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GEOLOGICAL INVESTIGATIONS FOR THE SULLIVANS CREEK SEWER TUNNEL, CANBERRA CITY, ACT 1978

by

P.H. Vanden Broek, D. Ramsay, & G. Sparksman

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SUMMARY OF CONCLUSIONS

(1) The present tunnel alignment appears to be the best available geologically considering the constraints imposed by existing easements; however, an alternative route could be considered for the section north of manhole 11.

(2) The rock to be excavated along the length of tunnel section is expected to include about 90% mudstone and 10% tuff and/or sandstone. About 60% of the mudstone is hard and slightly weathered to fresh. About 40% of the mudstone is soft and moderately to extremely weathered. Limestone has not been found along the alignment and is not likely to be present, but it cannot be ruled out from such a sedimentary sequence.

(3) At least three sets of planar defects can be expected in most sections. As many as five sets may be common in some sections where the rock mass is very closely jointed or fragmented. Variably spaced bedding planes are generally expected to dip east-northeast at 25^{o}.

(4) The water-table is generally only slightly above tunnel crown level and only minor inflows are expected. Rock permeabilities are generally expected to be low. Only near drillhole 1 is inflow from a surface water recharge source likely; this could result in significant water inflows. Large inflows from limestone are not likely to be encountered.

(5) Vibration test results indicate maximum charge sizes of 3.5 kg per delay close to the Lakeside Hotel, 1.5 kg per delay near Tasman House, and 0.25 kg per delay beneath the Child Care Centre. Special tunnelling methods may have to be considered near the Child Care Centre.

(6) About 1400 m of tunnel section is expected to have rock mass quality ranging from poor to exceptionally poor, 600 m is expected to range from poor to fair and about 200 m is expected to be good.

(7) Standup times calculated from drill cores range from less than 1 hour at drillhole 1 to 1 month at drillhole 8.

(8) The amount of overbreak above crown will depend primarily on (a) the type of excavation methods used; (b) the speed at which support can be installed; (c) steps taken to improve the rock mass before excavation, and (d) the presence and amount of groundwater inflows.

(9) It should be practicable to use a road-header type tunnel excavation machine from chainage 0+00 to 7+00. It may be possible to excavate other sections of the tunnel with such a machine, but harder rock between these sections may be beyond the machine's capabilities.

INTRODUCTION

This report describes the geological investigations carried out for the proposed sewer pipeline from Sullivans Creek to Commonwealth Avenue pumping station (Fig. 1). The consultant firm of Camp, Scott & Furphy Engineers Pty Ltd is designing the works for the National Capital Development Commission (NCDC). This report supplements a (previous) BMR feasibility report by Henderson (1978) which included information derived from inspections of nearby excavations by BMR geologists and from reports on drilling for foundation investigations of building sites. Subsequent data have been obtained from 21 diamond drillholes, three seismic refraction traverses along or close to the two alternative tunnel alignments, and vibration tests.

Information obtained during the investigation indicated that subsurface conditions were better for the alignment east of Commonwealth Avenue; however, information applicable to the alignment west of Commonwealth Avenue has also been included in this report.

All information obtained has been summarised on the tunnel section shown in Plates 1, 2, and 3.

ROCK MASS SUBSTANCE

ROCK TYPES

(a) City Hill Shale

The City Hill Shale is a sequence of sedimentary rocks comprising mainly calcareous mudstone, with some shale, siltstone, and fine-grained sandstone towards the top of the sequence. The possibility of the tunnel excavation intersecting a lens of limestone in such sediments cannot be ruled out, although limestone was not intersected in the drillholes or mapped in surface or subsurface exposures.

(b) Volcanic tuff member

Tuff was not intersected by the diamond drilling but has been previously mentioned in the feasibility report (Henderson, 1978). Interbeds of tuff are to be expected towards the top of the City Hill Shale, and could be in excess of 20 m thick at tunnel level.

WEATHERING

A definition of weathering categories has been included in Appendix 1.

Calcareous mudstone is particularly susceptible to leaching out of carbonate minerals, and mantles of altered rock (13 m thick in places) are preserved in areas that have not been greatly eroded or that have been downfaulted. The colour of the mudstone has been found to provide an indication of the degree of weathering (see Table 1).

TABLE 1. GENERAL CORRELATION BETWEEN DEGREE OF WEATHERING AND COLOUR FOR CALCAREOUS MUDSTONE

Degree of weathering	Colour
Extremely to highly weathered	Pale yellow to yellow brown, sometimes red
Moderately weathered	Yellow-brown to brown with some red-brown
Slightly weathered	Olivine to olive-brown
Fresh stained	Pale grey
Fresh	Blue-grey

The sandstone-shale-siltstone portion of the sequence has not been observed in the fresh state in the drillcores, and is expected to be moderately weathered at tunnel level.

Extremely weathered coarse-grained volcanic tuff was mapped in two excavations close to the Lakeside Hotel. Experience with similar beds elsewhere indicates that highly weathered tuff might extend to depths of more than 10 m, and interbeds of weathered tuff are expected to have properties similar to those of adjacent rocks.

ROCK STRENGTH AND HARDNESS

Point load strength tests were carried out on drillcore specimens obtained from near tunnel level. Two point load testing machines with different operators were used for testing two sets of similar rock samples.

Individual test results are plotted on the drill logs (Appendix 2) and all results are graphically represented in Figure 2.

Results given are for the point load strength index (Broch & Franklin 1972) standardised for a 50-mm core diameter (Is_{50}) and given in megapascals. Experience with point load strengths indicates that 24 x Is_{50} is quite a reasonable guide to the unconfined compressive strength. (M. Idnurm, BMR, personal communication).

Figure 2 shows that there is some correlation between degree of weathering and point load strength index, although slightly weathered rock exhibits quite a large scatter of values for point load strength.

No specific tests were carried out to determine hardness; however, fresh, fresh stained, and slightly weathered rock is moderately hard, and moderately to extremely weathered rock is soft (Appendix 1).

ROCK MASS DEFECTS

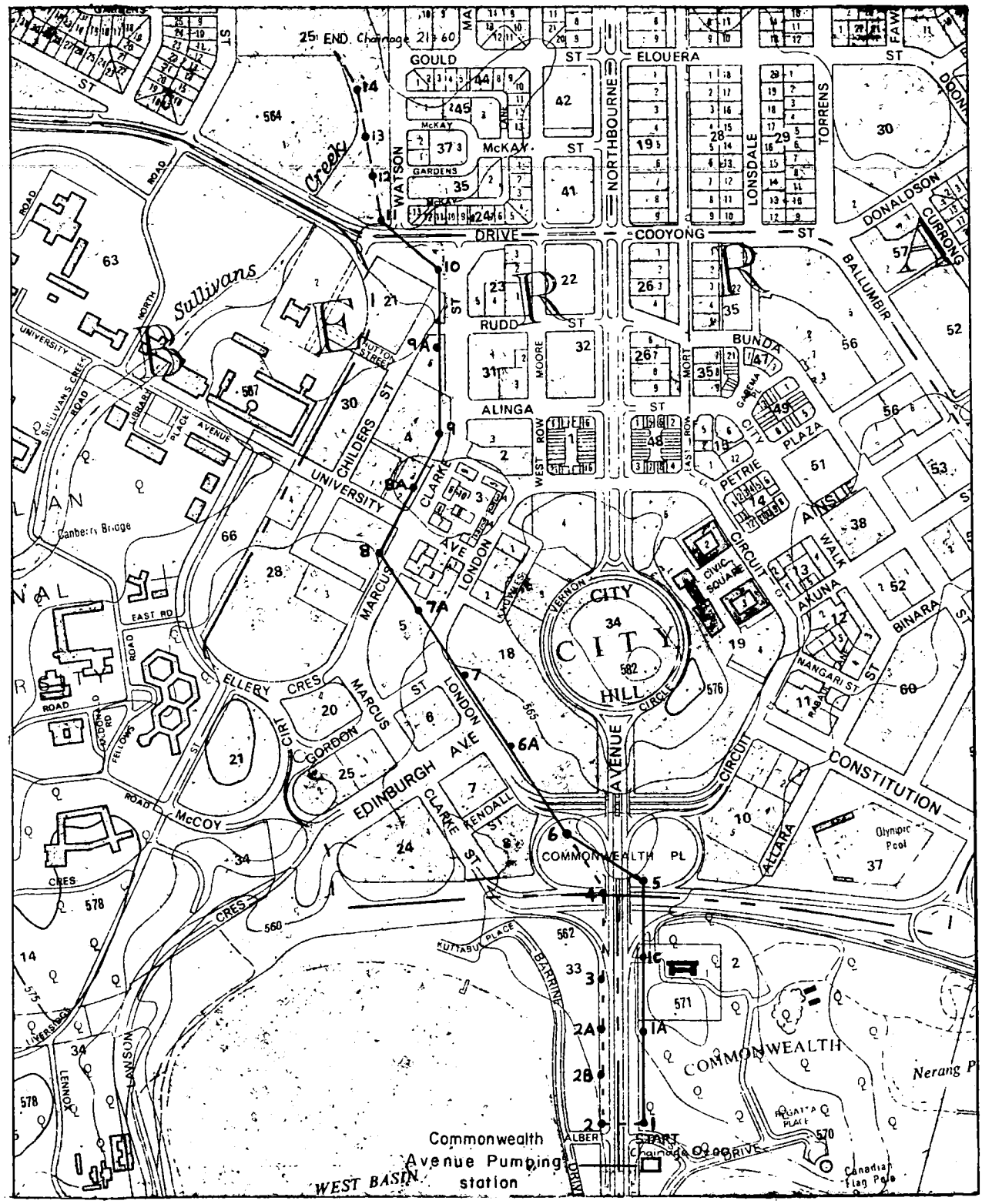
Rock mass defects include bedding, joints, and faults. Their spacing, orientation, roughness, and coatings have been taken into account when rock mass quality, standup times, and support requirements were calculated.

Defect surfaces are mostly clean or ironstained where the rock is relatively unweathered. Where the rock is moderately weathered most surfaces are iron or manganese-coated and some are clay-coated. Defect surfaces are mostly smooth and planar though some rough and planar surfaces were observed in fresh rock.

LOCATION MAP

Fig 1

SULLIVANS CREEK SEWER TUNNEL



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SCALE 1:10 000

250 0 500 1000 METRES

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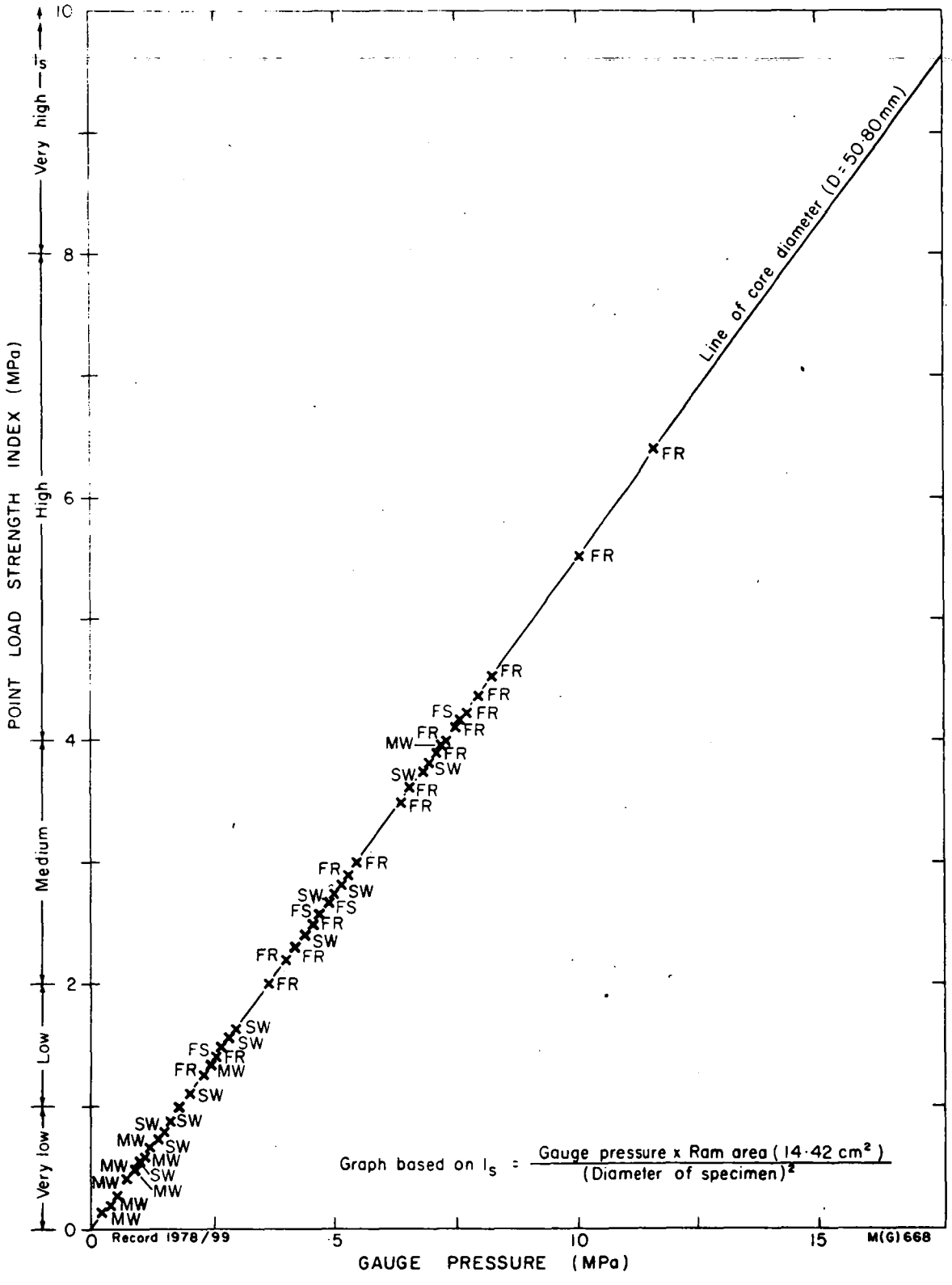


Fig. 2 Point Load Strength data chart

BEDDING

Bedding is generally not visible in drillcore of calcareous mudstone where it is fresh or slightly weathered; bedding in moderately weathered mudstone, shale, siltstone, and sandstone is visible in outcrop, building excavation sites, and trenches, and sometimes in drillcore. Bedding generally dips to the east or northeast at 25^{o} with bedding planes variably spaced. Poles to bedding planes have been plotted and contoured on a stereographic projection (Fig. 3).

JOINTS

At least three joint sets are expected to occur in the tunnel and four sets may be common for some very closely jointed and fragmented sections. Spacing of the joints determines the rock quality designation (RQD) which is defined as 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.

Drillcore was not oriented, therefore the effect of joint attitudes on tunnel stability is largely unknown though one set observed in excavations dips at $70^{o}/090^{o}$ (dip direction).

FAULTS

A number of small faults and sheared and fractured zones are expected to intersect the tunnel excavation. Movement along the faults is thought to have been small (generally less than a few metres). Alteration zones associated with faults are expected to be narrow and should not significantly influence tunnelling conditions.

Small faults could explain variations in the weathered profiles of some drillholes along tunnel section (e.g., holes 8, 8A, 10 and 11).

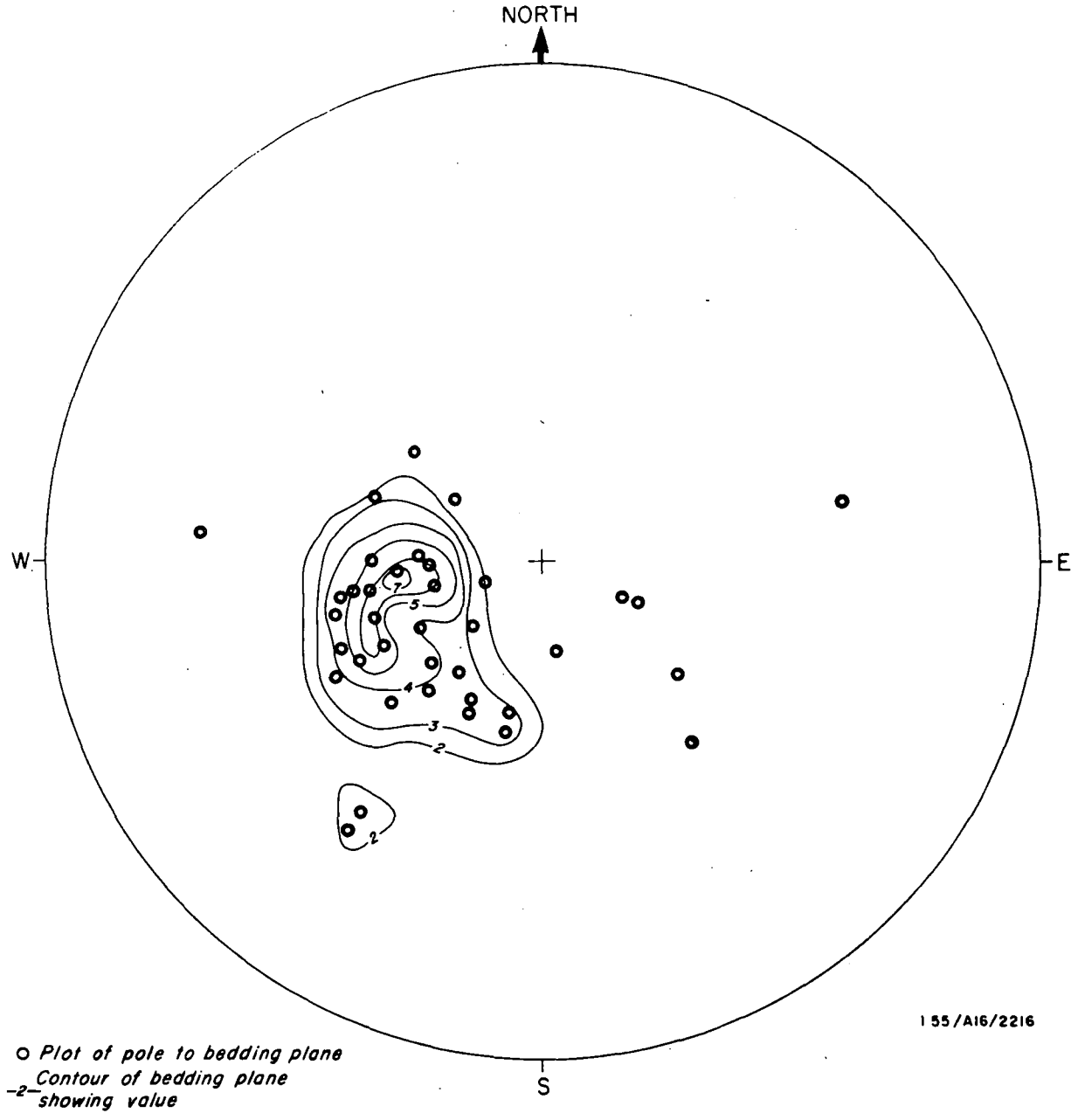


Fig. 3 Contoured stereographic projection of poles to bedding for City Hill Shale along tunnel route. Stereograph indicates average dip of beds to be Dip/Dip direction = 25/080

GROUNDWATER

WATER-LEVELS

Water-levels measured in each of the drillholes are plotted in Figures 4a, b, and c. Measurements taken between August to November 1978 show some interesting fluctuations in the groundwater-table.

The water-level in hole 1 remained steady, and was influenced by the normal hydraulic gradient that could be expected away from Lake Burley Griffin.

Holes 1A, 1C, 4, 6, 6A, 7 and 7A had water-levels that were below lake level for part of the time; such observations would not be expected in this groundwater situation. Lowering of the water-table may be due to leakage into the existing buried services, including sewers, or to pumping of water from the basements of nearby buildings.

Water-levels in holes 8 and 10 were abnormally high. This could be attributed either to inflows from perched aquifers or from the inflow or surface water after rainfall. These holes probably do not reflect the groundwater-level in the surrounding area.

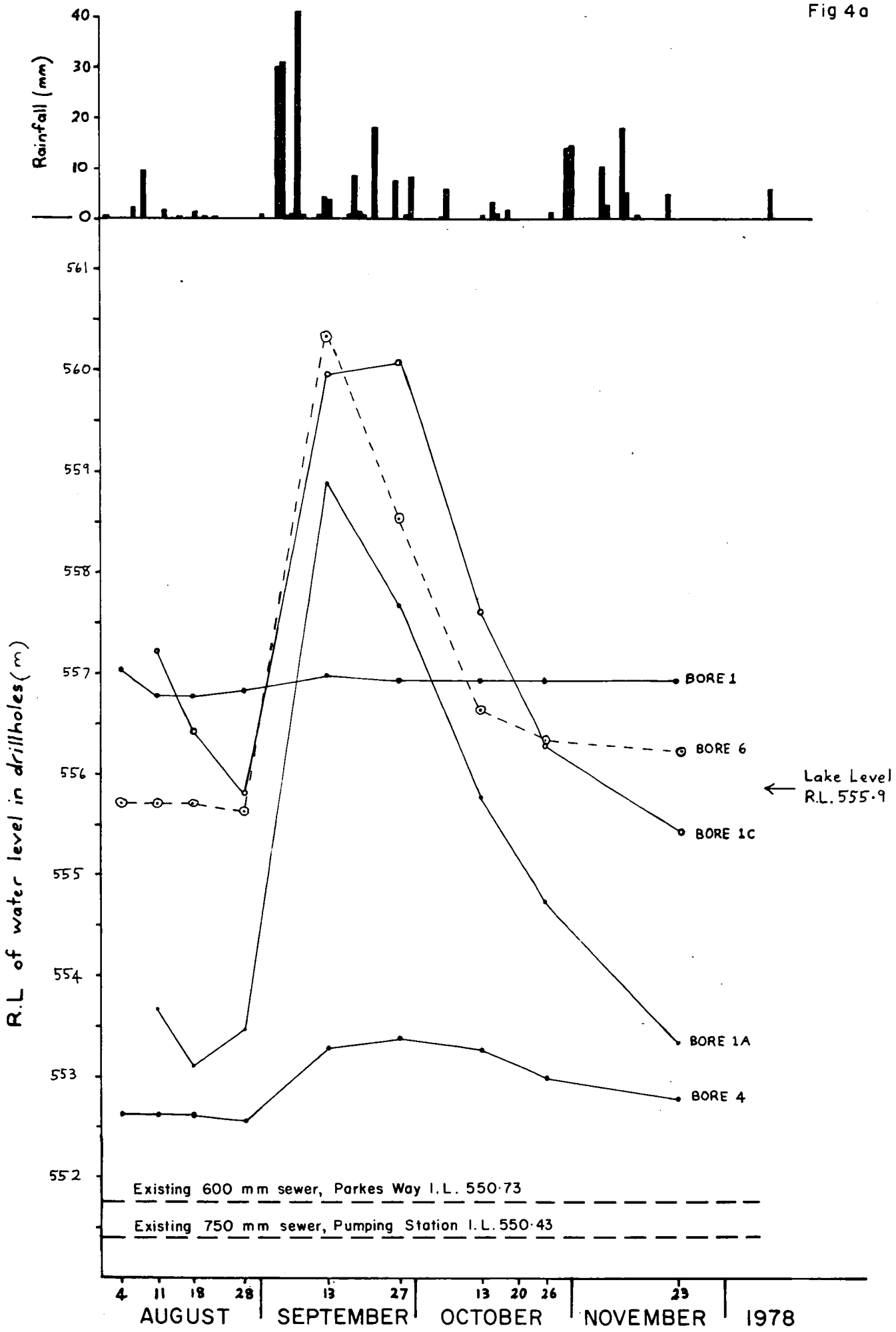
Water-levels in the remaining drillholes provide a reasonable guide to the groundwater conditions in their vicinity.

PERMEABILITY AND RECHARGE

Permeability of the calcareous mudstone is generally expected to be low (25 litres/minute/10 m of tunnel length) along most of the tunnel section, and recharge is likely to depend on rainfall and not surface water features such as Sullivans Creek and Lake Burley Griffin. However, the proximity of Lake Burley Griffin is expected to affect the tunnel near drillhole 1, where rocks are expected to be more permeable. Inflows in excess of about 125 litres/minute/10 m of tunnel length may occur, and will be maintained if there is a hydraulic connection to the lake.

Initial groundwater flows of 25-125 litres/minute/10 m section can be expected in a number of places as tunnel excavation proceeds. These flows are expected to be short-lived however, and should subside within a matter of days.

Fig 4a



Water-level measurements, Bores 1-6

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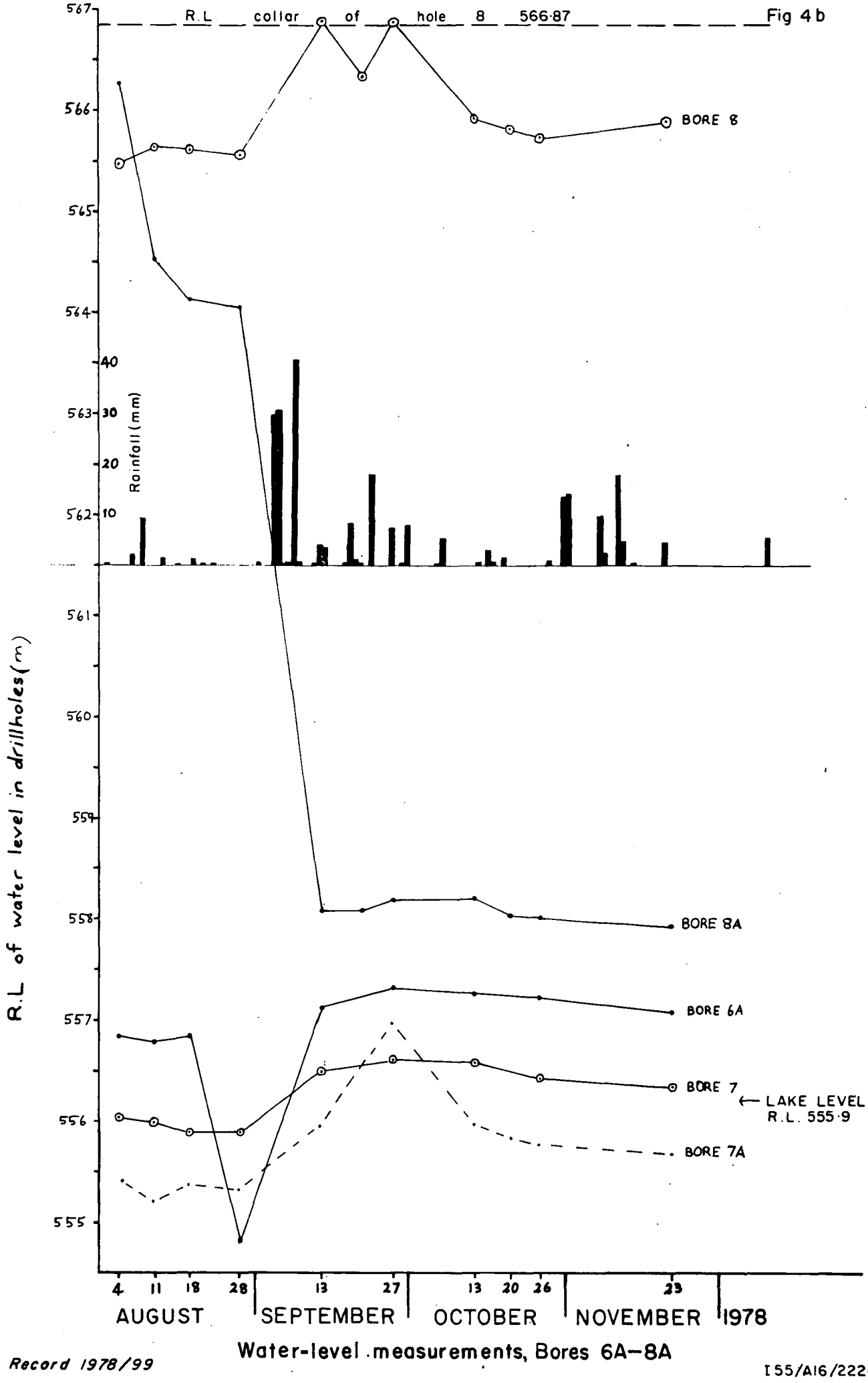

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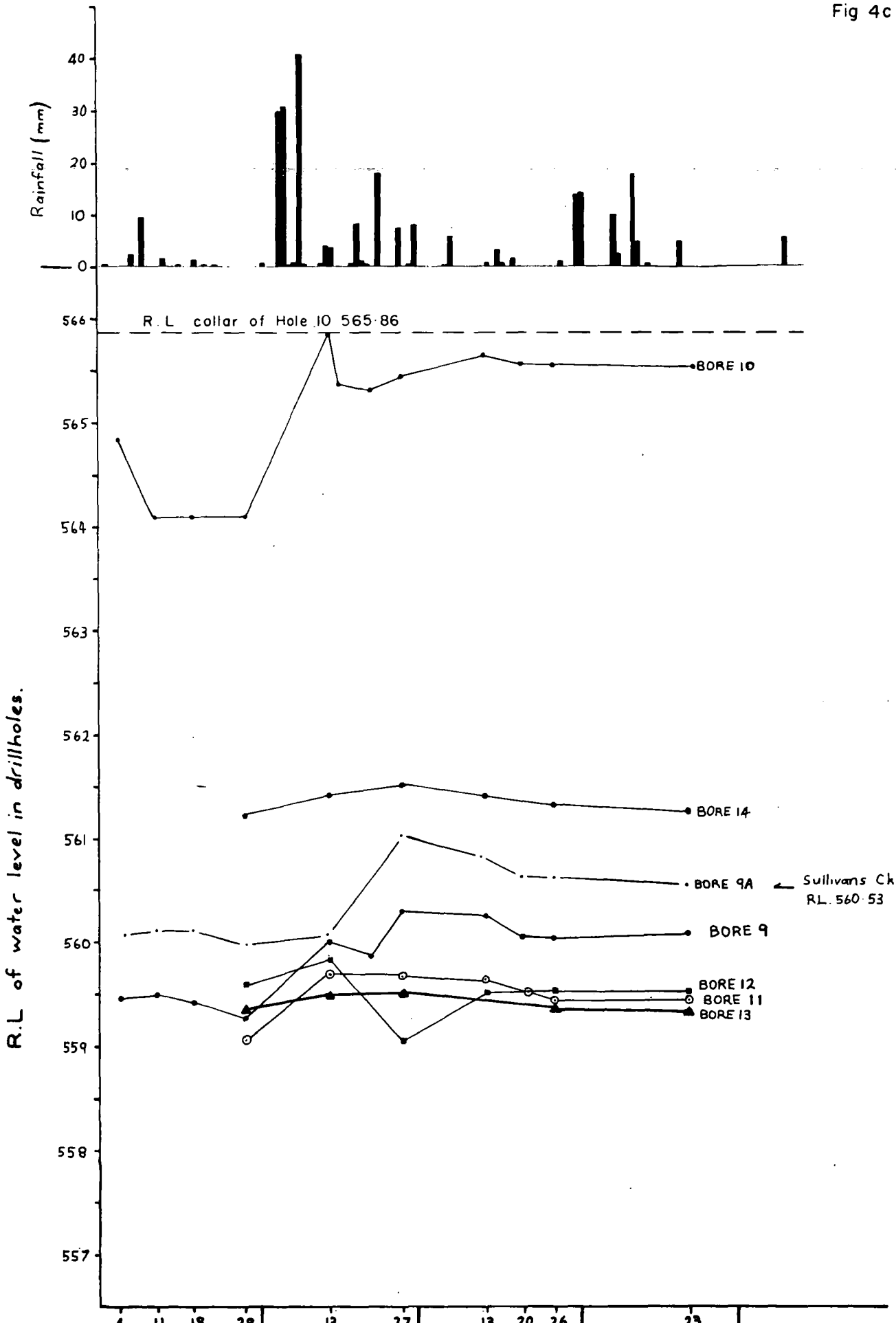
Fig 4c


Rainfall (mm)
40
30
20
10
0
566
R.L collar of Hole 10 565·86
565
564
563
562
561
560
559
558
557
R.L of water level in drillholes.
BORE 10
BORE 14
BORE 9A
Sullivans Ck
RL. 560·53
BORE 9
BORE 12
BORE 11
BORE 13
4
11
18
28
13
27
13
20
26
23
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
1978
Water-level measurements, Bores 9-14

If limestone is intersected by tunnel excavations (and this is considered unlikely), solution channels could introduce high flows; if such channels were in hydraulic continuity with the lake, such inflows would be hazardous. Limestone in the area lacks continuity and occurs as isolated lenses; if limestone lenses are present along the tunnel line, they would not be expected to have hydraulic continuity with the lake beyond chainage 9+00.

SEISMIC REFRACTION TRAVERSES

To aid prediction of ground conditions for the proposed tunnel, seismic refraction work was done where possible. Because much of the route is along streets in a built-up area, only three short traverses were possible (traversed A, B, C in Plates 1 and 2). The traverses had to be offset from the line of the tunnel because of its proximity to traffic and to underground services.

The seismic records and time-distance curves are available for inspection from the BMR on request.

Based on the measured seismic velocities and the degrees of weathering observed in diamond-drillhole cores, the following general correlation table is presented:

TABLE 2. CORRELATION BETWEEN SEISMIC VELOCITY AND DEGREE OF WEATHERING OF MUDSTONE AND SILTSTONE OF THE CITY HILL SHALE.

Seismic velocity range (m/s)	Expected degree of rock weathering
400 - 500	Soil, fill, and extremely weathered rock
1000 - 1300	Highly weathered rock
1300 - 1900	Moderately weathered rock
2000 - 2900	Moderately to slightly weathered rock
2900	Slightly weathered to fresh rock

VIBRATION TESTING

To provide a guide to charge sizes when blasting the tunnel, holes were drilled on tunnel line and to tunnel depth, and explosive charges detonated in them in order to measure the vibration levels produced at nearby buildings. From these results the maximum charge size permissible, to comply with the Standards Association of Asutralia (SAA) peak particle velocity limit (19 mm/s), was determined by extrapolation.

Most of the holes had partly collapsed so the charges were detonated at points above tunnel level. In some locations, two separate instruments recorded the same explosion.

The peak particle velocities recorded, along with other details are given in Table 3.

TABLE 3 - VIBRATION RECORDINGS

Depth of charge (m)	Charge size (kg)	Distance from hole to detector (m)	Peak particle velocity (mm/s)	Location of detector
9	0.34	50	5.6	front driveway of Lakeside Hotel
5	0.34	50	4.1	as above
5	1.02	(50	9.8	as above
		(55	7.8	bottom of bottleshop driveway
7.5	0.11	13	13.7	Child Care Centre, Marcus Clarke St
15	0.34	(30	8.6	outside barber's shop, Tasman House (a)
		(35	5.4	outside electricity substation, adjacent to Tasman House (b)
12	1.02	(30	16.2	as above (a)
		(35	7.8	as above (b)

If we assume sinusoidal vibration, then the peak particle velocuty (v) is given by the empirical formula:

$$v = \frac{2 \quad fk \quad w}{d}$$

where f is the frequency of the vibration
k is a site constant
w is the weight of explosives per delay
d is the distance from explosion to detector

Thus, for any particular location, f, k, and d are fixed, so v is proportional to w. Using this proportionality we can roughly predict the charge size which would produce a peak particle velocity of 19 mm/s, the limit recommended by the SAA for vibrations resulting from blasting in a built-up area.

From the figures shown in Table 1 the following maximum charge sizes were calculated:

Lakeside Hotel - 3.5 kg per delay
Tasman House - 1.5 kg per delay
Child Care Centre - 0.25 kg per delay.

Note that these figures are derived from an empirical formula, and serve only as a guide.

Vibration testing results indicate a severe limit to the charge size that can be used near the Child Care Centre. Such charge sizes may be impractical for tunnel excavation and special tunnelling methods may have to be considered for this section.

TUNNELLING CONDITIONS

Predicted tunnelling conditions based on a calculated rock mass quality, degree of weathering, standup times, RQD, and RCN are given in Plates 1, 2, and 3. Rock mass quality, roof support pressures, and support requirements at tunnel level have been estimated by using the methods proposed by Barton, Lien, & Lunde (1974), and are set out in Tables 4 and 5.

ROCK MASS QUALITY

Rock mass quality Q is calculated from the formula:

$$Q = \frac{RQD}{Jn} \times \frac{Jr}{Ja} \times \frac{Jw}{SRF}$$

Where: RQD = Rock quality designation
Jn = Joint set number
Jr = Joint roughness number
Ja = Joint alteration number
Jw = Joint water reduction factor
SRF = Stress reduction factor

These parameters were calculated at each drillhole for the zone of influence relevant to tunnel construction - namely the 2 m above and 1 m below crown where drill holes were on tunnel line, and for the total length of the hole above spring line where the drillholes were off tunnel line.

ROOF SUPPORT PRESSURE (P_{roof})

Roof support pressure is calculated from the formula

$$P_{roof} = \frac{2.0}{Jr} Q^{-\frac{1}{3}}.$$

Where P_{roof} = permanent roof support pressure in kilograms per square centimetre. In practice P_{roof} is obtained graphically from known values of Q and Jr. Where the value of P_{roof} obtained in this way exceeded δ d (density x depth) the approximate value of δ d is given.

SUPPORT REQUIREMENTS

Estimates for tunnel support requirements are obtained by plotting the rock mass quality Q versus the equivalent dimension (Barton & others 1974). The equivalent dimension is defined for this project as follows:

$$\text{Equivalent dimension} = \frac{\text{Diameter (m)}}{\text{ESR}}$$

Where ESR (excavation support ratio) depends essentially on the purpose for which the excavation is required. For this tunnel the value of ESR has been taken as 1.6 - 1.25 and the diameter as 2.5 m

$$\text{Equivalent dimension} = \frac{2.5}{1.6} - \frac{2.5}{1.25} = 1.56 - 2.0$$

Up to five support categories are expected in excavating the tunnel; these are set out below in Table 4.

TABLE 4. SUPPORT REQUIREMENTS

Support category	Description of rock mass quality (Q)	Description of support requirement
0	Ranges from Poor - good	No support required
25	Very poor	Systematic bolting (untensioned, grouted) 1 m + reinforced mesh or chain mesh, or small groups of steel sets at 1.5 m + light timber lagging
29	Very poor	Systematic bolting (untensioned grouted) 1 m + shotcrete 3-5 cm + reinforced mesh, or steel sets at 1.5 m + light-medium timber lagging
33	Extremely poor	Systematic bolting (grouted, post-tensioned) 1 m + shotcrete (mesh reinforced) 5-10 cm, or steel sets at 1.0-1.5 m + medium timber lagging.
36 or 37	Exceptionally poor	Shotcrete 10-50 cm (mesh reinforced) + systematic bolting (grouted, post-tensioned) 0.5-1.0 m, or steel sets at heavy to complete timber lagging.

Support given in terms of rock bolts, mesh, and shotcrete is based on 200 case records (Barton & others, 1974), and is probably the most suitable for machine-excavated sections. Where conventional drilling and blasting is used, steel supports and timber may be more appropriate.

Estimated rock mass quality, roof support pressure and support requirements at tunnel level have been calculated for each drillhole relevant to the present tunnel alignment; they are set out in Table 5.

ESTIMATION OF STANDUP TIMES

Standup times for the rock mass intersected at each drillhole on or close to tunnel alignment have been estimated using the rating method developed by Bieniawski (1974). The method takes into account the unconfined strength (or point load strength), RQD, joint spacing, joint orientation, joint condition, and groundwater inflow.

Ratings were applied to the zone of influence relevant to tunnel construction (see ROCK MASS QUALITY) and are set out in Table 6. The standup times given by this method agree fairly well with support calculations, but in a number of instances appear to underestimate the standup times observed for similar rock elsewhere. Standup times range from less than 1 hour in poor rock to about 1 month in fair rock.

TABLE 5. ESTIMATED ROCK MASS QUALITY, ROOF SUPPORT PRESSURES, AND SUPPORT REQUIREMENTS AT TUNNEL LEVEL (after Barton & others, 1974).

Hole No.	RQD %	Jn: No of joint sets	Jn: Rating	$RQD/_{Jn}$	$Jr/_{Ja}$	$Jw/_{SRF}$	Rock mass quality (Q): value	Rock mass quality (Q): Description	P_{roof} (kg/cm^2)	Support category
1	20	2+ random	6	$20/_{6}$	$2.0/_{1.0}$	$1.0/_{1.0}$ $.0.66/_{10}$	0.65 0.44	V. poor V. poor	1.0	0 25
1A	45	3	9	$45/_{9}$	$1.0/_{1.0}$	$1.0/_{5}$ $0.66/_{5}$	1.0 0.66	Poor V. poor	2.0	0 25
1C	27	3	9	$27/_{9}$	$2.0/_{1.0}$	$1.0/_{7.5}$	0.8	V. poor	1.25	25
4	0	4	15	$0/_{15}$	$1.0/_{1.0}$	$1.0/_{5}$	0	Exceptionally poor	2.0?	37
5	27	3	9	27/9	1.5/2.0	0.66/5.0	0.29	V. poor	2.0	29
6	0	4	15	$0/_{15}$	$1.0/_{1.0}$	$1.0/_{2.5}$	0	Exceptionally poor	2.0?	37
6A	0	4	15	$0/_{15}$	$1.0/_{1.0}$	$1.0/_{5.0}$	0	Exceptionally poor	2.0?	37
7	40	4	15	$40/_{15}$	$1.5/_{2.0}$	$1.0/_{2.5}$	0.8	V. poor	1.5	25
7A	68	3	9	$68/_{9}$	$1.5/_{1.0}$	$1.0/_{1.0}$	11.3	Good	0.5	0
8	43	2 + R	6	$93/_{6}$	$1.5/_{1.0}$	$0.66/_{1.0}$	15.4	Good	0.5	0
8A	39	2 + R	6	$39/_{6}$	$1.5/_{1.0}$	$0.66/_{5.0}$	1.2	Poor	1.0	0

TABLE 5 (Continued)

Hole No.	RQD %	Jn: No of joint sets	Jn: Rating	$RQD/_{Jn}$	$Jr/_{Ja}$	$Jw/_{SRF}$	Rock mass quality (Q): value	Rock mass quality (Q): Description	P_{roof} (kg/cm^2)	Support category
9	32	4	12	$32/_{12}$	$1.0/_{1.0}$	$1.0/_{5.0}$	0.53	V. Poor	2.0	25
9A	3	3	9	$3/_{9}$	$1.0/_{1.0}$	$1.0/_{1.0}$	0.33	V. poor	2.0	29
10	16	4	15	$16/_{15}$	$1.0/_{1.0}$	$0.8/_{2.5}$	0.34	V. poor	2.0	29
11	33	3 + R	12	$33/_{12}$	$1.0/_{1.0}$	$1.0/_{5.0}$	0.55	V. poor	2.0	25
12	64	2	4	$64/_{4}$	$1.0/_{1.0}$	$1.0/_{5}$	3.2	Poor	1.0	0
13	54	4 + R	15	$54/_{15}$	$1.5/_{1.0}$	$1.0/_{1.0}$	5.4	Fair	0.8	0
14	53	3 + R	12	$53/_{12}$	$1.0/_{3.0}$	$1.0/_{1.0}$	1.4	Poor	1.5	0

TABLE 6. ESTIMATION OF STANDUP TIMES AT TUNNEL LEVEL (after Bieniawski, 1974)

Hole	Strength		RQD		Joint ratings			Groundwater		Total	Rock	Standup
no.	u.c.s. (M.Pa)	Rating	%	Rating	Spacing	Orientation	Condition	Inflow/ 10 metres (Litre min)	Rating	rating	class	time
1	< 25	0	20	3	3	5	10	< 25 25-125	8 5	29 26	Poor (IV)	Less than 1 hour
1A	< 25	0	42	9	0	6	10	< 25 25-125	8 5	43 40	Poor (IV)	10 Hours
1C	< 25	0	27	8	10	6	10	< 25	8	42	Poor (IV)	10 Hours
4	< 25	0	0	3	5	3	10	< 25	8	28	Poor (IV)	Less than 1 hour
5	25-50	1	27	8	8	8	7	< 25	8	40	Poor (IV)	8 hours
6	< 25	0	0	3	5	3	10	< 25	8	29	Poor (IV)	About 1 hour
6A	< 25	0	0	3	5	3	10	< 25	8	29	Poor (IV)	About 1 hour
7	< 25	0	40	8	10	6	10	< 25	8	42	Poor (IV)	10 Hours
7A	50-100	2	68	14	15	6	10	< 25	8	55	Fair (III)	About 1 week
8	50-100	2	93	20	15	6	12	about 25	6	61	Fair	About 1 month
8A	< 25	0	39	8	10 5	6	10	25 -125	5	39 34	Poor	10 Hours 2 Hours

TABLE 6 (continued)

Hole	Strength		RQD		Joint ratings			Groundwater		Total	Rock	Standup
no.	u.c.s. (M.Pa)	Rating	%	Rating	Spacing	Orientation	Condition	Inflow/ 10 metres (Litre min)	Rating	rating	class	time
9	< 25	0	32	8	10	6	10	< 25	8	42	Poor	10 Hours
9A	< 25	0	3	3	5	6	10	< 25	8	32	Poor	2 Hours
10	< 25	0	16	3	10	6	10	25-125		5	34	Poor
11	50-100	2	33	8	10	6	10	< 25	8	44	Poor	10
12	50-100	2	64	14	10	6	10	< 25	8	54	Fair	1 Week
13	100-200	5	54	14	10	6	10	< 25	8	53	Fair	2 days
14	100-200	5	53	14	10	6	6	< 25	8	49	Poor	2 days

EXCAVATION METHOD AND POTENTIAL OVERBREAK

The section of tunnel from chainage 0+00 to 7+30 is capable of being excavated by a road-header type tunnel-excavating machine. The remainder of the tunnel is likely to require conventional drilling and blasting, although a small section from chainage 14+80 to 16+90 could probably be excavated by a tunnel excavation machine.

Should drilling and blasting methods be used for the entire tunnel excavation then large overbreak sections can be expected, particularly where the rock mass quality is extremely to exceptionally poor (see Plates 1, 2, and 3).

If a tunnelling machine is used for some sections of tunnel, then overbreak will be reduced, and steel mesh, rock bolts, and/or shotcrete could be installed where required. Steel supports and timber lagging may be more expedient where drill and blast methods of excavating are used.

Excavation of the tunnel section near drillhole 1 may intersect groundwater inflows larger than those found elsewhere along the tunnel. Excavation of this section after the remainder of the tunnel has depressed the potentiometric surface in adjacent areas could significantly reduce the quantity of water to be pumped.

A tunnelling option is available between manholes 11 and 15 via manholes 12, 13, and 14, and the expected geological conditions are shown in Plate 3. Alternatively a direct tunnelling option is available for the section north of manhole 11, thereby eliminating manholes 12, 13, and 14. The direct tunnel option would diverge by up to 40 m from the proposed alignment; however, from the limited information available, the rock intersected is likely to be similar to that along the proposed alignment, and tunnelling conditions would not be expected to diverge greatly from those of the proposed alignment.

RECOMMENDATIONS

(1) Piezometers should be monitored prior to and during construction.

(2) A road-header type tunnel-excavation machine could be considered for much of the tunnel in conjunction with steel mesh and rock bolt support system (shotcrete where necessary).

(3) A geologist should log all excavations and advise on geological aspects of tunnel excavation and support during construction.

(4) A 1 m-diameter drillhole should be drilled for inspection by tenderers. It should show the range of rock conditions that are likely to be intersected during tunnel construction and should also show the worst conditions that are likely to be intersected. Such a hole located at drill hole 6A would meet these requirements.

(5) Vibration measurements should be recorded during tunnel blasting to ensure that the blasting is carried out within the vibration limits specified by the SAA.

REFERENCES

BUREAU OF MINERAL RESOURCES: Project file 1978/101 (Restricted).

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BROCH, E., & FRANKLIN, J.A., 1972 - The point load strength test. International Journal Rock Mechanics & Mining Science, 9 669-97.

HENDERSON, G.A.M., 1978 - Geological notes on proposed Sullivans Creek to Commonwealth Avenue pumping station sewer augmentation and possible extension to King Edward Terrace, Canberra, A.C.T. Bureau of Mineral Resources, Australia, Record 1978/24 (unpublished).

APPENDIX 1

DEFINITION OF TERMS

1. WEATHERING OF ROCK

FRESH	:	No discolouration or loss in strength
FRESH STAINED	:	Limonitic staining along fractures, rock otherwise fresh and shows no loss of strength.
SLIGHTLY WEATHERED	:	Rock is slightly discoloured, but not noticeable lower in strength than the fresh rock.
MODERATELY WEATHERED	:	Rock is discoloured and noticeable weakened; N - size drill core generally cannot be broken by hand across the rock fabric.
HIGHLY WEATHERED	:	Rock is discoloured and weakened; N-size drill core can generally be broken by hand across the rock fabric.
EXTREMELY WEATHERED	:	Rock is decomposed to a soil, but the original rock fabric is mostly preserved.

2. PERCUSSIVE STRENGTH OF ROCK

STRONG TO VERY STRONG	:	Cannot be broken by repeated blows with a hammer.
MODERATELY STRONG	:	Rock broken by 3 or 4 blows.
WEAK	:	Rock broken by one blow.

3. HARDNESS OF ROCK

HARD TO VERY HARD	:	Impossible to scratch with knife blade.
MODERATELY HARD	:	Shallow scratches with knife blade.
SOFT	:	Deep scratches with knife blade.

4. DEFECT SPACING

WIDE	:	300-100 cm
MODERATELY WIDE	:	100-30 cm
CLOSE	:	10-3 cm
FRAGMENTED	:	< 3 cm

5. BEDDING

LAMINATED	: 10 mm thick
THINLY BEDDED	: 10-100 mm thick
THICKLY BEDDED	: 100 mm thick

6. ROCK CONDITION NUMBER

1 Hard and intact: Rock very hard and strong with no significant joints or other defects including bedding plane partings. No support required.

2 Hard, widely jointed rock: As above but bedding plane partings and joints spaced 1-3 m and tight. Joints rarely continuous for more than a few metres. No support necessary.

3 Moderately jointed or bedded: Rock generally hard and strong, with continuous joints or bedding plane partings spaced 0.5-1.0 m and usually fairly tight. Minor water seepages likely. Rock may be a little blocky in places and may need rock bolt support where defects are unfavourably oriented to tunnel alignment. Shotcrete may be effective.

4 Moderately jointed and seamy: As above but defect surfaces generally clay coated and loose. Rock may be criss-crossed with seams or shears and may be moderately weathered. Support generally required (1-m spaced sets) especially where opening is greater than 3 m in diameter. Shotcrete may be effective in places.

5 Closely jointed and seamy: Closely jointed, seamy, and fractured rock. Rock may be highly or extremely weathered. Where defect surfaces are open and clean water inflows may occur. Steel sets required with heavy lagging. Shotcrete may be effective if applied before ground commences movement.

APPENDIX 2

GEOLOGICAL LOGS OF DIAMOND-DRILLHOLES

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

PROJECT Gould St - Commonwealth Ave Sewer Tunnel
LOCATION eastern side of C/Wealth Ave
ANGLE FROM HORIZONTAL (θ) 90° DIRECTION
CO-ORDINATES 603 970 N 210 682 E R L OF 560.23 m

HOLE No. 1
Canberra 247
SHEET 1 OF 1

GEOLOGICAL LOG OF DRILL HOLE

Drilling information							Rock Substance				Rock Mass Defects			
Method	Drilling rate	Casing	Water	Pressure test *	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description: rock type, grain characteristics, colour, structure, minor components	Weathering or U.S.C.	Point load strength Is(50) (Pa) 10 3 1 0.3	Defect spacing (cm) 3000 1000 300 100 30	R Q D	Defect description: thickness, type, inclination, planarity, roughness, coating strength	Rock condition No (interpretive)
Auger						1		Not cored						
						2		cobbles	CH					
					50			organic sandy SILT	OL				Unconsolidated FILL	
				13.9.78		3							core loss	
				11.8.78 to 29.8.78		4		Gravel - sand - silt CLAY mixture	GC					
Diamond core					100	5		Fragmented MUDSTONE, clay and some pebbles						
					90									
					80	6								5
								Sandy CLAY	CL				core loss	
					100	7		Pale yellow-brown to red-brown MUDSTONE					very closely fragmented.	
	Tunnel				85	8			MW			10	fragmented	
													fragmented	
												10	core loss.	
					100	9							closely jointed, manganese staining on moderately to steeply dipping joint surfaces	4-5
												60		
						10							fragmented	
					90							0	core loss	
						11		End of hole R.L. = 549.23						

Drill type Pioneer
Feed Hydraulic
Core barrel type Triefus NMLC
Driller V. O'Brien
Commenced 25.7.78
Completed 26.7.78
Logged by P. VanDenBoek
Vertical scale 1:100

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

Water
10 Oct 73 water level date shown
Water inflow
Partial drilling water loss
Complete drilling water loss

Notes
Bedding & Joint Planes - Angles are measured relative to a plane normal to the core axis
* Water Pressure Tests

Core Photography Negative No		
Depth (m)	B & W	Colour
1.5 - 6.1	M 23241	
6.1 - 11.0		

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

PROJECT Gould St - Commonwealth Ave Sewer Tunnel
LOCATION Eastern side of Commonwealth Ave

HOLE No. 1A
Canberra 248

GEOLOGICAL LOG OF DRILL HOLE

ANGLE FROM HORIZONTAL (θ) 90° DIRECTION
CO-ORDINATES 603050N 210688E R L OF 561.66m

SHEET 1 OF 1

Drilling information							Rock Substance				Rock Mass Defects			
Method	Drilling rate	Casing	Water	Pressure test *	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description rock type, grain characteristics, colour, structure, minor components	Weathering	0.3 Point load 1.0 strength 3.0 10.0 Is(50)(MPa)	Defect spacing (cm) 10 30 100 300	R Q D	Defect description thickness, type, inclination, planarity, roughness, coating strength	Rock condition No (interpreted)
Auger						1		No Core						
Diamond Core			4·8·78 ▼ 13·9·78 ▼		60	2		Core loss				55	Closely jointed, clay on joints.	
					100	3		Pale green-brown mudstone	SW			0	Very closely jointed, clay on some joints.	
					100	4						25	Closely jointed, most joints moderately to steeply dipping and manganese stained. A few are clay coated.	3-4
					100	5						60		
						6		Fragmented rock	HW			45	Possible shear.	
					100	7		Pale yellow-brown mudstone	MW			53	Closely jointed with manganese staining on joints.	
			18·8·78 ▼		95	8		Core loss				40		3-4
Tunnel						9		Fragmented rock				20	Very closely jointed with fragmented sections.	
					100	10		Pale red-brown mudstone				0	Clay seam	
					100	11						45	Closely jointed with manganese staining on joints.	

End of Hole: R.L. = 550.66

Drill type Pioneer
Feed Hydraulic
Core barrel type Triefus NMLC
Driller V. O'Brien
Commenced 1/8/78
Completed 1/8/78
Logged by P. Vandenbreek
Vertical scale 1:100

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

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

Notes
Bedding & Joint Planes - Angles are measured relative to a plane normal to the core axis
* Water Pressure Tests

Core Photography Negative No

Depth (m)	B & W	Colour
1.5 - 6.3	M23241	
6.3 - 11.0		

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

PROJECT Gould St - Commonwealth Ave Sewer Tunnel
LOCATION East side of Commonwealth Ave
Canberra 249

HOLE No. LC

GEOLOGICAL LOG OF DRILL HOLE

ANGLE FROM HORIZONTAL (θ) 90° DIRECTION
CO-ORDINATES 603 216 N 210 209 E R.L. OF 563.98m

SHEET 1 OF 1

Drilling information								Rock Substance				Rock Mass Defects			
Method	Drilling rate	Casing	Water	Pressure test *	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description: rock type, grain characteristics, colour, structure, minor components	Weathering	Point load strength (0.3, 1.0, 3.0, 10.0 Is(50) MPa)	Defect spacing (cm) (3, 10, 30, 100, 300)	R.Q.D.	Defect description: thickness, type, inclination, planarity, roughness, coating strength	Rock condition No. (interpretive)
Auger						1		No core						
Diamond Core					100	2		Clay 1.0	HW EW			0	Fragmented with some clay seams.	4
					100	3		Pale yellow-brown to pale red-brown mudstone.	MW	×		50	Closely jointed, mostly stained with Manganese. Some thin clay seams.	
			13.9.78		80	4		Pale yellow mudstone. Clay 0.1	HW			20		3-4
					100	5		Pale yellow-brown to red brown mudstone.				0	seam 2-3 cm wide	
						6						35	Closely jointed with Manganese staining on joints	
			11.8.78		100	7		Fragmented rock	MW			50		
			28.8.78		100	8				× ×		35	Mostly closely jointed with manganese staining on moderately dipping joints	3-4
	Tunnel					9		Fragmented rock				30		
					100	10						45		
					100	11						47		
								End of Hole R.L. = 552.98						

Drill type Pioneer
Feed Hydraulic
Core barrel type Triefus NMLC
Driller V. O'Brian
Commenced 2/8/78
Completed 2/8/78
Logged by P. VandenBroek
Vertical scale 1:100

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

Water
10 Oct 73 water level date shown
Water Inflow
Partial drilling water loss
Complete drilling water loss

Notes
Bedding & Joint Planes - Angles are measured relative to a plane normal to the core axis
* Water Pressure Tests

Core Photography Negative No

Depth (m)	B & W	Colour
1.05 - 6	M23241	
6.0 - 11.0		

Record 1978/99

I55/A16/2230

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

PROJECT Gould St - Commonwealth Ave Sewer Tunnel
LOCATION Western side Commonwealth Ave
ANGLE FROM HORIZONTAL (θ) 90° DIRECTION
CO-ORDINATES 602 975 N 210 615 E R.L. OF 560.1L m

HOLE No 2
Canberra 250
SHEET 1 OF 1

GEOLOGICAL LOG OF DRILL HOLE

Depth (metres)	Graphic log & core loss	Substance description: rock type, grain characteristics, colour, structure, minor components	Weathering or U.S.C.	Rock Mass Defects: Defect description: thickness, type, inclination, planarity, roughness, coating strength	Rock condition No (interpretive)
1		Not cored			
2		Organic SILT	OL	Core loss	
3		Organic CLAY	OH		
		Gravelly SILT	GC	Core loss	
4		Boulders and Pebbles		Core loss	
5		Crushed ROCK and CLAY			
		Boulders			
6				Core loss	
7		Organic SILTY CLAY	OL		
8					
9				Core loss	
10					
		Pebbles			
11		Silty CLAY	CL		
		End of hole R.L = 549.11			

Method: Auger; Diamond core
Drilling rate
Casing
Water: 4-8-78; 13-9-78
Pressure test *
Lift & % core recovery: 55; 60; 25; 7; 100

Auger Samples
- Organic Silty CLAY
- Organic Silty CLAY
- Sandy CLAY

Rock Substance: 50 Point load 100 strength 300 1000 is(50)(KPa)
Rock Mass Defects: Defect spacing (cm) 30 100 300 1000; R.Q.D.

Drill type Pioneer
Feed Hydraulic
Core barrel type Triefus NMLC
Driller Vic O'Brien
Commenced 24-7-78
Completed 24-7-78
Logged by P. Vanden Broek
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

Core Photography Negative No

Depth (m)	B & W	Colour
1.5 - 6.65	M23241	
6.65 - 11.0		

Record 1978/99

I55/A16/2231

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

PROJECT Gould St - Commonwealth Ave Sewer Tunnel
LOCATION Western side of Commonwealth Ave between Holes 2B and 3
ANGLE FROM HORIZONTAL 90° DIRECTION
CO-ORDINATES 603 078N 210 623E R.L. OF 560·2

HOLE No 2A
Canberra 251
SHEET 1 OF 1

GEOLOGICAL LOG OF DRILL HOLE

Drilling information | Rock Substance | Rock Mass Defects

Method	Drilling rate	Casing	Water	Pressure test *	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description: rock type, grain characteristics, colour, structure, minor components	Weathering	10 Point load 100 strength 300 1000 is(50)(kPa)	Defect spacing (m) 0.1 0.3 1.0 3.0	RQD	Defect description: thickness, type, inclination, planarity, roughness, coating, strength	Rock condition No. (inter pretive)
Auger						1								
						2		Not cored.						
			4·8·78					Gravelly clay loam	GC				Fill	
			11·8·78 to 28·8·78		0	3		Orange sand clay	CI					
					100	4		Pale yellow-brown MUDSTONE						
					90	5		Pale orange-brown MUDSTONE						
Diamond core			13·9·78			6								
					100				MW					
						7								
					100									
						8		Pale yellow grey MUDSTONE						
					100									
						9								
					100									
						10								
					100									
						11								
								End of hole: R.L. = 549						

50 – clay seam and very closely fractured.
clay seam
30 – very closely fractured to fragmented.
40 – very closely fractured. 3-4
fragmented.
55
Closely jointed with black manganese staining on horizontal, moderately and steeply dipping joint
45 surfaces.
55 clay shear
50 3-4

Drill type Pioneer
Feed Hydraulic
Core barrel type Triefus NMLC
Driller Vic O'Brian
Commenced 31/7/78
Completed 31/7/78
Logged by P. Vanden Brock
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

Core Photography Negative No		
Depth (m)	B & W	Colour
2.15-7	M23241	
7-11.0		

Record 1978/99

I 55/A16/2232

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

PROJECT Gould St - Commonwealth Ave Sewer Tunnel

LOCATION western side of Commonwealth Ave, ~~~ north of hole 2

ANGLE FROM HORIZONTAL (θ) 90° DIRECTION

CO-ORDINATES 693 038 N 210 617 E R.L. OF 561

HOLE No. 2B Canberra 252

SHEET 1 OF 1

GEOLOGICAL LOG OF DRILL HOLE

Drilling information								Rock Substance				Rock Mass Defects			
Method	Drilling rate	Casing	Water	Pressure test *	Lift & % core recovery	Depth (metres)	Graphic log & Core loss	Substance description rock type, grain characteristics, colour, structure, minor components	Weathering or U.S.C.	30 Point load 100 strength 1000 lbs/sq in (kPa)	Defect spacing (cm)	R Q D	Defect description thickness, type, inclination, planarity, roughness, coating strength	Rock condition No (interpreted)
Auger						1		Not cored						
Diamond core			11-8-78 ▼ 13-9-78		65	2		Black organic SILT	OL				clay PP 1.5 – 5.0 kg/cm²	
					30	3		Pale yellow-brown GRAVEL-CLAY mixture	GC				PP 2.0 – 3.0 kg/cm² unconsolidated FILL	
					80	5		Yellow-brown, high plasticity CLAY	CH				PP 2.0 – 4.0 kg/cm²	
					75	7		Gravel-sand CLAY mixture.	GC					
					100	9		Red-brown sandy CLAY	CL				PP 2.0 – 3.0 kg/cm²	
					0	10		Yellow-brown gravel sand CLAY						
					60	11		yellow-brown MUDSTONE	MW				Bedrock?	
								End of hole R.L. = 550						

Drill type Pioneer

Feed Hydraulic

Core barrel type Triefus NMLC

Driller V. O'Brian

Commenced 3-8-78

Completed 7-8-78

Logged by P. VanderBroek

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

Core Photography Negative No

Depth (m)	B & W	Colour
1.5 – 6.65	M23241	
6.65 – 11.0		

Record 1978/99

I55/A16/2233

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

PROJECT Gould St-Commonwealth Ave Sewer Tunnel
LOCATION western side of Commonwealth Ave
ANGLE FROM HORIZONTAL (θ) 90° DIRECTION
CO-ORDINATES 603165N 210639E R.L. OF 562.68m

HOLE No. 3 Canberra 253
SHEET 1 OF 1

GEOLOGICAL LOG OF DRILL HOLE

Drilling information | Rock Substance | Rock Mass Defects

Method	Drilling rate	Casing	Water	Pressure test *	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description: rock type, grain characteristics, colour, structure, minor components	Weathering	30 Point load / 100 strength / 300 Is(50) (kPa)	Defect spacing (cm) 3 10 30 100 300	R.Q.D.	Defect description: thickness, type, inclination, planarity, roughness, coating strength	Rock condition No (interpretive)
Auger			4.8.78					Not cored						
					95	1		Pale yellow-brown MUDSTONE	HW			10	- Core fragmented	
						2			MW			25	- Closely jointed with black manganese staining on moderately dipping joints.	
								Clay 2.0	EW				- Possible Shear	
					100	3		Pale yellow-brown MUDSTONE	MW				- Core fragmented	3-4
								Clay 2.0	EW				- Possible shear	
						4		Pale yellow-brown MUDSTONE					- Closely jointed with black manganese staining on joints.	
					100	5							- Fragmented.	
Diamond core			13.9.78			6			MW			0	- Fragmented.	4
					100	7							- Very closely jointed	
					60	8		Fragmented rock Core loss					- Fragmented, possibly up to 1m thick	
					90	9		Pale yellow-brown to core loss pale yellow MUDSTONE						
					100	10			MW			15	- Closely jointed at high angle and Manganese coated.	4
						11						20	- Clay coating on high angle joints from 10.5 to 11.5 m.	
					100	11.50		End of hole R.L = 551.18						

Drill type Pioneer
Feed Hydraulic
Core barrel type Triefus NMLC
Driller Vin O'Brian
Commenced 21/7/78
Completed 21/7/78
Logged by P Vandenbroek
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

Core Photography Negative No

Depth (m)	B & W	Colour
0.6-5.65	33224	LL
5.65-10.8		
10.8-11.5		

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

PROJECT Gould St-Commonwealth Ave Sewer Tunnel
LOCATION Parks Way, under Commonwealth Ave overpass
ANGLE FROM HORIZONTAL (θ) 90° DIRECTION
CO-ORDINATES 603 351 N 210 672 E R L OF 560·19m

HOLE No. 4 Canberra 254
SHEET 1 OF 1

GEOLOGICAL LOG OF DRILL HOLE

Drilling information

Depth (metres)	Method	Drilling rate	Casing	Water	Pressure test *	Lift & % core recovery
0	Auger					
1						
2						100
3						
4						80
5	Diamond core					
6						90
7				4·8·78 ▼ 14·9·78		
8						98
9						
10						100

Rock Substance

Graphic log & core loss	Substance description: rock type, grain characteristics, colour, structure, minor components	Weathering	Point load 1·0 strength 3·0 Is(50) MPa
	Not cored		
	MUDSTONE Pale yellow-grey to yellow-brown	HW	
		EW	
	No Core		
	MUDSTONE Pale yellow-orange	HW	
	No core		
	MUDSTONE Pale yellow orange	MW	×
	End of hole R.L. = 550·19		

Rock Mass Defects

Defect spacing (cm) 3 10 30 100 300	R Q D	Defect description: thickness, type, inclination, planarity, roughness, coating strength	Rock condition No (interpretive)
		Closely fractured; iron staining on joints.	4
		Core fragmented; black manganese staining on joints. EW clay section from 3·75 to 4·00 m. General absence of clay coatings on joints.	5
	0	Closely fractured.	
		Core fragmented; black Manganese staining on joints. Clay 10cm wide at 8·9m	

Drill type Pioneer
Feed Hydraulic
Core barrel type Triefus NMLC
Driller V.O'Brien
Commenced 29·7·78
Completed 29·7·78
Logged by L.Vanderkolk
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

Core Photography Negative No

Depth (m)	B & W	Colour
1·0 - 6·0	M2324	
6·0 - 10·0		

Record 1978/99

155/A16/2235

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

PROJECT Gould St - Commonwealth Ave Sewer Tunnel
LOCATION Near Parkes Way between holes 1C and 6
ANGLE FROM HORIZONTAL (θ) 90° DIRECTION
CO-ORDINATES 693412N 210749E R L OF 564.19

HOLE No. 5
SHEET 1 OF 1

GEOLOGICAL LOG OF DRILL HOLE

Drilling information							Rock Substance			Rock Mass Defects				
Method	Drilling rate	Casing	Water	Pressure test *	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description rock type, grain characteristics, colour, structure, minor components	Weathering	30 Point load 100 strength 300 1000 Is(50)(KPa)	Defect spacing (cm) 3 10 30 100 300	R Q D	Defect description thickness, type, inclination, planarity, roughness, coating strength	Rock condition No (interpretive)
Auger						1		Not Cored						
Diamond core					70	2		35cm core loss	HW-EW			50	Most joints clay coated or surfaces highly weathered	
						3							closely jointed zone	
					100	4						30		
					100	5						70	Most joints stained with limonite and/or manganese. Most joints at 30°-45° and 65°-80°. At least 3 sets visible	
					100	6		Pale yellow-brown MUDSTONE (City Hill shale)	MW			50	Rock moderately strong	
					95	7						10	10cm wide fractured zone close intersecting joints	3
						8						90	High angle joints (65°-80°) are smoother than others and are probably normal to bedding	
			26.1.79		100	9		Bedding possibly at about 20°-25° (dip)				50		
					100	10			HW-MW			0	Closely jointed and fractured. Joint surfaces mostly highly weathered and stained; some clay coated.	4
						11			HW			30		
	TUNNEL				100	12			MW			40		3-4
						13						30	Sheared zone at about 50°. Minor amount of clay	
					100	14			HW			50		
					100	15			MW					
								End of hole						

Drill type Explorer
Feed Hydraulic
Core barrel type Triefus NMLC
Driller G. Curry
Commenced 24/1/79
Completed 24/1/79
Logged by DC Purcell
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

Core Photography Negative No

Depth (m)	B & W	Colour
	M23241	

Record 1978/99

155/A16/2236

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

PROJECT Gould St - Commonwealth Ave Sewer Tunnel
LOCATION exit ramp off Commonwealth Ave

HOLE No 6
Canberra 255

GEOLOGICAL LOG OF DRILL HOLE

ANGLE FROM HORIZONTAL (θ) 90° DIRECTION
CO-ORDINATES 603 485N 210 598E RL OF 562·83m

SHEET 1 OF 1

Drilling information							Rock Substance			Rock Mass Defects			
Method	Drilling rate	Casing	Water	Pressure test *	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description: rock type, grain characteristics, colour, structure, minor components	Weathering	Point load 1·0 strength 3·0 Is(50) MPa 10·0	Defect spacing (cm) 3·0 30·0 300	R Q D	Defect description: thickness, type, inclination, planarity, roughness, coating strength	Rock condition No (interpretive)
Auger						0								
						1								
						2		Not cored						
			▼14·9·78											
					100	3		MUDSTONE Pale orange-brown	HW to MW			40	Core closely fractured by moderately to steeply dipping joints. Joint surfaces manganese stained; general absence of clay coatings.	4 3-4
						4						10		
					100	5						20		
								Clay and crushed rock					15cm wide shear	
						6		MUDSTONE Pale yellow-brown.					Core is closely fractured by moderately dipping, manganese coated joints.	5
Diamond core					100	7			HW to MW			0		
			▼4·8·78 to 28·8·78											
	TUNNEL					8							Core totally fragmented.	
					100									
						9								
								MUDSTONE Pale pinkish brown	MW			60	Moderately to steeply dipping joints only, general absence of clay coatings and seams.	3
					100	10						80		
						11		End of hole RL = 551·83						

Drill type Pioneer
Feed Hydraulic
Core barrel type Triefus
NMLC
Driller V. O'Brien
Commenced 18·7·78
Completed 18·7·78
Logged by P. Vandenbeek
Vertical scale 1:100

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

Notes
Bedding & Joint Planes - Angles are measured relative to a plane normal to the core axis
* Water Pressure Tests

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

Core Photography Negative No		
Depth (m)	B & W	Colour
2·3-7·3	M22341	
7·3-11·0		

Record 1978/99

I 55/A16/2237

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

PROJECT Gould St - Commonwealth Ave Sewer Tunnel
LOCATION London Circuit, opposite Lakeside Hotel
ANGLE FROM HORIZONTAL (θ) 90° DIRECTION
CO-ORDINATES 603 640N 210 532E R L OF 562.69m

HOLE No. 6A
Canberra 256
SHEET 1 OF 1

GEOLOGICAL LOG OF DRILL HOLE

Drilling information								Rock Substance			Rock Mass Defects			
Method	Drilling rate	Casing	Water	Pressure test *	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description: rock type, grain characteristics, colour, structure, minor components	Weathering	Point load strength (50) MPa	Defect spacing (cm)	R Q D	Defect description: thickness, type, inclination, planarity, roughness, coating strength	Rock condition No (interpretive)
Auger						0				0.3 1.0 3.0 10.0	5 10 30 100 300			
						1		No core						
						2								
Diamond core					100	3		Pale brown MUDSTONE extremely weathered to clay	EW				Core totally fragmented.	4
			3·8·78 ▼ 14·9·78		95	4		Pale yellow-brown MUDSTONE not very hard, soft in places.	HW				Core closely jointed to totally fragmented; most joints in the 30°-60° range	4
						5								
	TUNNEL					6								
						7								
					95	8		No Core						
						9		Pale blue grey MUDSTONE hard and strong (City Hill Shale)	SW			80	Moderately to closely jointed; iron staining on joints. Some breaks possibly caused by drilling.	3
					100	10						70		
					100	11			FS					
								End of hole RL = 551.69						

Drill type Pioneer
Feed Hydraulic
Core barrel type Triefus NMLC
Driller V. O'Brian
Commenced 1·7·78
Completed 1·7·78
Logged by P. VandenBeek
Vertical scale 1:100

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

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

Notes
Bedding & Joint Planes - Angles are measured relative to a plane normal to the core axis
* Water Pressure Tests

Core Photography Negative No

Depth (m)	B & W	Colour
2.83-8.1	M23241	
8.1-11.0		

Record 1978/99

I 55/A16/2238

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT Gould St - Commonwealth Ave Sewer Tunnel
LOCATION London Circuit, next to Police Station carpark
ANGLE FROM HORIZONTAL (θ) 90° DIRECTION
CO-ORDINATES 603 723N 210 488E R L OF 563·79 m

HOLE No. 7
Canberra 257
SHEET 1 OF 1

Drilling information

Depth (metres)	Method	Drilling rate	Casing	Water	Pressure test *	Lift & % core recovery
0						
1	Auger					
2						75
3						100
4						100
5						
6						100
7	Diamond core			3·8·78 ▽		
8				14·9·78		100
9						100
10	TUNNEL					
11						100
12						100
13						

Rock Substance

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
0				
1		No core		
2		Pale grey-brown MUDSTONE	MW	
3				
4		Pale yellow-brown MUDSTONE	HW	
5		Pale grey-brown MUDSTONE	MW	X
6		Fragmented		
7		Pale grey MUDSTONE (City Hill Shale)	SW	
8				
9				
10				X X
11		Pale blue-grey MUDSTONE	FS	X
12				
13		End of hole RL = 550·79		

Rock Mass Defects

Depth (metres)	Defect spacing (cm) 3000 1000 300	R.Q.D.	Defect description: thickness, type, inclination, planarity, roughness, coating strength	Rock condition No. (interpretive)
1				
2		25	Core loss. Closely jointed with iron or manganese staining on joint surfaces.	
3		60		
4		15	Rock mostly fragmented.	
5		60	Closely jointed. Some break are drill induced.	3-4
6		24	Closely jointed	
7		40	very closely jointed	
8		60		
9		35	Closely jointed, iron staining on joint surfaces	
10		25		
11		67	Closely to moderately jointed. Some breaks are drill induced.	3
12		37		
13		60		

Drill type Pioneer
Feed Hydraulic
Core barrel type Triefus NMLC
Driller V. O'Brian
Commenced 6·7·78
Completed 7·7·78
Logged by P. VandenBrosk
Vertical scale 1:100

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

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

Notes
Bedding & Joint Planes - Angles are measured relative to a plane normal to the core axis
* Water Pressure Tests

Core Photography Negative No

Depth (m)	B & W	Colour
1·45-6·4	m 23241	
6·4-11·5		
11·5-13·0		

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

PROJECT Gould St-Commonwealth Ave Sewer Tunnel
LOCATION vacant land on western side of London Circuit
ANGLE FROM HORIZONTAL (θ) 90° DIRECTION
CO-ORDINATES 603 863N 210 423E R L OF 565.40m

HOLE No. 7A
Canberra 258
SHEET 1 OF 1

GEOLOGICAL LOG OF DRILL HOLE

Drilling information | Rock Substance | Rock Mass Defects

Method	Drilling rate	Casing	Water	Pressure test *	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description: rock type, grain characteristics, colour, structure, minor components	Weathering	Point load strength 0.3 / 1.0 / 3.0 / 10.0 Is(50) MPa	Defect spacing (cm) 3 / 10 / 30 / 100 / 300	R.Q.D.	Defect description: thickness, type, inclination, planarity, roughness, coating strength	Rock condition No (interpretive)
Auger					90	2	ooo	Quartz gravel						
					80	3		Yellow-brown weathered MUDSTONE	EW / HW / MW				Totally fragmented.	4
					100	4		Pale brown to pale grey MUDSTONE (City Hill Shale)	SW	x		10		
						5						50	Closely jointed with iron staining on joint surfaces. Moderately jointed with some drilling induced breaks	3
					100	6			FS			90		
						7			SW			30	Closely spaced joints, iron stained and moderately to steeply dipping.	3-4
					100	8			FS	x x		10		
						9						30	Mostly drilling induced breaks on rough irregular surfaces.	3
			▼14·9·78									80		
			▼28·8·78			10			Fr			100	Moderately to closely jointed, limonite staining on joints.	
Diamond core					100	11		Pale grey to blue-grey MUDSTONE, pyritic from 13.8m to 13.9m	SW	x		60	Possibly some cleavage developed by shearing pressure; probably not parallel to bedding.	3-4
	TUNNEL					12						30		
					100	13			Fr			10	Closely jointed and some drilling induced breaks.	
					100	14			FS			10	Joint's surface not stained.	
					100	15		End of hole RL = 550.40				0		

Drill type Pioneer
Feed Hydraulic
Core barrel type Triefus NMLC
Driller V.O'Brian
Commenced 29·6·78
Completed 30·6·78
Logged by P.VandenBrook
Vertical scale 1:100

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

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

Notes
Bedding & Joint Planes - Angles are measured relative to a plane normal to the core axis
* Water Pressure Tests

Core Photography Negative No

Depth (m)	B & W	Colour
1.8-7.0	M23241	
7.0-11.4		
11.4-15.0		

Record 1978/99

I55/A16/2240

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

PROJECT Gould St - Commonwealth Ave Sewer Tunnel
LOCATION School of Music, along side of Maccus Clark Street

HOLE No. 8
Canberra 259

GEOLOGICAL LOG OF DRILL HOLE

ANGLE FROM HORIZONTAL (θ) 90° DIRECTION
CO-ORDINATES 603 967 N 249 372 E R.L. OF 566·87m

SHEET 1 OF 1

Drilling information								Rock Substance			Rock Mass Defects			
Method	Drilling rate	Casing	Water	Pressure test *	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description rock type, grain characteristics, colour, structure, minor components	Weathering	0·3 Point load 1·0 strength 3·0 10·0 (50) MPa	Defect spacing (cm) 3 30 300 3000	R.Q.D.	Defect description thickness, type, inclination, planarity, roughness, coating strength	Rock condition No (interpretive)
Auger			15·9·78 28·8·78 3·9·78			0 1 2		No core						
Diamond core	TUNNEL				93	3			MW			45	Bedding and joint partings fractured, some clay	5
					100	4 5		MUDSTONE Blue-grey in colour where SW to Fr				0 60	Joints and bedding plane partings gradually become more widely spaced with depth. Generally no clay on defect surfaces.	
					100	6			SW	X		75	Bedding at about 60°	3-4
					100	7 8						33 85	Joints generally follow bedding and often normal to bedding and dip at about 30° (range 10°-30°)	
					100	9 10			Fr to FS			60 80	Most defects stained from surface to about 8m Sheared zones at: 7·5 - 7·6 m 8·15 - 8·35 m (little or no clay)	
					100	11 12 13						100 100		3 Some 2
					100	14 15				X		25 80	Closely intersecting joints at 15·4m and between 12·9 to 13·7 m	
					100	16 17						95 95		
						18		End of hole: R.L = 548·87				80		

Drill type Pioneer
Feed Hydraulic
Core barrel type Triefus NMLC
Driller V. O'Brian
Commenced 12·7·78
Completed 13·7·78
Logged by D. Purcell
Vertical scale 1:100

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

Water
10 Oct 73 water level date shown
Water inflow
Partial drilling water loss
Complete drilling water loss

Notes
Bedding & Joint Planes - Angles are measured relative to a plane normal to the core axis
* Water Pressure Tests

Core Photography Negative No		
Depth (m)	B & W	Colour
2·10 - 6·7	M23241	
6·7 - 11·55		
11·55 - 15·4		
15·4 - 18·0		

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

PROJECT Gould St - Commonwealth Ave Sewer Tunnel
LOCATION Car Park along Marcus Clark Street opposite Tasman House, Hobart Place Canberra 260
ANGLE FROM HORIZONTAL (θ) 90° DIRECTION
CO-ORDINATES 604 096N 310 458E R L OF 568·92 m

HOLE No. 8A
SHEET 1 OF 1

GEOLOGICAL LOG OF DRILL HOLE

Drilling information

Depth (m)	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) (10 / 30 / 100 / 300)	RQD	Defect description (thickness, type, inclination, planarity, roughness, coating strength)	Rock condition No (interpretive)
0								
1								
2		No Core						
3		Yellow-brown CLAY	EW				PP 0·5-2·5 kg/cm²	
		Quartz vein					Fragmented rock	
4			HW					5
5		Pale yellow-brown to red-brown MUDSTONE	MW			0	Totally fragmented	
6							Closely jointed, fragmented in places, some manganese staining on joint surfaces.	
7		No Core						
8		Pale yellow-brown MUDSTONE	MW			40	Closely jointed. Joints mostly moderately dipping and manganese stained.	3-4
9				×				
10		Pale green-grey MUDSTONE	SW			80	Moderately jointed; some breaks drill induced. No coatings on some joints, staining on others.	2-3
11						75		
12				×		56		
13		Pale yellow-brown MUDSTONE	HW			0	Closely jointed to fragmented	4
		Clay 3·5 kg/cm² PP					Fragmented rock	
14		Pale green-brown MUDSTONE	MW	×		25	Closely jointed with iron staining on joints.	
15		Pale green-grey MUDSTONE	SW			60		3
16		Pale grey MUDSTONE	FS	×		10	Closely jointed; iron stained, moderately to steeply dipping joints	
17		Pale blue-grey MUDSTONE (City Hill Shale)	Fr	×		50		
						75	Few joints, breaks are drill induced.	2
18		End of hole R.L.= 550·87						

Drilling information

Method	Drilling rate	Casing	Water	Pressure test *	Lift & % core recovery
Auger					
Diamond Core			3·8·78		30
					90
			28·8·78		
					60
					100
			13·9·78		
			8·1·79		100
					100
					100
	TUNNEL				90
					100
					100

Drill type Pioneer
Feed Hydraulic
Core barrel type Triefus NMLC
Driller V. O'Brian
Commenced 4:7:78
Completed 5:7:78
Logged by P. Vandenbroek
Vertical scale 1:100

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

Water
10 Oct 73 water level date shown
Water Inflow
Partial drilling water loss
Complete drilling water loss

Notes
Bedding & Joint Planes - Angles are measured relative to a plane normal to the core axis
* Water Pressure Tests

Core Photography Negative No

Depth (m)	B & W	Colour
1·65 - 6·6	73234	
6·6 - 10·5		
11·5 - 16·4		
16·4 - 18·05		

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT Gould St-Commonwealth Ave Sewer Tunnel
LOCATION Car park opposite Canberra House and western side of Marcus Clark Street Canberra 261
ANGLE FROM HORIZONTAL (θ) 90° DIRECTION
CO-ORDINATES 604 165 N 210 515 E R.L. OF 567.75 m

HOLE No. 9
SHEET 1 OF 1

Drilling information								Rock Substance			Rock Mass Defects			
Method	Drilling rate	Casing	Water	Pressure test *	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description: rock type, grain characteristics, colour, structure, minor components	Weathering	Point load 0.3 1.0 3.0 10.0 Is(50) MPa	Defect spacing (cm) 3 10 30 100	R.Q.D.	Defect description: thickness, type, inclination, planarity, roughness, coating strength	Rock condition No (interpretive)
Auger						0								
						1		No core						
						2								
					100	3		Pale yellow-brown MUDSTONE with black manganese staining on joint surfaces	EW-HW				Rock mostly closely jointed to fragmented. Some clay seams.	
					90	4		Pale yellow-brown MUDSTONE	MW	X		10	Closely to moderately jointed. Clay seams at 4.25-4.28, 4.38 and 4.47m	4
						5						25		
					100	6		Fragmented mudstone Clay PP 1 to 2 kg/cm²	EW-MW				Clay seam 40cm wide	5
						7		Fragmented mudstone Clay PP 0.5 kg/cm²				0	Clay seam 15cm wide	
Diamond core			13.9.78			8		Pale yellow-brown MUDSTONE	MW				Closely jointed with fragmented sections.	
			3.8.78 28.8.78		100	9						50		
						10		Pale grey-brown MUDSTONE	SW	X		65	Closely jointed with limonite staining on joints.	3-4
					100	11		Clay PP 0.4 kg/cm² Fragmented mudstone				0	Clay seam 5cm wide - Fragmented.	
						12						30		
	TUNNEL				100	13		Pale blue-grey MUDSTONE (City Hill Shale) with some staining on joint surfaces	FS	X		70	Joints moderately dipping and moderately to closely spaced.	2-3
					100	14						100		
						15		End of hole RL = 552.75 m						

Drill type Pioneer
Feed Hydraulic
Core barrel type Triefus NMLC
Driller V. O'Brien
Commenced 10.7.78
Completed 11.7.78
Logged by P. VanderBroek
Vertical scale 1:100

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

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

Notes
Bedding & Joint Planes - Angles are measured relative to a plane normal to the core axis
* Water Pressure Tests

Core Photography Negative No		
Depth (m)	B & W	Colour
2.0 - 7.0	102326	
7.0 - 12.0		
12 - 15.0		

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT Gould St - Commonwealth Ave Sewer Tunnel
LOCATION near All night chemist, and ex-health centre, Marcus Clack Street
ANGLE FROM HORIZONTAL (θ) 90° DIRECTION
CO-ORDINATES 604330N 210535E R L OF 564.97m

HOLE No. 9A
Canberra 262
SHEET 1 OF 1

Drilling information | Rock Substance | Rock Mass Defects

Method	Drilling rate	Casing	Water	Pressure test *	Lift & % core recovery	Depth (metres)	Graphic log & Core loss	Substance description: rock type, grain characteristics, colour, structure, minor components	Weathering	Point load 0·3 / 1·0 / 3·0 / 10·0 Is(50) MPa	Defect spacing (cm) 3 10 30 100 300	R Q D	Defect description: thickness, type, inclination, planarity, roughness, coating strength	Rock condition No (interpretive)
Auger						0								
						1		No core						
					100	2		Yellow-brown CLAY PP 0·1-0·2 kg/cm²	EW				Fragmented rock with some clay seams.	4
						3		Yellow brown MUDSTONE with some clay PP 0·5 kg/cm²						
			▼	13·9·78	100	4		Red-brown MUDSTONE with some manganese staining on joints.	MW	X		15	Closely fractured, some drilling induced breaks. Joint moderately dipping.	3-4
			▼	3·8·78 to 28·8·78	66	5								
						6		No core						
Diamond core					100	7		Yellow brown MUDSTONE	MW	X		0	Closely jointed to fragmented, general absence of clay on joints.	4
					100	8								
						9						10		
	TUNNEL				100	10		Pale yellow MUDSTONE	MW	X		0	Mostly closely jointed with zone of crushed fragmented rock	3-4
					100	11						25		
						12						10		4
					100	13		Fragmented rock Pale grey MUDSTONE	SW	XX		50	Closely jointed; general absence of coatings on surfaces. Joints moderately to steeply dipping, possibly parallel to bedding.	3
					100	14		Blue-grey MUDSTONE (City Hill Shale)	FS	X		40		
						15		End of Hole RL = 549·97						

Drill type Pioneer
Feed Hydraulic
Core barrel type Triefus NMLC
Driller V.O'Brian
Commenced 5·7·78
Completed 6·7·78
Logged by P.VandenBroek
Vertical scale 1:100

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

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

Notes
Bedding & Joint Planes - Angles are measured relative to a plane normal to the core axis
* Water Pressure Tests

Core Photography Negative No		
Depth (m)	B & W	Colour
2·0 - 7·0	M23241	
7·0 - 11·8		
11·8 - 15·0		

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

PROJECT Gould St - Commonwealth Ave Sewer Tunnel
LOCATION Corner of Marcus Clark and Barry Drive
ANGLE FROM HORIZONTAL (θ) 90° DIRECTION
CO-ORDINATES 604 464 N 210 552 E R L OF 565·86m

HOLE No. 10
Canberra 263
SHEET 1 OF 1

GEOLOGICAL LOG OF DRILL HOLE

Drilling information

Depth (m)	Substance description (rock type, grain characteristics, colour, structure, minor components)	Weathering	Defect spacing (cm)	R Q D	Defect description (thickness, type, inclination, planarity, roughness, coating strength)	Rock condition No (interpretive)
0						
1	No core					
2	Yellow-brown CLAY PP 0.1-1.5 kg/cm²	EW-HW			HW sections fragmented.	
2	Pale grey-brown MUDSTONE				Clay seams common and rock is very closely fractured to fragmented.	4-5
3				60		
4	Pale grey-brown MUDSTONE	MW		35	Possible shears. Mostly closely jointed, with clay coatings on moderately to shallow dipping joint surfaces	3-4
5				60		
6				70		2-3
7				10	Possible shears. Very closely fractured	
8				0	Fragmented. Shear	
9				30	Closely jointed & clay coated. Fragmented.	
10	Grey MUDSTONE (City Hill Shale)	SW		25	Mostly very closely jointed with clay on most joint surfaces.	3-4
11				0		
12				20		
13	Blue grey MUDSTONE	Fr		35	Mostly closely jointed with iron staining on most joint surface.	3
14				30		
15	Core not recovered			50		
	End of hole RL = 550·81					

Method: Auger; Diamond core
Drilling rate: TUNNEL
Water: 15·9·78; 3·8·78; 11·8·78 to 28·8·78
Pressure test *
Lift & % core recovery: 100; 100; 100; 100; 100; 75; 100; 100; 100; 100; 50
Graphic log & core loss
Point load strength Is(50) MPa: 0.3; 1.0; 3.0; 10.0
Defect spacing (cm): 3; 10; 30; 100; 300

Drill type Pioneer
Feed Hydraulic
Core barrel type Triefus NMLC
Driller V. O'Brian
Commenced 28.7.78
Completed 28.7.78
Logged by P. VandenBroek
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

Core Photography Negative No

Depth (m)	B & W	Colour
1·6 - 5·85	202324	
5·85 - 10·8		
10·8 - 15·05		

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

PROJECT Gould St - Commonwealth Ave Sewer Tunnel
LOCATION in park, north of Barry Drive, Turner

HOLE No. 11
Canberra 264

SHEET 1 OF 1

GEOLOGICAL LOG OF DRILL HOLE

ANGLE FROM HORIZONTAL (θ) 90° DIRECTION
CO-ORDINATES 604 563N 210 436E R.L. OF 563.07 m

Drilling information							Rock Substance			Rock Mass Defects			
Method	Drilling rate	Casing	Water	Pressure test *	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description: rock type, grain characteristics, colour, structure, minor components	Weathering	0.3 Point load 1.0 strength 3.0 10.0 Is(50) MPa	Defect spacing (cm) 3 10 30 100 300	R Q D	Defect description: thickness, type, inclination, planarity, roughness, coating strength	Rock condition No (interpretive)
Auger						0								
						1		Not cored						
					90	2		Yellow-brown MUDSTONE	MW			10	Core loss Clay seam PP 0.1 kg/cm²	
					100	3				x			Clay seam. Rock fragmented Clay seam. between seams.	4-5
				14·8·78				Grey-green MUDSTONE	SW			40	Fragmented	
				28·8·78	100	4								
								Blue-grey calcareous MUDSTONE	Fr	x		50	Shear 10cm wide	
Diamond Core						5								
					100			Grey-green calcareous MUDSTONE (City Hill Shale)	SW			40	Closely jointed to fragmented rock	3-4
	Drop Structure				100	6						20	Very closely fragmented Fragmented	
					100	7						35	Shear 2cm wide	
					100	8				x		45	Closely to very closely jointed rock with iron staining on joint surfaces.	3
					100	9		Grey calcareous MUDSTONE	FS					
						10								
					100	11		Blue-grey calcareous MUDSTONE	Fr	xx		80	Moderately to closely jointed rock with some iron staining on joint surfaces.	
					100	12						40		
								End of hole RL = 551·07						

Drill type Pioneer
Feed Hydraulic
Core barrel type Triefus NMLC
Driller V. O'Brian
Commenced 18·8·78
Completed 21·8·78
Logged by P. VandenBroek
Vertical scale 1:100

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

Water
10 Oct 73 water level date shown
Water inflow
Partial drilling water loss
Complete drilling water loss

Notes
Bedding & Joint Planes - Angles are measured relative to a plane normal to the core axis
* Water Pressure Tests

Core Photography Negative No		
Depth (m)	B & W	Colour
1.40-6.0	M23241	
6.0-10.0		
10.0-12.0		

Record 1978/99

I 55/ A16/2246

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

PROJECT Gould St–Commonwealth Ave Sewer Tunnel
LOCATION near Sullivan's Creek, Turner
ANGLE FROM HORIZONTAL (θ) 90° DIRECTION
CO-ORDINATES 604 633N 210 437E R L OF 561.92m

HOLE No. 12
Canberra 265
SHEET 1 OF 1

GEOLOGICAL LOG OF DRILL HOLE

Drilling information | Rock Substance | Rock Mass Defects

Method	Drilling rate	Casing	Water	Pressure test *	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description: rock type, grain characteristics, colour, structure, minor components	Weathering	Point load 0.3 1.0 3.0 10.0 Is(50) MPa	Defect spacing (cm) 3 10 30 100 300	RQD	Defect description: thickness, type, inclination, planarity, roughness, coating, strength	Rock condition No (interpretive)
Auger						0								
						1								
			14.9.78			2		Not cored						
			28.8.78		60			Topsoil (Driller's report)					Core loss	
Diamond Core						3		Grey calcareous MUDSTONE (City Hill Shale)		x		20	Closely to moderately jointed rock with manganese staining on joint surfaces.	
	PIPE				100							55		
						4			SW				Fragmented	
					100							40		3-4
						5								
												50	Fragmented	
	Tunnel				100	6		Blue-grey calcareous MUDSTONE		x		80	Mostly moderately jointed with uncoated joint surfaces.	
						7			Fr				Clay seam	
					80							85		3
						8		End of hole RL = 553.92					Core loss	

Drill type Pioneer
Feed Hydraulic
Core barrel type Triefus – NMLC
Driller V.O'Brian
Commenced 21.8.78
Completed 21.8.78
Logged by P.VandenBoek
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

Core Photography Negative No		
Depth (m)	B & W	Colour
2.1-6.9	M23241	
6.9-8.0		

Record 1978/99

155/A16/2247

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

PROJECT Gould St-Commonwealth Ave Sewer Tunnel
LOCATION along side of Sullivan's Creek, Turner

HOLE No. 13
Canberra 266

GEOLOGICAL LOG OF DRILL HOLE

ANGLE FROM HORIZONTAL (θ) 90° DIRECTION
CO-ORDINATES 604 705 N 210 438 E R L OF 562·74 m

SHEET 1 OF 1

Drilling information							Rock Substance				Rock Mass Defects			
Method	Drilling rate	Casing	Water	Pressure test *	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	R Q D	Defect description: thickness, type, inclination, planarity, roughness, coating strength	Rock condition No (interpreted)
Auger						0								
						1		Not cored						
					100	2		Dark grey organic SILT	OL					
								Green-grey MUDSTONE	SW			0	Closely fractured	
			14·9·78			3		core loss						4
Diamond core			29·8·78		50				SW	×		0		
	PIPE					4		Pale grey MUDSTONE				55	Closely jointed with iron staining on moderately to steeply dipping joint surfaces.	3
					100	5		(City Hill Shale)		× ×		60		
					100	6			FS					3-4
	Tunnel				100							20		
					100	7						80	Moderately jointed with uncoated, unstained joint surfaces.	2-3
								Blue-grey MUDSTONE	Fr	×				
						8		End of hole RL = 554·74						

Drill type Pioneer
Feed Hydraulic
Core barrel type Triefus NMLC
Driller V.O'Brian
Commenced 22·8·78
Completed 22·8·78
Logged by P.VandenBroek
Vertical scale 1:100

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

Notes
Bedding & Joint Planes - Angles are measured relative to a plane normal to the core axis
* Water Pressure Tests

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

Core Photography Negative No

Depth (m)	B & W	Colour
2·0 - 6·75	M23 24	
6·75 - 8·0		

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT Gould St - Commonwealth Ave Sewer Tunnel
LOCATION most northern hole along Sullivans Creek, opposite Turner.
ANGLE FROM HORIZONTAL (θ) 90° DIRECTION
CO-ORDINATES 604 780N 210 439E R.L. OF 562.52 m

HOLE No. 14
Canberra 267
SHEET 1 OF 1

Drilling information							Rock Substance			Rock Mass Defects			
Method	Drilling rate	Casing	Water	Pressure test *	Lift & % core recovery	Depth (metres)	Graphic log & core loss	Substance description: rock type, grain characteristics, colour, structure, minor components	Weathering	0.3 Point load 1.0 strength 3.0 Is(50) MPa 10.0	Defect spacing (cm) 3 10 30 100 300	R.Q.D.	Defect description: thickness, type, inclination, planarity, roughness, coating strength	Rock condition No. (interpretive)
Auger			14·9·78 28·8·78			0								
						1		Not cored						
						2		Dark grey organic SILT	OL					
Diamond Core	PIPE				100	3		Pale green-grey, fresh stained, calcareous MUDSTONE				45	Hard, closely to moderately jointed rock. Iron or manganese staining on most joint surfaces.	3
					100	4		(City Hill Shale)	FS			70		
					100	5						40		
	Tunnel				100	6						45		
					100	7						35		
						8		Clay				85	seam 3cm wide PP 0.0-0.1 kg/cm²	
								End of hole R.L. = 554.52						

Drill type Pioneer
Feed Hydraulic
Core barrel type Triefus NMLC
Driller V.Q'Brien
Commenced 23·8·78
Completed 23·8·78
Logged by P.VandenBrock
Vertical scale 1:100

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

Water
10 Oct 73 water level date shown
Water inflow
Partial drilling water loss
Complete drilling water loss

Notes
Bedding & Joint Planes - Angles are measured relative to a plane normal to the core axis
* Water Pressure Tests

Core Photography Negative No		
Depth (m)	B & W	Colour
2·0 - 6·72	M23241	
6·72 - 8·0		

Record 1978/99

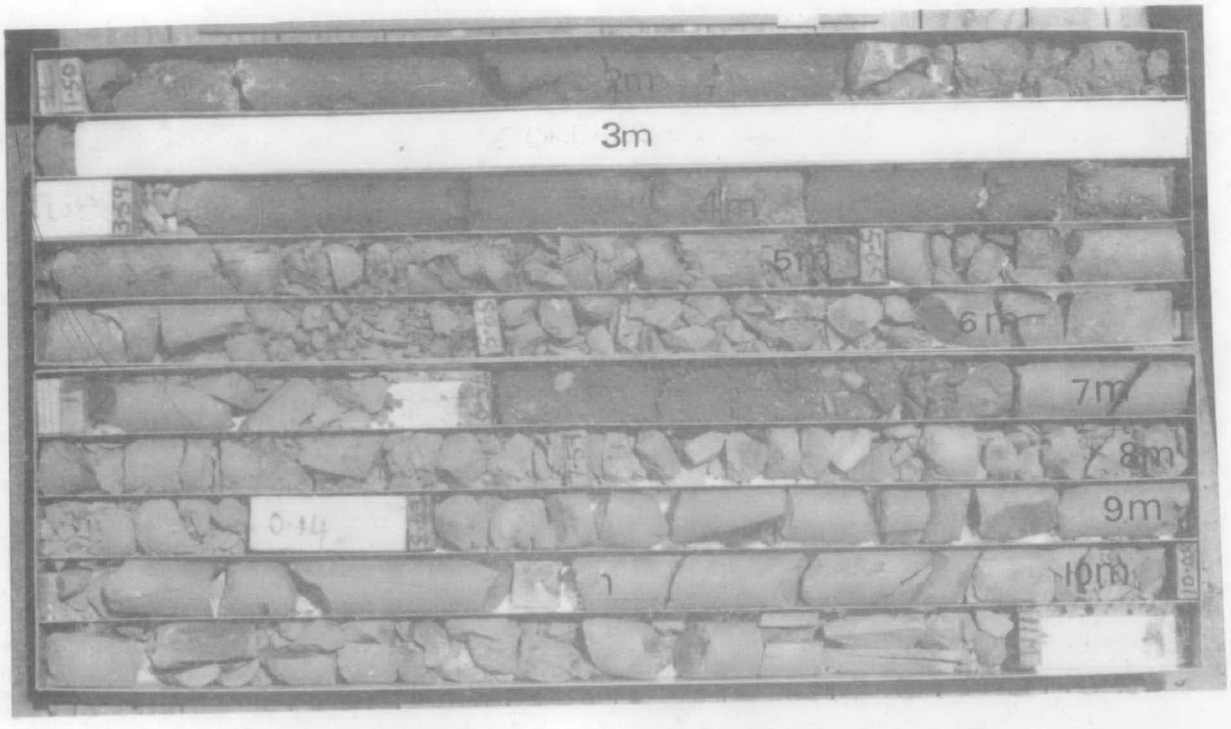
I55/A16/2249

APPENDIX 3

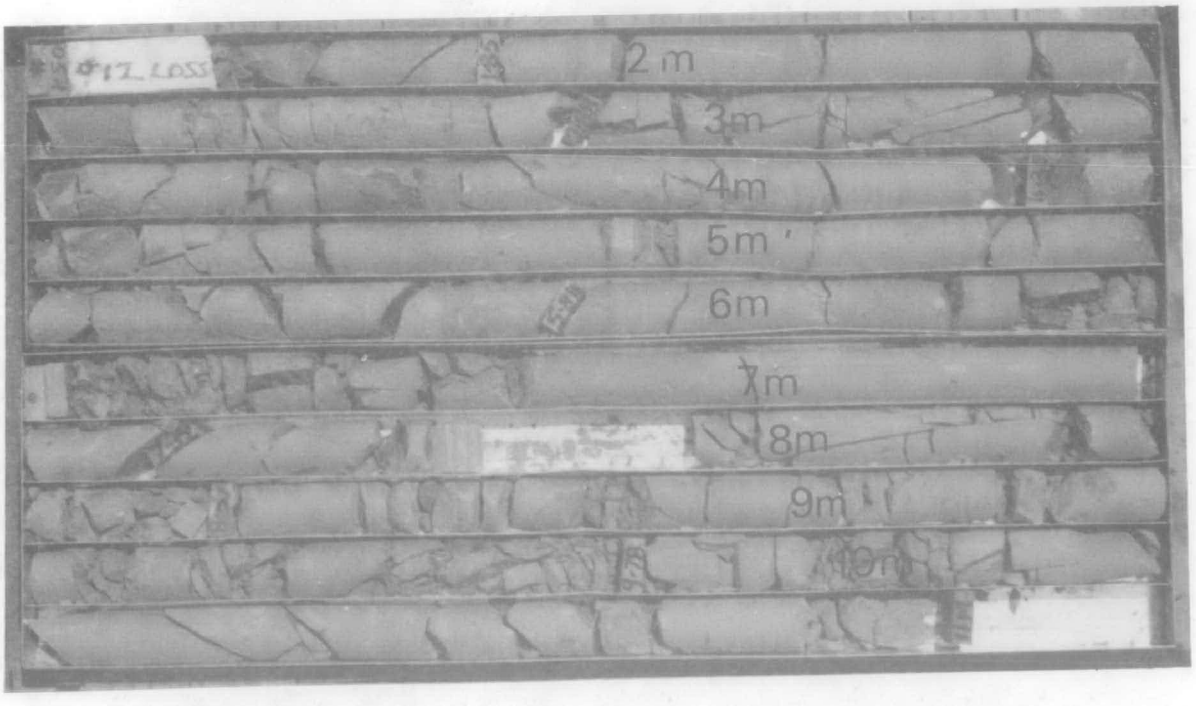
DRILLCORE PHOTOGRAPHS

SULLIVANS CREEK SEWER TUNNEL

HOLE 1



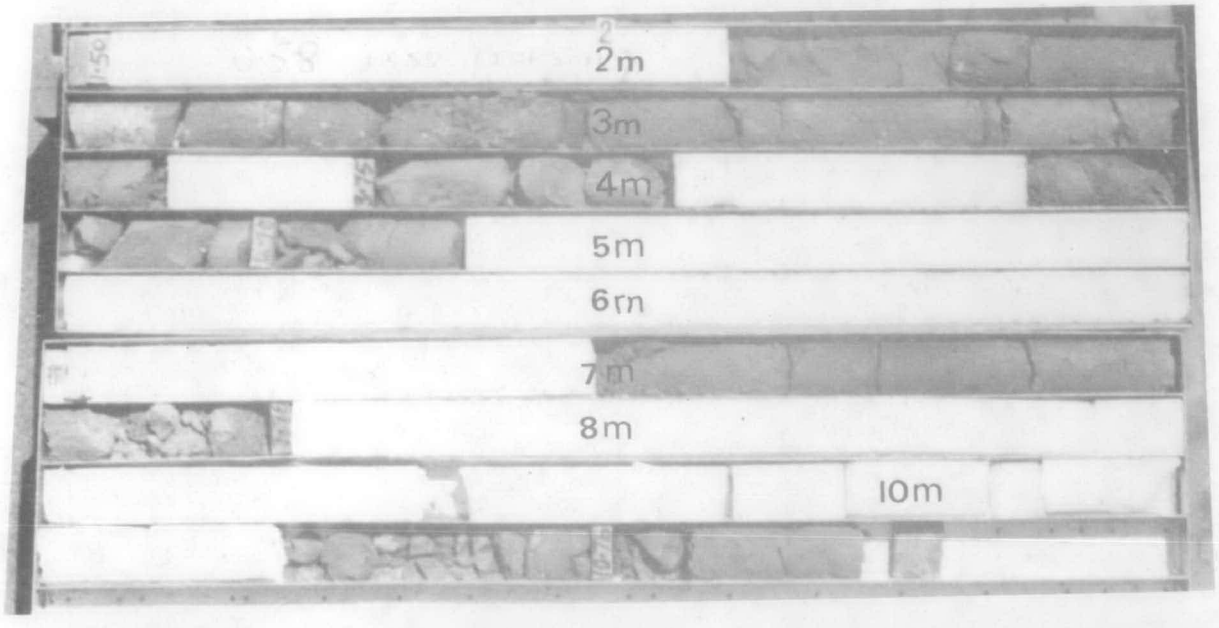
HOLE 1A



SULLIVANS CREEK SEWER TUNNEL

HOLE IC

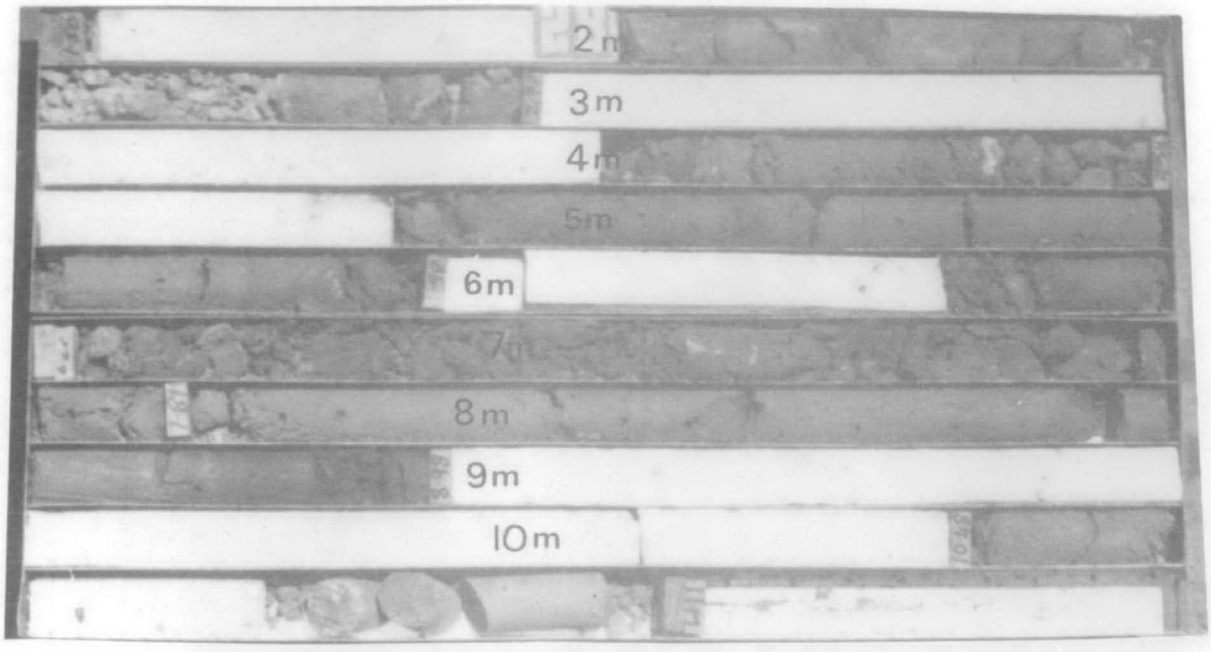
HOLE 2



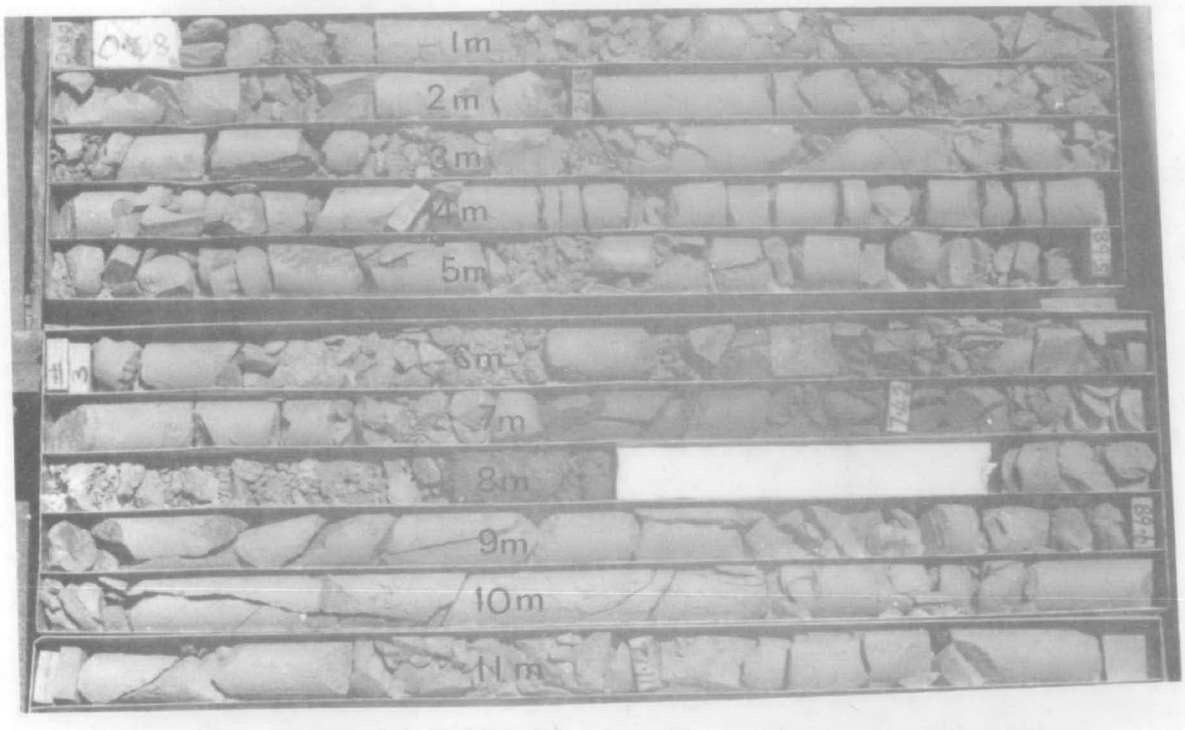
HOLE 2A

SULLIVANS CREEK SEWER TUNNEL

HOLE 2B



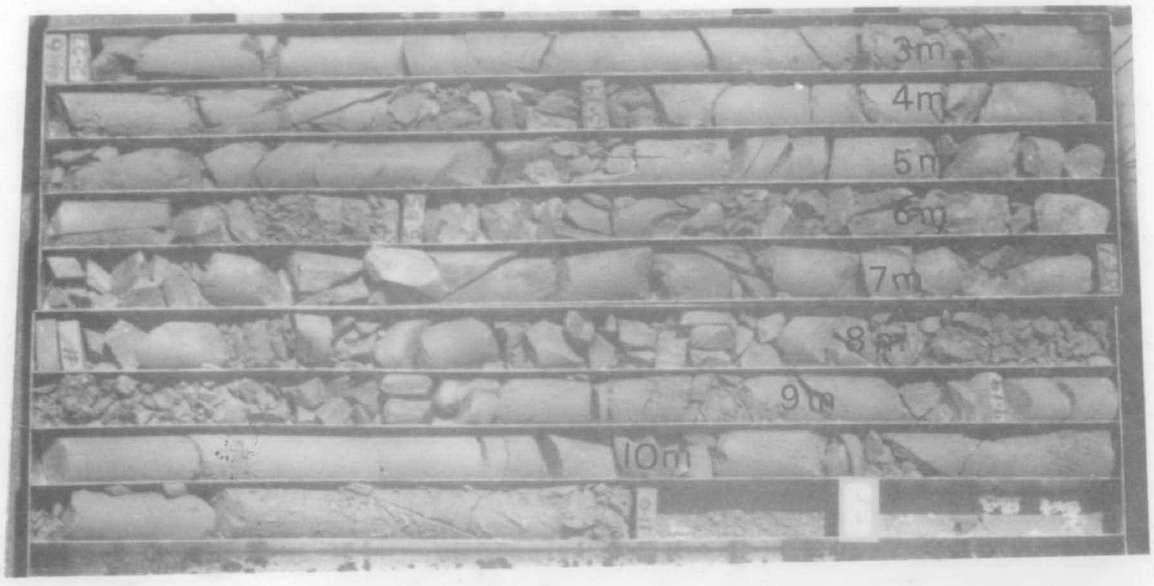
HOLE 3



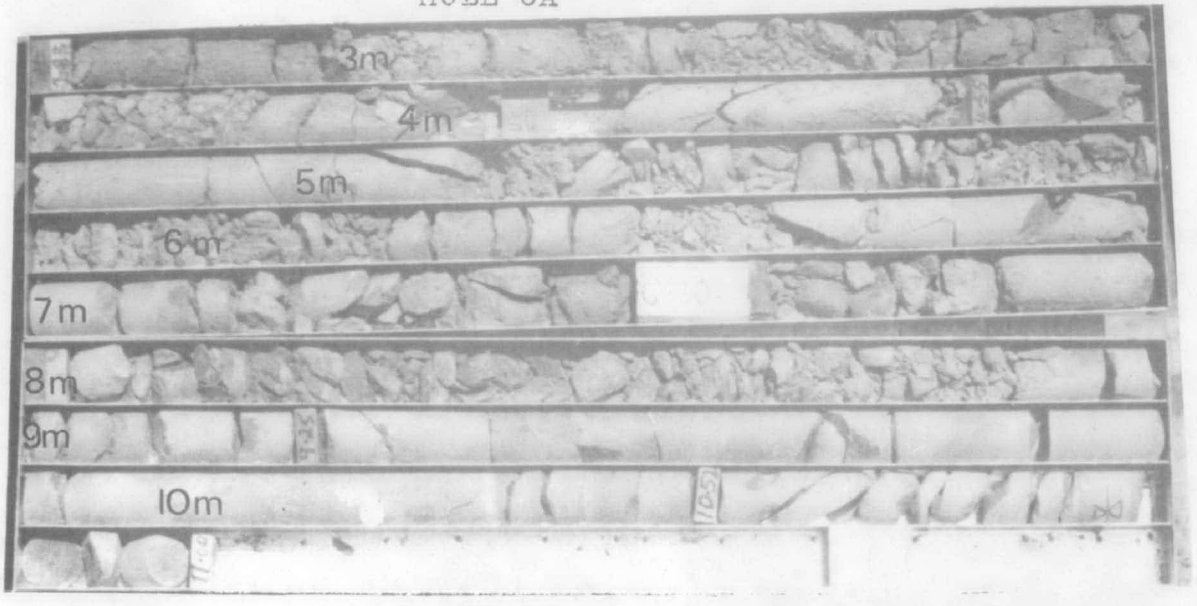
HOLE 4

SULLIVANS CREEK SEWER TUNNEL

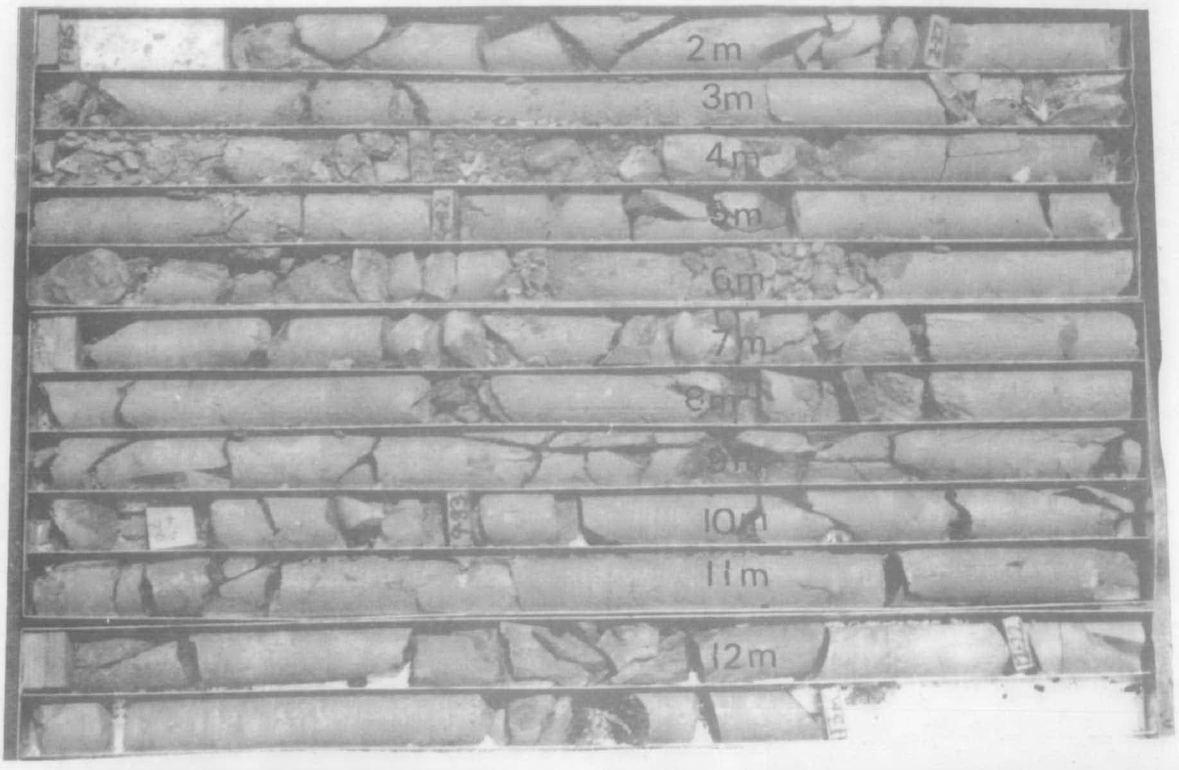
HOLE 6



HOLE 6A

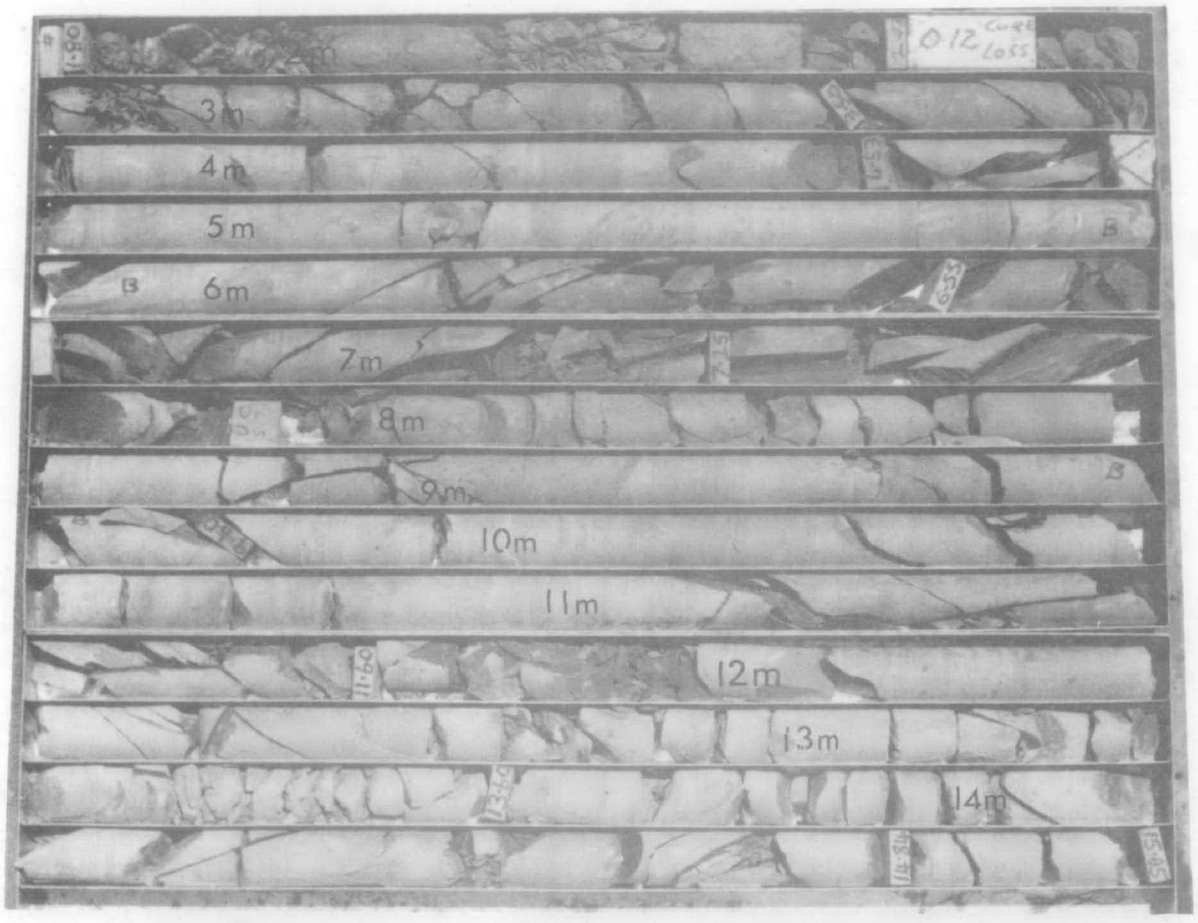


HOLE 7

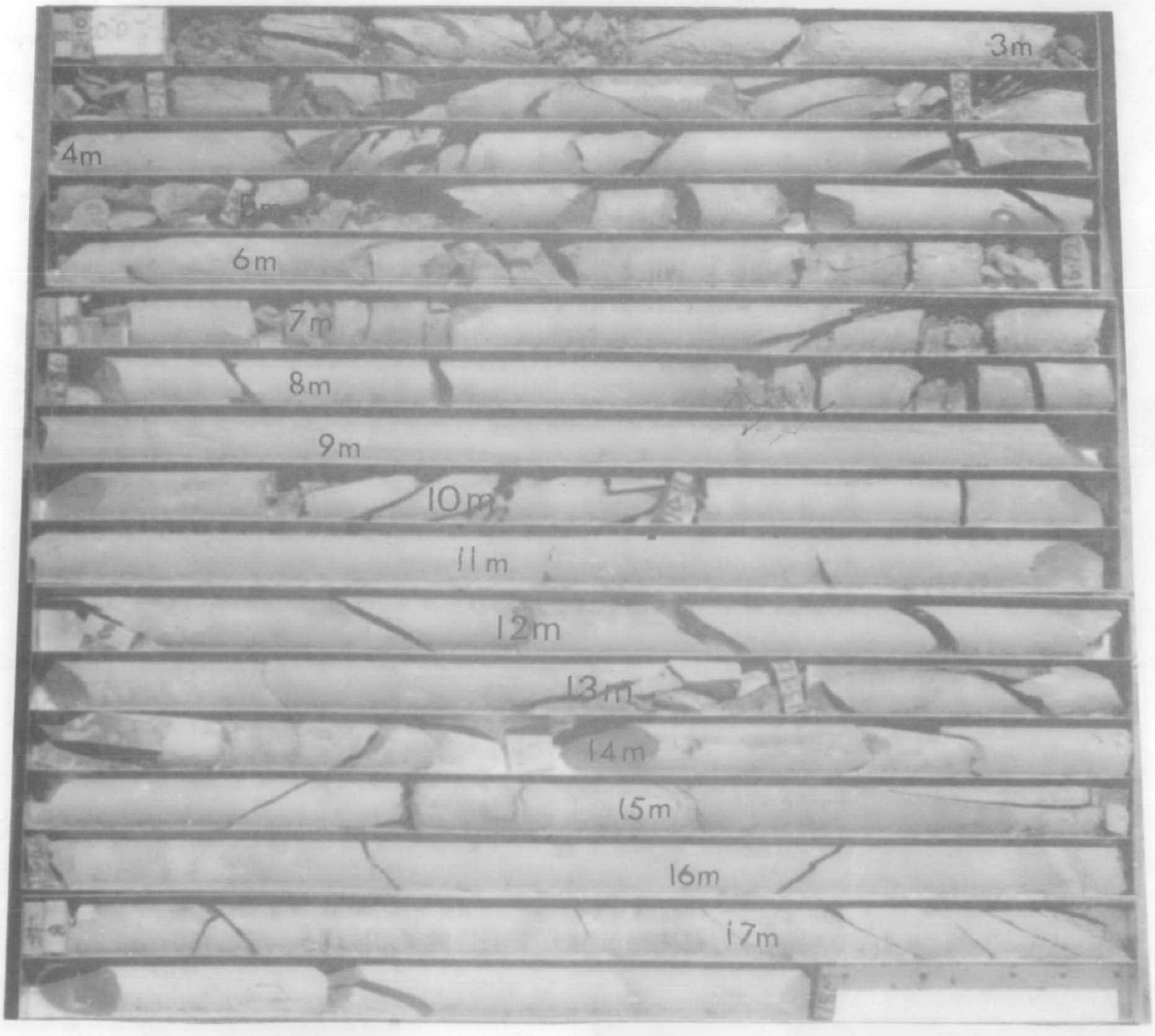


SULLIVANS CREEK SEWER TUNNEL

HOLE 7A

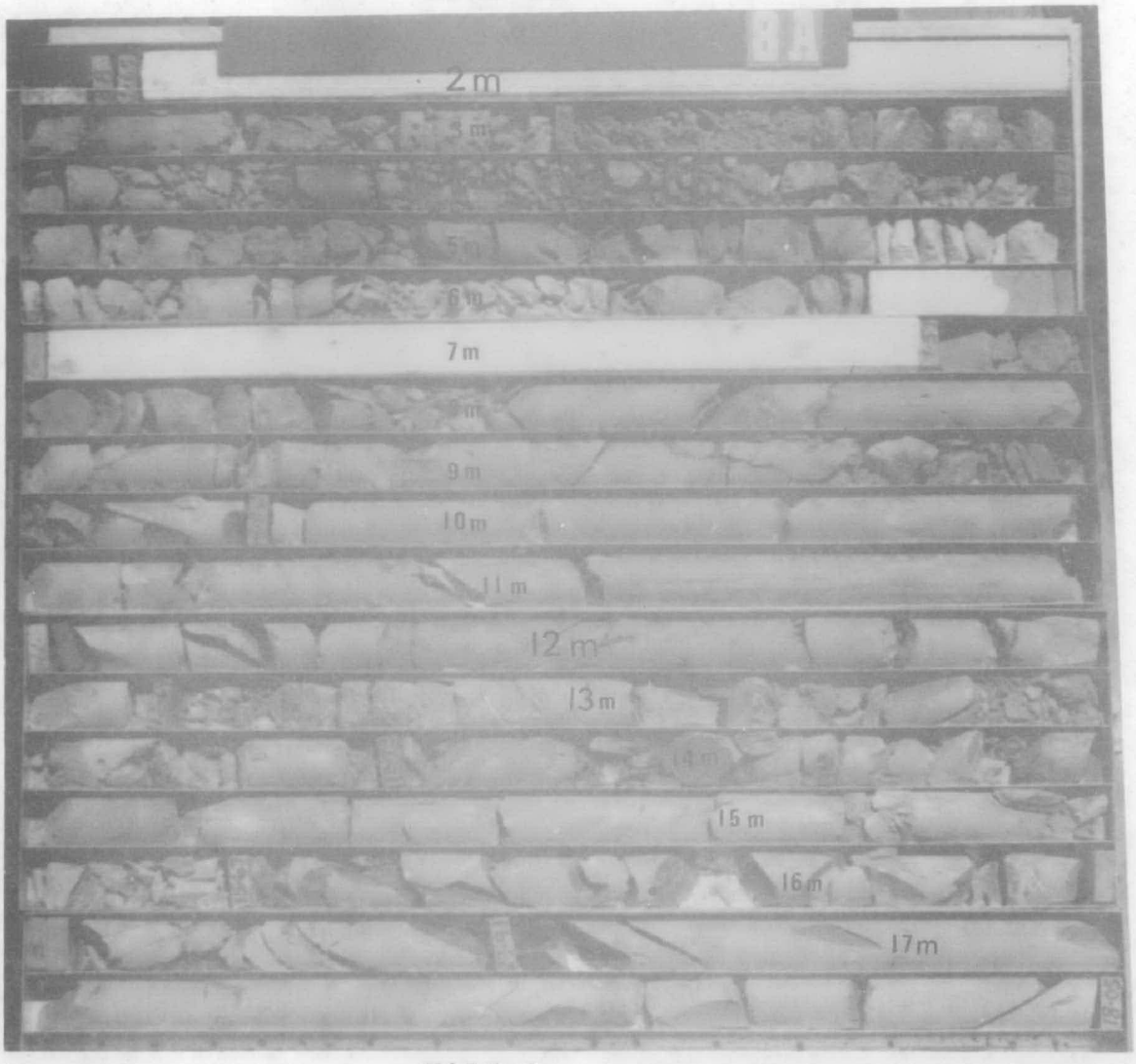


HOLE 8



SULLIVANS CREEK SEWER TUNNEL

HOLE 8A

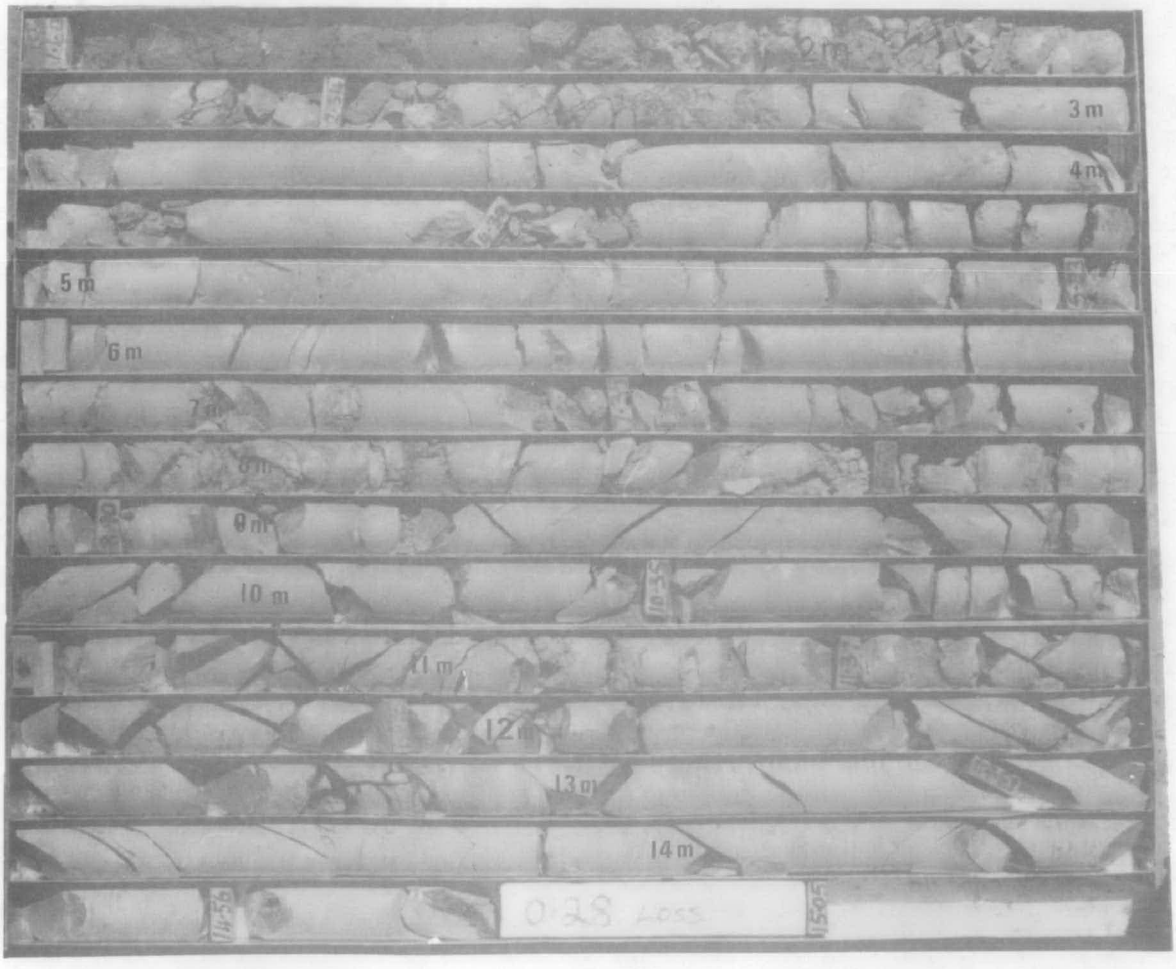


HOLE 9

SULLIVANS CREEK SEWER TUNNEL

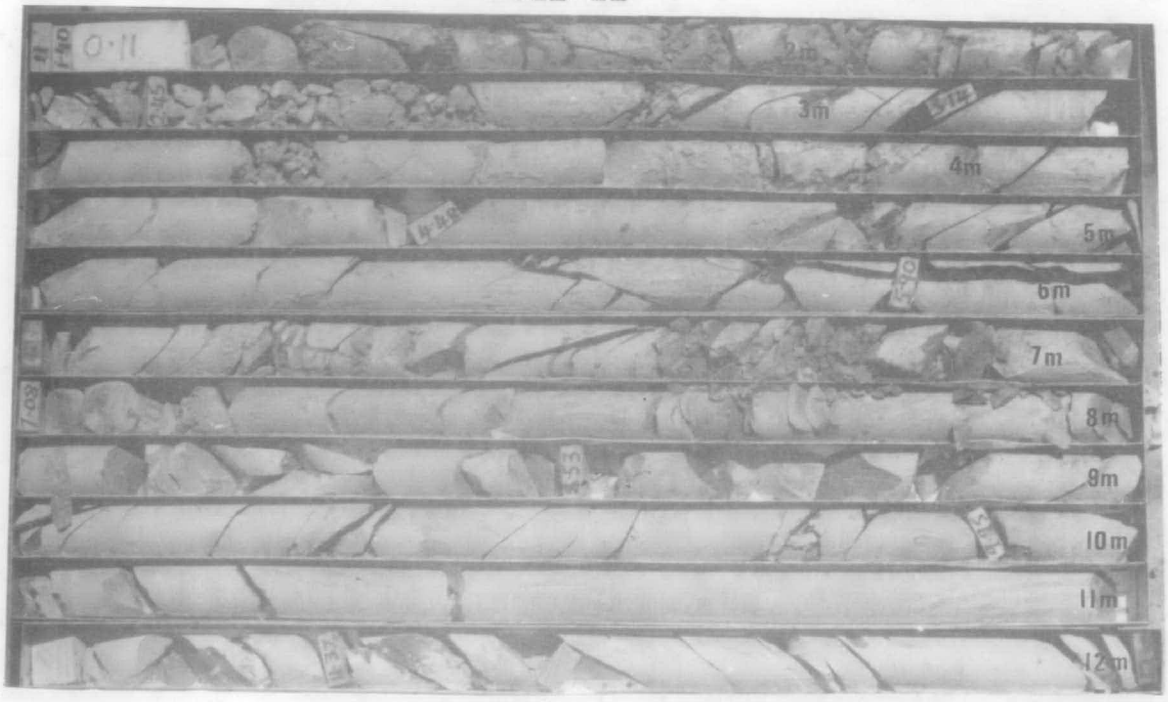
HOLE 9A

HOLE 10



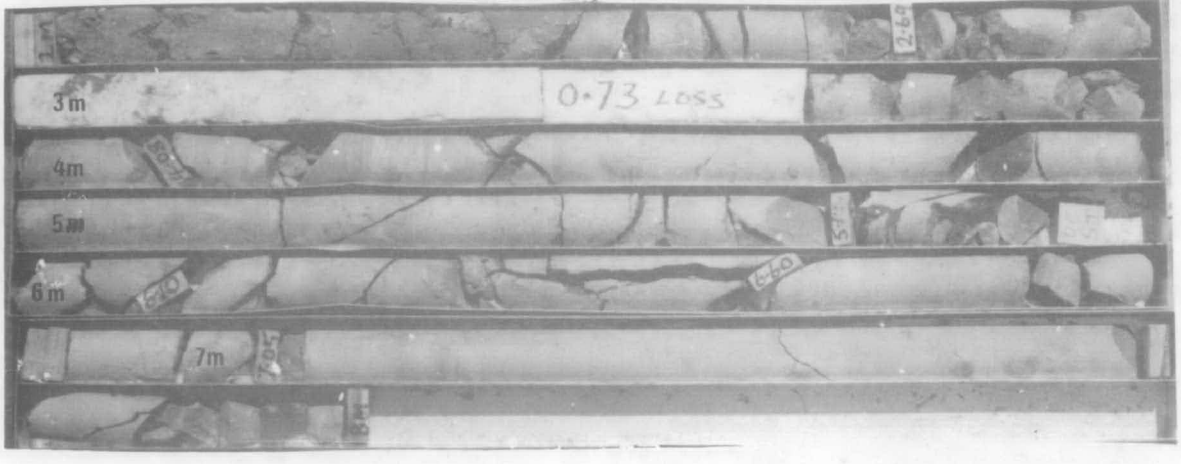
SULLIVANS CREEK SEWER TUNNEL

HOLE 11



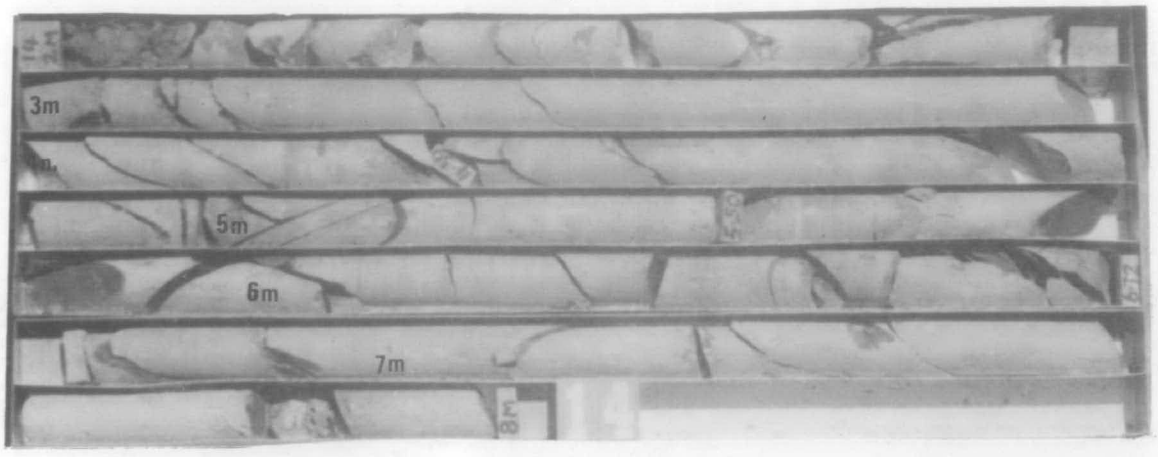
HOLE 12

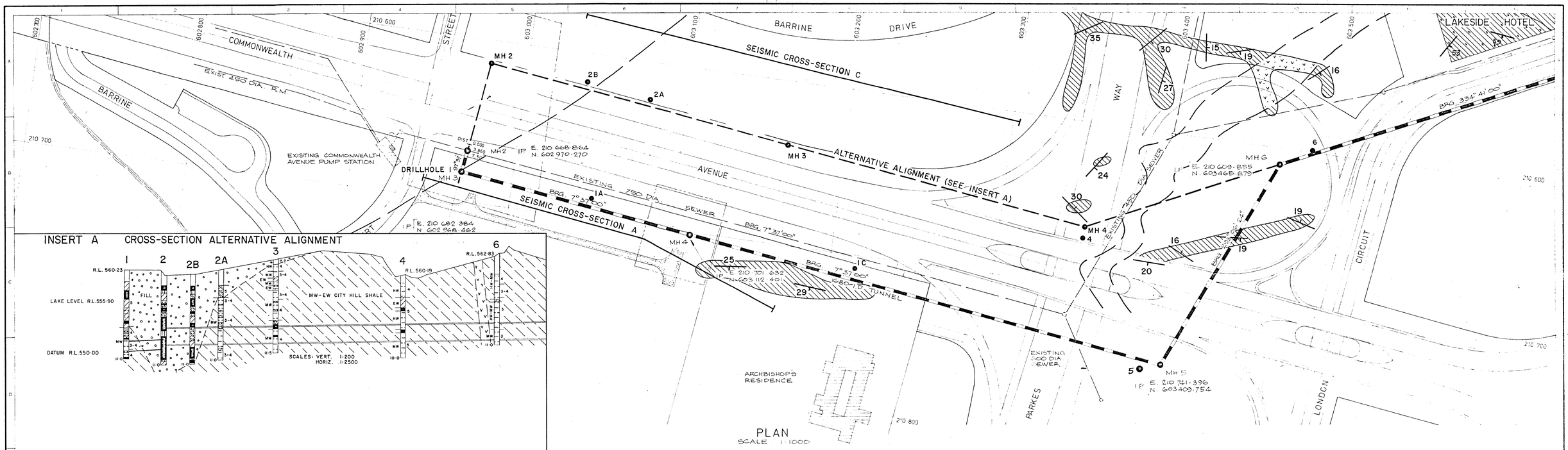
HOLE 13



SULLIVANS CREEK SEWER TUNNEL

HOLE 14



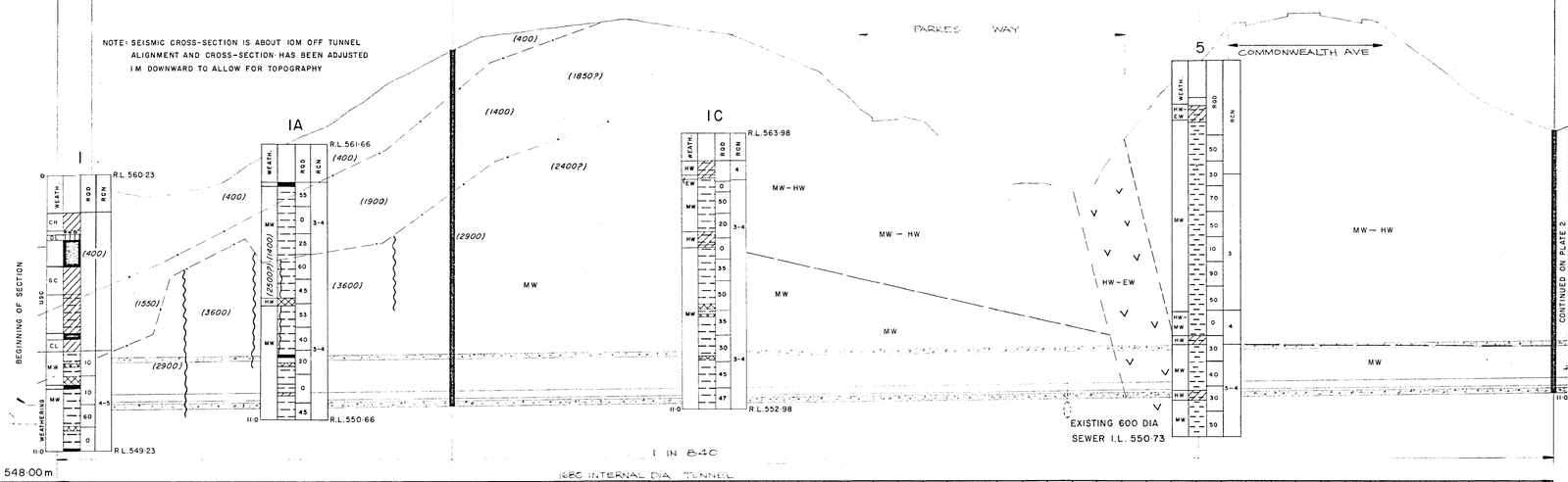


INSERT A CROSS-SECTION ALTERNATIVE ALIGNMENT

PLAN
SCALE 1:1000

MANHOLE No.	MH 2	MH 3		MH 4	MH 5	MH 6
INVERT LEVEL	551·316	551·320 551·346		551·493 551·518	551·850 551·876	552·019 552·044
EXISTING SURFACE LEVEL	560·59	560·0		562·50	564·90	562·10

NOTE: SEISMIC CROSS-SECTION IS ABOUT 10M OFF TUNNEL ALIGNMENT AND CROSS-SECTION HAS BEEN ADJUSTED 1M DOWNWARD TO ALLOW FOR TOPOGRAPHY



GRADE OF INVERT
DATUM LEVEL 548·00m

TUNNEL CHAINAGE (m)		1400 2400 3400 4400 5400 6400	
ROCK TYPE, HARDNESS AND STRENGTH AT T.L.		PALE YELLOW-BROWN TO REDDISH BROWN, MODERATELY WEATHERED MUDSTONE, SOFT AND WEAK ($I_{S(50)}$ 0·5 – 1·5 Mpa) SEISMIC VELOCITY VARIATIONS INDICATE CONSIDERABLE VARIATION IN ROCK COMPETENCE. FILL EXPECTED 1m ABOVE CROWN FROM CH 0+00 TO 0+40	PALE YELLOW-BROWN – REDDISH-BROWN, MODERATELY TO HIGHLY WEATHERED, FINE GRAINED SANDSTONES AND MUDSTONES WITH A THIN (POSSIBLY 25m) BED OF EXTREMELY WEATHERED, COARSE GRAINED VOLCANIC TUFF. ALL ROCKS EXPECTED TO BE SOFT AND WEAK.
ROCK MASS DEFECTS		THINLY BEDDED DIP/DIP DIR. ≈30/060 IN SOUTHERN PART OF SECTION SWINGING AROUND TO 20/080 IN NORTHERN PART, ORIENTATION FAIR – FAVOURABLE. OTHER DEFECTS ARE EXPECTED TO BE MOSTLY CLOSE TO VERY CLOSELY SPACED, UNALTERED, SMOOTH JOINTS; MODERATELY WIDELY SPACED SHEAR ZONES OF FRAGMENTED ROCK AND WIDELY SPACED CLAY SEAMS. ORIENTATIONS ARE EXPECTED TO RANGE FROM FAVOURABLE TO UNFAVOURABLE.	ROCKS GENERALLY EXPECTED TO BE THINLY BEDDED WITH DIP/DIP DIR. ≈25/060, HOWEVER LOCALLY THE DIP IS VARIABLE FROM NE TO W AND THIS IS THOUGHT TO BE DUE TO SMALL SCALE FOLDING. ROCK MASS IS EXPECTED TO BE VERY CLOSELY JOINTED TO FRAGMENTED ALONG SOME OF THIS SECTION. JOINTS ARE LIKELY TO BE UNALTERED, STAINED WITH MANGANESE OXIDES, AND FAIRLY SMOOTH. DEFECT ORIENTATION IS LIKELY TO VARY FROM FAIR TO VERY UNFAVOURABLE.
PREDICTED TUNNELLING CONDITIONS	ROCK MASS QUALITY (Q)	VERY POOR (0·4 – 0·6)	POOR – VERY POOR (0·6 – 1·0) VERY POOR (0·2 – 0·4)
	STAND-UP TIME	LESS THAN 1 HOUR CALC. FROM DRILL HOLE 1	ABOUT 10 HOURS CALCULATED FROM DRILL HOLES 1A AND 1C 8 HOURS CALCULATED FROM DRILL HOLE 5
	OVERBREAK	VARIABLE DEPENDING ON SPEED OF SUPPORT INSTALL.	DEPENDENT ON EXCAVATION METHODS AND SPEED OF SUPPORT INSTALLATION; O.B. POCKETS TO 1m PROBABLY COMMON WITH AVERAGE 0·25 – 0·5m LIKELY ESPECIALLY FOR SECTIONS WHICH ARE NOT SUPPORTED. CROWN LIKELY TO BE SLABBY.	DEPENDENT ON EXCAVATION METHODS. LARGE O.B. SECTIONS (GREATER THAN 1m) COULD OCCUR IF GROUND IS UNDULY DISTURBED AND SUPPORT IS NOT INSTALLED RAPIDLY.
	SUPPORT	CATEGORIES 25 & 29 EXPECTED	CATEGORIES 25 AND O DEPENDENT ON VARIATION IN ROCK MASS QUALITY	LARGE SECTIONS OF SUPPORT CATEGORY 29, POSSIBLY SOME CATEGORY 33 AND REMAINDER OF SECTION LIKELY TO BE CATEGORY 25
	GROUNDWATER INFLOWS	COULD BE SIGNIFICANT, THOUGH 25-125 L/MIN EXPECT.	MINOR INFLOWS ONLY EXPECTED ALONG THIS SECTION i.e. LESS THAN 25 LITRES/MIN PER 10m OF TUNNEL SECTION. GROUNDWATER TABLE FLUCTUATES WIDELY IN THIS SECTION FROM 2m BELOW SURFACE TO 2·5m BELOW LAKE LEVEL	MINOR INFLOWS ONLY EXPECTED. WATER TABLE GENERALLY EXPECTED TO BE AT OR SLIGHTLY ABOVE CROWN

SCALES VERT 1:100
HORIZ 1:1000

LEGEND

(1900) SEISMIC VELOCITY IN METRES/SECOND
INTERPRETED SEISMIC REFRACTOR BOUNDARY
SEISMIC ANOMALY BOUNDARY
EXISTING SEWER
PROPOSED 1680 I.D. TUNNEL
PROPOSED 1050 DIA CLASS 'Y' R.C.P.
PROPOSED 750 DIA CLASS 'X' R.C.P.
LOCATION OF MANHOLE AND/OR DRILLHOLES

GEOLOGY

ROCK TYPES
EW-HW MUDSTONE
MW MUDSTONE
SW MUDSTONE
FS-F MUDSTONE
VOLCANIC TUFF
FRACTURED ROCKS

SOIL TYPES
CLAY
ORGANIC SILT
GRAVEL OR FILL

(NOTE:- ZONES OF CORE LOSS REPRESENTED BY BLACKED IN GRAPHIC LOG COLUMN.)

PLAN VIEW
ALLUVIUM – GRAVEL, SAND AND CLAY
MUDSTONE, SHALE – SHALLOW WEATHERED
SHALE, MUDSTONE, SILTSTONE AND MINOR SANDSTONE – DEEPLY WEATHERED
COARSE TUFF – DEEPLY WEATHERED

IN SECTION
34 DIP AND STRIKE OF BEDDING
22 DIP AND STRIKE OF JOINT
GEOLOGICAL BOUNDARY – POSITION ACCURATE
GEOLOGICAL BOUNDARY – POSITION APPROX.
EW EXTREMELY WEATHERED
HW HIGHLY WEATHERED
MW MODERATELY WEATHERED
FS FRESH STAINED
F FRESH
INTERPRETED WEATHERING BOUNDARY
OB OVERBREAK

PLATE 1

REVISION	DESCRIPTION	DATE	REVISION	DESCRIPTION	DATE

AMMENDMENTS

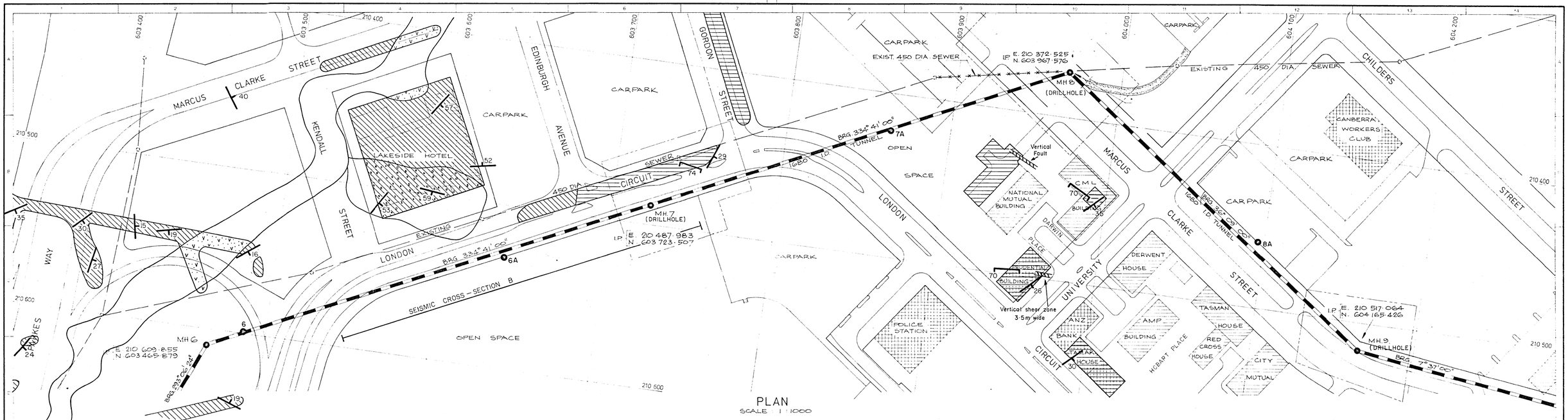
No.	DESCRIPTION	AUTHOR	DATE	CHECKED	DATE
A1					
A2					
A3					
A4					
A5					
A6					

SCALE 0 50 metres
Horizontal

COMMONWEALTH OF AUSTRALIA
BUREAU OF MINERAL RESOURCES
CANBERRA, ACT

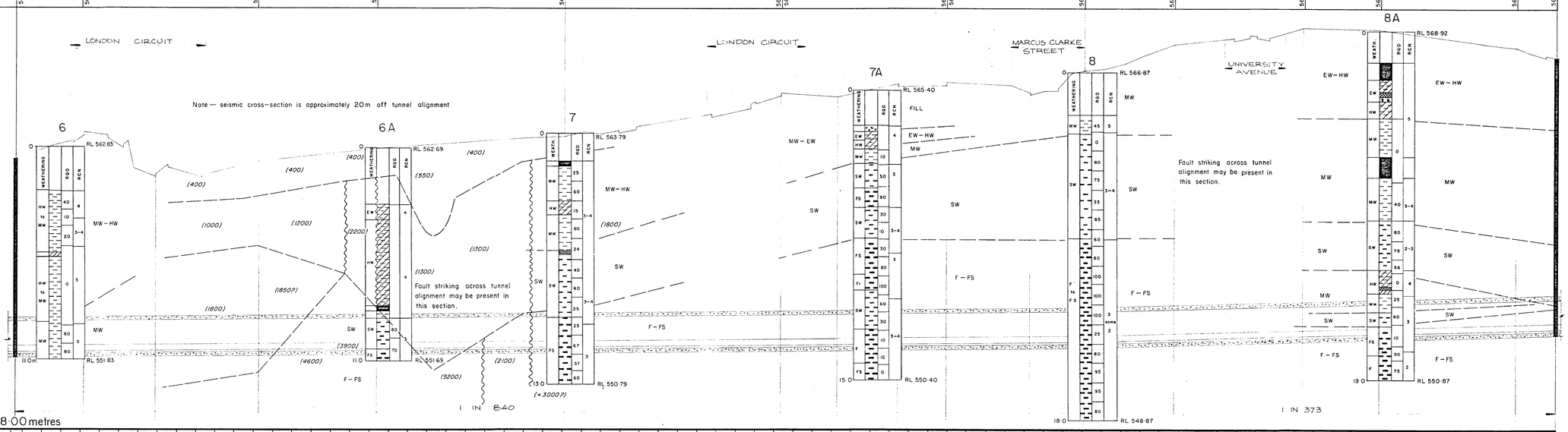
BASE MAP/SURVEY: Supplied by: Scott and Furphy Eng. Pty Ltd
GEOLOGY BY: P.H. Vorden Broek
COMPILED BY: G. Sparksman
CHECKED AND APPROVED: D.C. PURCELL, SENIOR GEOLOGIST
SUPERVISING GEOLOGIST: E.G. Wilson

TITLE: SULLIVANS CREEK SEWER TUNNEL
PROJECT: GEOLOGICAL PLAN AND SECTION
CHAINAGE: 0+17 to 6+05
TO ACCOMPANY: Record 1978/99
DRAWN BY: L. H.
DRAWING NUMBER: I55/A16/2213



PLAN
SCALE 1:1000

MANHOLE No.	MH 6				MH 7				MH 8				MH 9
INVERT LEVEL	550.009 550.044				552.359 552.384				552.681 552.706				553.338 553.363
EXISTING SURFACE LEVEL	562.1	563.50	561.98	562.69	563.34	565.45 565.60	565.87 566.00	566.73	568.16	568.97	568.92	567.98	567.48



GRADE OF INVERT

DATUM LEVEL 548·00 metres

TUNNEL CHAINAGE		7+00	8+00	9+00	10+00	11+00	12+00	13+00	14+00
ROCK TYPE, HARDNESS AND STRENGTH AT T.L.		Mostly pale yellow–brown to reddish brown, moderately weathered MUDSTONE with sections of pale grey to blue–grey, slightly weathered to fresh, calcareous MUDSTONE. Rocks will vary from soft and weak to hard and strong. Is(50) = 3·8 – 4·2 expected from CH 7+40 to 8+20		Mostly blue–grey calcareous MUDSTONE, moderately hard, moderately strong Is (50) = 1·5 M pa	Blue–grey fresh calcareous MUDSTONE, hard and strong Is(50) = 2·5–3·8 Mpa		Variable from blue–grey fresh calcareous MUDSTONE to pale yellow–brown, lightly to moderately weathered MUDSTONE. Hard & strong in places, soft & weak in some sections	
ROCK MASS DEFECTS		Bedding variable from thinly bedded to thickly bedded, dip/dip direction = 25/060 expected, orientation expected to be fair. Four joint sets observed in core, these were unaltered, smooth and very closely spaced with some sections fragmented. Widely spaced shears and clay seams are expected and one or two small faults could occur along this section. Defect orientations are expected to be unfavourable		Bedding commonly not visible in core due to unweathered nature of rock. Four joint sets observed in core; these were unaltered, smooth and closely spaced. Defect orientation* expected to be fair. Generally seams & shears should be absent	Bedding not visible in core due to unweathered nature of rock. Two or three joint sets observed in core, joints are tight, uncoated, rough, planer and moderately wide to closely spaced. Defect orientations are expected to be fair. Seams, shears and faults are expected to be absent		Thinly bedded, dip/direction = 25/060 expected, orientation of bedding favourable. Two joint sets & some random jointing observed in core. Joints tight; surfaces uncoated or stained, rough, planar & closely spaced.	*See plate 3
PREDICTED TUNNELLING CONDITIONS	ROCK MASS QUALITY(Q)	Sections of extremely poor to very poor ground, possibly some exceptionally poor sections (possibly 0).		Very poor to poor proceeding N.W. (0·8)	Good (11·3 – 15·4)		Fair to poor (1·2)		
	STANDUP TIME	About 1 hour calculated from drill holes 6 and 6A		10 hours calculated from drill hole 7	1 week to one month calculated from drill holes 7A and 8		2–10 hours calculated from drill hole 8A		
	OVERBREAK (O.B)	CH 7+40 approximate limit of machine excavation from the southern portal. Some large OB (>1m) expected if drill and blast methods are used from CH 8+00 to 8+80		Some O.B. pockets to 0·5m expected	Minimum O.B. expected, some pockets to 0·3m expected, depending on defects		O.B. pockets to 1m possible in blocky and seamy sections		
	SUPPORT	Large sections of support category 33 and 29 with possibly small sections of category 25		Categories 25 and 0 improving towards CH 10+00	Category 0		Category 0 to 25 with some 29 possible		
	GROUNDWATER INFLOWS	Minor inflows only expected. Water table fluctuates widely in drill hole 6 from within 2m of surface after heavy rain to 2m above crown during dry spells		Minor inflows initially, section expected to dry out after excavation	Minor inflows initially, most of section expected to dry up soon after excavation.		Minor inflows initially, much of section expected to dry up after excavation		

LONGITUDINAL SECTION SCALE: VERTICAL 1:100
HORIZONTAL 1:1000

PLATE 2

NOTE
1. FOR LEGEND REFER TO PLATE 1

REVISION	DESCRIPTION	DATE	REVISION	DESCRIPTION	DATE

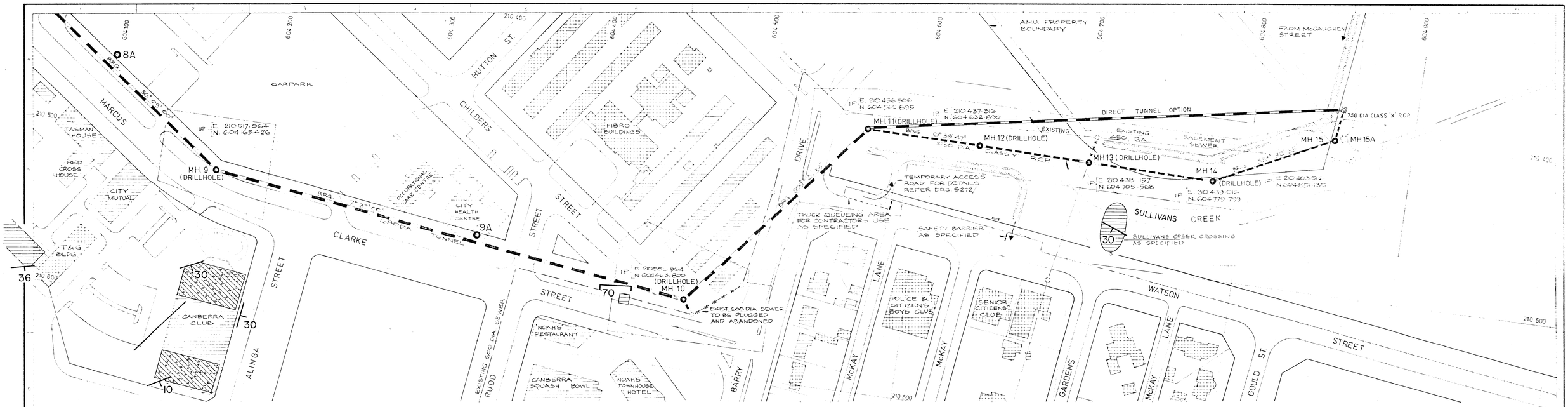
No.	DESCRIPTION	AUTHOR	DATE	CHECKED	DATE
A1					
A2					
A3					
A4					
A5					
A6					

SCALE 0 10 20 30 40 50 metres
Metric
BASE MAP / SURVEY: Supplied by Scott and Furphy Eng. Pty Ltd.
GEOLOGY BY: P.H. Vanden Broek
COMPILED BY: G. Sporksman
CHECKED AND APPROVED: D.C. PURCELL, SENIOR GEOLOGIST
SUPERVISING GEOLOGIST: E.G. Wilson
TO ACCOMPANY: Record 1977/99
DRAWN BY: IBH
DRAWING NUMBER: 155/A16/2214

COMMONWEALTH OF AUSTRALIA
BUREAU OF MINERAL RESOURCES
CANBERRA, ACT

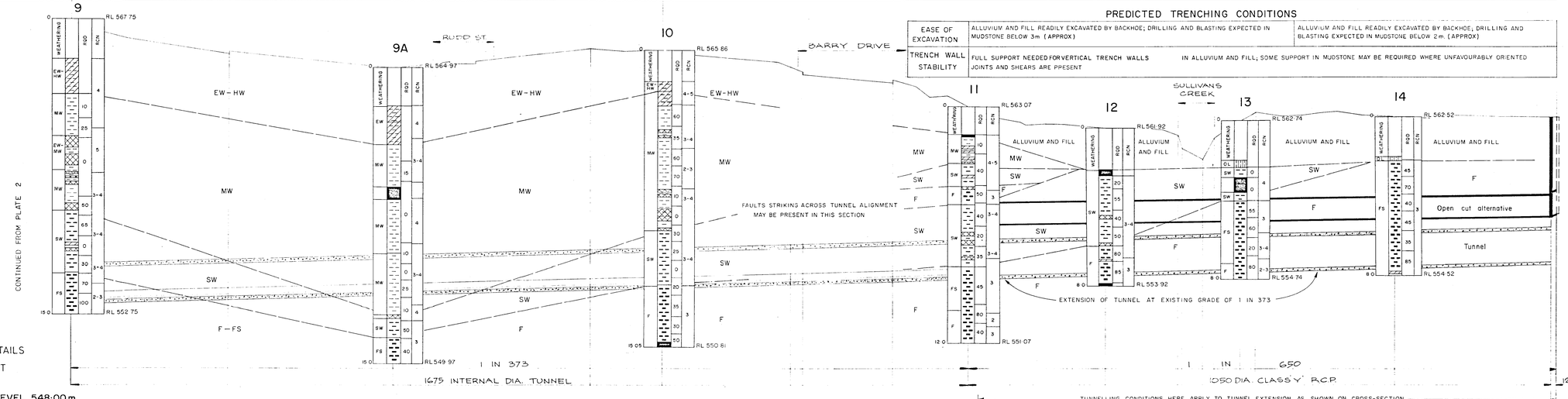
TITLE
SULLIVANS CREEK SEWER TUNNEL

PROJECT
GEOLOGICAL PLAN AND SECTION
CHAINAGE: 6+05 to 14+05



PLAN
SCALE 1:1000

MANHOLE No	MH 9			MH 10			MH 11	MH 12	MH 13	MH 14	MH 15	MH 15A EXISTING
INVERT LEVEL	553.338 553.363			554.146 554.170			554.562 557.064	557.166 557.191	557.268 557.293	557.393 557.418	557.515	557.65
EXISTING SURFACE LEVEL	567.48	565.70	564.97	565.85	565.05	564.63	564.24 564.34	563.07	561.91	561.51	560.35	562.57	562.53	562.51	562.69



BACKFILLING DETAILS
GRADE OF INVERT

PREDICTED TRENCHING CONDITIONS

EASE OF EXCAVATION	ALLUVIUM AND FILL READILY EXCAVATED BY BACKHOE; DRILLING AND BLASTING EXPECTED IN MUDSTONE BELOW 3m (APPROX)	ALLUVIUM AND FILL READILY EXCAVATED BY BACKHOE; DRILLING AND BLASTING EXPECTED IN MUDSTONE BELOW 2m (APPROX)
TRENCH WALL STABILITY	FULL SUPPORT NEEDED FOR VERTICAL TRENCH WALLS JOINTS AND SHEARS ARE PRESENT	IN ALLUVIUM AND FILL; SOME SUPPORT IN MUDSTONE MAY BE REQUIRED WHERE UNFAVOURABLY ORIENTED

DATUM LEVEL 548·00m

TUNNELLING CONDITIONS HERE APPLY TO TUNNEL EXTENSION AS SHOWN ON CROSS-SECTION

TUNNEL CHAINAGE		15+00	16+00	17+00	18+00	19+00	20+00	21+00
ROCK TYPE, HARDNESS AND STRENGTH AT T.L.		PALE GREY-BROWN, SLIGHTLY WEATHERED MUDSTONE, WEAK & SOFT, $I_{s(50)}$ 0·6 AT CROWN. HARD & STRONG IN LOWER HALF OF TUNNEL.	MOSTLY PALE TO YELLOW-BROWN, MODERATELY WEATHERED MUDSTONE, WEAK AND SOFT, $I_{s(50)}$ 0·6 - 1·0	MOSTLY PALE GREY SLIGHTLY WEATHERED CALCAREOUS MUDSTONE, MODERATELY HARD, MODERATELY STRONG $I_{s(50)}$ 1·0 - 3·0. INCREASING AMOUNTS OF FRESH BLUE CALCAREOUS MUDSTONE COMING INTO TUNNEL TOWARDS CH 19+50			PALE GREY TO GREEN-GREY FRESH MUDSTONE, HARD AND STRONG $I_{s(50)}$ 1·4 - 5·5	
ROCK MASS DEFECTS		FOUR DEFECT ORIENTATIONS OBSERVED IN CORE, MODERATELY WIDE TO CLOSELY SPACED JOINTS STAINED, PLANAR AND SMOOTH.	THREE JOINT ORIENTATIONS OBSERVED IN CORE. JOINT SURFACES ARE TIGHT, UNALTERED, UNCOATED, CLOSELY SPACED AND ORIENTATIONS ARE EXPECTED TO BE FAIR TO FAVOURABLE. WIDELY SPACED CLAY SEAMS OR SHEARS MAY BE PRESENT	UP TO FOUR JOINTS ORIENTATIONS WERE OBSERVED IN THE CORE, JOINT SURFACES ARE MOSTLY UNCOATED AND STAINED PLANAR AND SMOOTH. JOINTS BECOMING TIGHTER TOWARDS CH 19+50. ORIENTATIONS EXPECTED TO BE UNFAVOURABLE. POSSIBILITY OF A SMALL FAULT ALONG THIS SECTION WIDELY SPREAD CLAY SEAMS AND SHEARS LIKELY.			AT LEAST FOUR JOINT ORIENTATIONS OBSERVED IN DRILL CORE. JOINT SURFACES ARE UNALTERED, UNCOATED, STAINED SMOOTH PLANAR AND MODERATELY WIDE TO CLOSELY SPACED. JOINT ORIENTATIONS EXPECTED TO BE FAIR. FEW CLAY SEAMS OR SHEARS ARE EXPECTED	
PREDICTED TUNNELLING CONDITIONS	ROCK MASS QUALITY (Q)	VERY POOR (0·53)	VERY POOR (0·33)	POOR TO FAIR (0·34 - 3·2) TOWARDS CH 19+50			POOR TO FAIR (1·4 - 5·4)	
	STAND-UP TIME	10 HOURS CALCULATED FROM DRILLHOLE 9	2 HOURS CALCULATED FROM DRILLHOLE 9A	2 HOURS, 10 HOURS AND 1 WEEK CALCULATED FROM DRILL HOLES 10, 11 AND 12 RESPECTIVELY			2 DAYS CALCULATED FROM DRILL HOLES 13 AND 14	
	OVERBREAK	O.B. POCKETS TO 1m POSSIBLE IN BLOCKY AND SEAMY SECTIONS.	DEPENDENT ON METHOD OF EXCAVATION AND DIRECTION OF TUNNEL ADVANCE	DEPENDENT ON EXCAVATION METHODS. O.B. TO 1m IF DRILL AND BLAST METHODS ARE USED.			VERY LITTLE OR NO O.B. EXPECTED.	
	SUPPORT	CATEGORY 2S	MOSTLY CATEGORY 2S WITH POSSIBILITY OF 2S	MOSTLY CATEGORIES 0 AND 2S WITH POSSIBILITY OF SOME 2S			CATEGORY 0	
	GROUNDWATER INFLOWS	MINOR INFLOWS (<25 LITRES/MINS PER 10m SECTION LENGTH) ONLY	MINOR INFLOWS ONLY	SMALL INFLOWS 25-125 LITRES/MIN PER 10m SECTION EXPECTED			SMALL INFLOWS 25-125 LITRES/MIN PER 10m SECTION EXPECTED	

PLATE 3

LONGITUDINAL SECTION SCALES: VERTICAL 1:100
HORIZONTAL 1:1000

NOTE
1. FOR LEGEND REFER TO PLATE 1

REVISION	DESCRIPTION	DATE	REVISION	DESCRIPTION	DATE

No	DESCRIPTION	AUTHOR	DATE	CHECKED	DATE
A1					
A2					
A3					
A4					
A5					
A6					

SCALE 0 10 20 30 40 50 metres Horizontal

BASE MAP/SURVEY: Supplied by: SCOTT & FURPHY Eng. Pty. Ltd.
GEOLOGY BY: P.H. Vanden Broek
COMPILED BY: G. Sparksman
CHECKED AND APPROVED: D.C. PURCELL, SENIOR GEOLOGIST
SUPERVISING GEOLOGIST: E.G. Wilson

COMMONWEALTH OF AUSTRALIA
BUREAU OF MINERAL RESOURCES
CANBERRA, ACT

TITLE: SULLIVANS CREEK SEWER TUNNEL
PROJECT: GEOLOGICAL PLAN AND SECTION CHAINAGE 14+15 to 21+62

TO ACCOMPANY	DRAWN BY	DRAWING NUMBER
Record 1978/99	CAC	155/A16/2215