but well-rounded quartz, dense enough that they are just touching, and partly sericitized untwinned sodic plagioclase. As for 0064, mafic phenocrysts have been altered (low-grade greenschist metamorphism) to aggregates of Fe-poor chlorite, Fe-poor chlorite-sphene, and calcite-qtz-sphene. Some of the sphene occurs as radially-grown spheres.

Groundmass: structureless cryptocrystalline quartz-Fe-rich chlorite-albite-calcite.

(No. 75360028) Possibly sedimentary as quartz phenocrysts are generally not embayed, although some are angular. However, texture is similar to that of rhyodacites already described. Feldspar phenocrysts are replaced by sericite, clay or calcite; mafics (biotite, hornblende) replaced by colourless chlorite + opaques.

Groundmass consists of quartz, clay, calcite, sericite.

(No. 75360030) Probably sedimentary. Sub-angular quartz fragments occur in all sizes from micro-crystalline matrix to 1.5 mm (40%) and feldspar fragments comprise 25 percent of rock. Matrix consists of quartz clay-feldspar-calcite-opaques-chlorite no structure observed (sed. or volcanic).

Willow Bridge rhyolite (dark grey)

(No. 74360060) This sample (like most of those described) is comprised of distinct phenocryst and groundmass phases, each making up about 50 percent of the total rock.

Phenocrysts: i) clear, sometimes strained, quartz, 30 percent of total rock, from .05 mm (microphenocrysts) to 5 mm, mostly fragmented as well as embayed. Original crystal faces are either rounded or hexagonal (indicating high temperature origin).

ii) sericitized anhedral plagioclase (15%), smaller than quartz (indicating relatively deep level of derivation), also fragmented.

iii) sericite and chlorite (± opaques) pseudomorphs after biotite. Strongly deformed - probably during solidification of groundmass, as the contortions parallel the groundmass flow structure.

iv) rare CPX.

Groundmass: Cryptocrystalline partly devitrified qtz, Kspar, plag. Well-defined flow structure.

Accessory. Apatite, magnetite, zircon, goethite.

Willow Bridge dacite (dark grey and near base of unit)

(No. 74360061) Similar to 0060 except (i) phenocrysts comprise 35 percent instead of 50 percent of total rock, (ii) groundmass is fully devitrified, consequently flow pattern in the groundmass has been destroyed; deformed former biotite laths indicate that flow structure did originally exist.

Willow Bridge dacite (dark grey)

(No. 75360022) As for 74360061. Phenocrysts: (50%) fragmented phenocrysts and microphenocrysts, plagioclase, oscillatory zoned, twinned.

Groundmass: very dark, due to density of opaques, only incipient devitrification; flow structure evident.

(No. 75360023) As for 75360022. Biotite (now chlorite or sericite, + opaques) is strongly deformed and is strung out to narrow elongate laths concordant with the excellent groundmass flow structure; also crenulated.

NOTE: the chlorite replacing biotite is an intermediate biotite to chlorite alteration product, having higher birefringence than chlorite (same order of birefringence as sericite). Magnetite and apatite are accessory.

(No. 75360024) Porphyritic dacite (as for 0023)

(No. 75360025) Mineralogy as for 0023, 0024. Phenocrysts, fragmented phenocrysts and microphenocrysts comprise 50% of rock. Biotite is unaltered and undeformed, i.e. red-brown phenocrysts.

Willow Bridge dacite (light grey)

(No. 75360026) As for 0025. Phenocrysts: Nearly all fragmented. Biotite quite fresh, dark brown-pale green. Plagioclase shows good twinning and zoning (Ano - 10). No K-feldspar phenocrysts. Magnetite phenocrysts abundant.

Fresh orthophyroxene phenocrysts occur rarely and carry zircon inclusions.

Groundmass: Completely devitrified, quartz-albite-K-feldspar-chlorite.

(No. 75360027) Phenocrysts: Fragmented phenocrysts and microphenocrysts make up 50 percent of rock. They include embayed, generally rounded, non-undulose quartz, up to 5 mm diameter; smaller subhedral partly sericitized twinned plagioclase, zoned Ano - 10; strongly deformed chlorite + opaque pseudomorphs after biotite, chlorite pseudomorphs after hornblende.

Groundmass: devitrified crystocrystalline, no flow structure remaining.

Willow Bridge rhyolite (light grey)

(No. 74360069) Phenocrysts: Comprise 40 percent of total rock. Most of these are qtz, clear, highly fragmented, all with sharp angular edges. Both plagioclase (albite-twinned) and potash feldspar (microcline-twinned) occur. Some K-feldspar phenocrysts are altered to qtz-sericite. Biotite microphenocrysts (8%) are altered to opaques + epidote, and carry abundant zircon inclusions.

Groundmass: is devitrified, rarely recrystallized.

Granite Porphyry

(No. 74360062, 63) Similar mineralogy to 0060, 61 except for higher proportion of mafics in 0062, 63.

Phenocrysts. As for 0061 except quartz and plagioclase are both commonly 4 mm (indicating shallower level of commencement of crystallization than for 0061). Plagioclase is twinned, euhedral, composition not determinable because of sericitization.

Mafic phenocrysts (biotite, clinopyroxene) are pseudomorphed by quartz-chlorite ± calcite, sphene-chlorite-opaque oxide or sericite aggregates.

Groundmass. (50% of total rock) Fine-grained; probably recrystallized volcanic groundmass.

(No. 75360029) Phenocrysts: (40%) Large, embayed quartz, heavily corroded feldspars (to sericite, calcite, clay, dusted with opaques). Mafics altered to epidote or colourless chlorite + opaques. Calcite abundant in groundmass; associated with this calcite are abundant tiny (.05 mm) euhedral magnetites.

This rock seems to have partly sedimentary content.

TABLE G. CHEMICAL ANALYSES

	Green Rhyolite			Mount Painter Porphyry					Walker Volcanics Lower sequence	
	Tuggerunong tunnel		CST area	Mount Painter area					CST area	
Location (1:100 000 series)	Stn. 244+15	Stn. 246+35	811983 D1	878953	877952	959866	944872	938864	800000 E2	803018 E1
Registration No.	75840014	75840015	73840101	74840003	74840004	74840085	74840086	74840088	75840018	75840019
SiO_2	71.84	72.99	80.25	66.40	67.15	65.65	66.52	65.03	68.00	66.70
TiO_2	0.22	0.23	.22	.57	.54	.59	.57	.58	0.46	0.59
Al_2O_3	12.93	13.33	10.74	13.80	13.74	14.13	14.06	13.88	10.78	14.00
Fe_2O_3	1.39	0.53	.68	.81	.98	.30	.40	.46	1.15	0.26
FeO	0.55	0.80	.07	4.47	4.34	4.62	4.20	4.02	5.09	4.55
MnO	0.04	0.03	.01	.06	.09	.10	.07	.10	0.13	0.13
MgO	0.59	0.49	.23	2.02	3.09	3.09	2.80	2.80	4.01	2.65
CaO	2.49	1.73	.03	2.09	2.39	1.74	1.52	2.06	2.35	2.54
Na_2O	0.75	1.12	.52	1.73	1.82	2.10	1.92	1.98	1.08	2.58
K_2O	4.12	3.78	5.94	3.38	2.81	3.86	4.27	4.67	1.52	2.78
P_2O_5	0.06	0.06	.05	.11	.11	.06	.07	.07	0.10	0.11
H_2O+	2.23	2.47	.87	2.41	2.69	2.75	2.44	2.78	3.43	2.39
H_2O-	0.47	0.51	.15	.11	.13	.13	.08	.10	0.23	0.11
CO_2	1.95	1.80	.05	.05	.05	.75	.40	1.40	0.45	0.25
Cu	20	14	8	28	66	30	22	30	34	36
Zn	45	50	52	104	84	114	71	104	110	98
Co	2	3	6	20	16	2	4	2	6	2
Ni	2	14	2	24	20	22	36	28	22	16
Cr	15	15	25	75	80	85	80	85	75	75
V	35	50	5	135	130	145	170	180	170	140
Ba	620	540	680	580	500	620	640	640	380	540
Ce	80	100	40	80	70	60	80	80	100	110
La	40	60	30	40	60	50	60	60	40	50
Pb	36	34	30	14	20	12	8	12	36	34
Rb	240	210	200	150	130	170	160	200	75	135
Sr	50	100	50	130	130	100	80	44	110	160
Th	18	18	16	16	18	12	14	18	12	14
U	6	8	6	4	4	4	4	4	4	6
Zr	115	125	145	190	185	175	175	195	100	200
Nb	10	10	4	4	8	4	4	6	10	10
Y	30	30	20	20	20	25	25	30	25	25

TABLE G. (contd.)

	Walker Member (Purcell, in prep.)					Willow Bridge Tuff				
	Pine Ridge tunnel					North of Ginninderra Creek				
Location (1:100 000 series)	Stn. 23+70	Stn. 50+00	Stn. 26+50	Stn. 45+00	Stn. 45+00	759104	773123	757133	739214	803221
Registration No.	73840487	73840488	73840489	73840490	73840491	73840436	73840438	73840440	73840446	73840449
SiO_2	67.78	68.42	67.84	65.86	66.80	67.98	69.63	7.193	69.88	67.80
TiO_2	.54	.51	.55	.62	.55	.51	.46	.31	.41	.50
Al_2O_3	13.95	12.86	14.10	14.37	13.68	14.94	14.67	14.00	14.04	15.18
Fe_2O_3	2.12	2.58	.87	3.62	3.32	1.39	1.53	.15	1.05	1.25
FeO	2.08	3.73	4.06	1.63	1.63	2.35	1.98	1.73	2.14	2.44
MnO	-	.09		.08	.09	.04	.04	.03	.05	.05
MgO	1.70	1.63	1.92	1.70	1.46	1.43	1.30	.52	1.27	1.37
CaO	1.73	.41	.32	1.44	1.83	3.81	3.05	.73	3.10	3.70
Na_2O	2.33	.72	1.27	1.22	1.38	2.48	2.52	4.00	2.66	2.86
K_2O	3.55	5.46	6.43	6.46	5.88	2.85	3.29	4.49	3.16	2.97
P_2O_5	.11	.11	.14	.13	.12	.11	.10	.04	.08	.10
H_2O+	2.53	2.22	2.17	2.02	2.07	1.26	1.41	.87	1.22	1.54
H_2O-	.33	.26	.19	.22	.15	.16	.09	.13	.10	.10
CO_2	.90	.05	.05	.55	1.05	.05	.10	.05	.05	.05
Cu	14	8	6	6	12	18	20	44	24	22
Zn	56	55	53	50	58	59	45	56	50	74
Co	6	8	8	6	6	10	18	2	4	2
Ni	20	15	20	18	18	10	13	10	13	18
Cr	65	60	50	55	85	30	30	20	30	30
V	130	110	140	150	150	83	80	38	85	100
Ba	450	1180	1020	1330	1310	600	660	700	640	620
Ce	70	60	60	70	70	70	80	70	80	80
La	40	40	40	40	30	40	60	50	50	50
Pb	105	6	10	14	1150	14	14	4	22	18
Rb	250	240	230	310	280	110	125	180	120	120
Sr	95	40	45	60	50	195	185	190	180	220
Th	16	16	16	12	18	14	14	22	14	16
U	4	6	6	4	4	4	4	4	4	6
Zr	180	160	180	170	190	200	200	220	180	210
Nb	5	5	5	10	10	5	5	5	5	5
Y	30	30	30	30	25	25	30	30	25	25

TABLE G. (contd.)

	Willow Bridge Tuff								
	North of Ginninderra Creek								Dark grey near B.W.P.C.C.
Location (1:100 000 series)	783105	780130	822120	814153	802187	785160	738111	724107	822027 K3
Registration No.	73840455	73840457	73840458	73840460	73840463	73840464	73840465	73840470	75840020
SiO_2	70.42	69.33	74.92	66.80	67.98	67.91	68.09	68.61	72.01
TiO_2	.41	.46	.18	.53	.47	.49	.52	.48	0.31
Al_2O_3	14.32	14.43	12.92	15.40	14.[illegible]	14.81	15.05	14.61	13.34
Fe_2O_3	1.06	1.32	.89	1.44	1.11	1.19	1.41	1.21	0.85
FeO	2.14	2.11	.81	2.40	2.44	2.46	2.46	2.29	1.49
MnO	.05	.05	.05	.06	.06	.06	.06	.06	0.03
MgO	1.19	1.23	.65	1.49	1.51	1.73	1.57	1.72	0.95
CaO	3.49	3.66	.83	4.13	3.65	2.77	2.96	1.15	2.17
Na_2O	2.48	2.54	2.82	3.64	2.56	2.92	3.02	4.18	2.79
K_2O	3.01	3.03	5.09	2.94	3.03	3.20	3.27	3.48	3.93
P_2O_5	.09	.10	.04	.11	.11	.10	.11	.09	0.12
H_2O+	1.09	1.35	.78	1.13	1.27	1.45	1.53	1.42	1.01
H_2O-	.11	.11	.18	.11	.11	.17	.19	.22	0.04
CO_2	.05	.05	.05	.05	.05	.05	.05	.10	0.05
Cu	20	22	14	22	22	20	20	34	24
Zn	46	56	30	63	46	53	66	43	35
Co	10	14	4	4	2	10	10	8	2
Ni	13	18	15	15	15	18	15	18	12
Cr	20	20	10	25	25	20	23	25	20
V	85	98	40	113	98	100	100	100	95
Ba	580	600	400	620	620	630	620	580	680
Ce	90	90	90	80	80	70	80	80	130
La	40	40	60	50	40	50	50	30	70
Pb	20	18	24	14	18	26	16	10	46
Rb	120	130	230	120	120	120	130	110	155
Sr	190	190	85	210	200	200	190	153	170
Th	14	16	18	10	14	14	12	16	22
U	4	4	4	4	4	4	4	4	4
Zr	170	180	95	200	200	200	200	190	140
Nb	5	5	5	5	5	5	5	5	10
Y	35	25	80	25	25	30	25	25	25

APPENDIX 6

GROUNDWATER DATA

Conductivity and pH of water samples from GST bores.

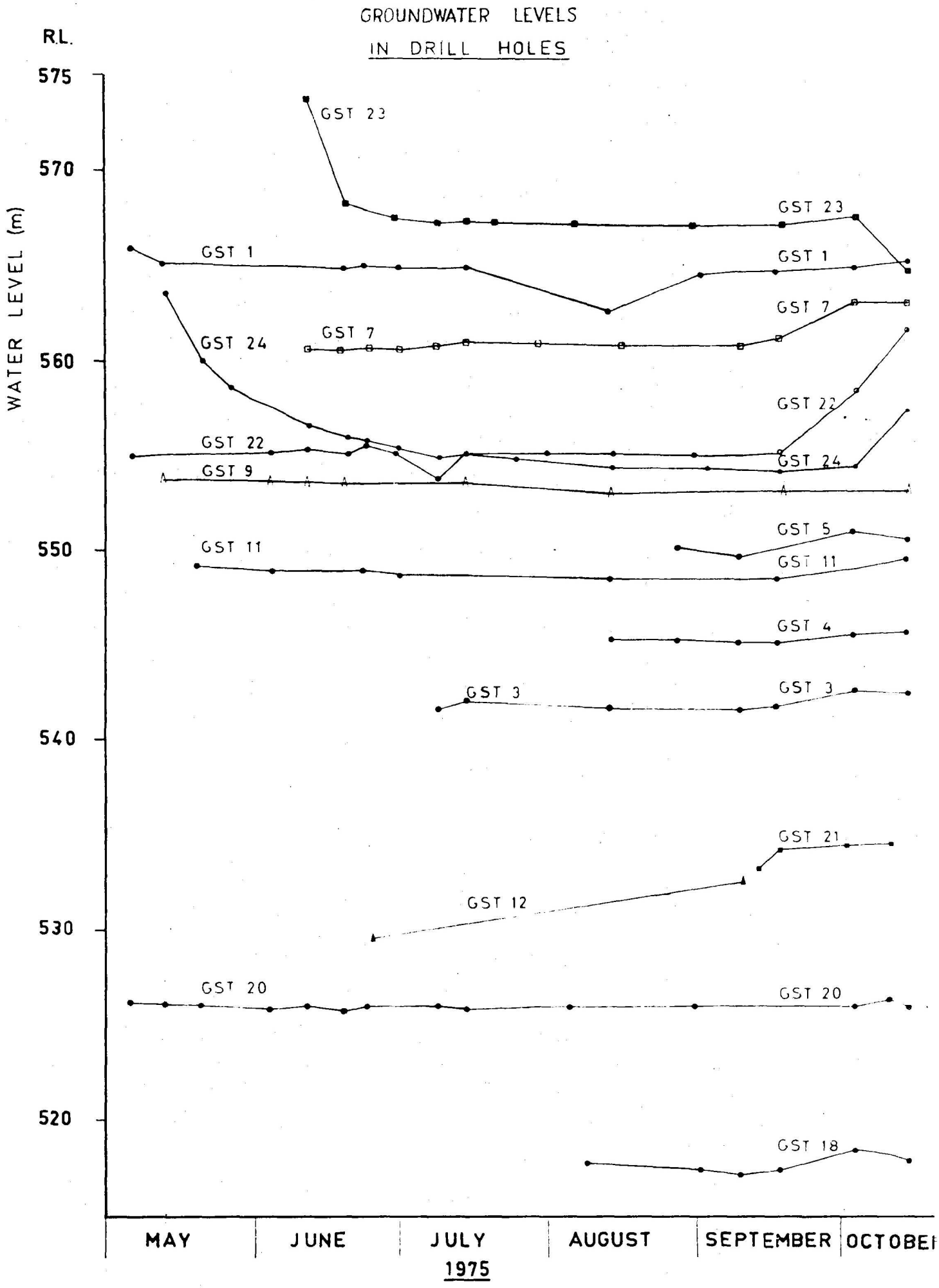
Date of sampling 14/10/75

		Specific Conductance $^{-1}cm^{-1}$	pH
GST	3	367	6.4
	4	550	6.0
	5	550	6.5
	7	1520	6.2
	17	608	5.8

Date of sampling 11/11/75

GST	17	688	5.9

FIGURE A


GROUNDWATER LEVELS
IN DRILL HOLES
RL.
WATER LEVEL (m)
575
570
560
550
540
530
520
GST 23
GST 23
GST 1
GST 1
GST 7
GST 7
GST 24
GST 22
GST 22
GST 24
GST 9
GST 5
GST 11
GST 11
GST 4
GST 3
GST 3
GST 21
GST 12
GST 20
GST 20
GST 18
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
1975

RELATIONSHIP BETWEEN OUTFLOW FROM GST 17 & WATERLEVEL IN GST 16

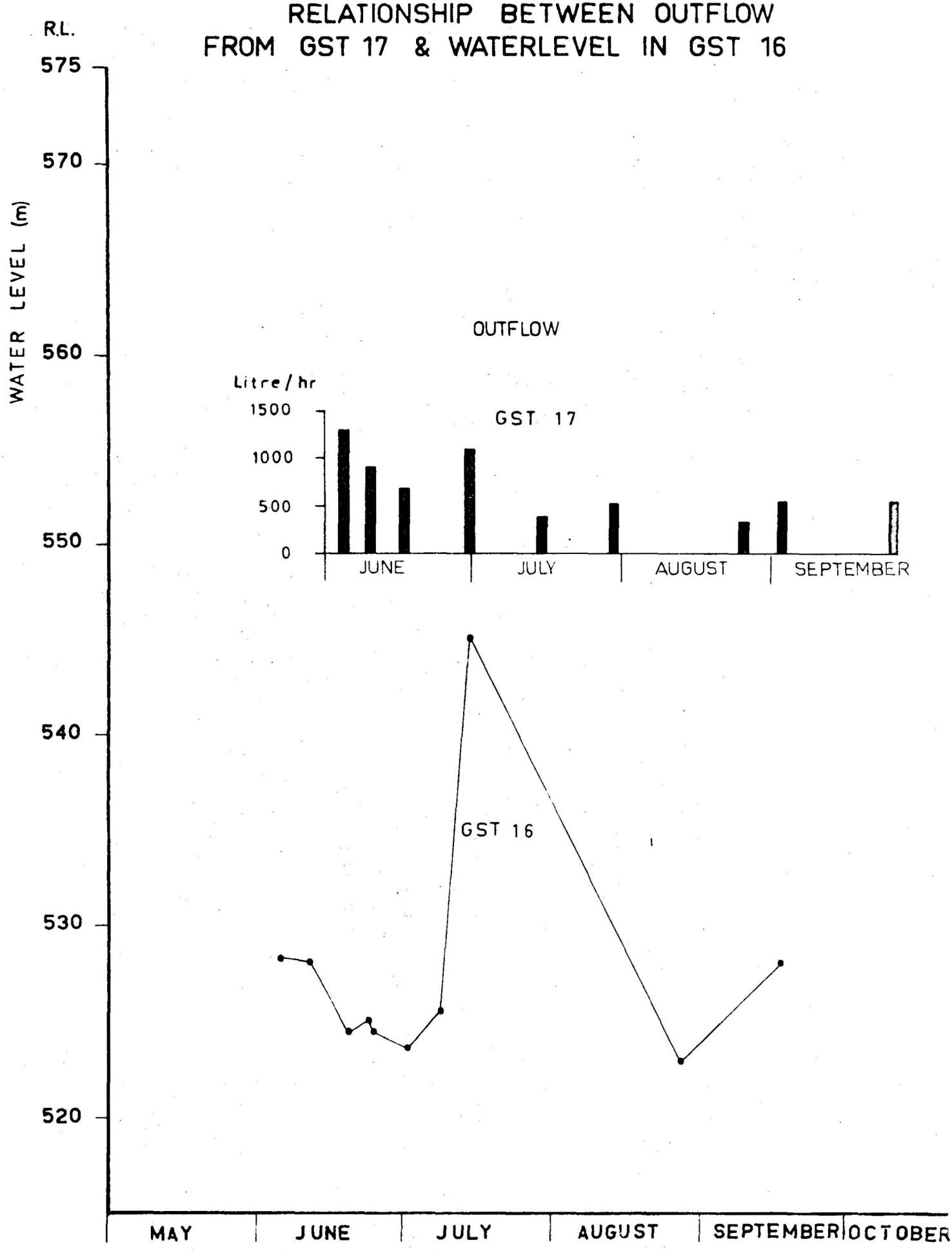
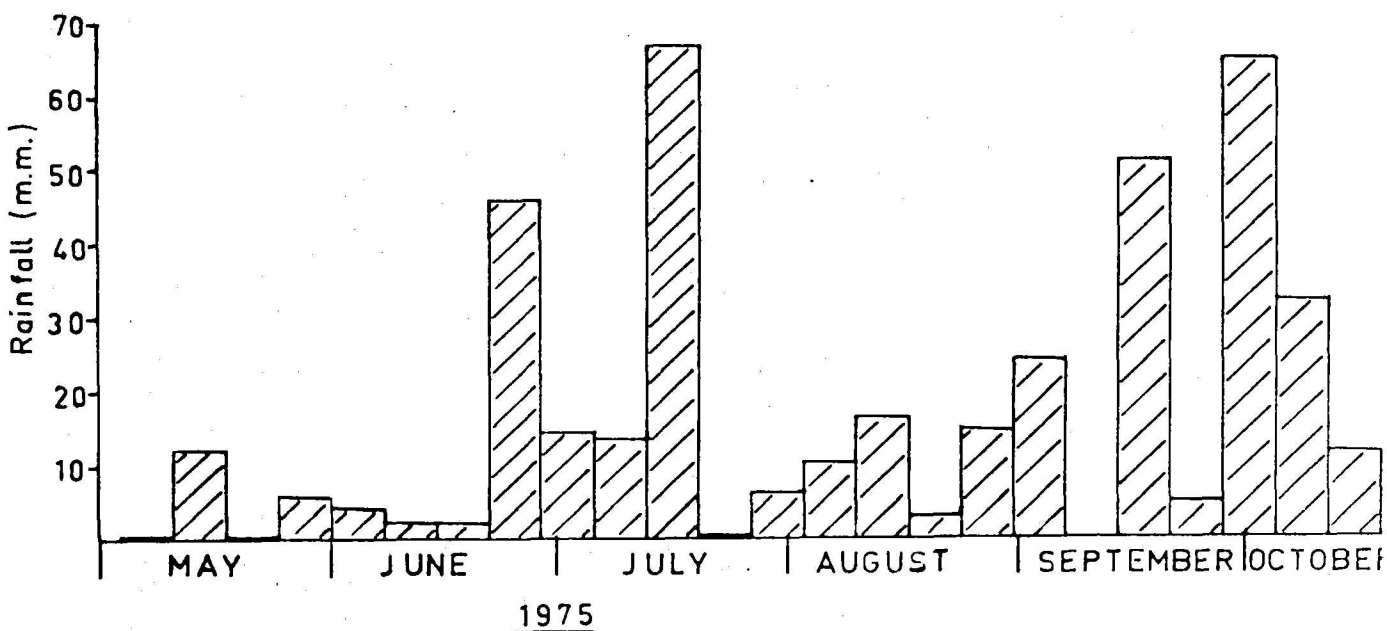


FIGURE C

RAINFALL RECORDINGS FOR GST AREA

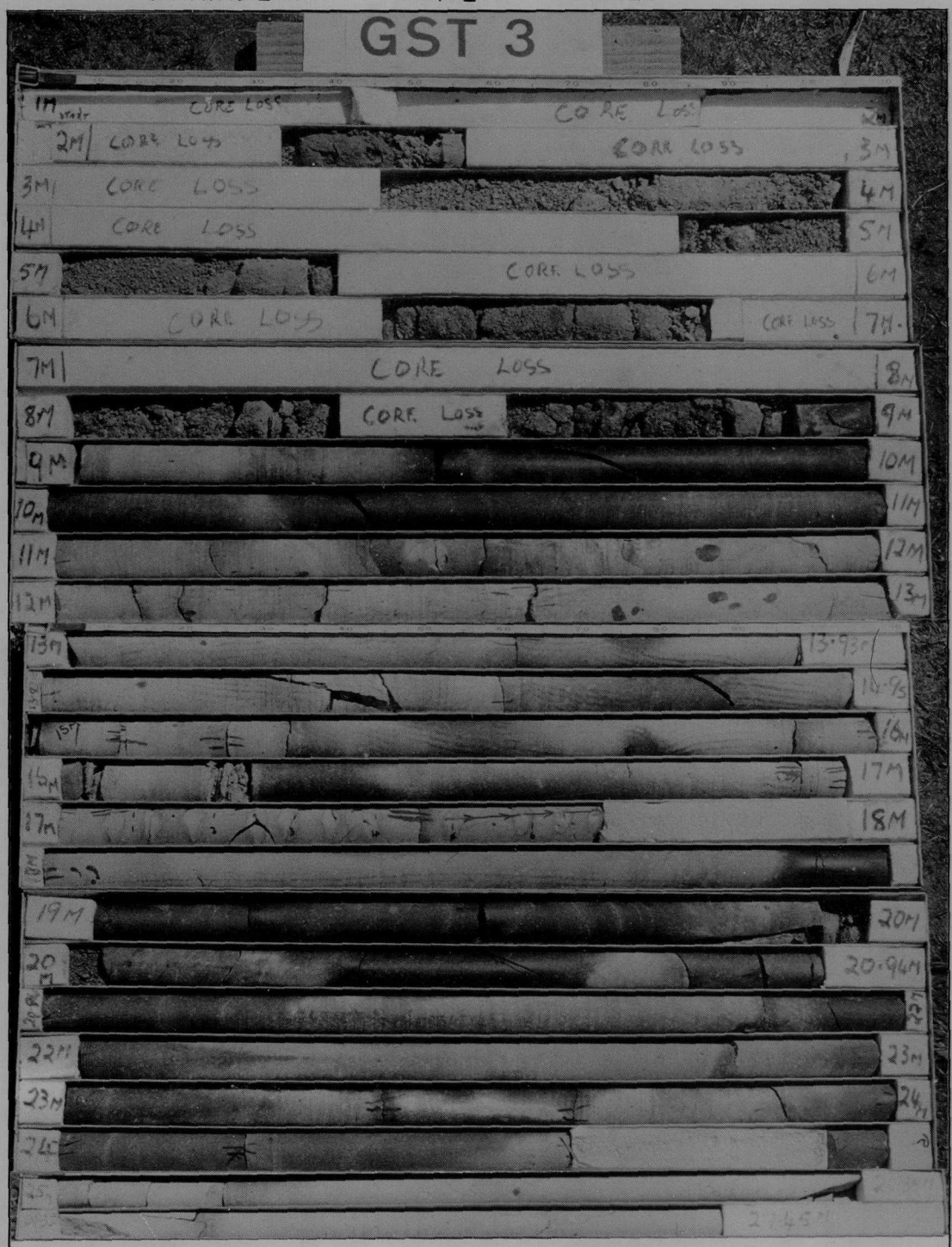


* Data taken from Bureau of Meterology Report :
Year 1975 ; Station 070059; Belconnen (Weetangera),
Lat. 35°15'S, Long. 149°3'E ; Elevation 624.7 m.

APPENDIX 7

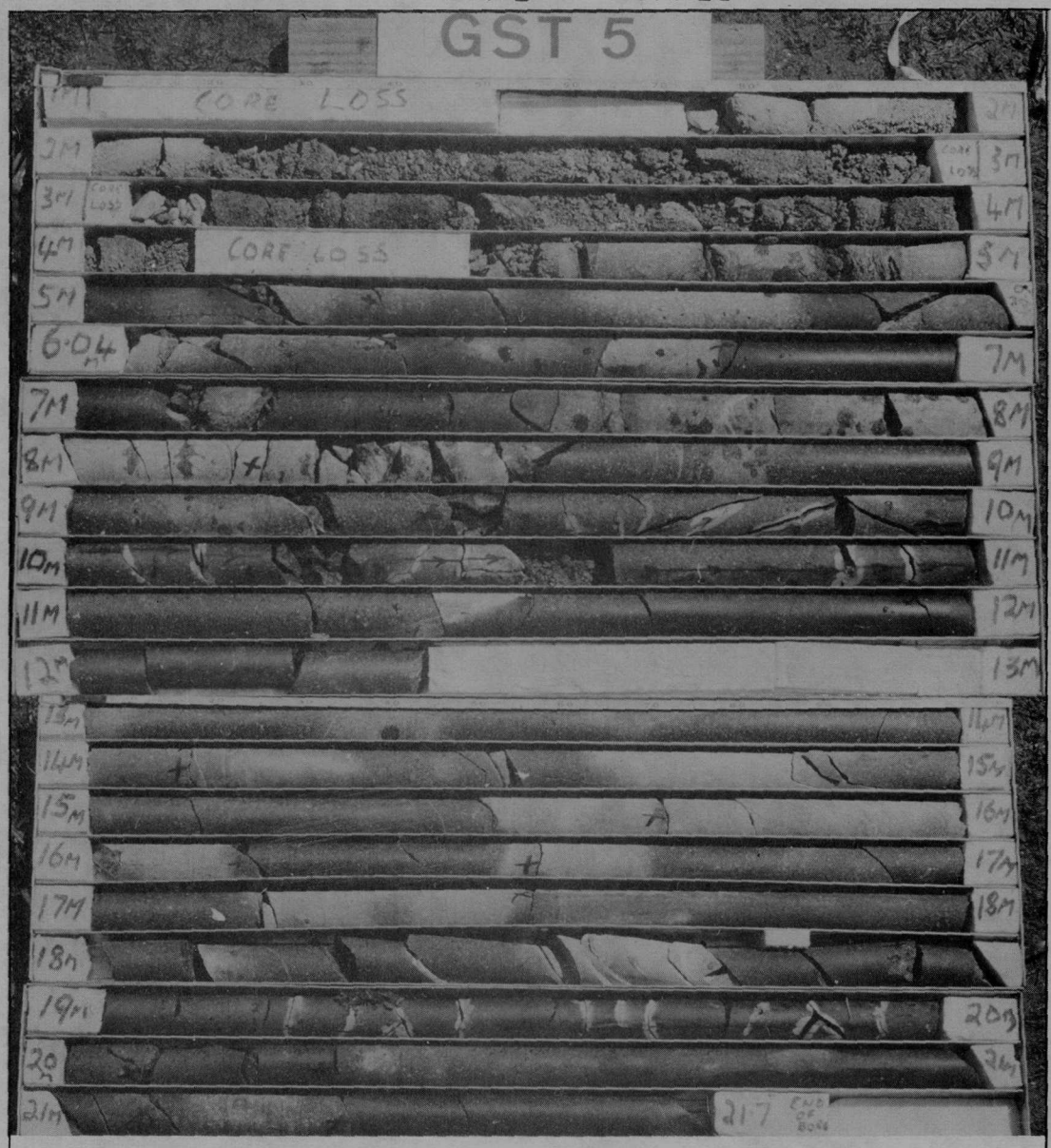
DRILL CORE PHOTOGRAPHS

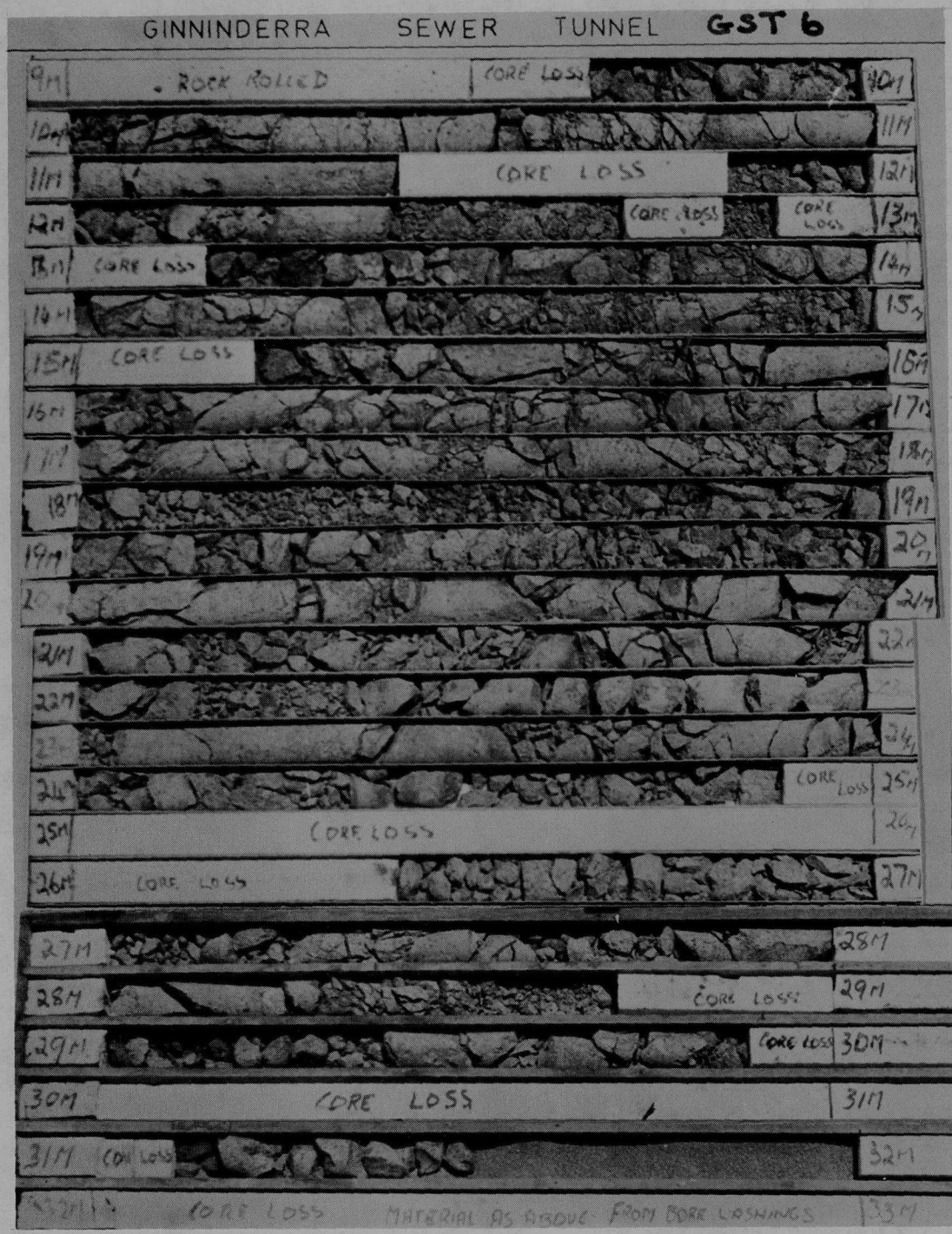
GINNINDERRA SEWER TUNNEL



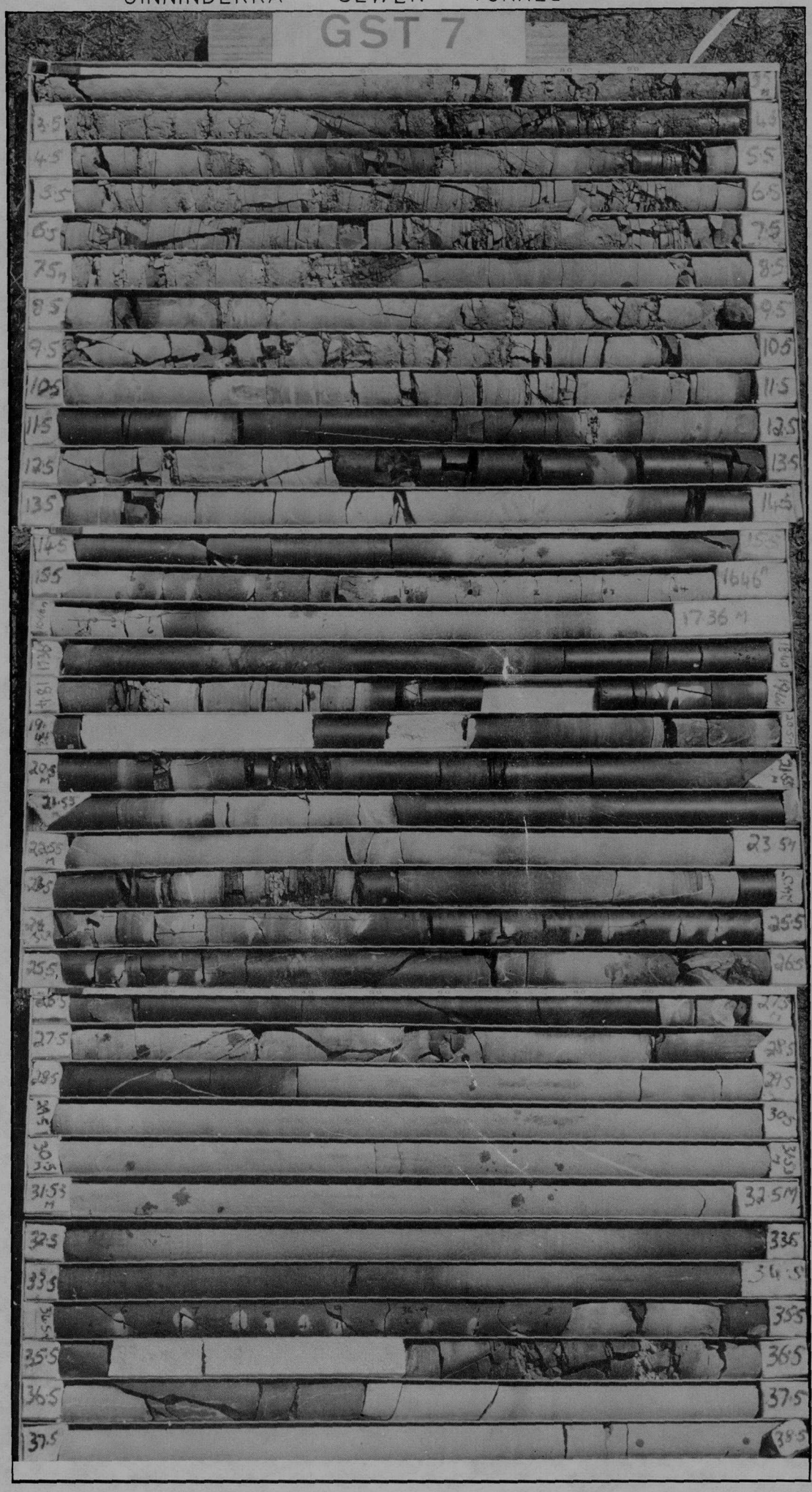
GINNINDERRA SEWER TUNNEL

GINNINDERRA SEWER TUNNEL




GINNINDERRA SEWER TUNNEL GST 6
9M
ROCK ROLLED
CORE LOSS
10M
11M
12M
CORE LOSS
13M
CORE LOSS
CORE LOSS
14M
15M
16M
CORE LOSS
17M
18M
19M
20M
21M
22M
23M
24M
CORE LOSS
25M
CORE LOSS
26M
CORE LOSS
27M
28M
CORE LOSS
29M
30M
CORE LOSS
31M
32M
CORE LOSS
MATERIAL AS ABOVE FROM BORE CASINGS
33M

GINNINDERRA SEWER TUNNEL



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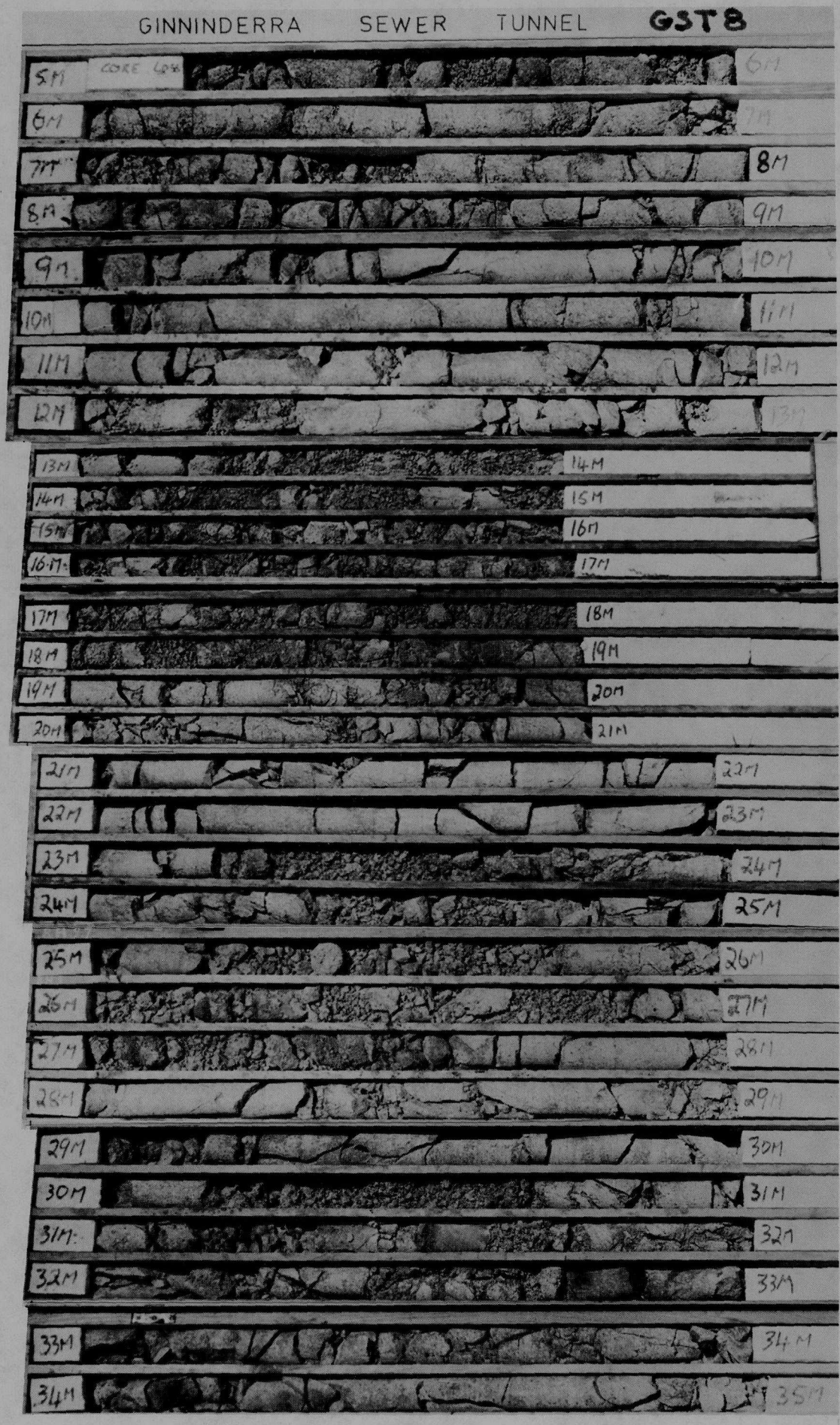
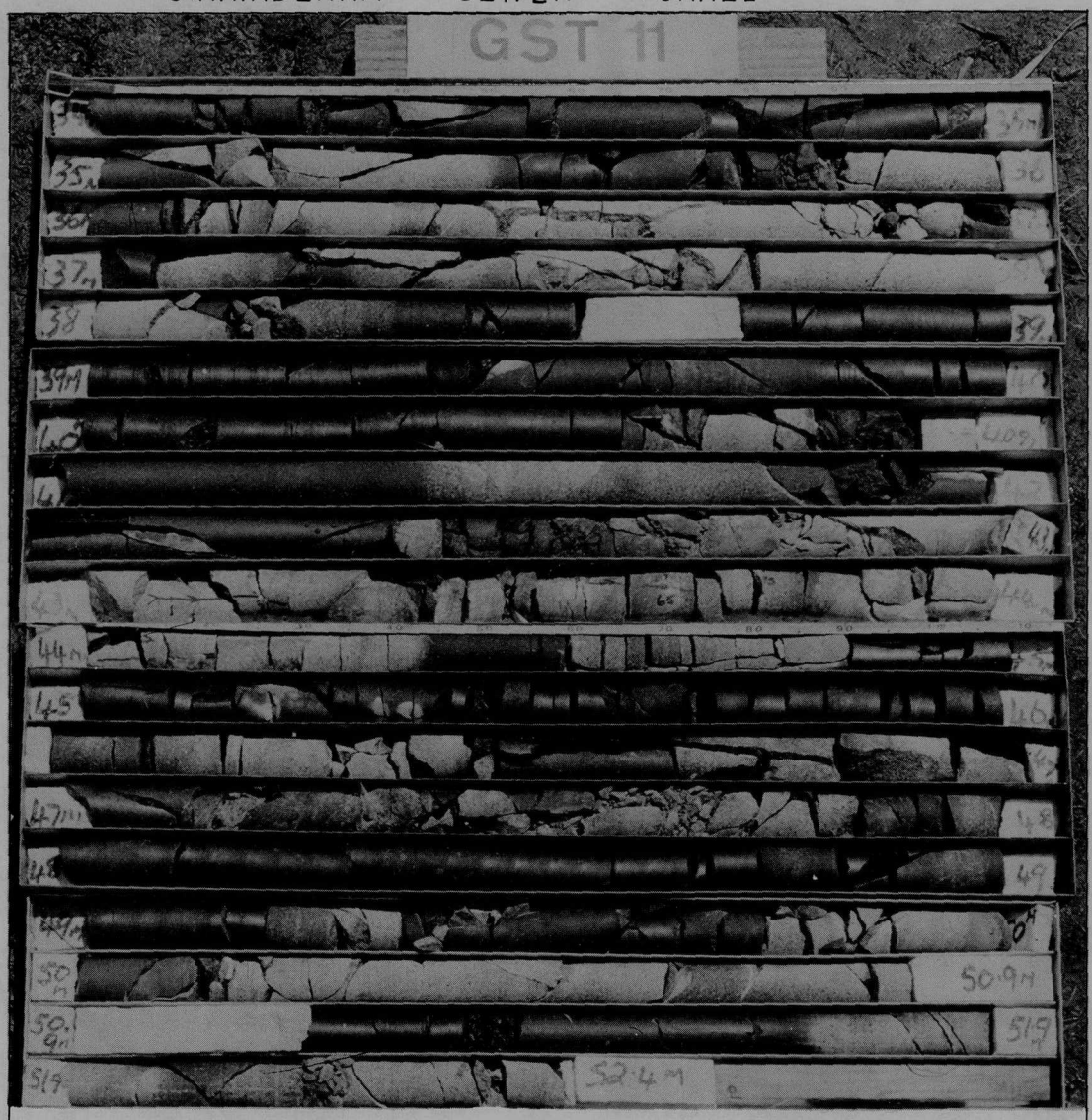

GINNINDERRA SEWER TUNNEL GST8
5M CORE LOSS
6M
7M
8M
9M
10M
11M
12M
13M
14M
15M
16M
17M
18M
19M
20M
21M
22M
23M
24M
25M
26M
27M
28M
29M
30M
31M
32M
33M
34M
35M

GINNINDERRA SEWER TUNNEL

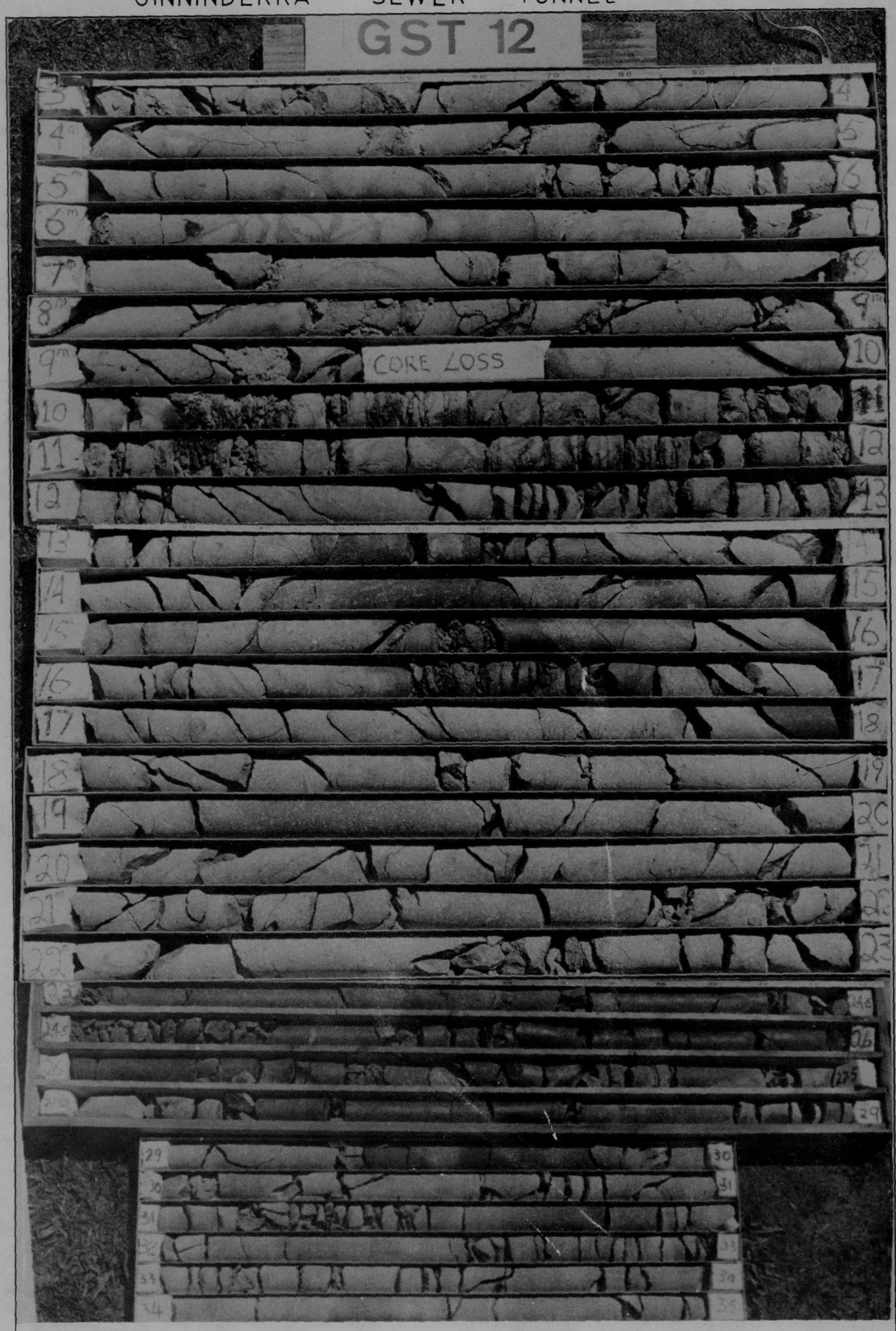
GINNINDERRA SEWER TUNNEL

GINNINDERRA SEWER TUNNEL

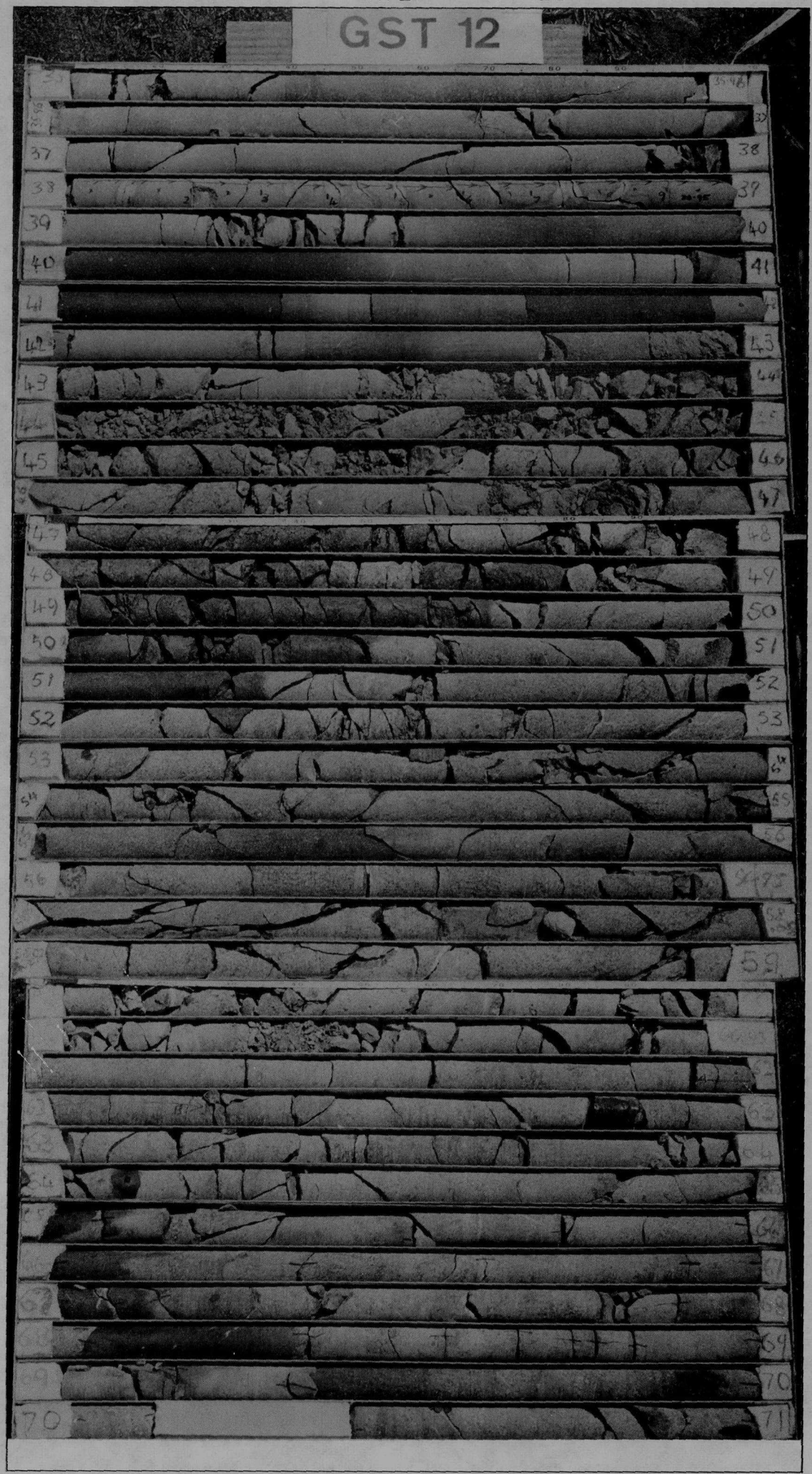
GINNINDERRA SEWER TUNNEL



GINNINDERRA SEWER TUNNEL



GINNINDERRA SEWER TUNNEL



GINNINDERRA SEWER TUNNEL

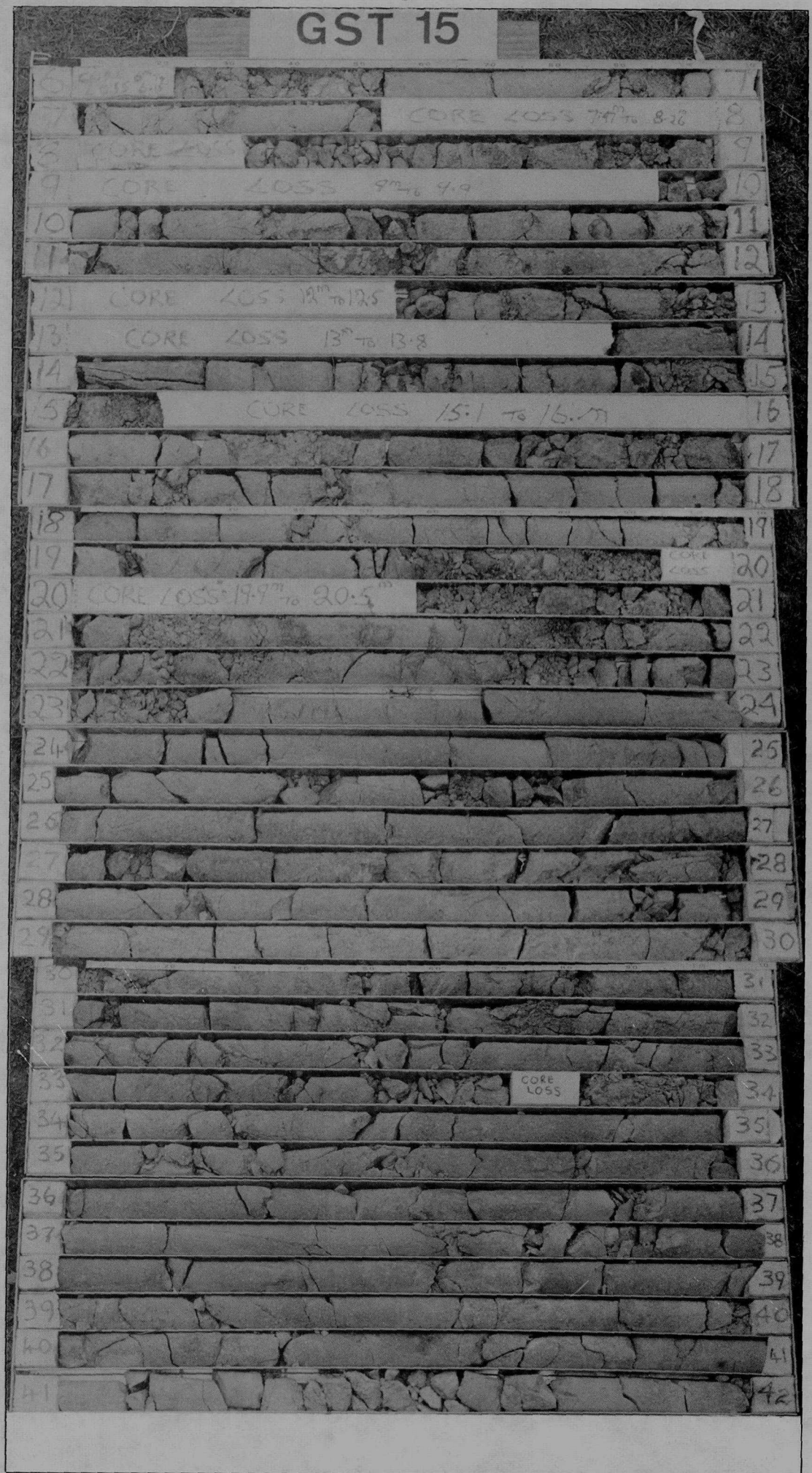
GINNINDERRA SEWER TUNNEL

GINNINDERRA SEWER TUNNEL

GINNINDERRA SEWER TUNNEL

GINNINDERRA SEWER TUNNEL

GINNINDERRA SEWER TUNNEL



GINNINDERRA SEWER TUNNEL

GINNINDERRA SEWER TUNNEL

GINNINDERRA SEWER TUNNEL

GINNINDERRA SEWER TUNNEL

GINNINDERRA SEWER TUNNEL

APPENDIX 8

GEOLOGICAL LOGS OF DIAMOND-DRILL HOLES

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT GINNINDERRA SEWER TUNNEL
LOCATION At chainage 2593 on centre line of tunnel. Approx. 600m SW of Belconnen Sub Station.
ANGLE FROM HORIZONTAL (θ) 0 DIRECTION
COORDINATES 198417E 612416N R L OF COLLAR 573·9m

HOLE NO GST.1 CANBERRA-108

SHEET 1 OF 4

Rock Type and Degree of Weathering	Description Lithology, colour, strength, etc	Lift and % core recovery	Depth (m)	Fracture Log	RQD	Structures Joints, veins, seams, faults, etc	Water Level
NOT	CORED	4·57	0–4.57 (HQ 635 at ~3.7)				
NO	CORE	25%	4.57–6.3				
EW Granite Porphyry	Yellow brown clayey sand to sandy clay.	7·01	6.3–7.01	N/A	0	SOIL PROPERTIES	
NO	CORE		7.01–8.0				▽ 22/1/75 (at ~8.0)
EW Granite Porphyry	Yellow brown clayey sand.	40% / 9·14	8.0–9.14	N/A	0	SOIL PROPERTIES	
NO	CORE	35%	9.14–10.8				▽ 5/5/75 (at ~9.4)
EW Granite Porphyry	Yellow brown clayey sand.	11·58	10.8–11.58	N/A	0	SOIL PROPERTIES	
NO	CORE	50%	11.58–12.3				
EW Granite Porphyry.	Yellow brown clayey sand.	13·11	12.3–13.11	N/A	0	SOIL PROPERTIES	
NO	CORE	10%	13.11–15.8				
HW	Yellow grey brown HW granite qzt, felspar + biotite. Phenocrysts up to 4mm. Weak, soft.	16·15	15.8–16.15	N/A	0		
NO	CORE	0% / 19·20	16.15–20				
		15%	19.20–20				

Casing: NOT PERFORATED (approx. 9–12 m); PERFORATED (approx. 17–19 m)

Drill type MAYHEW 1000
Feed HYDRAULIC
Core barrel type TREIFUS HQ, WIRE LINE
Driller L. KEAST (BMR)
Commenced 6/12/74
Completed 14/1/75
Logged by P.A. LANG
Vertical scale 1cm = 1m
Checked by D.C.P.

Notes

Fracture Log — Number of fractures per 25 cm of core. Zones of core loss blocked in
Bedding and Joint Planes — Angles are measured relative to a plane normal to the core axis
Defect spacing — av spacing of natural defects (shears, joints, fractures) occurring at specified intercept angle range
Water Level Measurements — ▼ Level when hole in progress at specified depth; ▽ Level in completed hole on specified date

EW–HW GRANITE PORPHYRY
NO CORE
N/A NOT APPLICABLE

Water Pressure Tests

* Values in lugeons should be read in conjunction with computation sheets. Test sections are indicated by blocked in strips

Core Photograph Negative No
Depth (m) Black & White Colour

155/A16/1467 1of4

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT GINNINDERRA SEWER TUNNEL
LOCATION At chainage 2593 on centre line of tunnel. Approx. 600m SW of Belconnen Sub Station.
ANGLE FROM HORIZONTAL (θ) 0 DIRECTION —
COORDINATES 198417E 612416N R.L. OF COLLAR 573.9m

HOLE NO GST 1 CANBERRA-108
SHEET 2 OF 4

Rock Type and Degree of Weathering	Description Lithology, colour, strength, etc	Casing	Graphic Log	Lift and % core recovery	Depth and size of Core	Fracture Log (0 6 12 18+)	RQD	Defect spacing Intercept Angle (0 30 60 80 90)	Structures Joints, veins, seams, faults, etc	Water Level	Water Pressure Test Losses (Lugeons) *
NO	CORE			15%							
EW-HW	As above but darker coloured. Much sand soft, weak.			21.34	21	N/A	0		SOIL PROPERTIES		
NO	CORE			10 %	22						
					23 HQ 635cm						
HW	"			24.39	24	N/A	0				
NO	CORE			20%	25						
HW	"			25.60		N/A	0				
MW Granite Porphyry	Medium grained, light grey granite porphyry		+	100%	26		20	core fragmented by joints at 0-30° 60°, 90°.			
			+	26.97	27						
			+	100%			20		Very close jointed. Most of core fragmented. Some pieces up to 15cm Joints wavy & irregular limonite staining on joints. No clay.		
			+	28.20	28						
			+	100%			0				
			+	29.57	29						
SW Granite Porphyry	Medium grained, light grey granite porphyry.		+	100%	30		50	core very close jointed. Joints at 0-30° spaced 3cm at 45° spaced 8cm at 60°, spaced 10cm.	← Clay veneer on joints		
			+	30.48							
			+	100%	31		60	Joints at 20° spaced 20-30 cm.			
			+	31.70							
Mainly FS to SW Granite Porphyry			+	100%	32		50	core fragmented. Joints 0-30°, 60° 90°	Joints wavy & irregular some slickensides. Chlorite & limonite on joints. No clay.		
			+	32.57							
			+	100% 33.18	33		50	most joints 0-30° spaced 10-20 cm some 45°-60°, spaced 50 cm.			
			+	100%	34		60				
			+	35.05	35						
NOT	CORED Rock Rolled			0% 35.66			0				
SW-FS Granite Porphyry	AS ABOVE		+	100% 35.97	36		80	most fracture sub horizontal spacing 30 cm.	Joints rough & irregular some limonite staining No clay.		
			+	100%	37		80				
			+	38.10	38						
			+	100%	39		75				
SW-MW			+		40						

Drill type MAYHEW 1000
Feed HYDRAULIC
Core barrel type TREFUS HQ WIRE LINE
Driller L.KEAST (BMR)
Commenced 6/12/74
Completed 14/1/75
Logged by P.A.LANG
Vertical scale 1cm = 1m
Checked by D.C.P.

Notes

Fracture Log — Number of fractures per 25 cm of core. Zones of core loss blacked in.

Bedding and Joint Planes — Angles are measured relative to a plane normal to the core axis.

Defect spacing — av. spacing of natural defects (shears, joints, fractures) occurring at specified intercept angle range.

Water Level Measurements — ▼ Level when hole in progress at specified depth. ▽ Level in completed hole on specified date.

GRANITE PORPHYRY

EW — COMPLETELY WEATHERED
HW — HIGHLY WEATHERED
MW — MODERATELY WEATHERED
SW — SLIGHTLY WEATH.
FS — FRESH STAINED
N/A — NOT APPLICABLE

Water Pressure Tests

* *Values in lugeons should be read in conjunction with computation sheets. Test sections are indicated by blacked in strips.*

Core Photograph Negative No.

Depth (m)	Black & White	Colour

155/A16/1467 2 of 4

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT GINNINDERRA SEWER TUNNEL
LOCATION At chainage 2593 on centre line of tunnel. Approx. 600m SW of Belconnen Sub Station.
ANGLE FROM HORIZONTAL (θ) 0 DIRECTION —
COORDINATES 198417E 612416N R.L. OF COLLAR 573·9m

HOLE NO GST 1 CANBERRA 108
SHEET 4 OF 4

Rock Type and Degree of Weathering	Description Lithology, colour, strength, etc	Casing	Graphic Log	Lift and % core recovery	Depth and size of Core	Fracture Log	RQD	Defect spacing Intercept Angle 0 30 60 80 90	Structures Joints, veins, seams, faults, etc	Water Level	Water Pressure Test Losses (Lugeons) *
FR crystal tuff arenite	Pale grey massive. Mod strong, hard to very hard.			100%	HQ 535cm	0 6 12	100		Some veining up to 1 mm thick. Most joints at 0°-20° A few widely spaced at about 60°. Joints moderately to widely spaced and tight. Ca deposit on some surfaces. Some fractures are drill induced.		Tight
					61		95				
					62		90				
					63		90				
					64		100				
				100%	65		95				
					66						
FR Shales and tuffaceous siltstone and sandstone.	Blue-grey, fine to medium grained, hard and strong				67		70		Contact strong and intact 0.5cm of calcite at contact BEDDING AT 10°		Tight except for ↙
					68		80		} Up to 5mm of soft calcite on joint surfaces		
					69		90		Most joints parallel to bedding. A few widely spaced joints occur normal to bedding		
	END OF HOLE 69.35m										

Drill type MAYHEW 1000
Feed HYDRAULIC
Core barrel type TREIFUS HQ, WIRE LINE
Driller L. KEAST (BMR)
Commenced 6/12/74
Completed 14/1/75
Logged by P A LANG
Vertical scale 1cm = 1m

Checked by DCP

Notes

Fracture Log — Number of fractures per 25 cm of core. Zones of core loss blacked in

Bedding and Joint Planes — Angles are measured relative to a plane normal to the core axis

Defect spacing - average spacing of natural defects (shears, joints, fractures) occurring at specified intercept angle range

Water Level Measurements — ▼ Level when hole in progress at specified depth
▽ Level in completed hole on specified date

SEE PREVIOUS

Water Pressure Tests

* Values in lugeons should be read in conjunction with computation sheets. Test sections are indicated by blacked in strips.

Core Photograph Negative No

Depth (m)	Black & White	Colour

155/A16/1467 4 of 4

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT GINNINDERRA SEWER TUNNEL*
LOCATION At station 9+97m. on centre line of old alignment of tunnel at northend. 800m. north of Parkwood Road. A.C.T.
ANGLE FROM HORIZONTAL (θ) 90° DIRECTION —
COORDINATES 199039E 6118821 R.L. OF COLLAR 563.5m.

HOLE NO G.S.T. 2.
CANBERRA 104
SHEET 1 OF 3

Drilling Information						Rock Substance			Rock Mass Defects			
Method	Casing	Water	Pressure test * (lugeons)	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description rock type: grain characteristics colour, structure, minor components	Weathering	Strength Is (50) (MPa) 0.03 0.3 3 10 30 100 300	Defect spacing (cm) 3 10 30 100 300	Defect description thickness, type, inclination, planarity, roughness, coating, strength. Particular / General	Rock condition No
ROCK ROLLING	NOT RECORDED	30/1	NOT TESTED	NOT CORED	1 2 3 4 5 6 7 8 9 10 11 12 13 14	NOT CORED	NOT CORED				NOT CORED	
DIAMOND DRILLING with BQ CORE BARREL				100%	15		DACITE Light grey, very hard, very strong. Quartz phenocrysts up to 3mm., pink feldspar phenocrysts. Calcite and epidote veins common.	MW to SW			Core fragmented most breaks (70%) at 30° - 45°. 10% at 80° - 90°. 20% at 0 - 30°. Joints, tight. Planar and rough to smooth. Cemented with pink calcite (cement moderately strong). Calcite and epidote veins up to 1cm. (strong).	3
				100%	16							
				100%	17			FS to FR			70% of breaks at 45° spaced 7 - 150cm 30% of breaks at 0 - 10° spaced 10 - 200 cm.	
				100%	18							
				100%	19			FR				2

Drill type Gemco
Feed Hydraulic
Core barrel type BQ 1 7/16" with WIRE LINE
Driller G. Brandon (BMR)
Commenced 20-11-74
Completed 12-2-75
Logged by P. Lang
Vertical scale 1cm = 1m

Weathering
Fr — Fresh
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. Test sections are indicated by blacked in strips.

Core Photograph Negative No

Depth (m)	Black & White	Colour

155/A16/1468 1 of 3

M(Pt) 221

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT GINNINDERRA SEWER TUNNEL
LOCATION At start of line of old alignment of tunnel at northend. 800m north of Packwood Rd. A.C.T.
ANGLE FROM HORIZONTAL (θ) 90° DIRECTION —
COORDINATES 199039E 11885N R.L. OF COLLAR 563.5m

HOLE NO GST 2
CANBERRA 109
SHEET 2 OF 3

Drilling Information | Rock Substance | Rock Mass Defects

Method	Casing	Water	Pressure test * (lugeons)	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description: rock type: grain characteristics, colour, structure, minor components.	Weathering	Strength Is (50) (MPa) 0.03 0.1 0.3 1.0 3.0 10.0	Defect spacing (cm) 3 10 30 100 300	Defect description: thickness, type, inclination, planarity, roughness, coating, strength. Particular / General	Rock condition No.
DIAMOND DRILLING - WIRELINE with DOUBLE TUBE BQ core barrel (1 7/16")			NOT TESTED	100%	21		DACITE Light grey, very hard, very strong. Pink calcite & green epidote veins from 2mm to 2cm wide, spaced 30cm to 2m.	FR			Joints very tight. Planar and rough to smooth. Joints generally cemented with pink to yellow calcite. Cement moderately strong. Calcite and epidote veins up to 1cm wide spaced 10cm to 2m. Rock would tend to break along these veins and cemented joints when tested.	2
				76%	22							
				92%	23							
				100%	24							
				100%	25							
					26							
					27							
				100%	28							
					29							
					30		As above but with more calcite and epidote veins					
				100%	31							
				96%	32			SW to FS				
				94%	33							
					34	loss						3
				87%	35			FR				
				100%	36			Mainly FR, some SW and FS.			Clay fillings up to 1cm in joints.	
					37	Core loss						4
				0%	38							
				90%	39							

Drill type Gemco
Feed Hydraulic
Core barrel type BQ 1 7/16" with WIRE LINE
Driller G. Brandon (BMR)
Commenced 20-11-74
Completed 19-2-75
Logged by P. Lang
Vertical scale 1cm ≡ 1m

Weathering
Fr — Fresh
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. Test sections are indicated by blacked in strips.

Core Photograph Negative No.

Depth (m)	Black & White	Colour

155/A16/1468 2 of 3

M(Pf) 221

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT GINNINDERRA SEWER TUNNEL
LOCATION At station 9+91m on centre line of old alignment of tunnel at northend 300m north of Parkwood Rd. A.C.T.
ANGLE FROM HORIZONTAL (θ) 90
DIRECTION —
COORDINATES 199039E 611885N
R.L. OF COLLAR 563.5m

HOLE NO. CSI 2
CANBERRA 1C?
SHEET 3 OF 3

Depth (metres)	Lift & % core recovery	Graphic log & core loss	Substance description	Weathering	Defect description – Particular	Defect description – General	Rock condition No.
40–41	90%	Core loss	DACITE. Light grey to dark grey to pink. Probably bedded ignimbrite with zones of alteration.	Mainly SW in places. FR. Some	Clay seams on joints up to 1cm. thick.	Rock mass seamy. Epidote & calcite veins common. Clay seams and clay on some Joints	4
41–43	98%						
43–44	100%			FR		Rockmass moderately tight. Joints generally weakly cemented with calcite and epidote veins. Calcite and epidote prolific. Joints mostly orientated at 30° spaced 10–60cm. some at 60°.	mostly 3 some 4
44–45	93%		Light grey and pink with epidote calcite veins.				
45–46	85%						
46	100%		Dark grey	Mainly FR, but with zones of alteration.	Rock hard Joints tight		
46–47			Medium grey altered				
47			Pink				
47–49	75%		Medium grey altered				
49		Core loss					
50–52	97%						
52			Medium grey altered				
52–53			Pink altered				
53–55	100%				Core fragmented limonite and calcite on joints.	Rock mass moderately tight. Some clay joint in places. Joints generally weakly cemented with pink calcite. Joints generally at 30°–45°. Some at 80°–90°.	
55–56	100%		Light grey Dacite		Clay seams		
56–58	100%						
58–59	100%						
59–60	100%						

60.27 m.

Method: DIAMOND DRILLING with BQ 1 7/16" WIRELINE DOUBLE TUBE CORE BARREL

Pressure test * (lugeons): NOT TESTED

Drill type Gemco
Feed Hydraulic
Core barrel type BQ 1 7/16" with WIRE LINE
Driller G. Brandon (BMR)
Commenced 20-11-74
Completed 14-2-75
Logged by F. Lang
Vertical scale 1cm = 1m

Weathering
Fr — Fresh
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. Test sections are indicated by blacked in strips.

Core Photograph Negative No.

Depth (m)	Black & White	Colour

155/A16/1466 3-53

M(Pf) 221

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT GINNINDERRA SEWER TUNNEL
LOCATION At inlet drop shaft at station 4+99 on centreline of tunnel.
ANGLE FROM HORIZONTAL (θ) 90° DIRECTION —
COORDINATES E 198948 N 612424 R.L. OF COLLAR 547.1m

HOLE NO GST 2
SHEET 1 OF 2

Drilling Information						Rock Substance				Rock Mass Defects		
Method	Casing	Water	Pressure test * (lugeons)	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description rock type: grain characteristics colour, structure, minor components.	RQD	Weathering	Strength Is (50) (MPa) 0·03 0·03–1 1·00 3·0·0	Defect spacing (cm) 3 30 100 300	Defect description thickness, type, inclination, planarity, roughness, coating, strength. Particular / General	Rock condition No.
Rock Rolled				NOT CORED	1	NOT CORED	NOT CORED						
NMLC		13/8	NOT TESTED	15	2	Core loss	insitu EW DACITE Yellow brown sandy clay to clayey sand.		EW			Mass has soil properties. Clayey sand. Most of the material is washed out during drilling. Will need support in shaft. Easily excavated by shovel to 9m.	5
				25	3	Core loss							
				40	4	Core loss		0					
				25	5	Core loss							
				23	6	Core loss							
				60	7	Core loss							
				100	8	loss							
				100	9		DACITE Light grey with quartz phenocrysts and pink feldspar in places. Also quartz epidote veins. Very hard, very strong.	80				2 x 70°-80° Joints at 60° to each other.	
				100	10			100				60° Joint	
				100	11			100					
				100	12			100	FS				
				100	13			100					
			0	100	14			75	SW			70° joint and 2 x 30° joints.	2
				100	15			100	FS				
				100	16			100	HW			7cm HW seam	
				100	17			90				← No natural defects →	
			0	100	18		Possible flow-banding. Dip? 30°-45°	100	FS				
				100	19			100					
				100				85	EW			10cm EW seam.	

Rock mass very strong. Very few natural defects. Most fractures in core are drill induced. Natural joint surfaces are very rough and very tight. Some limonite staining. No calcite. Some quartz-epidote veins (very strong). Note the EW and HW seams at 16.25 & 20m.

Drill type MOLE
Feed Hydraulic
Core barrel type NMLC with triple tube & split inner
Driller B. Harte (DHC)
Commenced 10/6/75
Completed 4/7/75
Logged by P.A. LANG
Vertical scale 1cm = 1m

Weathering
Fr — Fresh
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. Test sections are indicated by blacked in strips.

Core Photograph Negative No.

Depth (m)	Black & White	Colour

155/A16/1469 1of2

M(Pf) 221

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT GINNINDERRA SEWER TUNNEL
LOCATION At inlet drop shaft at station 4+99 on centre line of tunnel
ANGLE FROM HORIZONTAL (θ) 90°
DIRECTION —
COORDINATES E198948 N612424
R.L. OF COLLAR 547·1 m

HOLE NO GST 3
SHEET 2 OF 2

Drilling Information						Rock Substance					Rock Mass Defects		
Method	Casing	Water	Pressure test * (lugeons)	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description: rock type; grain characteristics; colour, structure, minor components.	RQD	Weathering	Strength Is (50) (MPa) 0·03 0·1 0·3 1 3 10 30	Defect spacing (cm) 3 10 30 100 300 1000	Defect description: thickness, type, inclination, planarity, roughness, coating, strength. Particular / General	Rock condition No.
NMLC TUNNEL			0	100	21		DACITE Light grey with quartz, phenocrysts up to 5mm. Quartz & epidote veins with pink feldspar. Extremely hard, extremely strong.	85	FS				
				100				100					
				100	22			100					
			0	100	23			100	FR				
				100	24			100					
				100	25			100					
				100	26			100				2 x 80° joints spaced 5cm with limonite staining.	
				100	27			100	FS FR			Very few natural defects. Most fractures of core are drill induced A few limonite stained joints widely spaced. Joints tight.	2
							END OF HOLE 27·45m.						

TUNNEL

Drill type MOLE
Feed Hydraulic
Core barrel type NMLC with triple tube & split inner
Driller B. Harte (DHC)
Commenced 10/6/75
Completed 4/7/75
Logged by P.A. LANG
Vertical scale 1cm=1m

Weathering
Fr — Fresh
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. Test sections are indicated by blacked in strips.

Core Photograph Negative No

Depth (m)	Black & White	Colour

155/A16/1469 2of2

M(Pf)221

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT GINNINDERRA SEWER TUNNEL
LOCATION At station 7+00 on centreline of tunnel
ANGLE FROM HORIZONTAL (θ) 90° DIRECTION —
COORDINATES E198916 N612225 R.L. OF COLLAR 556.8m

HOLE NO GGT 4
SHEET 1 OF 2

Drilling Information | Rock Substance | Rock Mass Defects

Method	Casing	Water	Pressure test * (lugeons)	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description rock type: grain characteristics colour, structure, minor components.	RQD	Weathering	Strength Is (50) (MPa) 0·03 0·1 0·3 1·00 3·00 10·0	Defect spacing (cm) 3 30 300	Defect description thickness, type, inclination, planarity, roughness, coating, strength. Particular / General	Rock condition No.
Rock Rolled			NOT TESTED	NOT CORED	1–5	NOT CORED	NOT CORED					NOT CORED	
NMLC				0	5	Core loss	EW DACITE Clayey sand to sandy clay - SC - CL.	0	EW			SOIL PROPERTIES	
				80	6			0					
				60	7	Core loss		0					
				0	8	Core loss		0					
				60	9			0					
				80				0					
Rock Rolled		13/8 ▼		NOT CORED	10–14	NOT CORED	NOT CORED					NOT CORED	
NMLC				100	15		DACITE Pale grey, with feldspar phenocrysts stained pink especially in zones of quartz - epidote veining. Quartz phenocrysts glassy and up to 5 mm.	90	SW			EW - HW seam. Some 60°-70° joints with clay.	4
				95	16				HW-EW				
					17			40	SW				
				100					MW			Wavy vertical joints + 45° joint.	
					18			25	SW				
				100	19			0				90° joint	3
				100				60	FS			45° joints.	

Rock mass close jointed mainly 3-15cm with weathered seams. 10 to 30 cm thick spaced approx. 1m. Joints commonly with veneer of clay. Quartz and epidote veins common. Most defects at 30°. Some at 60°.

Drill type MOLE
Feed Hydraulic
Core barrel type NMLC with triple tube & split inner
Driller R. Harte (CHC)
Commenced 7/7/75
Completed 16/7/75
Logged by R.A. LANG
Vertical scale 1cm = 1m

Weathering
Fr — Fresh
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. Test sections are indicated by blacked in strips.

Core Photograph Negative No.

Depth (m)	Black & White	Colour

155/A16/1470 1of2

M(Pf) 221

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

PROJECT GINNINDERRA SEWER TUNNEL
LOCATION At station 7+00 on centreline of tunnel

HOLE NO. GST 4

GEOLOGICAL LOG OF DRILL HOLE

ANGLE FROM HORIZONTAL (θ) 90° DIRECTION —
COORDINATES E 198916 N612225 R.L. OF COLLAR 556·8m.

SHEET 2 OF 2

Drilling Information					Rock Substance				Rock Mass Defects			
Method	Casing	Water	Pressure test * (lugeons)	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description rock type: grain characteristics colour, structure, minor components.	RQD	Weathering	Strength Is (50) (MPa) 0·03 0·003 0·3 3·0	Defect spacing (cm) 30 300 1000 3000	Defect description thickness, type, inclination, planarity, roughness, coating, strength. Particular / General	Rock condition No
NMLC			0	100	20		DACITE - pale grey. Commonly with pink stained feldspar phenocrysts especially in zones of quartz epidote veining. Quartz phenocrysts up to 5 mm. Generally very strong. Extremely strong in zones of no veining.	60	FS			The rock mass is generally close jointed and moderately tight. Defects are mainly joints at 30°, 45°-60° & 90°, and some minor fracture zones up to 20 cm wide at 70°-90°. Most joints are tight and weakly cemented with calcite & epidote. Some joints are fractured with calcite and epidote & some clay. Many quartz-epidote & calcite epidote veins (generally mod. strong).	3
			1·4	100	21			80					
				100	22			80					
				100	23								
				100	24			50					
				100	25			40					
				100	26			100					
			4·2	100	27			70					
			4·4	100	28			95					
				100	29			95					
				100	30			30					
			11·2	100	31			95					
				100	32			40					
				100	33			75					
				100	34								
				100	35								
					36		END OF HOLE 35·83m						

TUNNEL

TUNNEL

Drill type MOLE
Feed Hydraulic
Core barrel type NMLC with triple tube & split inner.
Driller B. Harte (DHC)
Commenced 7/7/75
Completed 16/7/75
Logged by P.A. LANG
Vertical scale 1cm=1m

Weathering
Fr — Fresh
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. Test sections are indicated by blacked in strips.

Core Photograph Negative No

Depth (m)	Black & White	Colour

155/A16/1470 2of2

M(Pf) 221

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT GINNINDERRA SEWER TUNNEL
LOCATION At chainage 210·311 (shaft site) on connection to existing Belconnen Sewer near Belconnen Polution Control Centre
ANGLE FROM HORIZONTAL (θ) 90 — DIRECTION —
COORDINATES E199140 N612425 — R.L. OF COLLAR 557·2 m

HOLE NO. GSJ 5

SHEET 1 OF 2

Drilling information — Method: NMLC (Rock Rolled to approx. 1.5 m); Casing; Water: 27/8 (water level at approx. 5.8 m)

Pressure test * (lugeons): 0–8 m NOT TESTED; 8–11 m: 8; 11–20 m: Unreliable results. W.P.T. show values ranging from 13 - 30 lugeons

Lift & % core recovery	RQD	Weathering
Not Cored		Soil
50 (Loss)	0	Soil
-90	0	EW
-90	0	EW
-90	0	EW
25 (loss)	0	EW
100	60	HW to MW
100	80	SW to FS
100	65	SW
100	0	SW
100	95	FS
100	90	FS
93	85	EW / FS
100	100	FS
100	90	FS
100	100	FS
100	85	FS
100	100	FS
100	100	FS
100	100	FS
100	80	FS
100	93	FS

Rock Substance — Substance description (rock type: grain characteristics, colour, structure, minor components)

0–2 m: SANDY CLAY FILL

4.5–8.5 m: Welded DACITE ignimbrite tuff or flow with banding in places. Mostly pale grey but some narrow bands of dark grey. Quartz phenocrysts up to 7 mm in light grey zones, smaller in dark zones. Pink feldspar in zones of quartz-epidote veining. Rock is extremely hard and extremely strong.

12 m: Dark grey band

13 m: Flow banding, dip approx. 30°-35°.

16 m: Flow banding, dip approx. 30°-35°.

Rock Mass Defects — Defect description (thickness, type, inclination, planarity, roughness, coating, strength)

Particular:

SOIL PROPERTIES
Easily excavatable by mechanical shovel or by back-hoe.

- 1cm HW seam at 60° with limonite staining.
- 3 joints at 60°-70° spaced 10cm with calcite & limonite. These joints are perp to a 30° joint set (spaced 15-40 cm), which is parallel to flow banding.
- 10 cm HW seam between joints at 30° and 60°.
- 2 joint sets at 30° each spaced 15cm + 1 at 60° spaced 30 cm.
- Core close jointed.
- 2 limonite stained joints at 60° spaced 10cm.
- 2 limonite stained joints at 0° & 60°.
- 14cm EW seam clayey sand, dip approx. 45°.
- Joints at approx. 30° parallel to banding, limonite stained, spaced 20 cm.
- 3 joints at 30°-45° spaced 2 cm with 1mm clay, calcite.
- 2 joints at 80° spaced 1cm with calcite & limonite.
- Pink calcite veins at 45°-60° not parallel to banding
- Joints at 30° parallel to banding spaced 30 cm with 1-2mm calcite.

General:

(0–4.5 m) Vertical slopes will need steel ring support with full timber lagging. — Rock condition No. 5

(4.5–10.5 m) Generally sound rock but with some weathered seams. 2 prominent joint sets above 7.5m. 1 at 30° parallel to banding spaced 15-40 cm and one at 60° perp. to banding spaced 10-30 cm. Below 7.5m another joint set at 30° not parallel to banding. Joints are mostly slightly open, limonite stained or weathered. Possibly some rock bolts & mesh in place. — Rock condition No. 3-4

(10.5–20 m) Rockmass generally very strong. Joints mostly at about 30°. Generally spaced 30 cm - 1m. (except from 16-19m). Surfaces generally rough & tight, commonly with flakey pink calcite cement (weak). Some joints are slightly open with limonite staining. Probably no support required but possibly a few random rock bolts. — Rock condition No. 2-3

TUNNEL (at approx. 19.5 m)

Drill type MOLE
Feed Hydraulic
Core barrel type NMLC with triple tube & split inner
Driller B. Harte (DHC)
Commenced 9/8/75
Completed 20/8/75
Logged by P.A. LANG
Vertical scale 1cm ≡ 1m

Weathering: Fr — Fresh; 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. Test sections are indicated by blacked in strips.

Core Photograph Negative No. — Depth (m) / Black & White / Colour

155/A16/1471 1of2

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT GINNINDERRA SEWER TUNNEL
LOCATION At chainage 210·311 (shaft site) on connection to existing Belconnen Sewer near Belconnen Polution Control
ANGLE FROM HORIZONTAL (θ) 90° DIRECTION —
COORDINATES E 199140 N 612425 R.L. OF COLLAR 557·2m

HOLE NO. GST 5 Centre.
SHEET 2 OF 2

Drilling Information						Rock Substance				Rock Mass Defects		
Method	Casng	Water	Pressure test * (lugeons)	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description rock type: grain characteristics colour, structure, minor components	RQD	Weathering	Strength Is (50) (MPa)	Defect spacing (cm)	Defect description thickness, type, inclination, planarity, roughness, coating, strength Particular / General	Rock condition No
NMLC TUNNEL			SEE ABOVE	100 / 100 / 100 / 100	21		DACITE as above. Light to medium grey becoming darker below 20·7m. Some pink feldspar below 21m banding at approx. 30-35°.	100 / 100 / 95 / 100	FS			Rockmass is very strong. Joints mostly at about 30° (not parallel to banding) Spaced 1m. above 21m, spaced 10-30 cm below 21m. Surfaces generally rough & tight with 1-2mm calcite.	2-3 TUNNEL
					22		END OF HOLE 21·7m						

Drill type MOLE
Feed Hydraulic
Core barrel type NMLC with triple tube & split inner
Driller B. Harte (DHC)
Commenced 9/8/75
Completed 20/8/75
Logged by R. ALANG
Vertical scale 1cm = 1m

Weathering
Fr — Fresh
SW — Slightly weathered
MW — Moderately weathered
HW — Highly weathered
EW — Extremely weathered

Water
10 Oct. '73 water level data 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. Test sections are indicated by blacked in strips.

Core Photograph Negative No.

Depth (m)	Black & White	Colour

155/A16/1471 2012

MP(P)221

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT GINNINDERRA SEWER TUNNEL
LOCATION ON TUNNEL C/L AT STN. 13+60 m
ANGLE FROM HORIZONTAL (θ). −45° DIRECTION. 203°(GRID)
CO-ORDINATES E 198813 N611573 R.L. OF COLLAR 554.4m

HOLE NO. GST 6
SHEET 1 OF 2

Drilling Information							Rock Substance		Rock Mass Defects					
Method	Drilling rate	Casing	Water	Pressure test * (lugeons)	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description: rock type : grain characteristics; colour, structure, minor components	Weathering	Point load strength Is(50)(MPa): 0.3 / 1.0 / 3.0 / 10	Defect spacing (cm): 3 / 10 / 30 / 100 / 300	R.Q.D.	Defect description: thickness, type, inclination, planarity, roughness, coating, strength. Particular — General	Rock condition No (interpretive)
ROCK ROLLED			water flowing from hole - slight			1 2 3 4 5 6 7 8 9		NOT CORED						
						9.5m	loss							
NMLC				NOT TESTED	95	10	+	GRANITE PORPHYRY Light blue-grey where fresh	HW and MW				Rock closely jointed. Joint surfaces often crushed. At least 50% of core is fragmented. Rock mass weak.	
					100	11	+							
					80	12	loss +							
					95	13	loss +					0		
					100	14	+							
					80	15	loss +		MOSTLY SW				Rock closely jointed. Core fractured. Rock mass loose and fairly weak. Individual rock fragments mostly hard and strong.	
					100	16	+							
					100	17	+					10		
					100	18	+					0		
					80	19	+							
					80	20	+					0		
					100									

Drill type CRAELIUS
Feed HYDRAULIC
Core barrel type NMLC Triple tube
Driller DHC
Commenced
Completed
Logged by D.C-Purcell
Vertical scale 1cm : 1m

Weathering
Fr – Fresh
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

155/A16/1493 1 of 2

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT GINNINDERRA SEWER TUNNEL
LOCATION ON TUNNEL C/L AT STN. 13+60m
ANGLE FROM HORIZONTAL (θ) −45° DIRECTION 203° (Grid)
CO-ORDINATES E 198813 N611573 R.L. OF COLLAR 554.4m

HOLE NO. GST 6
SHEET 2 OF 2

Drilling information							Rock Substance			Rock Mass Defects			
Method	Drilling rate	Casing	Water	Pressure test * (lugeons)	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description: rock type, grain characteristics, colour, structure, minor components	Weathering	Point load strength Is(50) (MPa) 0.3 1.0 3.0 10.0	Defect spacing (cm) 3 10 30 100 300	RQD	Defect description: thickness, type, inclination, planarity, roughness, coating, strength (Particular / General)	Rock condition No. (interpretive)
NMLC			Water flowing from hole 5/12/75		100	20	+	GRANITE PORPHYRY	SW and MW			20	As above. Heavy limonite staining above 24m. Rock closely jointed and fractured.	4 TO 5
					100	21	+							
					100	22	+					0		
					100	23	+		FRS				← Calcite vein	
					100	24	+					30	Below 24m the rock is tighter and the joints are mostly slickensided. Rock mass weak.	
					40	25	+							
					0	26	Loss					0		
					95	27	+							Mostly 4 some 5
					90		+							
					80	28	+		FR			10	As above. Some fractures appear drill-induced. Rock mass remains weak	
					80	29	loss							
					0	30	+					0		
					70	31	loss							
					10	32	+	This section of core obtained from bore washings. Therefore no structure obtained.				?		
						33	+	END OF HOLE 33.0m						
								Note: Tunnel crown not reached with this hole.						

Drill type CRAELIUS
Feed HYDRAULIC
Core barrel type NMLC Triple tube
Driller OHC (Harte)
Commenced
Completed
Logged by D C Purcell
Vertical scale 1cm : 1m

Weathering
Fr – Fresh
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

155/A16/1493 2 of 2

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT GINNINDERRA SEWER TUNNEL
LOCATION At SHAFT 2.4m west of centre line of Tunnel at Station 17+12
ANGLE FROM HORIZONTAL (θ) 90° DIRECTION —
COORDINATES E 198,757; N 611,225 R.L. OF COLLAR 563.0 m

HOLE NO GST 7
SHEET 1 OF 3

Drilling Information						Rock Substance					Rock Mass Defects		
Method	Casing	Water	Pressure test * (lugeons)	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description · rock type: grain characteristics colour, structure, minor components.	RQD	Weathering	Strength Is (50) (MPa) 0.3 0.03 0.003	Defect spacing (cm) 3000 300 30	Defect description thickness, type, inclination, planarity, roughness, coating, strength. Particular / General	Rock condition No.
Rock Rolled				Not Cored	1								
		▼ 18/6/75			2								
					3		CLAY orange-yellow to pale grey, high plasticity					clay	
				100	4		SHALE Dark brown laminated from 0.5mm to 10mm	0	HW-MW			Rockmass is weak but tight. Defects are mainly bedding planes. These are spaced 1mm to 5cm, but generally 0.5-2cm, 70°-80° jts are also present and some places spaced down to 2cms. Rock would probably fragment to gravel size on blasting. Joints & bedding planes gen. stained with limonite. Rock is clayey in some areas. Several clay seams & clayey zones. All joints & bedding planes appear tight.	5
				100	5		Some thin beds of tuffaceous sandstone up to 3cm. thick (10%)	0					
				100	6		Bedding dips approx. 10°. Soft Weak	0					
				100	7			0					
				100	8		mainly TUFFACEOUS SANDSTONE (80%) with some thin beds & intraclasts of shale.	30	mainly MW			Rockmass is stronger than above & improves with depth. Defect spacing is more variable. Bedding planes in sandstone less common & stronger than in the overlying shale. Defects are mainly joints at 60°-90° and drill induced fractures at 0-20°. Several clay seams & clayey zones 1-5cm wide spaced 20cm - 1m. Joints with limonite staining.	4
				100	9		Mod. soft, Mod weak	20					
				100	10			0					
				100				0					
				100	11			40					
				100	12		mainly SHALE Black. Some thin beds of Tuffaceous sandstone (dacite crystal tuff arenite)	50	SW-FS				3-4
				100	13		Hard. Mod weak	50					
				100	14		DACITE crystal tuff arenite with some inclusions and intraclasts of black shale	90	FR			Rock mass very strong. Continuous sticks of core up to 2m. Very few jts. Some jts near top, orientated at 60°, weakly cemented with powdery calcite. Some thin calcite veins (1mm thick) at 60°	2
				100	15								
				100	16		Very hard. Very strong	98					
				100	17								
				100	18			96				5cm clay seam horizontal	drill induced fractures horizontal, spaced 0.5-40 cms. Bedding planes & jts very tight & strong. Very few natural jts.
				100	19		SHALE Black, laminated, but bedding planes tight and strong, dip approx. 5°	85					
					20		Hard Mod. strong						

NMLC

NOT TESTED

0

0

grout

steel ring support & timber lagging necessary

may need steel ring support & timber lagging

Drill type MOLE
Feed Hydraulic
Core barrel type NMLC triple tube & split inner tube
Driller Bill Harte (D.H.C.)
Commenced 27/5/75
Completed 7/6/75
Logged by P. Lang
Vertical scale 1cm = 1m

Weathering
Fr — Fresh
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. Test sections are indicated by blacked in strips.

Core Photograph Negative No
Depth (m) | Black & White | Colour

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MP(P1)221

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

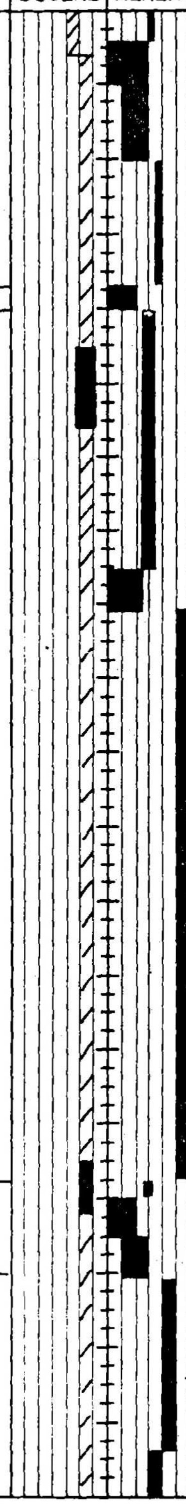
GEOLOGICAL LOG OF DRILL HOLE

PROJECT GINNINDERRA SEWER TUNNEL
LOCATION At SHAFT 2, 4m west of centre line of Tunnel at Station 17+12
ANGLE FROM HORIZONTAL (θ) 90°
DIRECTION —
COORDINATES E198,757; N611,225
R.L. OF COLLAR 56.0 m
HOLE NO GST 7
SHEET 2 OF 3

Drilling Information | Rock Substance | Rock Mass Defects

Method: NMLC

Depth (metres)	Pressure test * (lugeons)	Lift & % core recovery	Substance description (rock type: grain characteristics, colour, structure, minor components)	RQD	Weathering	Defect description – Particular	Defect description – General	Rock condition No.
20–20.6	0		SHALE as above	85		shale fractured along bedding planes (horizontal)	Rockmass is tight. Generally defects spaced 20 cm - 1 m, but narrow bands of shale are losely fractured along bedding planes (horizontal). Natural fractures in tuff are generally 60-80° + strongly cemented c calcite	3
20.6–21.6		100	mainly DACITE TUFF Some thin beds of shale & poorly sorted sandstone, some intra clasts of shale dip approx 5°	50	FR	Probably mostly drill induced in tuff.		
21.6–23		100		88				
23–24		100		97				
24–25		100		80	FS	Shale fractured along bedding planes (horizontal)		
25–26.5		100	shale & sandstone bands and contorted shale bands + intraclasts	95				
26.5–28		100		60		fractures at 60°-80°		
28–29.5	0	100	DACITE IGNIMBRITE TUFF Medium grey. Massive, becoming finer towards top (probably top of a flow?)	95	FR		No natural fractures. Core broken at end of each run and to fit into core box.	1
29.5–31		100		100				
31–32.5		100		100				
32.5–34		100		100				
34–35.5	NOT TESTED	100		100				
35.5–37	0	100		50	FS	Rock is fractured with calcite + clay seams up to 3 cms. Joints at 20°, spaced 10-30 cms c clay. Joints at 70°-80° c limonite staining.		3
37–38.5		100	TUFF (as above) becoming finer grained + more sandy towards 36m. (probably top of a flow?)	97	FR		Very few natural fractures. Most fractures drill-induced. Sticks of core 30 cm-2m.	1-2
38.5–40		100	fine grained band.	10(		fractures probably drill induced		



TUNNEL

Drill type MOLE
Feed Hydraulic
Core barrel type NMLC triple tube c split inner tube
Driller Bill Harte (D.H.C)
Commenced 29/5/75
Completed 7/6/75
Logged by P Lang
Vertical scale 1cm. ≅ 1m.

Weathering
Fr — Fresh
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. Test sections are indicated by blacked in strips.

Core Photograph Negative No.

Depth (m)	Black & White	Colour

155/A16/1472 2of3

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT GINNINDERRA SEWER TUNNEL
LOCATION At SHAFT 2, 4m west of centre line of Tunnel at Station 17+12
ANGLE FROM HORIZONTAL (θ) 90° DIRECTION
COORDINATES E198,757, N611,225 R.L. OF COLLAR 563.0m

HOLE NO GST 7
SHEET 3 OF 3

Drilling Information						Rock Substance					Rock Mass Defects		
Method	Casing	Water	Pressure test * (lugeons)	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description rock type: grain characteristics colour, structure, minor components.	RQD	Weathering	Strength Is (50) (MPa) 0.03 0.3 3 30 300	Defect spacing (cm) 3 30 300 3000	Defect description thickness, type, inclination, planarity, roughness, coating, strength. Particular / General	Rock condition No.
NMLC			0	100	41		DACITE IGNIMBRITE TUFF Very hard. Very strong.	100	FR				2
				100	42			75	FS			Vertical Joint wavy & irregular strong limonite staining. Some calcite. Rockmass is strong & tight Vertical joints strongly stained with limonite. Calcite veins up to 5mm thick at 60°. Most fractures are horizontal (probably drill induced.)	3
				100	43		TUFFACEOUS SANDSTONE (Tuff arenite)	66	SW-FS				2
					44		Pale grey. Fine to medium grained. Very hard. Very strong.						
							END OF HOLE 44.30m						
					45								

TUNNEL

Drill type MOLE
Feed Hydraulic
Core barrel type NMLC triple tube 2 split inner tube
Driller Bill Harte (D.H.C.)
Commenced 29/5/75
Completed 7/6/75
Logged by P Lang
Vertical scale 1cm = 1m

Weathering
Fr — Fresh
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. Test sections are indicated by blacked in strips.

Core Photograph Negative No

Depth (m)	Black & White	Colour

155/A16/1472 3 of 3

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BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT GINNINDERRA SEWER TUNNEL
LOCATION ON TUNNEL CL AT STN 13+20
ANGLE FROM HORIZONTAL (θ) 90°
CO-ORDINATES E 198816 N 611613
DIRECTION —
R.L. OF COLLAR 554.2 m

HOLE NO. GST 8
SHEET 1 OF 2

Drilling information							Rock Substance			Rock Mass Defects			
Method	Drilling rate	Casing	Water	Pressure test * (lugeons)	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description: rock type, grain characteristics, colour, structure, minor components	Weathering	Point load strength Is(50) (MPa) 0.3 1.0 3.0 10.0	Defect spacing (cm) 30 100 300	RQD	Defect description: thickness, type, inclinations, planarity, roughness, coating, strength. Particular / General	Rock condition hazard
ROCK ROLLED					NOT CORED	1 2 3 4 5		NOT CORED						
NMLC					60 75 100 80 80 95 80 100 100 100 95 95 100 95 100 95 95 95 95 100 95 80 100 100	6 7 8 9 10 11 12 13 14 15 16 17 18 19 20	+ + + + + + + + + + + + + + + + + + + +	GRANITE PORPHYRY Light blue-grey where fresh	HW to CW			0 20 0 0 20 30 10 10	Rock closely jointed and joints often crushed; clay on some joint surfaces. Most joint surfaces limonite and manganese stained.	
									HW and MW					
									MW					
								Mainly HW - some MW pieces				0	Rock crushed and sheared between 13m and 19m. Rock mass weak, some clay-limonite stained. Zone probably at about 45° from horizontal	5 TO 6
													Closely jointed, broken in parts	4

5112175 - a constant 0.2 m above ground surface

Drill type MOLE
Feed HYDRAULIC
Core barrel type NMLC Triple tube
Driller DHC (Harte)
Commenced
Completed
Logged by D.C. Purcell
Vertical scale 1 cm : 1 m

Weathering: Fr - Fresh; SW - Slightly weathered; MW - Moderately weathered; HW - Highly weathered; EW - Extremely weathered

Water: 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

155/416/1494 1 of 2

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT GINNINDERRA SEWER TUNNEL
LOCATION ON TUNNEL C/L AT STN. 13+20
ANGLE FROM HORIZONTAL (θ) 90° DIRECTION —
CO-ORDINATES E 198816 N 611613 R.L. OF COLLAR 554.2

HOLE NO. GST 8
SHEET 2 OF 2

Drilling Information							Rock Substance			Rock Mass Defects				
Method	Drilling rate	Casing	Water	Pressure test * (lugeons)	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description: rock type, grain characteristics, colour, structure, minor components	Weathering	Point load strength Is(50)(MPa): 0.3, 1.0, 3.0, 10	Defect spacing (cm): 10, 30, 100, 300	R Q D	Defect description: thickness, type, inclination, planarity, roughness, coating, strength — Particular / General	Rock condition No (interpretive)
NMLC				3	95	21	+	GRANITE PORPHYRY	MW and SW			10		4
					100	22	+		SW			30		
					90	23	+					40	Rock fairly hard and tight to about 23.3m	
					100	24	+					0	About 80% of this section of core sheared and crushed. Sections of hard intact rock up to 0.3m long separate sections of sheared and crushed rock. Direction of shearing not known but dips at about 40°. Heavy limonite staining in places; minor clay on defect surfaces	5 TO 6
					75	25	+							
					60									
					65	26	+							
					70									
					80	27	+							
					60									
					100	28	+					15		
												25		
						29	+					30	closely jointed, but otherwise fairly sound. Joints gen. sp. 10cm	
					100	30	+	TUNNEL	HW. SW where rock intact			10		4 TO 5
					70	31	+						Crushed and sheared 30.2 to 32.75m; stained, some clay.	
				1	95	32	+					0	From 32.75 to 35.0m rock is closely jointed and fractured. Rock mass weak. Individual pieces of intact core between defects are hard and strong.	
					95									
					100	33	+							
					100									
						34	+					25		
					100	35		END OF HOLE 35.0m						

Drill type MOLE
Feed HYDRAULIC
Core barrel type NMLC Triple tube
Driller DHC (Harte)
Commenced
Completed
Logged by D.C. Purcell
Vertical scale 1cm : 1m

Weathering
Fr – Fresh
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

155/A16/1494 2of2

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT GINNINDERRA SEWER TUNNEL
LOCATION At centre of proposed shaft 3 . . 4.26m. west of centre line of tunnel at station 33 +15.24m.
ANGLE FROM HORIZONTAL (θ) 90° DIRECTION —
COORDINATES 198130E . . . 609750N . . . . R.L. OF COLLAR 565m.

HOLE NO G.S.T. 9
SHEET 1 OF 3

Drilling Information | Rock Substance | Rock Mass Defects

Method	Casing	Water	Pressure test * (lugeons)	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description: rock type: grain characteristics, colour, structure, minor components.	RQD	Weathering	Strength Is (50) (MPa) 0.03 0.03–0.10 0.10–0.30	Defect spacing (cm) 3 30 300	Defect description: thickness, type, inclination, planarity, roughness, coating, strength. Particular / General	Rock condition No.
ROCK ROLLER and BORE FLUSHING			TESTED	NOT CORED	1–10	NOT CORED	Not cored slope wash					NOT CORED	
							Not cored granite porphyry soft, weak.		EW				
NMLC		3/6 ▼	NOT	16%	10–11	loss		0					
					11–12	+ + +	GRANITE PORPHYRY Soft and weak. Clayey sand. Brown with white feldspar.		EW				
				35%	12–13	loss		0	EW to HW			3cm. clay seam.	
				95%	13–14	+ + +		0	HW			Clay seams up to 2mm.	
				100%	14–15	+ + +		0	MW			Slightly sheared at 60°–70°, healed with clay. Weak.	
			0	100%	15–16	+ + +	GRANITE PORPHYRY Light grey with phenocrysts of quartz, feldspar, biotite and green epidote. Some dark green fine grained xenoliths. Hard, strong.	55	FS			Limonite staining & thin veneer of clay on joints. Close jointed & seamy. Many fractures healed with epidote	
				100%	16–17	+ + +		60				1mm. clay seam on 80° joint.	
				100%	17–18	+ + +		0	FR			Rock close jointed. Calcite on faces, no clay.	
			0	100%	18–19	+ + +		0					

Rock mass weathered and soft. — 4–5

Quality of rock improves below 11m. Fairly tight. Joint spacing up to 40 cm. Many healed with calcite (strong). Clay veneer on some joints. — 3

Drill type MOLE
Feed Hydraulic
Core barrel type NMLC, triple tube and split inner tube
Driller J. Morgan (DHC)
Commenced 10-4-75
Completed 21-4-75
Logged by P. Lang
Vertical scale 1cm = 1m

Weathering
Fr — Fresh
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. Test sections are indicated by blacked in strips.

Core Photograph Negative No.

Depth (m)	Black & White	Colour

155/A16/1473 1 of 3

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT GINNINDERRA SEWER TUNNEL
LOCATION At centre of proposed shaft 3 .4.2 m west of centre line of tunnel at station 33+15.24 m.
ANGLE FROM HORIZONTAL (θ) 90° DIRECTION
COORDINATES 19913mE 09750N R.L. OF COLLAR 565m

HOLE NO GSI
SHEET 2 OF 3

Drilling Information | Rock Substance | Rock Mass Defects

Method	Casing	Water	Pressure test * (lugeons)	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description: rock type, grain characteristics, colour, structure, minor components	RQD	Weathering	Strength Is (50) (MPa) 0.03 0.1 0.3 1.0 3.0 10.0	Defect spacing (cm) 30 100 300	Defect description: thickness, type, inclination, planarity, roughness, coating, strength — Particular	General	Rock condition No.
NMLC			0	100%	21		GRANITE PORPHYRY Pale pinkish, green grey, very Hard, & very strong.	30				Vertical joints with thin veneer of clay.	Rock mass moderately tight to very tight. Most joints @ 80°-90°. Joints cemented with calcite and chlorite. Cement moderately strong. Joints planar to wavy and rough and tight	3
				100%	22			10						
				100%	23			20				1m. of rock fractured with joints at 80° & 30° some clay on joint surfaces.		
					24			50					Some narrow fractured zones with clay.	4
				100%	25									
			0	100%	26			65	FR					
				100%	27			93						
					28									
				100%	29			75						
NX				100%	30			25						2
				100%	31			75						
			0		32							Core ground and broken by drill.		
				100%	33			75						
					34		GRANITE PORPHYRY Green. Hard and strong. Softer than above. Easier to drill Sheared and healed with chlorite veins throughout.		FR but slightly altered and chloritized.				Rock mass very tight. Joints cemented with calcite & chlorite. Most joints tight & strong but some vertical joints weakly cemented.	
					35			75				Core ground and broken by drill.		
NMLC				100%	36			30				Vertical fractures with calcite (weak).		
				100%	37									
			0	100%	38		GRANITE PORPHYRY Mainly very hard and very strong. Some slightly chloritised zones and some zones with many calcite veins.	90	FR				Rock mass very tight & strong. Joint surfaces rough. Most cemented with calcite.	2
				100%	39			75				Some clay, calcite & pyrite on joints		
				100%				100						

Drill type Mole
Feed Hydraulic
Core barrel type NMLC with triple tube split inner
Driller Wheatly (DHC)
Commenced 1-4-75
Completed 21-4-75
Logged by P. Lang
Vertical scale 1cm = 1m

Weathering
Fr — Fresh
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. Test sections are indicated by blacked in strips.

Core Photograph Negative No

Depth (m)	Black & White	Colour

155/A16/1473 2 of 3

M(Pt)221

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT GINNINDERRA SEWER TUNNEL
LOCATION At centre of proposed shaft 3. 426m west of tunnel at station 33+15.24m
ANGLE FROM HORIZONTAL (θ) 90° DIRECTION —
COORDINATES 198130E 609750N R.L. OF COLLAR 565m.

HOLE NO. GSI 9
SHEET 3 OF 3

Drilling · Information						Rock Substance				Rock Mass Defects			
Method	Casing	Water	Pressure test * (lugeons)	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description rock type: grain characteristics colour, structure, minor components.	RQD	Weathering	Strength Is (50) (MPa) 0.03 0.03–0.3 0.3–1.0 1.0–3.0 3.0	Defect spacing (cm) 3 30 100 300	Defect description thickness, type, inclination, planarity, roughness, coating, strength. Particular / General	Rock condition No.
TUNNEL NMLC			0	100%	41		GRANITE PORPHYRY Mainly very hard and very strong. Some zones with chlorite and calcite veins moderately hard & strong.	80					
				100%	42			100					
				100%	43			90					
			0	100%	44			85	FR			Rock mass mostly very strong and very tight. Some close jointed and fractured zones up to 30 cm. wide. Joints cemented with calcite (moderately strong) no clay. Joint surfaces rough most joints at 0-30° some at 60°-80°.	2-3
				100%	45							Rock closely jointed and fractured with calcite on joints. Cement moderately weak.	
				100%	46			100					
				100%	47			35				Some limonite staining on joints.	
				100%	48		END OF HOLE 48m.	100					

TUNNEL

Drill type Mole
Feed Hydraulic
Core barrel type NMLC with Triple tube & split inner
Driller B.Hart (DHC)
Commenced 10-4-75
Completed 21-4-75
Logged by P. Lang
Vertical scale 1cm=1m

Weathering
Fr — Fresh
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. Test sections are indicated by blacked in strips.

Core Photograph Negative No.

Depth (m)	Black & White	Colour

155/A16/1473 3013

M(Pf)221

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT GINNINDERRA SEWER TUNNEL
LOCATION Near 'Strathnairn' Homestead Belconnen A.C.T.
On tunnel line at station 37+80 m
ANGLE FROM HORIZONTAL (θ) 90° DIRECTION —
COORDINATES E 197,995 N 609,322 R.L. OF COLLAR 563.8m

HOLE NO G.S.T. 11
SHEET 2 OF 3

Drilling Information

Method	Casing	Water	Pressure test * (lugeons)	Lift & % core recovery	Depth (metres)
NMLC			0	100	21
				100	22
				100	23
				100	24
				98	25
				100	26
			0	100	27
				100	28
				100	29
				100	30
				100	31
				100	32
			0	100	33
				100	34
				100	35
				100	36
				100	37
				100	38
			0	100	39
				100	40

Rock Substance

Graphic log & core loss	Substance description: rock type; grain characteristics; colour, structure, minor components	RQD	Weathering	Strength Is (50) (MPa) 0.03 0.03–0.3 0.3–10 10
v v	DACITE IGNIMBRITE TUFF with flow banding	55	MW	
v v		45		
v v		25	SW–FS with seams of EW	
v v		35		
v v		50		
v v		35		
v v		0		
v v		30		
v v		60		
v v		70		
v v		80		
v v		50		
v v		25	FR	
v v		25		
v v		40		
v v		95		
v v		95		

Rock Mass Defects

Defect spacing (cm) 3 30 300 3000	Defect description: thickness, type, inclination, planarity, roughness, coating, strength — Particular	Defect description — General	Rock condition No.
	Vertical fractures spaced 0·5cm with limonite & clay	Rockmass mod. tight. Limonite & thin veneer of clay on most jts. A few crushed seams with clay 2-5cm wide spaced 8cm-3m, generally 50cm-3m. Joints at 30°, 45°, 90° spaced 10-30cm. Surfaces rough & irregular.	3-4
	clay veneer on joint		
	clay seams from 1cm to 5cm wide; Clayey gravel (GC) to Clayey sand (SC) seams at 0-30°		
	Drill induced fractures		
	5cm wide crushed seam with clay (GC)	SAME AS BELOW 27m	
		Core very fractured. Many clay seams 1-10cm wide. Whole zone is a clayey gravel	5
	clay seams up to 1cm at 40°–60°		3-4
	2cm crushed seam with veneer of clay		
	rock fragmented with vertical joints. Joints have chl & clay		
	15cm of clay seams (GC)		
	15cm of clay seams (GC)		
	Many drill induced fractures. Natural fractures at 80°–90°, 45°–60°, +30°. A few crushed seams (Clayey sand – Clayey gravel) 1-10cm wide spaced 1-6m generally at 30°–60°. Joints generally spaced 10-40cm. Surfaces generally rough & irregular. Many are slickensided with calcite-chlorite. Many joints weakly cemented with calcite-chlorite. Clay veneer on some joints. Rockmass tight.		

Drill type Mole
Feed Hydraulic
Core barrel type NMLC triple tube with split inner tube
Driller Bill Harte (D.H.C.)
Commenced 24/4/75
Completed 27/5/75
Logged by P. Lang
Vertical scale 1cm = 1m

Weathering
Fr — Fresh
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. Test sections are indicated by blacked in strips.

Core Photograph Negative No

Depth (m)	Black & White	Colour

155/A/6/1474 2 of 3

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BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT GINNINDERRA SEWER TUNNEL
LOCATION near Strathnairn Homestead Belconnen A.C.T.
on tunnel line at station 37+80 m
ANGLE FROM HORIZONTAL (θ) 90° DIRECTION —
COORDINATES E 197,995 N 609,322 R.L. OF COLLAR 563·8m

HOLE NO GST 11
SHEET 3 OF 3

Drilling Information						Rock Substance			Rock Mass Defects		
Method	Casing	Water	Pressure test * (lugeons)	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description: rock type; grain characteristics; colour, structure, minor components.	Weathering	Strength Is (50) (MPa) 0·03 — 3·00 — 10·0	Defect spacing (cm) 30 — 200 — 300	Defect description: thickness, type, inclination, planarity, roughness, coating, strength. Particular / General	Rock condition No.
NMLC			0	100	41	v v	DACITE IGNIMBRITE TUFF with flow banding.	FR	60		Fractured jts at 60° & Ca + clay on jts	
				100					80		continuous stick of core but with vertical fracture, calcite, chl. + clay.	
				100	42	v v						
					43	v v			40		fractured zone & crushed seams + clay	
			0	100	44	v v			40		vertical joint wavy + irregular & chlorite + calcite	3 - 4
				100	45	v v						
					46	v v			70			
				100	47	v v			10		Vertical joint same as above	
				100	48	v v					10cm crushed seam GC — core fractured by joints at 65°-60° + 90° Ca, Chl, Clay	
				100	49	v v			80		core generally fractured at 0-30° Joints at 30°-45° with calcite and chlorite. Joints at 60° with calcite chlorite and clay slickensided.	
				100	50	v v			70			
			NOT TESTED	100			fine grained siliceous green sandstone contacts tight (intrusive?) dip 10-20°		20		2 joint sets at 45° & calcite + chl.	3
				100	51	v v	DACITE IGNIMBRITE TUFF				10cm crushed seam with chlorite + calcite	
					52	v v			70		5cm crushed seam with chlorite + calcite	
							End of hole 52·40m					
					53							
					54							
					55							
					56							
					57							
					58							
					59							
					60							

Many drill induced fractures (horizontal). Most natural fractures steeper than 45°. Near vertical fractures appear most prominent and are some places partly sheared or crushed with a little clay but no limonite. Natural fractures spaced 10-50cm. Joints are mostly tight. Surfaces are rough & irregular, generally slickensided with calcite & chlorite. Clay veneer on some, a few crushed seams 1-5 cm wide, generally vertical.

TUNNEL

Drill type Mole
Feed Hydraulic
Core barrel type NMLC triple tube with split inner tube
Driller Bill Hearle (D.H.C.)
Commenced 24/4/75
Completed 27/5/75
Logged by P. Lang
Vertical scale 1 cm = 1 m

Weathering
Fr — Fresh
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. Test sections are indicated by blacked in strips.

Core Photograph Negative No.

Depth (m)	Black & White	Colour

155/A16/1474 3of3

AM(Pf) 221

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT GINNINDERRA SEWER TUNNEL
LOCATION At station 40+50 on centre line of tunnel
ANGLE FROM HORIZONTAL (θ) 45° DIRECTION 023° grid
COORDINATES E199,784 N609,070 R.L. OF COLLAR 570.8

HOLE NO. GST 12
SHEET 1 OF 5

Drilling Information | **Rock Substance** | **Rock Mass Defects**

Columns: Method | Casing | Water | Pressure test * (lugeons) | Lift & % core recovery | Depth (metres) | Graphic log & core loss | Substance description: rock type: grain characteristics, colour, structure, minor components | RQD | Weathering | Strength Is (50) (MPa) 0.03 0.1 0.3 1 3 10 | Defect spacing (cm) 3 10 30 100 300 | Defect description: thickness, type, inclination, planarity, roughness, coating, strength. Particular / General | Rock condition No.

Method: Rock Rolled (0–3 m); NMLC (3–20 m)

Pressure test: NOT TESTED

Water: 9/6/75 (at approx. 13.2 m); 24/6/75 (at approx. 17.8 m)

Depth (m)	Core recovery %	Substance description	RQD	Weathering
0–3	Not Cored	Topsoil		
3–3.5	100	DACITE blue grey to green-grey when fresh. qtz phenocrysts up 2mm	0	Mostly HW but with harrow seams of EW and blocks of SW between large joint blocks
3.5–5	100		40	
5–6.5	100		50	
6.5–7.5	100		45	
7.5–9	100		40	
9–9.3	50	Core loss	0	
9.3–11	100		20	SW
11–12.5	100		15	HW c̄ EW seams
12.5–14	100		20	Mainly SW. Some MW
14–15.5	100		25	
15.5–16.5	100		45	
16.5–18	100		20	
18–19.5	100		50	
19.5–20			35	

Defect description – Particular

Approx. depth (m)	Description
6	crushed seams 1–3 cms spaced 10cms
9.2	5cm sandy clay seam.
12.5	3cm crushed seam
13.4	25cm crushed seam (Gc)
15.6	10cm crushed seam (Gc)
16.7	30cm crushed seam (Gc)
18.6	crushed seams c̄ clay up to 3cm. wide (Gc)

Defect description – General

Depth interval	Description	Rock condition No.
3–10.5 m	Rockmass very close jointed (generally < 10 cm) & seamy; most joints at 45°. Some at 90°. Most joints have clay veneer or clay seam up to 1cm thick. All joints limonite stained & incipient joints throughout rockmass have limonite staining & cement.	4–5
10.5–12.5 m	Rockmass very close jointed > Sc. Much clayey sand (Sc). Sheared.	4–5
12.5–17.8 m	Rockmass is very close jointed (3-20cm) & fractured. Crushed seams from 5-30cm thick spaced approx. 1m consist mainly of sand + gravel (Gw). Much limonite staining. Some clay in some seams. Most fractures at 45-60°. Joint surfaces rough c̄ thick limonite coating.	4
17.8–20 m	Rock is sheared at 60°. Healed with limonite, chlorite & clay (hard).	

Drill type Fox
Feed Hydraulic
Core barrel type NMLC
tripple tube c̄ split inner tube
Driller Derreck Wheatley, T. Sterk
Commenced 3/5/75
Completed 18/6/75
Logged by P. Lang
Vertical scale 1cm ≡ 1m

Weathering
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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.
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Core Photograph Negative No.

Depth (m)	Black & White	Colour

155/A16/14.75 1of5

M(Pf) 221

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

PROJECT GINNINDERRA SEWER TUNNEL
LOCATION At station 40+50 on centre line of tunnel
ANGLE FROM HORIZONTAL (θ) 45° DIRECTION 023° grid
COORDINATES E 199,784 N 609,070 R.L. OF COLLAR 570.8

HOLE NO. GST 12
SHEET 2 OF 5

GEOLOGICAL LOG OF DRILL HOLE

Drilling Information

Method	Casing	Water	Pressure test * (lugeons)	Lift & % core recovery	Depth (metres)
NMLC			NOT TESTED	100	21
				100	22
				100	23
				100	24
				100	25
				100	26
				100	27
				100	28
				100	29
			0	100	30
				100	31
				100	32
				100	33
				100	34
				100	35
				100	36
			0	100	37
				100	38
				100	39
				100	40

Rock Substance

Graphic log & core loss	Substance description: rock type: grain characteristics colour, structure, minor components.	RQD	Weathering	Strength Is (50) (MPa) 0.03 0.1 0.3 1.0 3.0 10 30 100 300
V	DACITE mostly sheared but healed with chlorite & limonite. Red stained quartz phenocrysts up to 3mm & green (epidote?) inclusions up to 3 cm in places.	35	Mostly SW-FS. Some HW seams along j'ts.	
V		35		
V		55		
V		35		
V		30		
V		25		
V		65		
V		65	FR	
V		60		
V		65		
V		75		
V		100		
V		70	FS	
V		85	FR	
V		95		

Rock Mass Defects

Defect spacing (cm) 3 10 30 100 300	Defect description: thickness, type, inclination, planarity, roughness, coating, strength. Particular	General	Rock condition No.
	Rock sheared. Healed in places but several crushed seams HW, little clay.	Rockmass is fairly tight. Rock has been sheared but is mostly healed with chlorite. Defects are mostly joints and fractured zones from 10 cms to 1m wide spaced 30 cm to 2m. Above 25.0m fractured zones are gravel with limonite, clay & chlorite. Below 25.0m fractured zones are strongly slickensided with chlorite. Clay seams are rare and less than 2cm wide. Joints are generally spaced 10-30 cm and are strongly stained with limonite above 25.0m. All joints are strongly slickensided with chlorite.	4
	crushed seum some clay		
	Crushed seam		
	10 cm crushed seam		3-4
	50 cm close jointed & fractured ± chl.		
	2cm fractured ± chl. fractured & slickensided ± chlorite		
	Very close jtd & slickensided ± chl.		
	25cm fractured zone ± 2cm sheared ± chl. & some clay.		
	3 cm GC	Rockmass is tight. Many fractures are drill induced. Shearing (healed with chlorite veins) and most natural fractures are oriented at 60-80° & 45°. Natural fractures spaced mostly 30cm - 1m.	2-3
	3 cm GC		
	Very close jtd. Slickensided ± chl. Partly drill induced.		
	10 cm fractured zone ± chl. 2 directions at 45° to core.		

Drill type Fox
Feed Hydraulic
Core barrel type NMLC triple tube ± split inner tube
Driller Derreck Wheatley, T Sterk
Commenced 3/5/75
Completed 18/6/75
Logged by P Lang
Vertical scale 1cm = 1m

Weathering
Fr — Fresh
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.
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Core Photograph Negative No.

Depth (m)	Black & White	Colour

155/A16/1475 2015

M(Pf) 221

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT GINNINDERRA SEWER TUNNEL
LOCATION At Station 40+50 on centre line of tunnel
ANGLE FROM HORIZONTAL (θ) 45° DIRECTION 023° grid
COORDINATES E 199,784 N 609,070 R.L. OF COLLAR 570.8

HOLE NO. GST 12
SHEET 3 OF 5

Drilling Information						Rock Substance					Rock Mass Defects		
Method	Casing	Water	Pressure test * (lugeons)	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description rock type: grain characteristics colour, structure, minor components.	R.Q.D.	Weathering	Strength Is (50) (MPa) 0.03 0.03–0.3 0.3–3.0 3.0–10 10–30 30–100 100–300 300	Defect spacing (cm) 3 10 30 100 300	Defect description thickness, type, inclination, planarity, roughness, coating, strength. Particular / General	Rock condition No.
N.M.L.C.			0	100	41	V	DACITE Sheared & healed with chlorite. Red stained quartz phenocrysts.	95				Rockmass very strong, very tight. Fractures probably all drill induced.	2
				100	42	V	Becoming finer grained towards bottom. Hard & strong.	90					
			0	100	43		FAULT ZONE Rock is strongly sheared.	45				Rockmass is a clayey gravel. Very soft & weak. Much clay & chlorite. 60% of rock mass composed of fragments < 2cm in a sandy clay matrix. Shearing is at 45-60°	5
				90?	44		Very weak & soft. Much clay & chlorite.	0					
				90?	45		Dacite ignimbrite tuff below 43.5m. Also	0					
				100	46		strongly sheared with clay & chlorite.	10					
				100	47		DACITE IGNIMBRITE TUFF medium grey Very hard, very strong	8				Joints are tight. Rockmass is sheared, but mod. strong. Crushed seams up to 5cm. wide & fractured zones up to 30cm wide spaced 10-30 cm. down to 50.5m, then spaced about 1m. to 52.5m. Shearing & mgst joints are at 30-45°. A few at 60°.	4
				100	48								
				100	49			0					
			0	100	50			35	FR				3
				100	51								
				100	52			40					
				100	53			25					
				100	54			30				Vertical Joint.	
				100	55			55					
			0	100	56			40				Vertical Joint.	
				100	57								
				100	58			40					
				100	59							5cm. shear at 60°. 5cm. clay & Ca seam.	
				100	60			25				Rockmass close jointed but tight. Joints generally slickensided with black chlorite. Some veins & calcite cement. Most joints at 45° (2 sets) and at 60°. Some at 90°. Some fractured zones and some fracturing along 90° joints. Surfaces mostly wavy, irregular & rough.	4

Steel set support at approx. 1.3m intervals. Probably necessary in tunnel at this chainage.

Drill type Fox
Feed Hydraulic
Core barrel type NMLC triple tube & splitinner tube
Driller A. Wheatly, T. Sterk
Commenced 3/5/75
Completed 18/6/75
Logged by P. Lang
Vertical scale 1 cm = 1 m

Weathering
Fr — Fresh
SW — Slightly weathered
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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. Test sections are indicated by blacked in strips.

Core Photograph Negative No

Depth (m)	Black & White	Colour

155/A16/1475 3 of 5

M(Pf) 221

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT GLENNINDERRA SEWER TUNNEL
LOCATION At station 40+50 on centre line of tunnel
ANGLE FROM HORIZONTAL (θ) 45° DIRECTION 023° grid
COORDINATES E 199784 N 609,070 R.L. OF COLLAR 570.8

HOLE NO. GST 12
SHEET 4 OF 5

Drilling Information						Rock Substance				Rock Mass Defects		
Method	Casing	Water	Pressure test * (lugeons)	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description rock type: grain characteristics colour, structure, minor components.	R.Q.D.	Weathering	Strength Is (50) (MPa) 0.03 0.00 0.000	Defect spacing (cm) 3000 300	Defect description thickness, type, inclination, planarity, roughness, coating, strength Particular / General	Rock condition No.
NMLC			0	100	60		DACITE IGNIMBRITE TUFF	25				10cm crushed seam ± clayey sand (SC)	4
				100	61		Bedding and/or flow banding	65				5cm fractured.	
				100	62		Very hard, very strong	45					
					63		Bedding planes are not a weakness.						
			0	100	64			50				10cm fractured ± some clay.	
				100	65			75					
					66								
			0	100	67			75				5cm fractured	
				100	68			90				5cm fractured at 60°	
					69				FR			Joint at 60° ± clay (// to bedding)	2-3
			0	100	70		banding dips approx. 8°-10° west.	95				Rockmass strong & tight. Many drill induced fractures. This rock breaks more easily across the rock fabric than the granite. Should break up to pieces from 10-30 cm across when blasted. Several sticks of core 50-70 cms long. Natural defects are joints generally spaced 30cm-1m but up to 2m. In places spaced 7-10cms. Most natural joints are at 60-70° or 30-45° to core. Joint surfaces are generally cemented with calcite usually less than 1 mm thick. Many joints are slickensided.	
				100	71			80					
					72								
			0	100	73			100					
				100	74			75					
					75								
			0	100	76			100					
				100	77			75					
					78							1cm thick calcite vein at 70°	3
			0	100	79			55				1cm thick calcite vein at 60°	
					80							As above but core more closely jointed due to 2 intersecting joint sets at 45° to core and one wavy joint at 80°-90° to core. Also calcite veins up to 1cm thick.	

TUNNEL

TUNNEL

Drill type Fox
Feed Hydraulic
Core barrel type NMLC triple tube ± split inner tube
Driller D. Whealy, T. Sterk
Commenced 3/5/75
Completed 18/4/75
Logged by P. Lang
Vertical scale 1cm = 1m

Weathering
Fr — Fresh
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. Test sections are indicated by blacked in strips.

Core Photograph Negative No.

Depth (m)	Black & White	Colour

155/A16/1475 4 of 5

M(Pf) 221

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT GINNDERRA SEWER TUNNEL
LOCATION At station 40+50 on centre line of tunnel
ANGLE FROM HORIZONTAL (θ) 45° DIRECTION 023° grid.
COORDINATES E 199,784 N 609,070 R.L. OF COLLAR 570·8

HOLE NO. GST 12
SHEET 5 OF 5

Drilling Information						Rock Substance				Rock Mass Defects		
Method	Casing	Water	Pressure test * (lugeons)	% Lift & core recovery	Depth (metres)	Graphic log & core loss	Substance description rock type, grain characteristics, colour, structure, minor components.	RQD	Weathering	Strength Is (50) (MPa) 0.03 0.1 0.3 1 3 10 30 100 300	Defect spacing (cm) 3 10 30 100 300	Defect description thickness, type, inclination, planarity, roughness, coating, strength. Particular / General	Rock condition No.
NMLC.			0	100	81		DACITE IGNMBRITE TUFF Hard, strong	65	FR			same as above 78m	2-3
							END OF HOLE 81·28						

Drill type Fox
Feed Hydraulic
Core barrel type NMLC
triple tube & split inner tube
Driller D. Wheatly, T. Steck
Commenced 3/5/75
Completed 18/6/75
Logged by P. Lang
Vertical scale 1cm = 1m

Weathering
Fr — Fresh
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. Test sections are indicated by blacked in strips.

Core Photograph Negative No.

Depth (m)	Black & White	Colour

155/A16/1473 5of5

M(Pf) 221

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT GINNINDERRA SEWER TUNNEL
LOCATION 50m west of tunnel line at station 42+62
ANGLE FROM HORIZONTAL (θ) 38° DIRECTION 125° grid
COORDINATES E 197,719 N 608,906 R.L. OF COLLAR 546·5m

HOLE NO GST 13
SHEET 1 OF 5

Drilling Information | Rock Substance | Rock Mass Defects

Method	Casing	Water	Pressure test * (lugeons)	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description rock type: grain characteristics colour, structure, minor components.	RQD	Weathering	Strength Is (50) (MPa) 0·03 0·03-0·1 0·1-0·3 0·3-1·0 1·0-3·0 10·0	Defect spacing (cm) 3 10 30 100 300	Defect description thickness, type, inclination, planarity, roughness, coating, strength. Particular / General	Rock condition No.
Rock Rolled.				NOT CORED	1	NOT CORED	NOT CORED						
				NOT CORED	2	NOT CORED							
				NOT CORED	3	NOT CORED							
				80		100%	DACITE weathered.	0	EW to HW			Rock mass fractured and seamy: Very weak. Clay seams up to 20 cm thick.	5
				40		100%		0					
				60	4	loss		0					
				75		100%		0					
				75	5	100%		24					
				50		loss		0					
				80	6	100%		0					
				35	7			0					
				70	8	loss		0					
				100	9	loss		0					
NMLC			NOT TESTED	100	10		DACITE Quartz phenocrysts up to 3mm. Blue grey when fresh.	45	Mostly SW. Some MW near top. Some FS near bottom.			Rock mass is close to very close jointed with some fractured zones, up to 50cm wide spaced 1-5m. Some crushed seams with chlorite clay & sandy clay up to 10cm thick spaced 30cm-5m. Most joints at 30° (2 sets) and 60°. Rock mass riddled with cavities, up to 2mm (these are partly healed fractures where calcite cement may have been dissolved out, leaving cavities). All joint surfaces down to 18m have a thick limonite staining. Some chlorite & chlorite clay below 18m	4
				100	11			15					
				100	12			50					
				100	13			80					
				100	14			30					
				100	15			20					
				100	16			0					
				100	17			55	FR				
				100	18			25					
					19								

Drill type FOX
Feed Hydraulic
Core barrel type NMLC with tripple tube & split inner
Driller J.Morgan (DHC)
Commenced 23/6/75
Completed 9/7/75
Logged by P.A.LANG
Vertical scale 1cm=1m

Weathering
Fr — Fresh
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. Test sections are indicated by blacked in strips.

Core Photograph Negative No.

Depth (m)	Black & White	Colour

155/A16/1476 1 of 5

M(Pf) 221

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT GINNINDERRA SEWER TUNNEL
LOCATION 50m west of tunnel line at station 42+62
ANGLE FROM HORIZONTAL (θ) 38° DIRECTION 125° grid
COORDINATES E 197719 N 608906 R.L. OF COLLAR 546.5m

HOLE NO. GST 13
SHEET 2 OF 5

Drilling Information						Rock Substance				Rock Mass Defects		
Method	Casing	Water	Pressure test * (lugeons)	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description rock type: grain characteristics colour, structure, minor components.	RQD	Weathering	Strength Is (50) (MPa) 0·03 0·1 0·3 1·0 3·0 10·0	Defect spacing (cm) 30 100 300	Defect description thickness, type, inclination, planarity, roughness, coating, strength. Particular / General	Rock condition No.
NMLC			NOT TESTED	100	21	V	DACITE Blue grey. Stained purple in places. Quartz phenocrysts up to 3mm. Hard and strong.	25				Fractured zones with chlorite and a thin veneer of clay. Slickensides.	
				100	22	V		55				Close jointed with several intersecting joints. Surfaces cemented with calcite.	
				100	23	V		60				Many drill induced fractures Some shearing with chlorite	
				100	24	V		60					
				100	25	V		60					
				100	26	V		80					
				100	27	V		80				Surfaces with chlorite & chlorite clay.	
				100	28	V		80					
				100	29	V		80					
				100	30	V		70	FR			Vertical joint with calcite.	
			7	100	31	V	DACITE Mostly green grey below 30m due to epidote and chlorite in rock. Some zones with purple staining.	80				Sheared with chlorite and slickensides.	
				100	32	V		80					
				100	33	V		75				Several close spaced 60°-80° joint sets. Intersect to give fracture core. Chlorite & calcite.	
				100	34	V		75					
				100	35	V		40				85° joint smooth & planar & slickensided with chlorite.	
				100	36	V		40				Close jointed	
				100	37	V		60					
			1	100	38	V		65					
				100	39	V		65					
				100		V		60					

Rock mass is close jointed, but fairly tight and fairly strong. Most joints are at about 30° to core (2 sets). Also some 45°-60° joints. Surfaces are mostly smooth and planar with chlorite and calcite. Many are slickensided. Core is fractured in a few places where several joints intersect. Some joints with chlorite and slickensides. Many calcite veins. 3

Drill type FCX
Feed Hydraulic
Core barrel type NMLC with triple tube & split inner
Driller J.Morgan (OHC)
Commenced 23/6/75
Completed 3/7/75
Logged by E.A.LANG
Vertical scale 1cm = 1m

Weathering
Fr — Fresh
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. Test sections are indicated by blacked in strips.

Core Photograph Negative No.

Depth (m)	Black & White	Colour

155/A16/1476 2 of 5

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT GINNINDERRA SEWER TUNNEL
LOCATION 50m west of tunnel line at station 42+62
ANGLE FROM HORIZONTAL (θ) 38° DIRECTION 125 grid
COORDINATES E 197,719 N 608,906 R.L. OF COLLAR 546·5m

HOLE NO GST 13
SHEET 3 OF 5

Drilling Information						Rock Substance					Rock Mass Defects		
Method	Casing	Water	Pressure test * (lugeons)	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description rock type: grain characteristics colour, structure, minor components.	RQD	Weathering	Strength Is (50) (MPa) 0·03 0·1 0·3 1·0 3·0 10·0	Defect spacing (cm) 3 30 300 3000	Defect description thickness, type, inclination, planarity, roughness, coating, strength. Particular	Defect description General	Rock condition No.
NMLC			1	100	41	V	DACITE With quartz phenocrysts up to 3mm. Blue grey when fresh. Stained purple by hydrothermally deposited haematite in some zones. Green grey due to epidote near fault.	70	FR				Rock mass is close jointed but fairly tight. Joints are generally spaced 3-20 cm, and oriented at 30° (2 sets), & 80°-90°. Surfaces are mostly slickensided with chlorite and calcite. A few have a thin veneer of clay. A few crushed seams with chlorite and clay (generally <1cm thick) orientated at 45° and 85°-90°. Many thin calcite veins (strong).	3
				100	42	V		80						
					43	V								
			10	100	44	V		60						
					45	V						1cm crushed seam with chlorite & clay.		
				100				65						
					46	V						30cm of crushed seams with chlorite & clay.		
				100	47	V		40						
					48	V						Near vertical joint, planar and smooth. Slickensided with chlorite, calcite and a thin veneer of clay		
				100				50						
					49	V								
			1	100	50	V		50						
					51	V						2 vertical joints spaced 1cm. Slickensided with chlorite and clay.		
				100				60						
					52	V								
				100	53	V		50				1cm crushed seam with chlorite & clay.		
					54	V								
				100	55	V		80						
					56	V		40						
				100	57	V								
					58	V		40						
				100	59	V		50						
				100		V		30				2 crushed seams, <5cm thick with chlorite.		

Drill type FOX
Feed Hydraulic
Core barrel type NMLC with triple tube & split inner
Driller J.Morgan (DHC)
Commenced 23/6/75
Completed 9/7/75
Logged by P.A.LANG
Vertical scale 1cm ≡ 1m

Weathering
Fr — Fresh
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. Test sections are indicated by blacked in strips.

Core Photograph Negative No.

Depth (m)	Black & White	Colour
155/A16/1476 3of5		

M(Pf) 221

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT GINNINDERRA SEWER TUNNEL
LOCATION 50m west of tunnel line at station 42+62
ANGLE FROM HORIZONTAL (θ) 38° DIRECTION 125° grid
COORDINATES E 197719 N 608906 R.L. OF COLLAR 546·5m

HOLE NO. GST 13
SHEET 4 OF 5

TUNNEL

Drilling Information						Rock Substance				Rock Mass Defects		
Method	Casing	Water	Pressure test * (lugeons)	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description: rock type; grain characteristics; colour, structure, minor components.	RQD	Weathering	Strength Is (50) (MPa) 0·03 0·1 0·3 1·0 3·0 10·0	Defect spacing (cm) 10 30 100 300 1000 3000	Defect description: thickness, type, inclination, planarity, roughness, coating, strength. Particular / General	Rock condition No.
NMLC			1-2	100	61	V	DACITE With quartz phenocrysts up to 3cm. Green due to epidote. Partly sheared in places and healed with epidote and calcite.	30				2 Rock is crushed & fractured with 2 joint sets at 60° with chlorite.	
				100	62	V		80				Joints spaced 0°-30° spaced 1-3 cm.	
				100	63	V		90					
				100	64	V		50				2 joint sets at 30° each spaced 8 cm.	
				100	65	V							3
				100	66	V		40					
			<1	100	67	V		50					
				100	68	V						5cm crushed seam with chlorite.	
				100	69	V		35	FR				
				100	70	V							
				100	71	V		35				2cm & 5cm crushed seam with chlorite	
							SHALE Black, sheared at approx. 45°.					Sheared shale	
				100	72		RHYOLITE Sheared, green, with some sheared black shale (shearing at approx 70°).	20				Sheared & crushed rhyolite	
				100	73								
				100	74			30				50cm crushed and sheared.	
			<1	100	75			35					4-5
				100	76			40				Fault zone. Rock mass is sheared but is mostly healed with chlorite, weak to moderately strong. Many crushed seams with chlorite & some clay 1cm - 50cm wide spaced 10cm - 1m. In healed rock joints are generally at 0-30° and spaced 5-15cm.	
				100	77								
				100	78			15				Crushed seams. 1-10cm thick with chlorite & some clay.	
				100	79		RHYOLITE Green mottled. Silicious with black chlorite. Hard, strong.	60				SEE BELOW	3
				100				85					

TUNNEL

Rock mass is close jointed but moderately tight. Joints generally spaced 3-30 cm. 2 sets at 30° 1 at 60° and random joints, surfaces slickensided with chlorite. A few fractured zones up to 20 cm wide at 60°-70°

Drill type FOX
Feed Hydraulic
Core barrel type NMLC with triple tube & split barrel
Driller J. Morgan (DHC)
Commenced 23/6/75
Completed 9/7/75
Logged by E.A. LANG
Vertical scale 1cm = 1m

Weathering
Fr — Fresh
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. Test sections are indicated by blacked in strips.

Core Photograph Negative No.

Depth (m)	Black & White	Colour

155/A16/1476 4 of 5

M(P)122

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

PROJECT GINNINDERRA SEWER TUNNEL
LOCATION 50m west of tunnel line at station 42+62

HOLE NO GST 13

GEOLOGICAL LOG OF DRILL HOLE

ANGLE FROM HORIZONTAL (θ) 38° DIRECTION 125° grid
COORDINATES E 197,719 N 608906 R.L. OF COLLAR 546·5m

SHEET 5 OF 5

Drilling Information						Rock Substance				Rock Mass Defects		
Method	Casing	Water	Pressure test * (lugeons)	Litt & % core recovery	Depth (metres)	Graphic log & core loss	Substance description rock type: grain characteristics colour, structure, minor components	RQD	Weathering	Strength Is (50) (MPa) 0·03 0·03–0·3 0·3–3·0 3·0	Defect spacing (cm) 30 30–300 300	Defect description thickness, type, inclination, planarity, roughness, coating, strength. Particular / General	Rock condition No.
NMLC			0	100	81		RHYOLITE Green mottled. Silicious with black chlorite.	85	FR			Rock mass is close jointed but moderately tight. 2 joint sets at 30° spaced 10cm + 1 set at 60° + random joints. Surfaces slickensided with chlorite.	3
				100	82			60					
				100	83			75					
				100	84			65					
					85		END OF HOLE 85·45m						

Drill type FOX
Feed Hydraulic
Core barrel type NMLC with triple tube & split inner
Driller J. Morgan (DHC)
Commenced 23/6/75
Completed 9/7/75
Logged by P.A. LANG
Vertical scale 1cm = 1m

Weathering
Fr — Fresh
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. Test sections are indicated by blacked in strips.

Core Photograph Negative No.

Depth (m)	Black & White	Colour

155/A16/1476 5 of 5

M(Pf) 221

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

PROJECT GINNINDERRA SEWER TUNNEL
LOCATION 28·5m west of tunnel line at station 43+54
HOLE NO. GST 14

GEOLOGICAL LOG OF DRILL HOLE

ANGLE FROM HORIZONTAL (θ) 30° DIRECTION 124° (grid)
COORDINATES E197698·8 N608805·7 R.L. OF COLLAR 534·9m
SHEET 1 OF 3

Drilling Information						Rock Substance					Rock Mass Defects		
Method	Casing	Water	Pressure test * (lugeons)	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description rock type: grain characteristics colour, structure, minor components.	RQD	Weathering	Strength Is (50) (MPa) 0·03 0·03–0·3 0·3–1·0 1·0–3·0 3·0	Defect spacing (cm) 3 10 30 100 300	Defect description thickness, type, inclination, planarity, roughness, coating, strength. Particular / General	Rock condition No.
Rock Rolled		21/8	NOT TESTED	NOT CORED	1–9	NOT CORED	NOT CORED					NOT CORED	
NMLC				100	9–10	V	DACITE – Sheared	0	Mainly HW - MW			Rock mass fractured and sheared and seamy. Clay seams 1-10 cm thick common. Joints at 45°, 60° & 30° commonly spaced 1-5cm, fragment core into a gravel. A few sticks of core up to 30 cm long, are weak with many incipient fractures.	5
				100	10–11	V		0					
				100	11–12	V		25					
				100	12–13	V		0					
				100	13–14	V		0					
				100				0					
				100				80					
				100	14–15	V		45	Mainly SW - MW, some HW seams.				
				100	15–16	V		40					
				100	16–17	V		0					
				100	17–18	V		10					
				100				0					
				100	18–19	V	DACITE Stained purple. Quartz phenocrysts. Hard. Moderately strong.	15	FR			Rock mass is close jointed. Joints mainly at 30° & 45°. Generally spaced 3-10 cm. Surfaces with calcite or some with chlorite clay. Some crushed seams up to 5cm thick spaced 30cm - 50cm.	3-4
				100	19	V		20					

Drill type CRAELIUS
Feed Hydraulic
Core barrel type NMLC with triple tube & split inner
Driller D.Wheatly (DHC)
Commenced 24/6/75
Completed 7/7/75
Logged by P.A.LANG
Vertical scale 1cm = 1m

Weathering
Fr — Fresh
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. Test sections are indicated by blacked in strips.

Core Photograph Negative No.

Depth (m)	Black & White	Colour

155/A16/1477 1of3

M(Pf)221

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT GINNINDERRA SEWER TUNNEL
LOCATION 28.5m west of tunnel line at station 43+54
ANGLE FROM HORIZONTAL (θ) 30° DIRECTION 124° (grid)
COORDINATES E197698.8 N6088057 R.L. OF COLLAR 534.9m

HOLE NO. GST 14
SHEET 2 OF 3

Drilling Information						Rock Substance				Rock Mass Defects		
Method	Casing	Water	Pressure test * (lugeons)	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description rock type: grain characteristics colour, structure, minor components.	RQD	Weathering	Strength Is (50) (MPa) 0.03 0.1 0.3 1.0 3.0 10.0	Defect spacing (cm) 3 30 100 300	Defect description thickness, type, inclination, planarity, roughness, coating, strength. Particular / General	Rock condition No.
NMLC			NOT TESTED	100	21	V	DACITE Mostly stained. Purple with dark green (chlorite) veins throughout. Hard. Moderately strong.	40	FR			Rock mass is close jointed and inplaces fractured (15%) with many defect surfaces greasy &/or slickensided. In close jointed zones joints are generally spaced 3-10 cm and oriented at 30°(2 sets) and 60°-90° to core. Surfaces are strongly slickensided with chlorite and calcite. Many are greasy with a thin coating of clay. In fractured zones spacing is <1mm to 2 cm. Surfaces are strongly slickensided with chlorite & greasy.	3-4
				100	22	V		10					4
				100	23	V		35					
				100	24	V		60					3-4
					25	V							
			0	100	26	V		35					
				100	27	V		10					
				100	28	V		15					4
				100	29	V							
				100	30	V		30					
				00	31	V		35					
			0		32	V							
				100	33	V		0					
				100	34	V		15					5
			0	100	35	V		30					
				100	36	V		25					
				100	37	V		0					
			4	100	38	V		15				Rock mass is close jointed, and in places fractured sheared & seamy. Crushed seams with clay from 1-10 cm thick at 60°-80°, spaced 30 cm approx.	4-5
				100	39	V		40					

TUNNEL

TUNNEL

Drill type CRAELIUS
Feed Hydraulic
Core barrel type NMLC triple tube split inner
Driller D.Wheatly (DHC)
Commenced 24/6/75
Completed 7/7/75
Logged by P.A.LANG
Vertical scale 1cm=1m

Weathering
Fr — Fresh
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. Test sections are indicated by blacked in strips.

Core Photograph Negative No.

Depth (m)	Black & White	Colour

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M(Pf) 221

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT GINNINDERRA SEWER TUNNEL
LOCATION 28·5m west of tunnel line at station 43+54
ANGLE FROM HORIZONTAL (θ) 30° DIRECTION 124° (grid)
COORDINATES E 197698·8 N6088057 R.L. OF COLLAR 534·9m

HOLE NO. GSI 14
SHEET 3 OF 3

Drilling Information						Rock Substance					Rock Mass Defects		
Method	Casing	Water	Pressure test * (lugeons)	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description rock type: grain characteristics colour, structure, minor components.	RQD	Weathering	Strength Is (50) (MPa) 0·03 0·1 0·3 1·0 3·0 10	Defect spacing (cm) 10 30 100 300	Defect description thickness, type, inclination, planarity, roughness, coating, strength. Particular / General	Rock condition No
NMLC			<1	100	41	V	DACITE Purple	55	FR			Rock mass is close jointed and inplaces fractured. Joints are coated with chlorite (weak) and some thin veneer of clay. Some crushed seams up to 10 cm thick.	4
				100	42	V		35					
					43	V	END OF HOLE 43·25m						

Drill type CRAELIUS
Feed Hydraulic
Core barrel type NMLC with triple tube & split inner
Driller D.Wheatly (DHC)
Commenced 24/6/75
Completed 7/7/75
Logged by P.A.LANG
Vertical scale 1cm = 1m

Weathering
Fr — Fresh
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. Test sections are indicated by blacked in strips.

Core Photograph Negative No.

Depth (m)	Black & White	Colour

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M(Pf) 221

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT GINNINDERRA SEWER TUNNEL
LOCATION 42·3m west of tunnel line at station 44+40
ANGLE FROM HORIZONTAL (θ) 30° DIRECTION 138° grid
COORDINATES E 197662 N 608745 R.L. OF COLLAR 543m

HOLE NO. GST 15
SHEET 1 OF 3

Drilling Information						Rock Substance				Rock Mass Defects		
Method	Casing	Water	Pressure test * (lugeons)	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description rock type: grain characteristics colour, structure, minor components.		Weathering	Strength Is (50) (MPa) 0·03 — 0·3 — 1·0	Defect spacing (cm) 30 — 300	Defect description thickness, type, inclination, planarity, roughness, coating, strength. Particular / General	Rock condition No.
Rock Rolled				NOT CORED	1–6	NOT CORED	NOT CORED					NOT CORED	
NMLC			NOT TESTED	80	6–7	loss	FAULT BRECCIA Partly healed & cemented, partly loose and fractured or held together with heavy fat clay. Rock fragments are mostly Walker Member Dacite above 16m. with increasing proportion of purple Rhyodacite towards 16m.	20	some EW seams.			Faulted rock. Sheared and fractured. Healed in places. Loose or held together with heavy clay in other places. Many clay seams up to 30cm thick. Fractured zones with clay up to 1m. thick.	5
				35	7–8	loss		0					
				35	8–9	loss		0					
				100	9–10	loss		45					
				45	10–11	loss		0					
				45	11–12	loss		7					
				100	12–13	loss		0					
				25	13–14	loss		10					
				95	14–15		FAULT BRECCIA As above but rock fragments are purple rhyodacite.	20	Mostly HW			Close jointed rock. Joints with clay veneer, and limonite staining. Fractured and healed in places.	4
				100	15–16			40	MW				
				98	16–17			15	HW			Fractured to gravel size.	5

Drill type CRAELIUS
Feed Hydraulic
Core barrel type NMLC with triple tube & pistol bits
Driller D.Wheatly (DHC) R.White
Commenced 11-7-75
Completed 11-8-75
Logged by P.A.LANG
Vertical scale 1cm=1m

Weathering
Fr — Fresh
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. Test sections are indicated by blacked in strips.

Core Photograph Negative No.

Depth (m)	Black & White	Colour

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V(Pt)221

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT GINNINDERRA SEWER TUNNEL
LOCATION 42·3m west of tunnel at station 44+40
ANGLE FROM HORIZONTAL (θ) 30°
DIRECTION 138° grid
COORDINATES E197662 N608745
R.L. OF COLLAR 543m
HOLE NO. GSJ 15
SHEET 2 OF 3

Method	Pressure test * (lugeons)	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description: rock type; grain characteristics, colour, structure, minor components		Weathering	Defect description (Particular)	Rock condition No.
NMLC	NOT TESTED	45	20.5–21	loss	Purple RHYODACITE. Partly altered. Moderately strong. Fairly soft to drill.	0	HW	Rock completely fractured to gravel. Many clay seams.	5
		100	21–22			0			
		98	22–23			0			
		90	23			0			
		100	23–24.5			85	MW to FS		4–5
		98	24.5–25.5			45		5cm gravelly clay; 20cm gravelly clay	
		100	25.5–26.8			60			
		95	27			60		20cm gravelly clay.	
		100	27–28.5			30		90° fractured zone with clay, 5cm thick.	
		100	28.5–30			65		10cm gravelly clay	
	0	100	30–31.5			40		Clay seams.; 25cm gravelly clay	
		100	31.5–33.3			35			
		85	33.3–34.7	loss		30		50cm gravelly clay.	
		100	34.7–36.3			35	FR	Fractured with clay seams.	
	0	100	36.3–37.7			25		5cm gravelly clay; 20cm gravelly clay.	
		100	37.7–39.2			60			
		100	39.2–40			50			

Defect description (General): Rock mass is close jointed (generally 10-20 cm) and seamy. Joint surfaces are generally coated with 1-5 mm of clay and limonite stained above 34m. There are many crushed seams (sandy clay - gravelly clay) generally about 5-20 cm but up to 50cm thick, spaced approx. 1m. Probably need steel set support.

Drill type CRAELIUS
Feed Hydraulic
Core barrel type NMLC with triple tube & split inner
Driller D.Wheatly, R.White (DHC)
Commenced 11-7-75
Completed 11-8-75
Logged by F.A.LANG
Vertical scale 1cm≡1m

Weathering
Fr — Fresh
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. Test sections are indicated by blacked in strips.

Core Photograph Negative No.

Depth (m)	Black & White	Colour

I55/A16/1478 2 of 3

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

PROJECT GINNINDERRA SEWER TUNNEL
LOCATION 42·3m west of tunnel line at station 44+40

HOLE NO. GST 15

GEOLOGICAL LOG OF DRILL HOLE

ANGLE FROM HORIZONTAL (θ) 30° DIRECTION 138° grid
COORDINATES E 197662 N 608745 R.L. OF COLLAR 543m

SHEET 3 OF 3

Drilling Information					Rock Substance			Rock Mass Defects		
Method	Casing	Water	Pressure test * (lugeons)	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description rock type: grain characteristics colour, structure, minor components.	Weathering	Strength Is (50) (MPa) 0·03 0·03–0·10 0·10–0·30 0·30–1·00 1·00–3·00 3·00–10·0	Defect spacing (cm) 3 10 30 100 300	Defect description thickness, type, inclination, planarity, roughness, coating, strength Particular / General	Rock condition No.
NMLC			0	100	41		Purple RHYODACITE Partly altered, Moderately strong. Fairly soft to drill!	FR	50		40cm gravelly clay	4-5
				95					10			
				100	42				45			
				100	43						30cm gravelly clay	
			0	100	44				40			
				100	45				0		50cm fractured with clay. Gravelly clay.	
				100	46				50		Fractured	
				100	47				30		Fractured	
			0	100	48				50		Near 90° fracture zone with clay. 2m of core.	
				100	49				0			
				100	50							
				100	51				20			
				100	52				50			
				100	53							
			0	100	54				50			4
				100	55							
				100	56				35			
				100	57				60		10cm clay seam	
				100	58							
				100	59				45			
							END OF HOLE 59·38m					

TUNNEL

TUNNEL

Rock mass is generally close jointed (10-15 cm) and in places fractured. Joints are generally coated with 1-5 mm of clay. Fractured zones generally 60°-90° to core and up to 2m of core is affected in each zone. Fractured zones have much clay. Crushed seams up to 30 cm thick spaced > 1m. Probably need steel support.

Rock mass is close jointed (generally 10-15 cm). Many joints have a veneer of clay. Some clay seams up to 10 cm thick (rare). Most joints at 30° some at 80°. Possibly need steel set support.

Drill type CRAELIUS
Feed Hydraulic
Core barrel type NMLC with triple tube
Driller D.Wheatly, R.White (DHC)
Commenced 11-7-75
Completed 11-8-75
Logged by P.A.LANG
Vertical scale 1cm = 1m

Weathering
Fr — Fresh
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. Test sections are indicated by blacked in strips.

Core Photograph Negative No.

Depth (m)	Black & White	Colour

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M(Pf) 221

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT GINNINDERRA SEWER TUNNEL
LOCATION Ai station 46+00 on centreline of tunnel
ANGLE FROM HORIZONTAL (θ) 90° DIRECTION —
COORDINATES 197629E 608565N R.L. OF COLLAR 569.0m

HOLE NO. GST 10
SHEET 1 OF 3

Drilling Information						Rock Substance					Rock Mass Defects			
Method	Casing	Water	Pressure test * (lugeons)	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description rock type: grain characteristics colour, structure, minor components.	RQD	Weathering	Strength Is (50) (MPa) 0.03 0.1 0.3 1.00 3.0 10.0	Defect spacing (cm) 3 30 300	Defect description thickness, type, inclination, planarity, roughness, coating, strength. Particular / General	Rock condition No.
Rock Rolled	NIL		NOT TESTED	NOT CORED	1								
NMLC				100	2			60	MW			10cm sandy clay joint filling. 2cm sandy clay joint filling. 2cm sandy clay joint filling. all at 30°	
				100	3			60	SW			2 joint sets : 0-30°, 45-60° and random joints.	
				100	4			50				Thin veneer of sandy clay on joints for 10cm.	
				100	5							20cm of horizontal fractures spaced 2mm - 2cm. 10cm with clay and limonite infilling on joints	
				100	6			90				1cm with clay and limonite	
				100	7								
				100	8		RHYOLITE Pale green. Silicious with quartz phenocrysts. Hard, strong.	80	SW to FS			2cm yellow clay and limonite	
				100	9			75					
				100	10			80				2 joint sets : 30°-45°, 45-60° in opposite directions and random joints.	
				100	11							Rock mass moderately strong. Joints heavily stained with limonite but tight. Some joints cemented with limonite (moderately strong) did not break during drilling, but may open up during blasting. Joints spaced generally 10-40 cm. Some joints are crushed and partly sheared with clay.	3
				100	12			70					
				100	13								
				100	14			80					
				100	15			93					
				100	16			93	MW to SW				
				100	17			50					
				100	18			75				Rock close jointed, and fractured (many fractures are drill induced) Defects are joints and fractures spaced often < 7cm, but up to 40 cms, with crumby zones generally less than 5 cm wide spaced from 20-50 cm. Mostly horizontal. Probably need support.	4
				100	19			85	FS				

Drill type MLE
Feed Hydraulic
Core barrel type NMLC with triple tube & split inner
Driller B.Harte (DHC)
Commenced 13/5/75
Completed 26/5/75
Logged by P.A.LANG
Vertical scale 1cm = 1m

Weathering
Fr — Fresh
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. Test sections are indicated by blacked in strips.

Core Photograph Negative No.

Depth (m)	Black & White	Colour

155/A16/1479 1 of 3

M(Pf) 221

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT GINNINDERRA SEWER TUNNEL
LOCATION At station 46+00 on centreline of tunnel
ANGLE FROM HORIZONTAL (θ) 90 DIRECTION
COORDINATES 197629E 608565N R.L. OF COLLAR 569.0m

HOLE NO. GSI 16
SHEET 2 OF 3

Drilling Information | Rock Substance | Rock Mass Defects

Method	Casing	Water	Pressure test * (lugeons)	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description: rock type; grain characteristics; colour, structure, minor components.	RQD	Weathering	Strength Is (50) (MPa) 0.03 0.1 0.3 1.0 3.0	Defect spacing (cm) 30 100 300	Defect description: thickness, type, inclination, planarity, roughness, coating, strength. Particular / General	Rock condition No.
NMLC	Grouted off		NOT TESTED	100	21		RHYOLITE Pale green, hard & strong	85				Cavity 8cm x 3cm x 1cm. with limonite encrustation. 45°. Open joints & limonite encrusted cavities. Limonite stained open joints. 1cm thick epidote vein, runs 30cm along core (tight)	
				100	22			67					
				100	23			70					
				100				80					
				100	24		RHYOLITE Blue green, hard & strong	67	SW			Open joints and cavities, 5cm x 3cm x 1cm with limonite encrustation.	
					25				FS				
			0	100	26			75				Open joints and limonite encrusted cavities.	
				100	27			85					
				100	28							5cm & 3cm wide crushed seams with clay & epidote.	
				100	29			93					
				100	30		RHYOLITE Pale green	95				2-5cm crushed & sheared. No clay. 10 cm crushed & sheared. No clay.	
				100	31			80					
			0	100	32				MW-HW			50cm wide weathered zone with cavities and clay.	
				100	33			55					
				100	34			80				5-10cm crushed zones with clay.	
				100	35		RHYODACITE Purple, Hard & mod. strong	65	FS			10cm crushed seam with clay	
				100	36							1cm crushed seam, with clay	
			0	100	37			60					
				100	38			80					
				100	39			65				5cm crushed seam.	

Core riddled with cavities, up to 7 cm across. All thickly coated with limonite. Cavities appear to be mainly discontinuous / partly healed fractures. Rock mass close jointed. Joints spaced 10 / 30 cm, mostly at ~60°. Joints mostly tight (except cavities) and often cemented. 50% of healed fractures will probably break on blasting. Support not likely. — Rock condition No. 3-4

Rock mass blocky and seamy. Joints spaced mainly 10 - 30 cm with limonite or a veneer of clay, with crushed seams up to 20 cm wide with clay spaced 25 cm to 2m. Joints are fairly tight, generally 30° - 45°. Mostly wavy and irregular. Support not likely. — Rock condition No. 4

3/6/75

Drill type MOLE
Feed Hydraulic
Core barrel type NMLC with triple tube & split inner
Driller B. Harte (DHC)
Commenced 13/5/75
Completed 26/5/75
Logged by P.A. LANG
Vertical scale 1cm=1m

Weathering
Fr — Fresh
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. Test sections are indicated by blacked in strips.

Core Photograph Negative No.

Depth (m)	Black & White	Colour

153/A16/1479 2 of 3

M(Pf) 221

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT GINNINDERRA SEWER TUNNEL
LOCATION At station 46+00 on centreline of tunnel
ANGLE FROM HORIZONTAL (θ) 90° DIRECTION -
COORDINATES 197629E 608565N R.L. OF COLLAR 569·0 m

HOLE NO. GT 16
SHEET 3 OF 3

Drilling Information						Rock Substance				Rock Mass Defects		
Method	Casing	Water	Pressure test * (lugeons)	Litt & % core recovery	Depth (metres)	Graphic log & core loss	Substance description rock type: grain characteristics colour, structure, minor components.		Weathering	Strength Is (50) (MPa) 0·03 0·03–0·3 0·3–3·0 3·0	Defect spacing (cm) 3 30 300 3	Defect description thickness, type, inclination, planarity, roughness, coating, strength. Particular / General	Rock condition No.
NMLC		11/6/75	0	100	41			40					
				100	42			0	FS altered				
				100				10					
			0	100	43		RHYODACITE Purple Moderately soft, weak.	55				Rock mass is very seamy, weak. Defects are all joints all clay coated & crushed seams with clay. Joints spaced 10-30 cm, commonly 1-16 cm. Crushed sandy clay seams often spaced 5-10 cm. Support very likely.	5
				100	44								
				100	45			0					
		18/6/75		100	46			7					
				100	47			60	FR altered				
				100	48		RHYOLITE Purplish green. Moderately soft, weak. Rock is partly sheared & healed with epidote.	85				Rock mass weak Core broken into lengths 10-30cm. Rock sheared and healed with epidote & clay. Clay veneer on joints. No crushed seams Incipient healed fractures at 80°-90°. Many incipient fractures would break during blasting.	4
			0	100	49			55				clay seams 3-7cm wide.	
				100	50		RHYODACITE Purple. Moderately soft, weak. Rock is sheared & healed with epidote and clay veins.	10				20cm thick clay seam dip 30-45°. Rock mass very seamy. Clay seams & crushed sandy clay seams 5-20cm wide, spaced 15-20 cm. Rock mass riddled with incipient fractures cemented with clay. Support likely.	5
				100	51			10					
				100	52			10					4
					53		END OF HOLE 53·15m						

TUNNEL

TUNNEL

Drill type MOLE
Feed Hydraulic
Core barrel type NMLC with triple tube & split inner
Driller B.Harte (DHC)
Commenced 13/5/75
Completed 26/5/75
Logged by P.A.LANG
Vertical scale 1cm/1m

Weathering
Fr — Fresh
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. Test sections are indicated by blacked in strips.

Core Photograph Negative No.

Depth (m)	Black & White	Colour

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M(Pf) 221

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT GINNINDERRA SEWER TUNNEL

LOCATION At station 47+50 on centreline of tunnel

ANGLE FROM HORIZONTAL (θ) 30° DIRECTION 025 grid

COORDINATES E197569 N608429 R.L. OF COLLAR 522.2m

HOLE NO. GSI 17

SHEET 1 OF 2

Drilling Information | Rock Substance | Rock Mass Defects

Method	Casing	Water	Pressure test * (lugeons)	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description: rock type, grain characteristics, colour, structure, minor components.	RQD	Weathering	Strength Is (50) (MPa) 0.03 0.1 0.3 1.0 3.00 10.0	Defect spacing (cm) 3 30 100 300	Defect description: thickness, type, inclination, planarity, roughness, coating, strength. Particular / General	Rock condition No.
Rock Rolled		Water flowing from collar at rates shown below	NOT TESTED	NOT CORED	1	NOT CORED							
				90	2		SHEARED ZONE Fragments of shale and rhyolite in heavy fat clay matrix.	0	EW to HW			Steel sets at 60cm to 1m spacing, with continuous timber lagging will be required.	5
				100									
				100	3								
				100									
					4								
				55	5	loss						Rock mass is a clayey gravel.	
				95	6		RHYOLITE, green. Hard, moderately strong.	0					
				100	7			0	SW to FS			Will need steel set support at 1·0-1·3m spacing. Rock mass is very close jointed and fractured. Joints are spaced 1-10cm. There are some crushed seams (clayey gravel) up to 2cm wide, spaced 1-2m at 60° to core (probably vertical).	4
				100	8			7					
				100	9			0					
				100	10			15					
				100	11			10					
				100	12			25					
				100	13			40					
			800 L/hr	100	14			50				Probably need steel sets at 1·3m spacing or pattern rock bolts. Rock mass is stronger below 13m. Joints are tighter and more widely spaced (1-20 cm but generally 3-20 cm). There are some fractured zones up to 10cm wide spaced 50 cm - 2m at 60°-80° to core (probably vertical).	
				100	15			50	FR				4
			8·5 Lugeon	100	16			30					
				100	17			50					
			← contin.	100	18			70				Joints at 30°-80° are predominant. Surfaces are generally slickensided with chlorite. Thin veneer of clay on some surfaces, decreasing below 13m. Rock mass is riddled with cavities up to 1cm. but generally less than 2mm across. Cavities are partly healed fractures. They are discontinuous but form weaknesses along which the rock breaks during drilling, and will probably break when blasted.	3
			800 L/hr ← 13·0 Lugeons	100	19			90					

TUNNEL NMLC TUNNEL

Drill type CRAELIUS

Feed Hydraulic

Core barrel type NMLC with triple tube & split inner

Driller D. Wheatly (DHC)

Commenced 2/6/75

Completed 14/6/75

Logged by P.A. LANG

Vertical scale 1cm = 1m

Weathering

Fr — Fresh

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. Test sections are indicated by blocked in strips.

Core Photograph Negative No.

Depth (m)	Black & White	Colour

155/A16/1480 1 of 2

M(Pf) 221

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT GINNINDERRA SEWER TUNNEL
LOCATION At station 49+00 on centre line of tunnel
ANGLE FROM HORIZONTAL (θ) 90° DIRECTION —
COORDINATES E 197471·5 N 608319·7 R.L. OF COLLAR 529m

HOLE NO GST 18
SHEET 1 OF 2

Drilling Information | Rock Substance | Rock Mass Defects

Method	Casing	Water	Pressure test * (lugeons)	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description: rock type; grain characteristics, colour, structure, minor components.	RQD	Weathering	Strength Is (50) (MPa) 0·03 0·03–0·3 0·3–1·0 1·0	Defect spacing (cm) 3 30 100 300	Defect description: thickness, type, inclination, planarity, roughness, coating, strength. Particular / General	Rock condition No.
Rock Rolled			NOT TESTED	Not Cored									
				90	1	V		0	HW to MW				
				100		V		15				Mainly sound rock but intersected by 2 joints at 30° spaced 5-30 cm and one at 60°-80° spaced 10 cm. Clay seams 1-5cm on several joints spaced 10-30 cm.	
				100	2	V		0					
				100	3	V	Welded DACITE Ignimbrite crystal tuff. Blue grey to purplish grey where fresh. Quartz phenocrysts up to 3mm (often stained red) in a dark fine grained groundmass. Very hard, very strong.	25					
				100	4	V		50				10cm crushed seam.	4-5
				100	5	V							
				100	6	V		35	MW to SW			Joints with coating of clay. 1mm - 5cm thick.	
				100	7	V		35				1cm clay seam 15cm of crushed seams with clay.	
				100	8	V		30				Crushed seams with clay.	
				100	9	V		30				Vertical joints limonite stained.	
				100	10	V							
				100	11	V		60				1-2cm shear with clay and chlorite at 10°.	
				100	12	V		80				Limonite stained joint at 80°.	
			9	100	13	V		20	SW to FS			Close jointed & fractured by joints at 30-45° 2 sets each spaced 10cm + 1 at 60°-80°. Surfaces generally limonite stained Some crushed seams, with clay up to 1cm.	
				100	14	V							
				100	15	V		55				2cm crushed seam 1cm crushed seam	
				100	16	V		45				Very close jointed with greasy clay seams up to 2cm thick, spaced 5-10cm.	
				100	17	V							
			3-4	100	18	V	AS ABOVE - but stained purple with hydrothermally deposited haematite.	60	FR			25cm crushed seam. Sandy clay.	
				100	19	V		85				Joints tight. Slickensided with calcite & chlorite. 20cm of crushed seams at 10°, up to 5cm each.	

Rock mass is close jointed (generally 5-10cm but up to 30cm) and seamy. Many joints have 1-10 mm of clay. Several crushed seams with clay generally 1-5cm but up to 30cm thick spaced generally 10-30 cm but up to 1m. Core is ground up by drilling in several places. Above 17m. several joint sets at 30°-45° in opposite directions spaced approx. 10cm. have caused core to be fractured in places. Probably need steel sets without clay are stained with limonite. spaced 1·0 — 1·5m.

TUNNEL — NMLC — TUNNEL

Drill type MOLE
Feed Hydraulic
Core barrel type NMLC with triple tube & split inner
Driller B Harte (DHC)
Commenced 29/7/75
Completed 2/8/75
Logged by PALANG
Vertical scale 1cm = 1m

Weathering
Fr — Fresh
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. Test sections are indicated by blacked in strips.

Core Photograph Negative No.

Depth (m)	Black & White	Colour

155/A16/1481 1 of 2

M(Pf) 221

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT GINNINDERRA SEWER TUNNEL
LOCATION At station 49+00 on centre line of tunnel
ANGLE FROM HORIZONTAL (θ) 90 DIRECTION —
COORDINATES E 197471·5 N 6083197 R.L. OF COLLAR 529 m.

HOLE NO. GSI 18
SHEET 2 OF 2

Drilling Information						Rock Substance					Rock Mass Defects		
Method	Casing	Water	Pressure test * (lugeons)	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description rock type: grain characteristics colour, structure, minor components.	RQD	Weathering	Strength Is (50) (MPa) 0·03 0·1 0·3 1·0 3·0 10	Defect spacing (cm) 30 100 300 1000 3000	Defect description thickness, type, inclination, planarity, roughness, coating, strength. Particular / General	Rock condition No.
NMLC			3-4	100	21	V	DACITE as above	40	FR			Joints at 0-30° spaced 5-15 cm mostly with 1-10 mm of greasy clay.	4
							END OF HOLE 20·74 m.						

Drill type MOLE
Feed Hydraulic
Core barrel type NMLC with triple tube & split inner
Driller B. Harte (DHC)
Commenced 29/7/75
Completed 2/8/75
Logged by P.A. LANG
Vertical scale 1cm = 1m

Weathering
Fr — Fresh
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. Test sections are indicated by blacked in strips.

Core Photograph Negative No.

Depth (m)	Black & White	Colour

155/A16/1481 2 of 2

M(Pf) 221

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT GINNINDERRA SEWER TUNNEL
LOCATION 20m east of tunnel line at station 52+00
ANGLE FROM HORIZONTAL (θ) 90° DIRECTION —
COORDINATES E 137260 N 608100 R.L. OF COLLAR 572m

OBS BORE HOLE NO. GSJ 20
CANBERRA 136
SHEET 1 OF 2

Drilling Information						Rock Substance			Rock Mass Defects			
Method	Casing	Water	Pressure test * (lugeons)	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description rock type: grain characteristics colour, structure, minor components.	Weathering	Strength Is (50) (MPa) 0.03 0.1 0.3 1.00 3.00 10.0	Defect spacing (cm) 3.0 30.0 300 300	Defect description thickness, type, inclination, planarity, roughness, coating, strength. Particular / General	Rock condition No.
Rock Rolled — chips collected at 05m intervals.			NOT TESTED	NOT CORED	2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40	NOT CORED	DACITE Blue grey when fresh. Commonly stained purple. Very hard, very strong.	FR			Rock mass very strong. Joints tight.	Mainly 2-3

Drill type MEYHEW
Feed Hydraulic
Core barrel type
NOT CORED
Driller T Shanahan (BMR)
Commenced 19/3/75
Completed 10/4/75
Logged by R.A.LANG
Vertical scale 1cm = 2m

Weathering
Fr — Fresh
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. Test sections are indicated by blacked in strips.

Core Photograph Negative No.

Depth (m)	Black & White	Colour

155/A16/1482 1 of 2

M(Pf) 221

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT GINNINDERRA SEWER TUNNEL
LOCATION 20m East of tunnel line at station 52+00
ANGLE FROM HORIZONTAL (θ) 90° DIRECTION —
COORDINATES 157260E [illegible] R.L. OF COLLAR 572m.

OBS BORE HOLE NO G.S.L. 20
CANBERRA
SHEET 2 OF 2

Drilling Information | Rock Substance | Rock Mass Defects

Method	Casing	Water	Pressure test * (lugeons)	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description: rock type; grain characteristics; colour, structure, minor components.	Weathering	Strength Is (50) (MPa) 0.03 0.03–0.3 0.3–1 1–3 3–10 10–30 30–100 100–300	Defect spacing (cm) 3 10 30 100 300	Defect description: thickness, type, inclination, planarity, roughness, coating, strength. Particular / General	Rock condition No.
Rock rolled – chips at 0.3m intervals. TREFOS 2½" triple tube core barrel with split inner tube & DIAMOND BIT	TUNNEL	5/3/75 ▼	NOT TESTED	NOT CORED	41–59	NOT CORED	NOT CORED				NOT CORED	
				100%	50	V	BLUE GREY DACITE – with red stained quartz phenocrysts and green inclusions up to 2cm (epidote?) Very hard, very strong.				Thin veneer of clay on some joints. Joints rough. Rock mass fairly tight.	3
				100%	51–52	V						
				100%	52–53	V						
				100%	53–54	V					Drill core fragmented by shaking drill rig	
				100%	54	V		FR			1cm. clay seam	2
				100%	54–55	V					Some clay seams. Rock mass is very strong. Joints strongly cemented with calcite. Sticks of core up to 1.5m. long. Most joints at 30°, one at 90°. Joints rough.	
				100%	55	V					1cm. clay seam	
				100%	55–59	V						
				100%	59	V						

60-10m.

TUNNEL

Drill type Meyhew
Feed Hydraulic
Core barrel type TREFOS 2½" triple tube split inner
Driller T. Shanahan (BMR)
Commenced 19-3-75
Completed 10-4-75
Logged by P. Lang
Vertical scale 1cm=1m

Weathering
Fr — Fresh
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. Test sections are indicated by blacked in strips.

Core Photograph Negative No.

Depth (m)	Black & White	Colour

155/A16/1482 2 of 2

M(Pf) 221

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT GINNINDERRA SEWER TUNNEL
LOCATION 22·5 m East of tunnel line at station 43+53
ANGLE FROM HORIZONTAL (θ) 90° DIRECTION –
COORDINATES E 197749 N 608790 R.L. OF COLLAR 540m

HOLE NO GST 21
SHEET 1 OF 2

Drilling information						Rock substance					Rock mass defects		
Method	Casing	Water	Pressure test * (lugeons)	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description: rock type; grain characteristics; colour, structure, minor components	RQD	Weathering	Strength Is (50) (MPa) 0·03 0·03–0·3 0·3–1·0 1·0–3·0	Defect spacing (cm) 3 10 30 100 300	Defect description: thickness, type, inclination, planarity, roughness, coating, strength. Particular / General	Rock condition No.
Rock Rolled		▼ 11/9/75	NOT TESTED	NOT CORED	1–17	NOT CORED	NOT CORED					NOT CORED	
Diamond coring				100	17–18		Green RHYOLITE Quartz phenocrysts up to 5mm. Pink feldspars up to 2mm. Mafic veinlets throughout.	75	FR			Rock mass is close jointed but tight. Joints at all angles, generally spaced <30 cm. Surfaces strongly slickensided with chlorite. Some with a thin veneer of clay.	3
				100	18–19								

Drill type Meyhew
Feed Hydraulic
Core barrel type TRIEVUS 2½ triple tube split inner
Driller E Lodwick (BMR)
Commenced 5/9/75
Completed 12/9/75
Logged by P.A.LANG
Vertical scale 1cm=1m

Weathering
Fr — Fresh
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. Test sections are indicated by blacked in strips.

• Core Photograph Negative No

Depth (m)	Black & White	Colour

155/A16/1483 1 of 2

M(Pt)221

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT GINNINDERRA SEWER TUNNEL
LOCATION 22.5m East of tunnel line at station 43+53
ANGLE FROM HORIZONTAL (θ) 90° DIRECTION —
COORDINATES E 197749 N 608790 R.L. OF COLLAR 540m

OBS BORE HOLE NO. GSI 21
SHEET 2 OF 2

Drilling Information						Rock Substance					Rock Mass Defects		
Method	Casing	Water	Pressure test * (lugeons)	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description rock type: grain characteristics colour, structure, minor components.	RQD	Weathering	Strength Is (50) (MPa) 0.03 0.1 0.3 1.0 3.0 10.0	Defect spacing (cm) 3 10 30 100 300 1000	Defect description thickness, type, inclination, planarity, roughness, coating, strength. Particular	Defect description General	Rock condition No.
TUNNEL Diamond coring			NOT TESTED	100	21		RHYOLITE	60	FR			Some crushed seams up to 1cm, but most fractures are drill induced.	Core close jointed generally < 20 cm. Many incipient fractures partly healed. Joint surfaces strongly slickensided with chlorite Some calcite cement.	3-4 TUNNEL
				100	22		As above	60						
					23		END OF HOLE 23.0m							

Drill type Meyhew
Feed Hydraulic
Core barrel type TRELEUS 2½" triple tube - split inner
Driller E. Lodwick (BMR)
Commenced 5/9/75
Completed 12/9/75
Logged by P.A. Lang
Vertical scale 1cm ≡ 1m

Weathering
Fr — Fresh
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. Test sections are indicated by blacked in strips.

Core Photograph Negative No.

Depth (m)	Black & White	Colour

155/A16/1483 2of2

M(Pf) 221

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

PROJECT GINNINDERRA SEWER TUNNEL
LOCATION 20m East of tunnel line at station 35+30

USS BORE HOLE NO G.S.T. 22

GEOLOGICAL LOG OF DRILL HOLE

ANGLE FROM HORIZONTAL (θ) 90° DIRECTION —
COORDINATES 198071E 609545N R.L. OF COLLAR 574 m.

SHEET 1 OF 2

Drilling Information						Rock Substance			Rock Mass Defects			
Method	Casing	Water	Pressure test * (lugeons)	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description: rock type; grain characteristics; colour, structure, minor components	Weathering	Strength Is (50) (MPa) 0.03 0.03–0.3 0.3–3 3–10	Defect spacing (cm) 3 30 300 3000	Defect description: thickness, type, inclination, planarity, roughness, coating, strength — Particular / General	Rock condition No
Rock Rolling	Nil			Not Cored	1–3	Not cored	NOT CORED				NOT CORED	
DRILL TECH TUNGSTEN BIT			NOT TESTED	85%	3–4		QUARTZ FELDSPAR SANDSTONE Medium grained Brownish yellow & laminated. Rock is soft and weak. Some zones weathered to a sandy clay. Bedding horizontal	HW			Clay on joints clay infillings up to 1cm. Joints spaced 3–12 cm. Joints cemented with limonite. Weak. Rock mass is weak. Core fragmented by drill into lengths 3–20 cm. 90% of breaks are horizontal (parallel to bedding) bedding planes mostly tight and moderately strong.	4–5
				100%	4–5							
				95%	5–6							
				85%	6–7							
				95%	7–8		Pale yellow laminated siltstone 80% & sandstone same as above 20%.					
				85%	8–9	loss	Small faults < 1cm displacement. Crossbedding < 1cm. Scour & fill structures < 1cm.					
				95%	9–10		Intrusive contact, but no evidence of chilled margin or of baked sediments. GRANITE PORPHYRY Light brown (HW) medium grained.				Rock mass is weak. Defects weak. Joints mostly 30° to 45°, spaced 10 – 30 cm. Thin veneer of clay on some joints. Joints smooth, planar and moderately tight.	
				95%	10–11							
				95%	11–12							
				95%	12–13							
				85%	13–14							
				85%	14–15	loss		HW				
				85%	15–16							
				85%	16–17							
				95%	17–18							
				100%	18–19							
				95%	19–20							
TREIFUS 2½" core with triple tube core barrel & split inner tube		10/10/73		90%								

Drill type Meyhew
Feed Hydraulic
Core barrel type Treifus 2½" triple tube split inner
Driller T. Shanahan (Brik)
Commenced 11-4-75
Completed 17-4-75
Logged by P. Lang
Vertical scale 1cm = 1m.

Weathering
Fr — Fresh
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. Test sections are indicated by blacked in strips.

Core Photograph Negative No

Depth (m)	Black & White	Colour

155/A16/1484 1of2

M(Pf) 221

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT GINNINDERRA SEWER TUNNEL
LOCATION 20m. East of tunnel line at station 35+30
ANGLE FROM HORIZONTAL (θ) 90° DIRECTION —
COORDINATES 198071E 609545N R.L. OF COLLAR 574m

HOLE NO G.S.T. 22
SHEET 2 OF 2

Drilling Information | Rock Substance | Rock Mass Defects

Method	Casing	Water	Pressure test * (lugeons)	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description: rock type, grain characteristics, colour, structure, minor components.	Weathering	Strength Is (50) (MPa) 0.03–3.000 10.0	Defect spacing (cm) 3 100 1000 300	Defect description: thickness, type, inclination, planarity, roughness, coating, strength. Particular / General	Rock condition No.
DIAMOND BIT Treifus core barrel	DRILL TECH. TUNGSTEN BIT. TREIFUS CORE BARREL 2½" CORE.		NOT TESTED	60%	21	Core loss + +	GRANITE PORPHYRY Moderately hard, weak. Pinkish brown to yellow brown.	EW				
				100%	22	+ +		HW mainly				
				75%	23	loss +						
				90%	24	loss +		EW to HW				
				85%	25	+ +						
				35%	26	Core loss +						
				50%	27	Core loss					Rock mass is weak. Joints commonly clay coated. Zones of EW rock (clayey sand) up to 1m wide.	5
				30%	28	+ + +	PINK GRANITE PORPHYRY Very hard, very strong.	MW			Rock mass is strong. Calcite and chlorite on joints. Joint cement moderately strong.	
				85% 100% 100%	29		END OF HOLE 29m.	FS				
					30							

Drill type Meybew
Feed Hydraulic
Core barrel type Treifus 2½" triple tube split inner
Driller T. Shanahan (BMR)
Commenced 11-4-75
Completed 17-4-75
Logged by P. Lang
Vertical scale 1cm=1m

Weathering
Fr — Fresh
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. Test sections are indicated by blacked in strips.

Core Photograph Negative No

Depth (m)	Black & White	Colour

155/A16/1484 2of2

M(Pf) 221

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT QUINNINDERRA SEWER TUNNEL
LOCATION 20m East of tunnel line at Station 29+50
ANGLE FROM HORIZONTAL (θ) 90° DIRECTION —
COORDINATES 198,296E 610,074N R.L. OF COLLAR 585 m

HOLE NO. GST 23 Canberra 137
SHEET 1 OF 4

Drilling Information | Rock Substance | Rock Mass Defects

Method	Casing	Water	Pressure test * (lugeons)	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description rock type: grain characteristics colour, structure, minor components.	Weathering	Strength Is (50) (MPa) 0.03 0.03–0.3 0.3–3.0 3.0	Defect spacing (cm) 3 30 300 300	Defect description thickness, type, inclination, planarity, roughness, coating, strength Particular / General	Rock condition No.
Rock Rolled				Not Cored	1–3	Not Cored	NOT CORED	EW			NOT CORED	
				95	3–4		GRANITE PORPHYRY (with xenoliths) yellow brown when weathered					
				98	5–6		Weak soft.	HW				5
				90	6–7							
				100	7–9							
					9–10			EW				
				100	10–11			HW				
					11–12							
				100	12–13		Weak to mod. weak. Mod. hard.	HW to MW			Rockmass is weak. 3 joint sets: J_1 90°, J_2 0–30° spaced 10–60 cms. J_3 45° spaced 2m on core. Joint surfaces generally coated with clay + limonite. Some joints below 15m are cemented with powdery calcite (weak, soft). Most joint surfaces wavy & irregular to rough	4
				100	13–16							
				100	16–17							
				95	17–20							
TREIFUS 2½" Tripple tube core barrel with split inner tube + bottom discharge diamond bit.		13/9	NOT TESTED									

Drill type MEYHEW
Feed Hydraulic
Core barrel type Treifus 2½" tripple tube & split inner tube
Driller Shannahan (BMR)
Commenced 9/5/75
Completed 9/6/75
Logged by P Lang
Vertical scale 1 cm ≡ 1 m

Weathering
Fr — Fresh
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. Test sections are indicated by blacked in strips.

Core Photograph Negative No.

Depth (m)	Black & White	Colour

155/A16/1485 1 of 4

M(Pf) 221

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT GINNINDERRA SEWER TUNNEL
LOCATION 20m East of tunnel line at Station 29+50
ANGLE FROM HORIZONTAL (θ) 90° DIRECTION —
COORDINATES 198,296 E 610,074 N R.L. OF COLLAR 585m

OBS BORE
HOLE NO. GST 23
Canberra 137
SHEET 2 OF 4

Drilling Information | Rock Substance | Rock Mass Defects

Method	Casing	Water	Pressure test * (lugeons)	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description: rock type: grain characteristics, colour, structure, minor components.	Weathering	Strength Is (50) (MPa) 0·03 0·1 0·3 1·0 3·0 10·0	Defect spacing (cm) 3 30 300 3000	Defect description: thickness, type, inclination, planarity, roughness, coating, strength. Particular / General	Rock condition No.
TREIFUS 2½" Tripple tube core barrel with split inner tube, + bottom discharge diamond bit.			NOT TESTED	60	21		GRANITE PORPHYRY (many xenoliths up to 10cms) Pale greenish grey. Very hard. very strong	mostly HW some EW seams			Rockmass is weak. Core is fragmented due to a vertical joint which runs full length of this zone. Many EW seams and EW joint fillings. Clay on joints.	5
				100	22							
				100	23							
				85	24							
				93	25			SW			Rockmass is tight + strong. Joints with limonite + a little calcite. Rock MW near joints, FR-SW between joints. Joints all at 0-30°, irregular.	3
				100	26							
				100	27						core fractured	
				100	28							2
				100	29						1cm calcite + clay seam. 10 cm. of joints at 30° spaced 1-3cm.	
				100	30							
				100	31			FS			Rockmass is very strong and very tight. R.Q.D. generally 95-100. Joints very tight. Joints cemented with calcite (strong). Some limonite staining. Surfaces rough & irregular.	
				100	32							
				100	33							
				100	34							
				100	35						10 cm healed shear horizontal	
				100	36						10 cm healed shear horizontal 10 cm shear ± Ca + Chl. slickensided 10 cm crushed seam ± chl. + Ca on jts + limonite staining.	
				100	37							
				100	38			FR			20cms of close jointed rock ± chl. + Ca slickensides. Jts. at 30°	
				100	39						Joints generally cemented with calcite & chlorite and strongly slickensided. Surfaces rough. Some sheared zones healed with chlorite, spaced 30cm. to 2m.	
				100	40							

Drill type MEYHEW
Feed Hydraulic
Core barrel type Treifus 2½" tripple tube ± split inner tube
Driller Shannahan (BMR)
Commenced 9/5/75
Completed 9/6/75
Logged by P. Lang
Vertical scale 1cm ≡ 1m

Weathering
Fr — Fresh
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. Test sections are indicated by blacked in strips.

Core Photograph Negative No.

Depth (m)	Black & White	Colour

155/A16/1485 2of4

M(Pf) 221

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT GINNINDERRA SEWER TUNNEL
LOCATION 20m East of tunnel line at Station 29+50
ANGLE FROM HORIZONTAL (θ) 90° DIRECTION —
COORDINATES 198,296 E 610,074 N R.L. OF COLLAR 585m

OBS BORE
HOLE NO. GST 23
Canberra 137
SHEET 3 OF 4

Drilling Information | Rock Substance | Rock Mass Defects

Method	Casing	Water	Pressure test * (lugeons)	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description rock type: grain characteristics colour, structure, minor components.	Weathering	Strength Is (50) (MPa) 0·03 0·03–3 3·0 10·0	Defect spacing (cm) 3 30 300	Defect description thickness, type, Inclination, planarity, roughness, coating, strength. Particular / General	Rock condition No.
TREIFUS 2½" Triple tube core barrel with split inner tube + bottom discharge diamond bit.			NOT TESTED	100	41							
				100	42							
					43							
				100	44							
					45							
				100	46							
					47							
				100	48		GRANITE PORPHYRY (many xenoliths) Pale grey Very hard. Very strong	FR			Several jts at 60° + incipient fractures healed with calcite	1 – 2
					49							
				100	50						Rock sheared at 60°–80° but healed ± chlorite	
					51						Mod. strong	
				100	52							
					53							
					54						Rockmass is very strong + very tight. R.Q.D. generally 100. Joints very rough + very tight. Cemented with calcite + chlorite (Very strong). Many surfaces are slickensided. Sticks of core up to 2m. long. Most breaks in core are at 0–30° (probably drill induced). Incipient fractures at steeper angles are strongly cemented and did not break during drilling.	
				100	55							
					56						2 Vertical jts at rt. angles Very wavy + irregular + rough but tight. Weakly cemented with calcite + powdery calcite clay. Also some joints slickensided with chlorite	2 – 3
					57							
					58						Rockmass strong. Joints very tight. Cemented with calcite. Some chlorite. All fractures are at 0–30° (Probably drill induced)	2
				100	59							
					60							

Drill type MEYHEW
Feed Hydraulic
Core barrel type Treifus 2½" triple tube ± split inner tube
Driller Shannahan (B.M.R.)
Commenced 9/5/75
Completed 9/6/75
Logged by P. Lang
Vertical scale 1cm = 1m

Weathering
Fr — Fresh
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. Test sections are indicated by blacked in strips.

Core Photograph Negative No.

Depth (m)	Black & White	Colour

M(Pf) 221

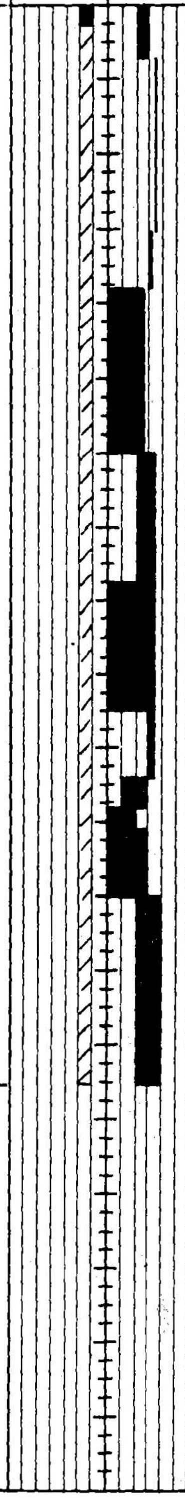
BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT GINNINDERRA SEWER TUNNEL
LOCATION 20m East of tunnel line at Station 29+50
ANGLE FROM HORIZONTAL (θ) 90° DIRECTION —
COORDINATES 198,296E 610,074N R.L. OF COLLAR 585m

OBS BORE HOLE NO. GST 23
Canberra 137
SHEET 4 OF 4

Drilling Information						Rock Substance				Rock Mass Defects			
Method	Casing	Water	Pressure test * (lugeons)	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description rock type: grain characteristics colour, structure, minor components.	Weathering	Strength Is (50) (MPa) 0.03 0.1 0.3 1 3 10	Defect spacing (cm) 3 10 30 100 300	Defect description thickness, type, inclination, planarity, roughness, coating, strength. Particular / General	Rock condition No.	
Treifus 2⅜" tripple tube core barrel with split inner tube + bottom discharge diamond bit.			NOT TESTED	100	61, 62	+					Rockmass very strong. Joints very tight. Mostly cemented with calcite (strong). All fractures are at 0-30°. (Probably drill induced)	2	
				100	63, 64, 65	+							TUNNEL
				100	66, 67	+	GRANITE PORPHYRY Pale grey. Very hard. Very strong.	FR			Rockmass is strong + tight. 2 vertical joint sets at approx. 60° to each other. One is smooth and planar and spaced 3 cms. One is wavy and irregular spaced ? 3 cms. Also one 45-60° joint set spaced > 1m. Surfaces are weakly cemented with powdery calcite and calcite clay	(2) - 3	
				100	68, 69	+							
				100	70, 71, 72	+							
				100	73, 74	+					Rockmass is very strong. Joints very tight. Slickensided with chlorite. All fractures are at 0-30°. (Probably drill induced)	2	
							END OF HOLE 74.50m.						



Drill type MEYHEW
Feed Hydraulic
Core barrel type Treifus 2⅜" tripple tube c̄ split inner tube
Driller Shanahan (B.M.R.)
Commenced 9/5/75
Completed 9/6/75
Logged by P. Lang
Vertical scale 1cm = 1m

Weathering

Fr — Fresh
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. Test sections are indicated by blacked in strips.

Core Photograph Negative No.

Depth (m)	Black & White	Colour

155/A16/1485 4 of 4

M(Pf) 221

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT GINNINDERRA SEWER TUNNEL
LOCATION 20m East of tunnel line at station 36+50
ANGLE FROM HORIZONTAL (θ) 90° DIRECTION —
COORDINATES 198021E 609440N R.L. OF COLLAR 575.7m

HOLE NO. GST 24
CANBERRA 1:58
SHEET 1 OF 3

Method	Depth (metres)	Lift & % core recovery	Graphic log & core loss	Substance description	Weathering
Rock Rolled	0–3	Not Cored	Not Cored	NOT CORED	
TREIFUS 2½" TRIPLE TUBE core barrel with split inner tube and Drill tek TUNGSTEN BIT.	3–4	70°/o	loss	GRANITE PORPHYRY Completely decomposed to a Yellow - Brown. Clayey sand (some sandy clay) Very weak, very soft.	EW
	4–5	50°/o	loss		
	5–6	65°/o	loss		
	6–8	60%	core loss / loss		
	8–9	90°/o		GRANITE PORPHYRY Decomposed to Yellow - brown. Very weak, very soft. Can be broken up in fingers.	HW
	9–11	98°/o			
	11–13	100°/o			
	13–15	100°/o			
	15–16	90°/o	loss		
	16–18	100°/o			
	18–20	100°/o			

Casing: cased throughout.

Water: 12/5 ▼ (11.7 m); 20/5 ▼ (15.3 m); 3/6 ▼ (17.8 m)

Pressure test * (lugeons): NOT TESTED

Strength Is (50) (MPa): 0.03 0.1 0.3 1 3 10

Defect spacing (cm): 3 10 30 100 300

Depth (metres)	Defect description (Particular / General)	Rock condition No.
0–3	NOT CORED	
3–20	Rock substance is very soft and weak. So rock mass has strength of rock substance. Joints mostly 0-30°, limonite and clay coated. Smooth & planar.	5

Drill type MAYHEW
Feed Hydraulic
Core barrel type TREIFUS 2½" with triple tube & split inner
Driller J. Shanahan (BMR)
Commenced 17-4-75
Completed 8-5-75
Logged by P. Lang
Vertical scale 1cm = 1m.

Weathering
Fr — Fresh
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. Test sections are indicated by blacked in strips.

Core Photograph Negative No.

Depth (m)	Black & White	Colour

155/A16/1492 1 of 3

M(Pf)221

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT GINNINDERRA SEWER TUNNEL
LOCATION 20m. East of tunnel line at station 36+50
ANGLE FROM HORIZONTAL (θ) 90° DIRECTION —
COORDINATES 198021E 609440N R.L. OF COLLAR 575.7m

OBS. BORE HOLE NO. GS 24
CANBERRA 138
SHEET 2 OF 3

Drilling Information						Rock Substance			Rock Mass Defects			
Method	Casing	Water	Pressure test * (lugeons)	Litt & % core recovery	Depth (metres)	Graphic log & core loss	Substance description rock type: grain characteristics colour, structure, minor components.	Weathering	Strength Is (50) (MPa) 0.03 0.1 0.3 1 3 10 30	Defect spacing (cm) 3 10 30 100 300	Defect description thickness, type, inclination, planarity, roughness, coating, strength. Particular / General	Rock condition No.
DRILL TEK TUNGSTEN BIT.		17/9/75	NOT TESTED	90%	21	loss	GRANITE PORPHYRY Weak, moderately hard Yellow brown.	HW to MW			Joints at 30°, 45°, 60°, 80° and 90°. Clay on joint surfaces.	5
DIAMOND BIT.				90%	22						Joints at 80° and 30°	
				100%				SW to FS			Rock mass probably blocky and seamy. Joints generally spaced about 30 cm. Joints at 80°-90° are rough. Joints at 30° are planar and smooth. Many joints have from 1-5mm of clay. Some clay seams up to 10mm thick.	4
				100%	23						Planar joints with limonite coating 80°	
							GRANITE PORPHYRY Hard and strong. Green grey with some very thin calcite veins, and some xenoliths up to 20cm thick.				Joints with up to 5mm of clay at 30°	
				100%	24							
					25						Joints at 30° and 90° with up to 5mm of clay.	
				100%	26			FS			Crushed seam with clay.	
											80° joint planar and smooth with clay.	
				100%	27						Joints at 30° and 80° with limonite.	
				100%	28						Clay seams up to 5mm thick.	
					29							
				100%	30							
					31						Most joints at 0-30° some at 80°.	
				100%	32							
				100%	33						Near vertical joints wavy and irregular.	
				90%	34			FR			Joints at 60° spaced 30 cm.	
				100%	35							
					36						Core fractured by 60° joints.	
				100%	37							
				100%							Fractured and chloritized.	
				100%	38							
				100%							Vertical joint smooth and planar.	
				100%	39						Core fractured by rig. Joints with chlorite and some clay.	
TREIFUS 2½" TRIPLE TUBE core barrel with split inner tube											Rock mass mostly strong and moderately faint. Most joints very rough and irregular. Strongly cemented with calcite and chlorite. Many are slickensided. Some of the joints at 80° are smooth and planar. Joints mostly spaced approximately 30 cm. Some zones with joints spaced 10 cm.	3

Drill type MAYHEW
Feed Hydraulic
Core barrel type TREIFUS 2½" with triple tube & split inner
Driller I. Shanahan (BMR)
Commenced 17.4.75
Completed 8.5.75
Logged by P. Lany
Vertical scale 1:100

Weathering
Fr — Fresh
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. Test sections are indicated by blacked in strips.

Core Photograph Negative No.

Depth (m)	Black & White	Colour

155/A16/1492 2 of 3

M(Pf) 221

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT GINNINDERRA SEWER TUNNEL
LOCATION 20m East of tunnel line at station 36+50
ANGLE FROM HORIZONTAL (θ) 90° DIRECTION —
COORDINATES 198021E 609440 N R.L. OF COLLAR 575.7m

OBS. BORE HOLE NO. GST 24
CANBERRA 138
SHEET 3 OF 3

Drilling Information — Method: TREIFUS 2½" TRIPLE TUBE CORE BARREL with split inner tube & diamond Bit. Pressure test * (lugeons): NOT TESTED

Rock Substance — GRANITE PORPHYRY. Green grey to pink. Very hard, very strong. Weathering: FR

Lift & % core recovery	Depth (metres)	Defect description (Particular)
98%	40–41	Vertical joints spaced 1cm. Slickensided with chlorite. Chlorite and clay seams. Core fragmented.
95%	42	
100%	43–45	60°-40° Joints
100%	46–47	Epidote & chlorite on 80° joints (fractured)
100%	48	Chlorite coated joints and rock fragments. Fragments 1-10mm thick but long & platy.
100%	49–50	Wavy, rough vertical Joints, in places cemented with calcite and chlorite & intact runs full lenght of core.
100%	51	Core fragmented Joints at 90° & 0° Probably due to shaking rig. (to fractured rock healed with chlorite. Core fragmented. Partly due to shaking core barrel. Partly due)
100%	52	
100%	53	Core in lenghts up to 60 cm but many incipient fractures mostly at 90° cemented with chlorite and calcite.
100%	54	Most joints at 45-60° and 90°. Core partly fractured by rig.
100%	55–56	Vertical joints wavy and rough
100%	56–57	Vertical joints wavy but smooth.
100%	57–58	Vertical joints rough and irregular.
100%	58–59	
100%	59–60	

General (40–42 m): Rock mass moderately weak. Vertical joints, fluxed chlorite and clay. Rock condition No. 4

General (42–60 m): Rock mass generally strong and tight. Joints generally moderately tight and spaced up to 40cm. Joint surfaces generally wavy and irregular and rough. Generally cemented with calcite (cement strong) and chlorite (cement weak). Some places slickensided and with epidote. Many vertical joints (wavy and irregular), some joints at 0-30° (wavy and irregular), and some joints at 60-80° (smooth). Rock condition No. 3

TUNNEL (approx. 55–58 m)

END OF HOLE 60.0m.

Drill type MAYHEW
Feed Hydraulic
Core barrel type TREIFUS 2½" triple tube & split inner
Driller J. Shanahan (BMR)
Commenced 17.4.75
Completed 8.5.75
Logged by P. Lang
Vertical scale 1cm ≡ 1m

Weathering
Fr — Fresh
SW — Slightly weathered
MW — Moderately weathered
HW — Highly weathered
EW — Extremely weathered

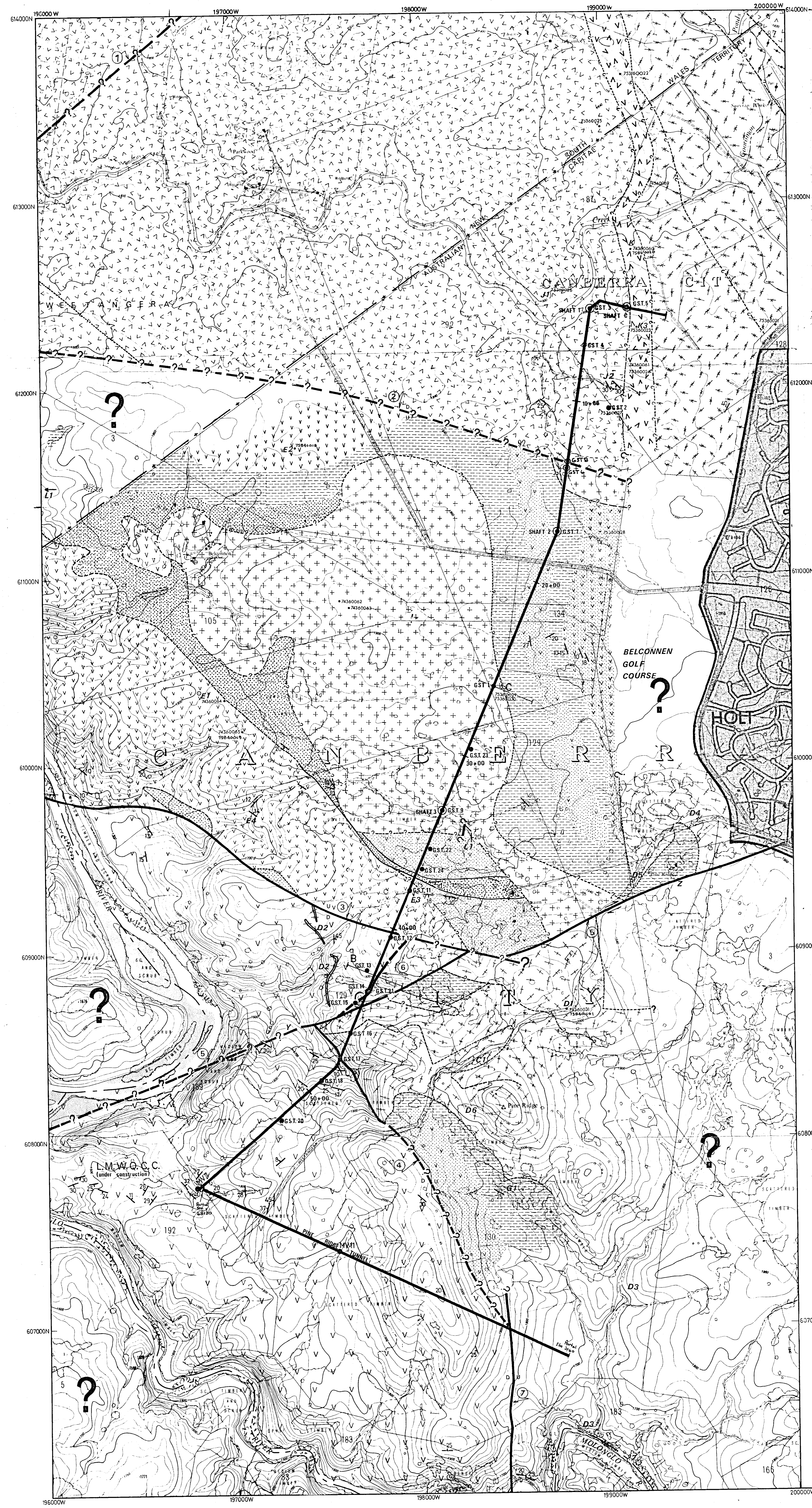
Water
10 Oct. '73 water level date shown
Water inflow
Partial drilling water loss
Complete drilling water loss

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. Test sections are indicated by blacked in strips.

Core Photograph Negative No. — Depth (m) / Black & White / Colour

155/A16/1492 3 of 3

M(Pf) 221



GINNINDERRA SEWER TUNNEL
Interpretative Solid Geology

STRATIGRAPHIC SEQUENCE

ROCK NAME	UNIT NAME	AGE
Granite porphyry	Ginninderra Porphyry [1]	Ludlovian
Light grey dacitic densely welded pyroclastic flows. Dark grey member at base.	Willow Bridge Tuff [2]	Ludlovian
unconformity		
Dacitic densely welded tuffs & pyroclastic flows. Bedding in places.	Walker Volcanics [3]	Wenlockian
Dacitic welded tuffs, agglomerates, pyroclastic flows, sills & dykes. [4]	Walker Volcanics [3]	Wenlockian
Quartz sandstone marker bed.	Walker Volcanics [3]	Wenlockian
Shale. Thin beds interbedded with pyroclastics.	Walker Volcanics [3]	Wenlockian
Sandstone. Thin beds interbedded with shales & pyroclastics.	Walker Volcanics [3]	Wenlockian
Green rhyolite		Wenlockian
Purple rhyodacite		Wenlockian
Purple rhyodacite		
Pink rhyolite		

1 Registered

2 Named by Link 1971, replaces Laidlaw Volcanics

3 Refer 1:100,000 Geological Sheet, BRINDABELLA, M.Owen et al, 1975, Preliminary Edition.

4 Regarded as intrusive equivalent of Mount Painter Porphyry, with associated extrusive rocks.

REFERENCE

40+00 — Tunnel line with tunnel station in metres

SHAFT 1 G.S.T. 3 — Shaft

FAULTS

(2) — Fault number referred to in text

U D — Position accurate (upthrown & downthrown sides indicated)

Position approximate

Fault inferred

Fault breccia

N MN 12°

GEOLOGICAL BOUNDARIES

Position accurate

Position approximate

--?--?- Boundary inferred

BEDDING

30 — Dip and strike of bedding

DRILL HOLES

G.S.T. 20 — Diamond-drill hole

• 75840101 — Specimen locality and registered number

A — Locality referred to in text

Seismic cross traverse

SCALE

500 0 500 1000m.

Grid coordinates in metres

Contours in feet above Mean Sea Level

LEGEND

Road, sealed; Road, not sealed; Vehicle Track with grid; Railway line; Bridge, Culvert; Property boundary, fenced (Por. Bdy.); Property boundary, unfenced (Por. Bdy. Approx.); Fence with gate

Co-axial cable; Telephone or telegraph line; Power transmission line; Contours with contour value (1900); Trigonometrical station, Bench mark; Spot elevation (1941); Watercourse, intermittent; River or stream, perennial

Dam, Tank; Edge of timber; Cutting, Embankment; Scour, Rock outcrop; Sand, Marsh; Territorial boundary; District boundary; Division boundary

No	Description	Author	Checked
A1	Localities referred to in text added	DCP	27/1/76 DCP
A2	GST 6 & GST 8 added	DCP	28/1/76 DCP
A3	Sample locations corrected for 75840019, 75840018, 75840020 and 73840101	DCP	10/2/76
A4	Seismic cross traverses added	DCP	1/4/76
A5			

AMENDMENTS

SCALE 0 100 200 300 400 500m

Base map/survey ACT PLANNING SERIES P19 & P27

Geology by P.A. LANG

Compiled and checked P.A.L. Project geologist

Checked and approved D.C.P. Senior geologist

E.G.W. Supervising geologist

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

TITLE INTERPRETATIVE SOLID GEOLOGY

PROJECT GINNINDERRA SEWER TUNNEL

To accompany Record 1976/44

Drawn by D.G. T.K.

Drawing No. 155/A16/1456

Plate 1

GINNINDERRA SEWER TUNNEL
Surface Geology (STNS 00+79 to 8+00)

STRATIGRAPHIC SEQUENCE

ROCK NAME	UNIT NAME	AGE
Granite porphyry	Ginninderra Porphyry [1]	Ludlovian
Light grey dacitic densely welded pyroclastic flows. Dark grey member at base.	Willow Bridge Tuff [2]	Ludlovian
unconformity		
Dacitic densely welded tuffs & pyroclastic flows. Bedding in places.	Walker Volcanics [3]	Wenlockian
Dacitic welded tuffs, agglomerates, pyroclastic flows sills & dykes. [4]	Walker Volcanics [3]	Wenlockian
Quartz sandstone marker bed.	Walker Volcanics [3]	Wenlockian
Shale. Thin beds interbedded with pyroclastics.	Walker Volcanics [3]	Wenlockian
Sandstone. Thin beds interbedded with shales & pyroclastics.	Walker Volcanics [3]	Wenlockian
Green rhyolite.	Walker Volcanics [3]	Wenlockian
Purple rhyodacite.	Walker Volcanics [3]	Wenlockian
Purple tuffs, tuffaceous sandstones & shales.		
Purple rhyodacite.		
Pink rhyolite.		

1 Registered

2 Named by Link (1971); replaces Laidlaw Volcanics.

3 Refer 1:100,000 Geological Sheet, BRINDABELLA, M.Owen et al, 1975, Preliminary Edition.

4 Regarded as intrusive equivalents of Mount Painter Porphyry, with associated extrusive rocks.

REFERENCE

54+00 Tunnel line with tunnel station in metres

FAULTS
- Position accurate
- Position approximate
- Fault inferred
- Sheared zone
- Shear, vertical
- Shear, showing dip (70)
- Fault breccia
- Photo-lineament

GEOLOGICAL BOUNDARIES
- Position accurate
- Position approximate
- Boundary inferred

OUTCROP BOUNDARY
- Boundary of solid outcrop
- Boundary of scattered outcrop
- Boundary of area with floaters

JOINTS
- Dip and strike of joint
- Strike of vertical joint

DRILL HOLES
- GST 1 Diamond-drill hole vertical.
- GST 17 Diamond-drill hole (angle)
- GST 20 Observation borehole
- 2m. Hand auger hole showing depth.
- •75360021 Specimen locality and registered number.

N MN 12°

SCALE

100 0 100 200 300m

Grid coordinates in metres
Contours in feet above Mean Sea Level

Road kerbed; Road, not kerbed; Vehicle Track; Concrete footpath; Foot track; Bridge or culvert; Property boundary, fenced; Property boundary, unfenced; Fence with gate; Telephone or telegraph line with pole; Co-axial cable; Railway line; Power transmission line with pole; Contours with contour value; Bench mark, Spot elevation; Trigonometrical station; Photogrammetric control point; Watercourse, intermittent; River or stream, perennial; Tree and position; Edge of timber; Cutting, Embankment; Scour, Rock outcrop; Sand, Marsh; Division boundary; District boundary; Territorial boundary

AMENDMENTS No.	Description	Author	Checked
A1			
A2			
A3			
A4			
A5			

SCALE 20 0 20 40 60 80 100

Base map/survey ACT CONTOUR SERIES F3D

Geology by P A LANG

Compiled and checked PAL Project geologist

Checked and approved DCP Senior geologist

EGW Supervising geologist

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

TITLE DETAIL SURFACE GEOLOGY

PROJECT GINNINDERRA SEWER TUNNEL STNS 00+79 to 8+00

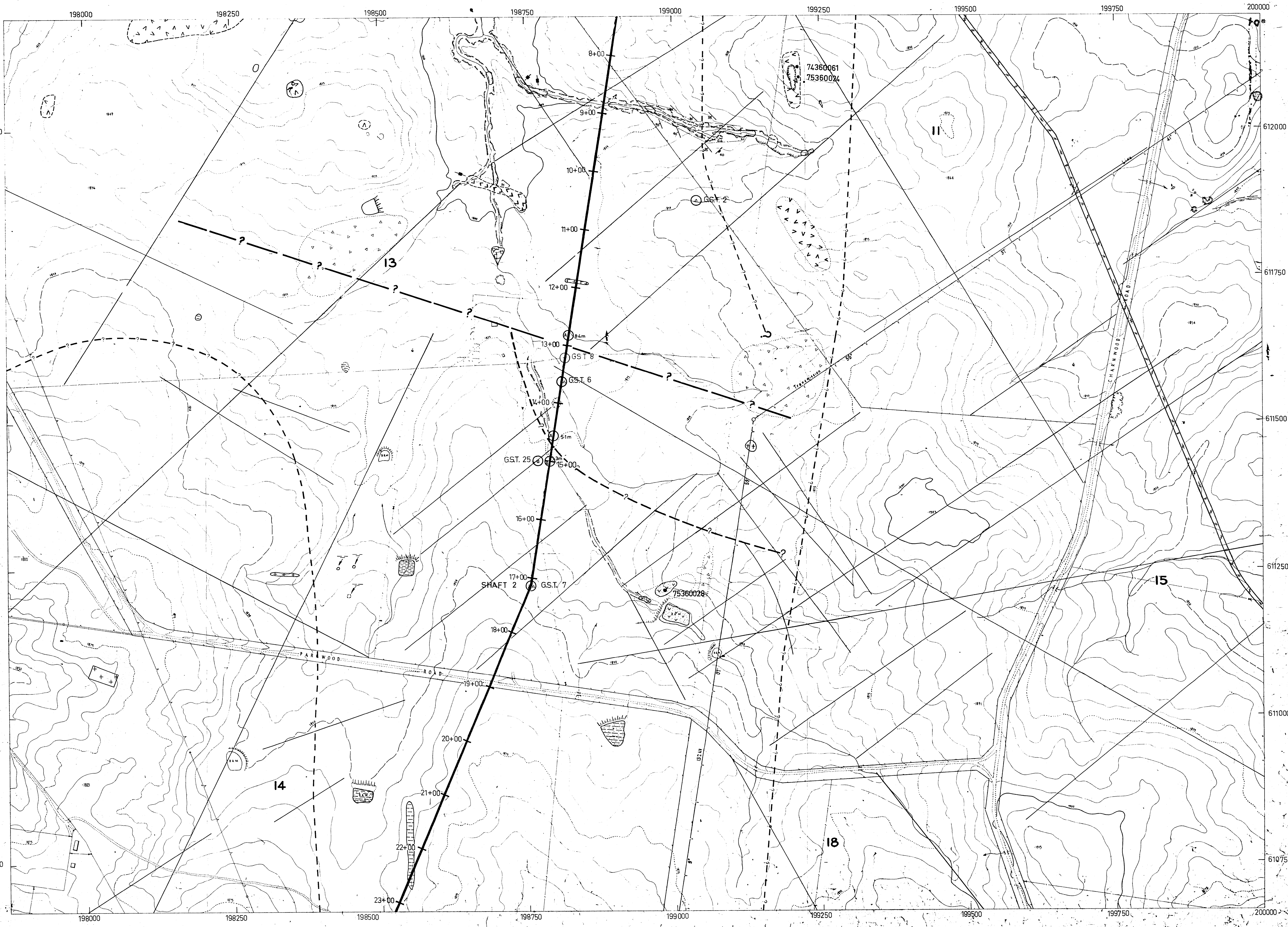
To accompany Record 1976/44

Drawn by DG TPK

Drawing No. 155/A16/1457

Plate 2

GINNINDERRA SEWER TUNNEL
Surface Geology (STNS 8+00 to 23+00)



STRATIGRAPHIC SEQUENCE

ROCK NAME	UNIT NAME	AGE
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unconformity		
Dacitic densely welded tuffs & pyroclastic flows. Bedding in places.	Walker Volcanics [3]	Wenlockian
Dacitic welded tuffs, agglomerates, pyroclastic flows sills & dykes. [4]		
Quartz sandstone marker bed.		
Shale. Thin beds interbedded with pyroclastics.		
Sandstone. Thin beds interbedded with shales & pyroclastics.		
Green rhyolite		
Purple rhyodacite.		
Purple tuffs, tuffaceous sandstones & shales.		
Purple rhyodacite.		
Pink rhyolite.		

1 Registered
2 Named by Link (1971), replaces Laidlaw Volcanics.
3 Regarded as intrusive equivalents of Mount Painter Porphyry with associated extrusive rocks.
4 Refer 1:100,000 Geological Sheet, BRINDABELLA, M.Owen et al, 1975, Preliminary Edition.

REFERENCE

54+00 Tunnel line with tunnel station in metres

FAULTS
- Position accurate
- Position approximate
- Fault inferred
- Sheared zone
- Shear, vertical
- Shear, showing dip
- Fault breccia
- Photo-lineament

GEOLOGICAL BOUNDARIES
- Position accurate
- Position approximate
- Boundary inferred

OUTCROP BOUNDARY
- Boundary of solid outcrop
- Boundary of scattered outcrop
- Boundary of area with floaters

JOINTS
- Dip and strike of joint
- Strike of vertical joint

DRILL HOLES
- GST 1 Diamond-drill hole vertical.
- GST 17 Diamond-drill hole (angle)
- GST 20 Observation borehole
- 2m. Hand auger hole showing depth.
- •75360021 Specimen locality and registered number.

N MN 12°

SCALE

100 0 100 200 300m

Grid coordinates in metres
Contours in feet above Mean Sea Level

AMENDMENTS			
No.	Description	Author	Checked
A1	GST 8 added (27/1/76)	DCP	DCP
A2			
A3			
A4			
A5			

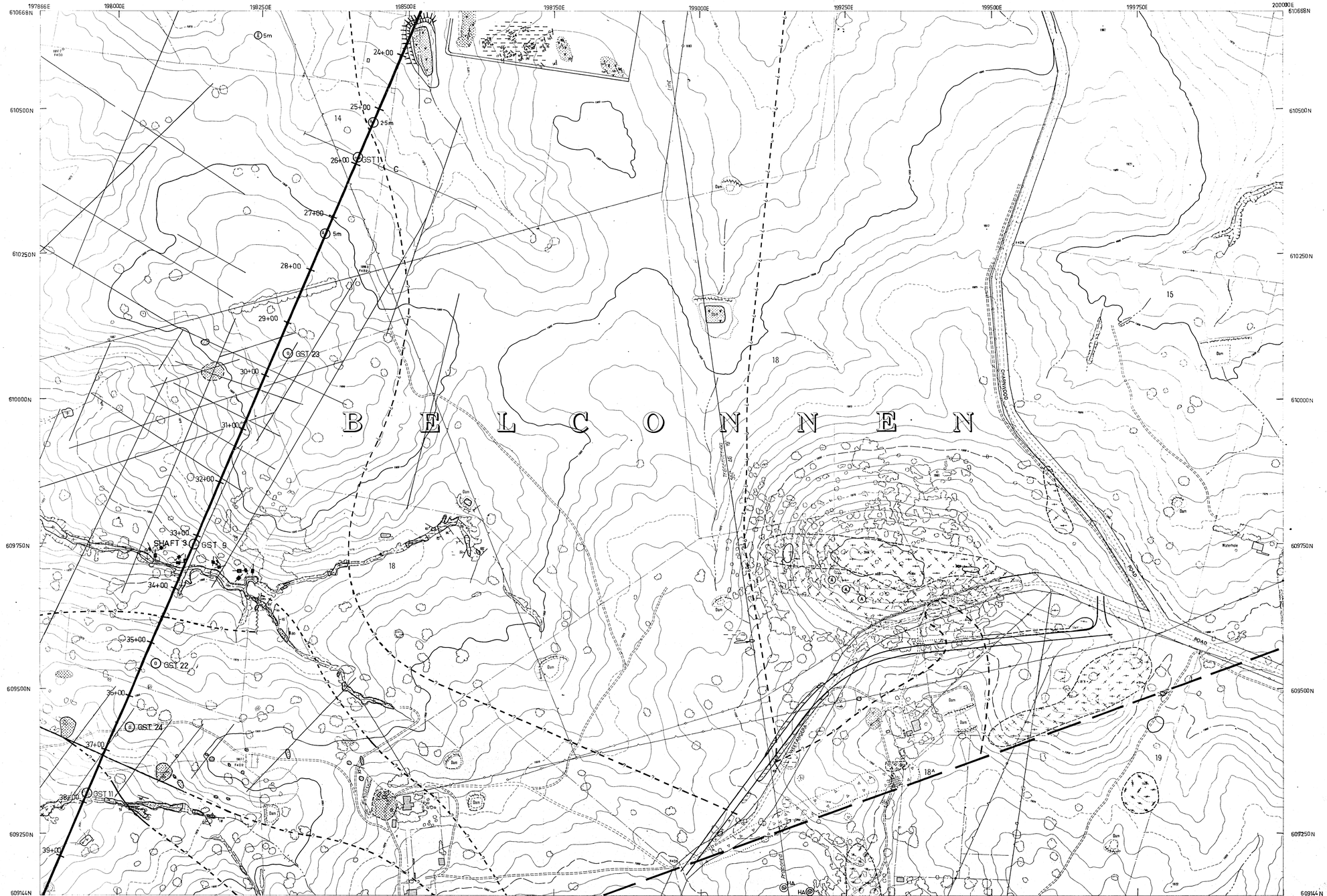
SCALE 20 0 20 40 60 80 100

Base map/survey: ACT DETAIL SERIES F4B
Geology by: P A LANG
Compiled and checked: PAL, Project geologist
Checked and approved: DCP, Senior geologist
EGW, Supervising geologist

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

TITLE: DETAIL SURFACE GEOLOGY
PROJECT: GINNINDERRA SEWER TUNNEL STNS 8+00 to 23+00
To accompany Record 1976/44
Drawn by
Drawing No. 155/A16/1458

Plate 3



GINNINDERRA SEWER TUNNEL
Surface Geology (STNS 23+00 to 39+80)

STRATIGRAPHIC SEQUENCE

ROCK NAME	UNIT NAME	AGE
Granite porphyry	Ginninderra Porphyry[1]	Ludlovian
Light grey dacitic densely welded pyroclastic flows	Willow Bridge Tuff[2]	
Dark grey member at base.		
unconformity		
Dacitic densely welded tuffs & pyroclastic flows. Bedding in places.	Walker Volcanics[3]	Wenlockian
Dacitic welded tuffs, agglomerates, pyroclastic flows sills & dykes.[4]		
Quartz sandstone marker bed.		
Shale. Thin beds interbedded with pyroclastics.		
Sandstone. Thin beds interbedded with shales & pyroclastics.		
Green rhyolite.		
Purple rhyodacite.		
Purple tuffs, tuffaceous sandstones & shales.		
Purple rhyodacite.		
Pink rhyolite.		

1 Registered

2 Named by Link (1971) replaces Laidlaw Volcanics.

3 Refer 1:100000 Geological Sheet, BRINDABELLA, M.Owen et al., 1975, Preliminary Edition.

4 Regarded as intrusive equivalent of Mount Painter Porphyry with associated extrusive rocks.

REFERENCE

54+00 Tunnel line with tunnel station in metres

FAULTS
- Position accurate
- Position approximate
- Fault inferred
- Sheared zone
- Shear, vertical
- Shear, showing dip
- Fault breccia
- Photo-lineament

GEOLOGICAL BOUNDARIES
- Position accurate
- Position approximate
- Boundary inferred

OUTCROP BOUNDARY
- Boundary of solid outcrop
- Boundary of scattered outcrop
- Boundary of area with floaters

JOINTS
- Dip and strike of joint
- Strike of vertical joint

DRILL HOLES
- GST 1 Diamond-drill hole vertical.
- GST 17 Diamond-drill hole (angle)
- GST 20 Observation borehole
- 2m. Hand auger hole showing depth.
- 75360021 Specimen locality and registered number.
- C Siesmic cross-traverse

N MN 12°

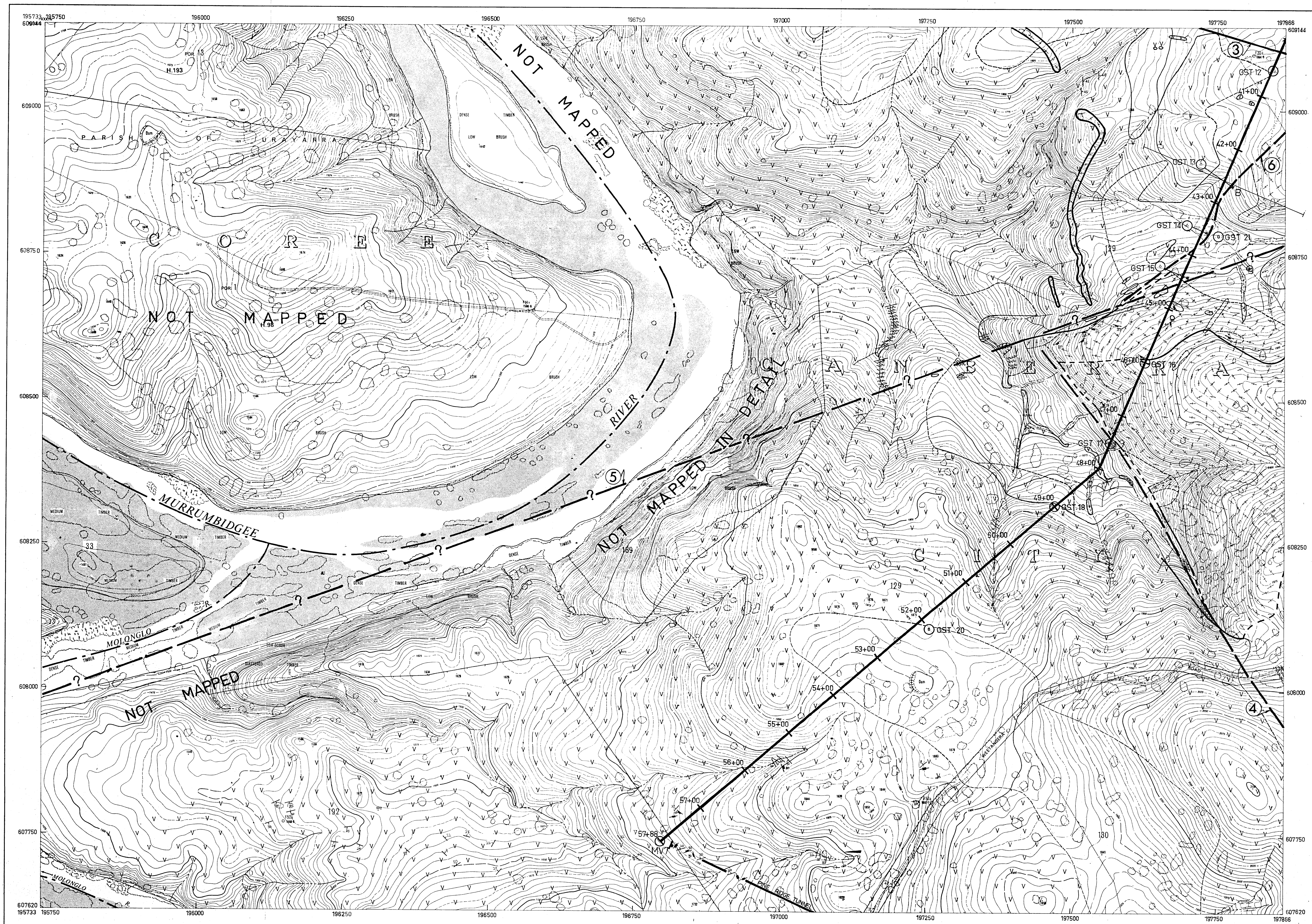
SCALE

100 0 100 200 300m

Grid coordinates in metres
Contours in feet above Mean Sea Level

AMENDMENTS				SCALE	COMMONWEALTH OF AUSTRALIA BUREAU OF MINERAL RESOURCES CANBERRA, A.C.T.
No.	Description	Author	Checked	20 0 20 40 60 80 100	
A1				Base map/survey ACT DETAIL SERIES FAD	TITLE DETAIL SURFACE GEOLOGY
A2				Geology by P A LANG	
A3				Compiled and checked P A L (Project geologist)	Checked and approved D C P (Senior geologist)
A4				PROJECT GINNINDERRA SEWER TUNNEL STNS 23+00 to 39+80	
A5				E G W (Supervising geologist)	To accompany Record 1976/64 — Drawn by — Drawing No. 155/A16/1459

Plate 4



GINNINDERRA SEWER TUNNEL
Surface Geology (STNS 39+80 to 57+88)

STRATIGRAPHIC SEQUENCE

ROCK NAME	UNIT NAME	AGE
Granite porphyry	Ginninderra Porphyry[1]	Ludlovian
Light grey dacitic densely welded pyroclastic flows. Dark grey member at base.	Willow Bridge Tuff[2]	Ludlovian
unconformity		
Dacitic densely welded tuffs & pyroclastic flows. Bedding in places.	Walker Volcanics[3]	Wenlockian
Dacitic welded tuffs, agglomerates, pyroclastic flows sills & dykes.[4]	Walker Volcanics[3]	Wenlockian
Quartz sandstone marker bed.	Walker Volcanics[3]	Wenlockian
Shale. Thin beds interbedded with pyroclastics.	Walker Volcanics[3]	Wenlockian
Sandstone. Thin beds interbedded with shales & pyroclastics.	Walker Volcanics[3]	Wenlockian
Green rhyolite.		Wenlockian
Purple rhyodacite.		Wenlockian
Purple tuffs, tuffaceous sandstones & shales.		
Purple rhyodacite.		
Pink rhyolite.		

1 Registered

2 Named by Link (1971); replaces Laidlaw Volcanics.

3 Refer 1:100,000 Geological Sheet, BRINDABELLA, M.Owen et al, 1975, Preliminary Edition.

4 Regarded as intrusive equivalent of Mount Painter Porphyry with associated extrusive rocks.

REFERENCE

54+00 Tunnel line with tunnel station in metres

FAULTS

- Position accurate
- Position approximate
- Fault inferred
- Sheared zone
- Shear, vertical
- Shear, showing dip
- Fault breccia
- Photo-lineament

GEOLOGICAL BOUNDARIES

- Position accurate
- Position approximate
- Boundary inferred

OUTCROP BOUNDARY

- Boundary of solid outcrop
- Boundary of scattered outcrop
- Boundary of area with floaters

JOINTS

- Dip and strike of joint
- Strike of vertical joint

DRILL HOLES

- GST 1 Diamond-drill hole vertical.
- GST 17 Diamond-drill hole (angle)
- GST 20 Observation borehole.
- 2m. Hand-auger hole showing depth.
- •75360021 Specimen locality and registered number.
- B Siesmic cross-traverse

N MN 12°

SCALE

100 0 100 200 300m

Grid coordinates in metres
Contours in feet above Mean Sea Level

AMENDMENTS			
No.	Description	Author	Checked
A1	Seismic cross traverse B added	DCP	DCP
A2			
A3			
A4			
A5			

SCALE 20 0 20 40 60 80 100

Base map/survey ACT DETAIL SERIES F5A

Geology by P A LANG

Compiled and checked PAL Project geologist

Checked and approved DCP Senior geologist

EGW Supervising geologist

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

TITLE DETAIL SURFACE GEOLOGY

PROJECT GINNINDERRA SEWER TUNNEL STNS 39+80 to 57+88

To accompany Record 1976/44

Drawn by DG TPK

Drawing No. 155/A16/1460

Plate 5

GEOLOGICAL SECTION ALONG TUNNEL LINE

GEOLOGICAL PLAN ALONG TUNNEL LINE (At surface)

TUNNEL STATION (metres)	20+00 · 19+00 · 18+00 · 17+00 · 16+00 · 15+00	15+00 · 14+00 · 13+00	13+00 · 12+00 · 11+00 · 10
ROCK HARDNESS AND STRENGTH	Dacite UCS 150 – 250 MPa, av 200 MPa. Av hardness 72 Shore Units	No data from GST 6 and GST 8	Mostly extremely hard and strong. UCS 173 to 492 MPa, av. 300 MPa. Zones of partly epidotised rock with UCS 173 – 273 MPa, av. 220 MPa. Av hardness 100 Shore Units
ROCK MASS DEFECTS	Mainly competent dacite with joints spaced mostly 30 cm – 1 m but up to 3 m. Joints generally tight and cemented with calcite. Possibly some minor faults and fractured and seamy zones. Possibly some thin lenses of shale	Main defects will be confined to contacts. Granite contact with dacite to the south probably a narrow fractured zone. Contact with welded dacite to north probably fractured and sheared from 13+20 to about 14+00	Zones of very strong and competent rock with very few defects. Joints spaced up to 3 m, very tight. Zones of close jointed mod tight rock (joint spacing generally 10 – 60 cm but up to 1 m) with surfaces generally weakly cemented with pink powdery calcite. Many qtz – epidote veins. Some joints slightly open. Some narrow seamy zones.
PREDICTED OVERBREAK (Due to rock mass defects only)	Mostly negligible but in blocky zones blocks up to 30 cm may fall out beyond C line. Unfavourable orientation of prominent defects may cause > 30 cm overbreak beyond C line. Shale lenses may cause more overbreak	Overbreak > 1 m possible at north contact, if accompanied by moderate to large water inflows overbreak could approach 2 m in places. Overbreak elsewhere < 30 cm, but up to 1 m possible at south contact	In competent rock negligible overbreak. In blocky zones, blocks generally < 30 cm may fall out beyond C – line. Unfavourable orientation of some defects may cause > 60 cm overbreak beyond C line (rare)
PREDICTED TUNNEL CONDITION	Mostly 2 – 3, probably some 4	Mostly 3. 4 at south contact and 5 at and near north contact and fault zone	Mostly 2 to 3. Some 4
PREDICTED SUPPORT REQUIREMENTS	Possibly some steel sets but total for section probably < 50 m. Probably some random rock bolts in blocky areas in dacite or in any slabby shale	Up to 100 m of tunnel may need steel set support – mainly confined to north contact and fault zone	Very little expected. Possibly some steel sets in 2600 m/sec zone. Total for section probably < 30 m
PREDICTED WATER INFLOWS	Mostly dry to damp. Persistant seepages and dripping from some fractured zones. Some minor initial inflows (< 1 m³/hr) from some open joints or fractured zones. Inflows up to 5 m³/hr are possible but very unlikely	Mostly damp away from contacts. Up to 3 m³ initial inflow south contact. Up to 10 m³ initial inflow north contact and fault zone. Inflows at contacts may continue at up to 1 m³ (south) and 2 m³ (north contact)	Mostly dry to damp. Persistant seepage and dripping from some fractured zones. Possibly some defects with initial inflows up to 1 m³/hr. Inflows up to 10 m³/hr very unlikely. Initial inflows will decrease rapidly after excavation

GEOLOGICAL SECTION ALONG TUNNEL LINE

GEOLOGICAL PLAN ALONG TUNNEL LINE (At surface)

TUNNEL STATION (metres)	10+00 · 9+00 · 8+00 · 7+00 · 6+00 · 5+00	5+00	4+00	3+00	2+00 · 1+00 · 00
ROCK HARDNESS AND STRENGTH	Mostly extremely hard and strong. UCS 173 – 492, av 300 MPa. Zones of partly altered and epidotised rock at GST 2 and GST 4 with UCS 173 – 273 MPa. Av. hardness 100 Shore Units	OPEN CUT EXCAVATION Generally excavatable by bulldozer with ripper. Some blasting necessary near invert. Sides of excavation will need to be battered or supported	Mostly soft and fairly weak	UCS average 300 MPa	OPEN CUT EXCAVATION 1. Extremely to highly weathered dacite to base of excavation along most of section – Excavatable by large backhoe without preblasting 2. Probably a few boulders of fresh dacite generally < 2 m in diameter sitting in extremely weathered dacite – need blasting and/or jack picking 3. Some moderately to slightly weathered dacite near stn 2+00 – Probably need blasting or jack picking
ROCK MASS DEFECTS	Zones of very strong and competent rock with very few defects. Joints spaced up to 3 m very tight. Zones of close jointed mod tight rock (joint spacing generally 10 – 60 cm but up to 1 m) with surfaces generally weakly cemented with pink powdery calcite. Many quartz – epidote veins. Some joints slightly open. Some narrow seamy zones		Weathering is the main defect. Rock EW to MW. Possibly some SW near invert	Strong and fairly tight SW – FS dacite	
PREDICTED OVERBREAK (Due to rock mass defects only)	In competent rock negligible overbreak. In blocky zones, blocks generally < 30 cm may fall out beyond C line. Unfavourable orientation of prominent defects may cause > 60 cm overbreak beyond C line (rare)		If very carefully excavated, overbreak could be kept to a minimum	Small to negligible	
PREDICTED TUNNEL CONDITION	Mostly 2 – 3, some 4		Mainly 5 to 6. Possibly some 4 near invert	Mainly 3	
PREDICTED SUPPORT REQUIREMENTS	Very little expected. Probably < 50 m total of steel sets. Possibly some rock bolts		100% steel set support indicated	Probably none	
PREDICTED WATER INFLOWS	Mostly dry to damp. Persistant seepage or dripping from some fractured zones. Possibly some fractured zones with initial inflows up to 1 m³/hr decreasing after excavation. Inflows up to 10 m³/hr are possible but very unlikely		Initially < 5 m³/hr. Most will flow from the intermediate – bedrock velocity interface	Initially < 5 m³/hr and rapidly decreasing	Mostly dry. Possibly some minor seepages

REFERENCE

SUMMARY LOG OF DRILL HOLES

① Rock - material type
② Degrees of weathering
- EW Extremely weathered
- HW Highly weathered
- MW Moderately weathered
- SW Slightly weathered
- FS Fresh stained
- FR Fresh

③ Rock Condition Number (see text for definitions)

Water level in drill hole

ROCK TYPES

- Granite Porphyry
- Welded dacite, light grey
- Welded dacite, dark grey
- Dacite, Sandstone, Shale } interbedded
- Purple rhyodacite

SEISMIC

- Intermediate seismic velocity refractor
- Highest seismic velocity refractor
- (600) Seismic velocity in metres per second

GEOLOGICAL

- Boundaries approximate
- Boundaries inferred
- Fault zone approximate
- Trend line of bedding
- GST 3 Drill hole number and location
- GST 6 Angle drill hole number and location
- L Airphoto - lineation

AMENDMENTS

No	DESCRIPTION	AUTHOR / CHECKED	DATE
1	Section from 13+00 to 15+00 added - based on latest information from GST 6 and 8. Air photo lineations and outcrops also added	DCP / DCP	27/1/76 / 27/1/76
2			
3			
4			
5			
6			

GEOLOGY BY P.A. LANG

COMPILED AND CHECKED: P.A.L, PROJECT GEOLOGIST

CHECKED AND APPROVED: D.C. Purcell, SENIOR GEOLOGIST

SUPERVISING GEOLOGIST

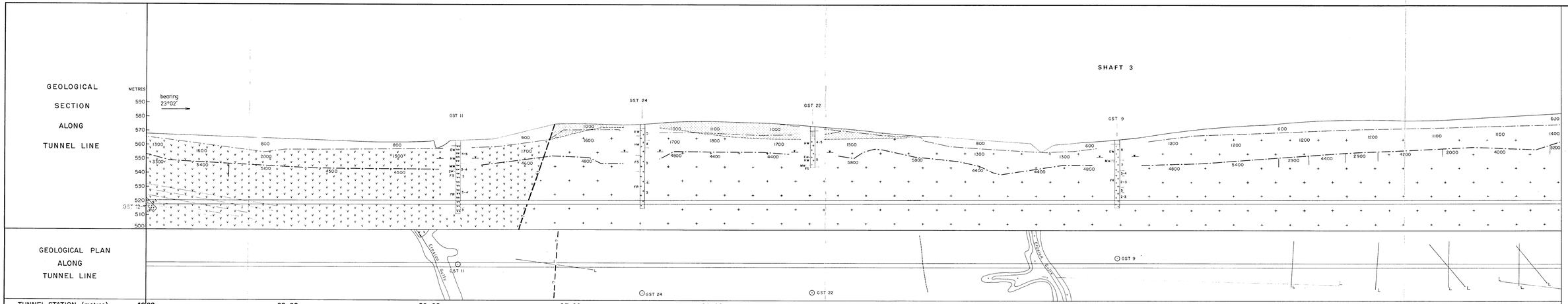
Scale: 0 10 20 30 40 50 m; $\frac{V}{H} = 1$

TITLE: INTERPRETATIVE GEOLOGICAL SECTION ALONG TUNNEL LINE STATION 00+50 TO 20+00

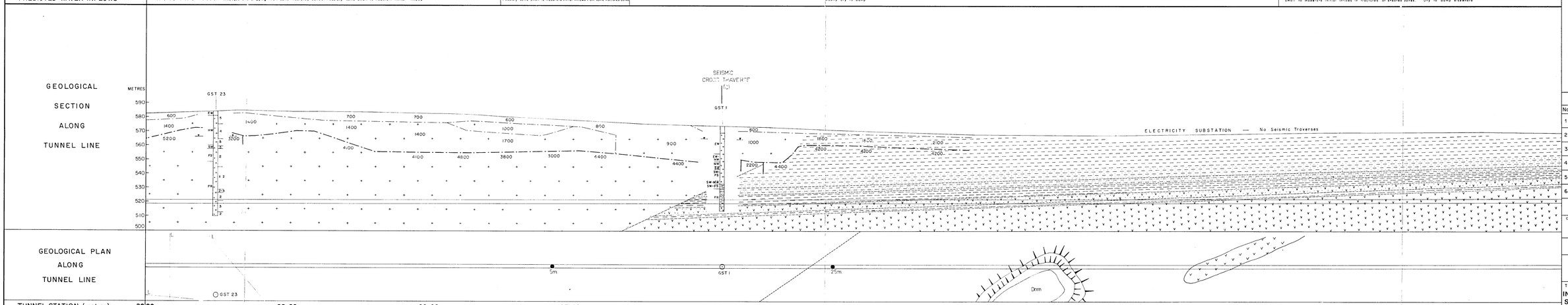
PROJECT: GINNINDERRA SEWER TUNNEL

TO ACCOMPANY RECORD 1976/44 — SHEET 1 OF 3

DRAWING NUMBER I55/A16/1306A — PLATE 6



TUNNEL STATION (metres)	40·00 – 39·00 – 38·00 – 37·00 – 36·00 – 35·00 – 34·00 – 33·00 – 32·00 – 31·00 – 30			
ROCK HARDNESS and STRENGTH	Rock breaks fairly easily across the rock fabric. Probably breaks to pieces from 10 - 30 cm when blasted			
ROCK MASS DEFECTS (Cut to rock mass defects only)	Rock mass is mostly tight with joints spaced 30 - 60 cm (10 - 40 cm in some areas) and generally cemented with calcite. Probably blocky in places. Probably some fractured and seamy areas, especially near granite contact.	Mostly tight but probably some fractured and seamy areas.	The rock mass is very tight with joints generally spaced 30 cm – 1 m and commonly cemented with calcite. Possibly some narrow fractured or sheared zones. (None detected during drilling)	Up to 60 m (total) of sheared and/or fractured and/or blocky and seamy rock with mostly tight sound rock elsewhere.
PREDICTED OVERBREAK (Cut to rock mass defects only)	Generally very little to negligible. Small to moderate in some fractured, seamy or blocky zones.	Small to moderate in fractured and seamy areas, negligible elsewhere	very little to negligible	Small to moderate in sheared fractured or blocky zones. Negligible elsewhere
PREDICTED TUNNEL CONDITION	Mostly 3. Some 4.	Mostly 3 - 4	Mostly 2 - 3	Mostly 3. Some sections of 4 - 5
PREDICTED SUPPORT REQUIREMENTS	Possibly some random rock bolts in blocky sections. Possibly some short lengths of steel set support. (Probably < 30 m total)	Possibly some rock bolts and/or steel sets.	Very little if any.	Up to 60 m of steel sets. Probably some random rock bolts.
PREDICTED WATER INFLOWS	Mostly dry to damp. Persistent seepages and dripping from some fractured zones. Possibly some small to moderate initial inflows.	Possibly some small to moderate initial inflows from some fractured zones.	Mostly dry to damp.	Small to moderate initial inflows in fractured or sheared zones. Dry to damp elsewhere.



TUNNEL STATION (metres)	30·00 – 29·00 – 28·00 – 27·00 – 26·00 – 25·00 – 24·00 – 23·00 – 22·00 – 21·00 – 20		
ROCK HARDNESS and STRENGTH			
ROCK MASS DEFECTS (Cut to rock mass defects only)	The Rock mass is mostly very tight with joints generally spaced 30 cm - 1 m and commonly cemented with calcite. Probably some narrow fractured or sheared zones (< 40 m total), some blocky zones.	Probably some fractured rock	Mostly competent docite with tight joints mostly spaced 30 cm – 1 m. Some thin lenses of shale mostly competent and with tight bedding planes but possibly some zones with up to 1 m of clay on bedding planes. Slabbing ? Probably some minor to moderate folding in places. Possibly some minor faults and fractured and seamy zones.
PREDICTED OVERBREAK (Cut to rock mass defects only)	Negligible for most of section. Small to moderate in some fractured, sheared or blocky zones.	Small to moderate in fractured zone	Negligible in most of section but may be moderate in shale due to drilling on bedding planes. May be moderate in fractured areas or in areas of minor folding and clay on bedding planes
PREDICTED TUNNEL CONDITION	Mostly 2 - 3 Probably some 4	Probably some 4	Mostly 2 - 3 Probably some 4
PREDICTED SUPPORT REQUIREMENTS	Possibly some random rock bolts of any blocky sections. Possibly some short lengths of steel set support. Total for section probably 0 - 30 m	Possibly some steel sets or rock bolts	Possibly some steel sets but total for section probably < 50 m. Probably some random rock bolts in blocky areas in docite, or in slabby areas in shale.
PREDICTED WATER INFLOWS	Mostly dry to damp. Persistent seepages and dripping from some fractured zones. Possibly some small to moderate initial inflows from some fractured zones.	Probably < 0.02 m³/hr initially decreasing to < 0.01 m³/hr	Mostly dry to damp. Persistent seepages and dripping from some fractured zones. Possibly some small to moderate initial inflows from some fractured zones.

REFERENCE

SUMMARY LOG OF DRILL HOLES

② ③ ① Rock material type
② Degrees of weathering
EW Extremely weathered
HW Highly weathered
MW Moderately weathered
SW Slightly weathered
FS Fresh stained
FR Fresh
③ Rock Condition Number (See text for definitions)
Water level in drill hole

ROCK TYPES

Soil and slope wash
Granite Porphyry
Dacite, Sandstone, Shale — Interbedded

SEISMIC

Intermediate seismic velocity refractor
Highest seismic velocity refractor
(600) Seismic velocity in metres per second

GEOLOGICAL

Boundaries approximate
Boundaries inferred
Fault inferred
Trend line
Solid outcrop, Rubbly outcrop — in plan only
GST 9 Drill hole number and location (in plan)
Airphoto-lineation
6m Auger hole showing depth

AMENDMENTS

No	DESCRIPTION	AUTHOR	CHECKED
1	Locations and outcrops marked on plan	STILING Dept	Dept
2			
3			
4			
5			
6			

GEOLOGY BY P.A. LANG

COMPILED AND CHECKED	CHECKED AND APPROVED
P.A.L.	D.C.Purcell
PROJECT GEOLOGIST	SENIOR GEOLOGIST

SUPERVISING GEOLOGIST

Scale 0 10 20 30 40 50 metres 1:1

TITLE

INTERPRETATIVE GEOLOGICAL SECTION ALONG TUNNEL LINE STATION 20+00 TO 40+00

PROJECT

GINNINDERRA SEWER TUNNEL

TO ACCOMPANY RECORD 1976/44	SHEET 2 OF 3
DRAWING NUMBER 155/816/1307	PLATE 7

TUNNEL STATION (metres)	60+00 · 59+00 · 58+00 · 57+00 · 56+00 · 55+00 · 54+00 · 53+00 · 52+00 · 51+00 · 50	
ROCK HARDNESS AND STRENGTH		Mostly very hard and very strong. UCS 200 - 218 MPa, av. 207 MPa. Av. hardness 88 shore units. Zones of blue grey dacite will be harder and stronger than these figures. Zones of green grey will be slightly weaker and softer. Generally drill penetration is slow and drill wear rate high
ROCK MASS DEFECTS	Recomend portal at Stn 57+55 (See text for details)	Rockmass is mostly competent. Occasional sections of less competent rock (fractured, sheared or seamy zones). Joint spacing variable, mostly 30 to 60 cm; joint surfaces generally rough and tight
PREDICTED OVERBREAK Due to rock mass defects only		In competent rock generally negligible over break, but some blocks up to 30 cm may fall out beyond C line. Fall out of some blocks up to 60 cm beyond C line in blocky zones or where the prominent joints 20°/SW/130° (bedding) and 90°/070°, 60°/NW/040° intersect the tunnel. Unfavourable orientation of prominent defects (e.g. "greasy backs") may cause > 60 cm overbreak beyond C line (rare)
PREDICTED TUNNEL CONDITION		Generally 3 (55%). Some zones of 2 (20%) and 4 (23%). Narrow zones of 5 (2%). Percentages in brackets are from same rock type in Pine Ridge tunnel
PREDICTED SUPPORT REQUIREMENTS		Some narrow sheared and/or fractured zones will require short length (6 - 15 m) of steel set support. Total for section probably less than 30 m (excluding portals). Some random rock bolts in blocky zones
PREDICTED WATER INFLOWS		Mosty dry to damp. May be a few fractured zones with initial inflows up to 10 m³/hr decreasing rapidly after excavation. Total outflow at portal expected to be < 10 m³/hr during excavation decreasing to 3 m³/hr after excavation completed

TUNNEL STATION (metres)	50+00 · 49+00 · 48+00		47+00 · 46+00	45+00 · 44+00	43+00 · 42+00 · 41+00 · 40
ROCK HARDNESS AND STRENGTH	Av UCS 96 - 145 MPa, av. hardness 68 Shore Units (GST 18)	Recommend portal at station 47+40. Slumping expected in east wall of open cut. Initial water inflows up to 10 m³/hr from portal face. Rock at portal face close jointed and fractured; bolts and mesh will be required to stabilise face	UCS 220 - 322 MPa, av. 260 MPa. Av. hardness 96 Shore Units	UCS (from Point load) 110 MPa. Av. hardness 78 Shore Units	UCS (from Point Load) av 170 MPa. Hardness and strength expected to be similar to Stn 50+00 to 57+00 in most zones but may be weaker in some zones
ROCK MASS DEFECTS	Bedding planes dip 20° South (dip of tunnel drive); probably sheared in part. Some crushed seamy up to 20 cm thick. Clay coated joints common		Close jointed (10 - 30 cm); loose and open in places	Blocky and mostly seamy; clayey fractures and sheared zones common	Rockmass is mostly competent. Possibly some sections of less competent rock (fractured, sheared or seamy zones). Joint spacing generally 10 - 30 cm but up to 1 m, and generally tight
PREDICTED OVERBREAK Due to rock mass defects only	Most overbreak probably associated with greasy bedding planes: blocks generally < 60 cm may fall out beyond C line		Where loose and open blocks generally < 60 cm may fall out beyond C - line	Where blocky and seamy, blocks < 60 cm may fall out beyond C line. Some fractured or sheared zones may produce section of overbreak > 60 cm beyond C line	In competent rock, blocks < 30 cm may fall out beyong C - line; larger overbreak may be associated with some defect zones
PREDICTED TUNNEL CONDITION	Mostly 4 Probably some 5 / Recommend portal at Stn. 48 + 90		Mainly 3 to 4	Mainly 4. Long sections of 5 possible	Probably mostly 3 - 4
PREDICTED SUPPORT REQUIREMENTS	Up to 80 m of steel sets Portal face probably require some bolts and mesh / (See text for details)		Probably < 50 m of steel set support	Up to 250 m of steel set support	Probably less than 50 m of steel set support. Possibly some random rock bolts in any blocky zones
PREDICTED WATER INFLOWS	Probably only seepages; any initial inflows < 0.5 m³/hr decreasing rapidly to seepage		Initially high close to portal (possibly up to 20m³/hr). Gradual decrease to < 5m³/hr	Mostly damp with seepages. Possibly some minor initial inflows (< 3 m³/hr) from any open joints or fractured zones	Mostly damp. Persistent seepage or dripping from some fractured zones; initial inflows up to 10 m³/hr possible from some open jointed or fractured zones

REFERENCE

SUMMARY LOG OF DRILL HOLES

① Rock - material type
② Degrees of weathering
EW Extremely weathered
HW Highly weathered
MW Moderately weathered
SW Slightly weathered
FS Fresh stained
FR Fresh
③ Rock Condition Number (see text for definitions)
Water level in drill hole

ROCK TYPES

Soil and slopewash
Scree and colluvium
Dacite, blue - grey to purple
Rhyolite, green
Rhyolite, purple
Dacite grey

SEISMIC

Intermediate seismic velocity refractor
Highest seismic velocity refractor
(600) Seismic velocity in metres per second

GEOLOGICAL

Boundaries approximate
Boundaries inferred
Fault zone approximate
Trend line of bedding
Solid outcrop } in plan only
Rubbly outcrop } in plan only
GST 20 Drill hole number and location
GST 17 Angle drill hole number and location
GST 15 Trace of drill hole in plane of section

AMENDMENTS

No	DESCRIPTION	AUTHOR	CHECKED
1	Plan view of faults between 48+00 and 40+00 added	DCP 28/1/76	DCP
2			
3			
4			
5			

GEOLOGY BY P.A. LANG

COMPILED AND CHECKED: P.A.L, PROJECT GEOLOGIST
CHECKED AND APPROVED: D.C. Purcell, SENIOR GEOLOGIST

E.G. Wilson, SUPERVISING GEOLOGIST

Scale 0 10 20 30 40 50 metres, V/H = 1

TITLE
INTERPRETATIVE GEOLOGICAL SECTION ALONG TUNNEL LINE STATION 40+00 TO 57+88

PROJECT
GINNINDERRA SEWER TUNNEL

TO ACCOMPANY RECORD 1976/44 — SHEET 3 OF 3
DRAWING NUMBER I 55/A16/1308 — PLATE 8