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PRELIMINARY GEOLOGICAL INVESTIGATIONS OF TENNENT DAM SITES 2 AND 3, GUDGENBY RIVER, A.C.T., 1975

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Gudgenby River - looking upstream from damsite 2 axis

CONTENTS

TABLES

Page

PLATES

FIGURES

SUMMARY

Two dam sites - 2 and 3 - on the Gudgenby River were investigated in November-December 1975 for the construction of an earth and rock fill dam.

Both sites are underlain by foliated Tharwa Adamellite, which is extensively sheared and faulted on the right (eastern) abutments - especially at dam site 3. The north-trending Murrumbidgee Fault lies about 1 km east of the dam sites and has no direct influence on either of them.

Weathering of the rock differs at both sites, but depths to fresh rock are greater on the right abutments. At dam site 2, there is evidence of past landslide activity on the lower part of the right abutment. No instability of this nature is evident at dam site 3, where, however, the underlying rock is weak and highly to moderately weathered to a depth of 20 m on the right abutment.

Sites for two water-treatment plants were also investigated. The western site, on a low rocky hill, has suitable foundations at floor level RL 705 m, but up to 20 m of rock will have to be excavated, mostly by blasting; this material would be suitable for rock fill for the dam. The eastern site is on level ground, with 2-3 m of gravelly soil overlying rock; suitable foundations are expected with a minimum of excavation, but a number of low-velocity zones probably indicate deeper weathering along sheared zones.

Details of construction materials have been comprehensively covered in previous surveys in the area. Additional quarry sites for rock fill have been located upstream and downstream of the dam sites to satisfy any requirements for two-stage construction of the dam.

INTRODUCTION

At the request of the Department of Construction (DC) the Bureau of Mineral Resources (BMR) carried out a geological investigation of two alternative dam sites and two water-treatment plant sites on the Gudgenby River, A.C.T., near Mount Tennent. The locations are shown in Figure 1 and Plate 1, and the dam sites are referred to as Tennent dam sites 2 and 3. The dam sites are shown in plan view on Plate 1 as earth and rock fill embankments and the report is mainly concerned with this type of construction.

Another dam site on the Gudgenby River located 400 m upstream from dam site 2 was investigated by Buchhorn (1968) and Henderson (1973), and is now referred to as dam site 1 (Plate 1). Dam site 1 was considered as an alternative to Googong dam site for construction; however, Googong was preferred and is now under construction.

The alternative projects that are being considered are an off-river storage for the Murrumbidgee River, or a run-of-river storage for the Gudgenby River with the option of increasing the dam capacity at a future date to store water from the Murrumbidgee. The preliminary design details are listed below in Table 1.

TABLE 1. PRELIMINARY DESIGN DETAILS

		DAM SITE 2*	DAM SITE 3*
Top RL of reservoir		680 m	680 m
Dam height		100.3 m	85.0 m
Dam volume		3 540000 m^3	3 005 870 m^3
**	Earth core	710 000 m^3	600 000 m^3
	Filter zone	180 000 m^3	150 000 m^3
	Rock fill	2 650 000 m^3	2 260 000 m^3

* Figures supplied by Department of Construction.

** Assuming core is 20% of total volume, filter zone 5%, and rock fill 75%.

Dam sites 2 and 3 were geologically mapped at a scale of 1:2500, and hand augering of superficial materials was carried out over the eastern water treatment plant site. Seismic refraction traverses were carried out by the Engineering Geophysics Group along the centrelines of both dam sites and across the spillway sites (Plate 1). The seismic traverse on dam site 3 was extended to the east as far as Smiths Road, to provide information on changes in the rock mass that take place with proximity to the Murrumbidgee Fault (Horsfall, 1976).

PHYSIOGRAPHY

Both dam sites are on the Gudgenby River (Fig. 1), which flows in a northerly direction to join the Murrumbidgee River 1 km from dam site 2. At dam site 2 the river has incised a gorge up to 100 m deep into a partly dissected plateau. To the west Mount Tennent rises to 1370 m. Upstream from dam site 3 the gorge widens into the undulating cleared pasture land of the Gudgenby and Naas valleys.

REGIONAL GEOLOGY

The dam sites, treatment plants, and reservoir area are underlain by granitic rocks of the Murrumbidgee Batholith (Plate 1), a large, granitic composite intrusion concordant with the regional north-south structural trend. Two granitic types are exposed in the area: the Tharwa Adamellite, which crops out at both dam sites; and the Clear Range Granodiorite, which crops out farther south in the reservoir area (Snelling, 1960). These granitic rocks have intruded Silurian sediments and volcanics to the east (Richardson, 1975), and in this area the contact has been obscured by shearing associated with the Murrumbidgee Fault.

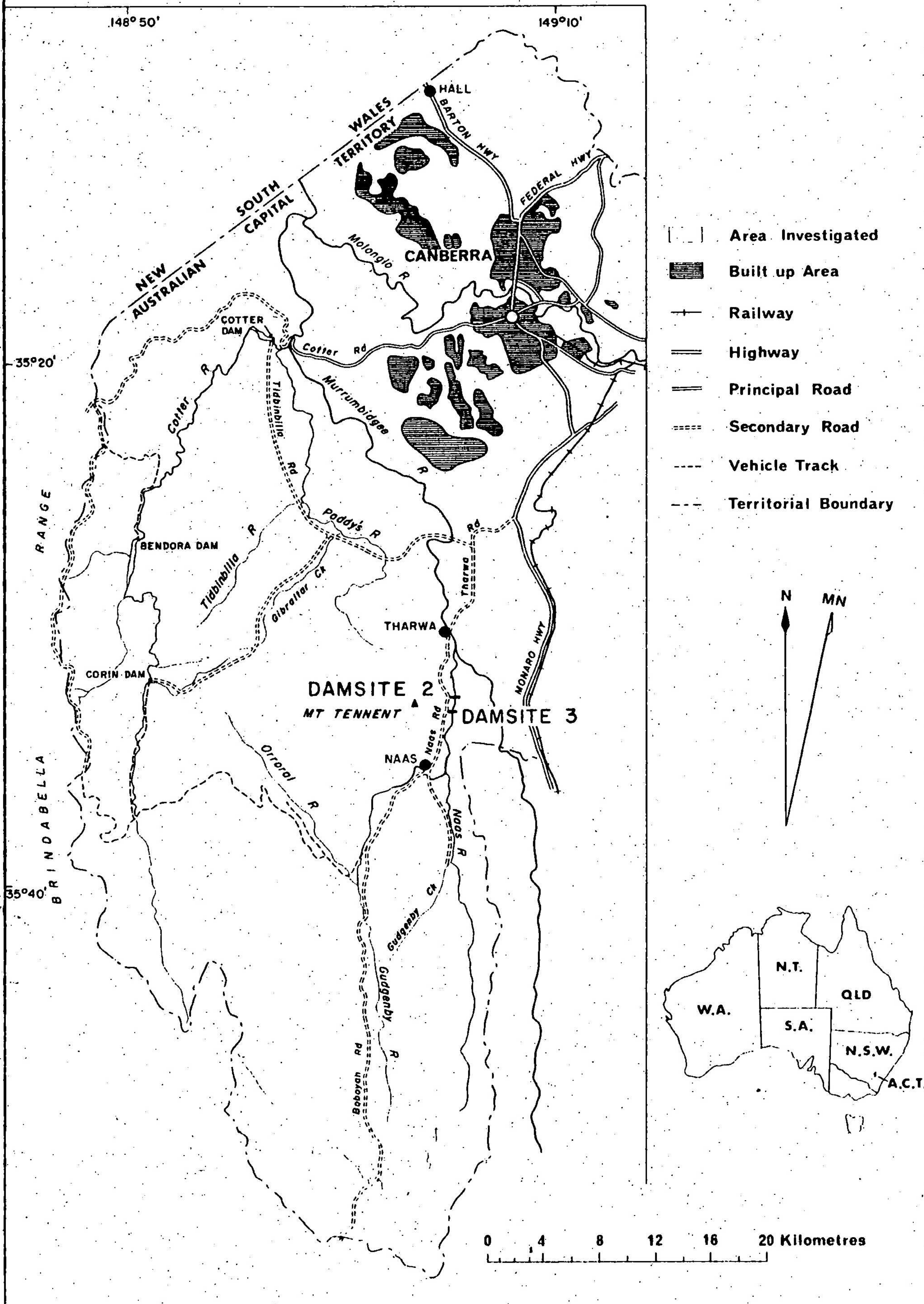
The Murrumbidgee Fault, which forms the eastern boundary of the batholith near the dam sites, is thought to have been formed about 350 million years ago, and renewed minor activity has probably taken place since the Kosciusko Uplift in the Pleistocene (about 1 million years ago).

Components of the batholith usually have a primary foliation* which is indicated by the orientation of xenoliths. A secondary (metamorphic) foliation is superimposed on rocks adjacent to the Murrumbidgee Fault - e.g., the Tharwa Adamellite.

* Underlined words defined in Glossary.

TENNENT DAMSITES 2 & 3 LOCATION MAP

Figure 1



Record 1977/18

155/A16/1697

DAM SITE 2

The geology of dam site 2 is shown in Plate 2. The site is asymmetric with steep, irregular slopes on the eastern side. Plate 4 shows an interpretative section east-west along the dam centreline. Figure 2 is a general view of the right abutment.

GENERAL GEOLOGY

Rock types

The Tharwa Adamellite is a grey coarse-grained rock containing quartz, feldspar, biotite, and muscovite. Where the rock is weathered the feldspars are altered to clay, and the micas to iron oxides, chlorite, and sericite.

Dark fine-grained elongate xenoliths defining the primary foliation are present in the left abutment.

The adamellite is generally foliated, with some local variation to non-foliated textures on the one hand and gneissic textures on the other. The rock is described as gneissic where mineral banding is apparent and the rock substance is considerably weakened.

Also present are aplite dykes, which are fine-grained, in places foliated, and contain quartz, feldspar, and minor biotite. Veins of quartz, pegmatite, and blastomylonite crop out towards the top of the right abutment associated with gneissic adamellite.

Surficial deposits

Alluvium up to 120 m wide and 6-8 m deep covers the valley floor. The Gudgenby River flows along the eastern side of the valley close to the right abutment with two wide river terraces on the western side. The lower river terrace close to the river consists of fine to coarse micaceous quartz sand and large subrounded blocks of adamellite. There is a lack of gravel-size material at this locality. The older (upper) terrace contains sand and silt which have undergone some mineral alteration and weathering.

Fig. 2 View of right abutment, dam site 2

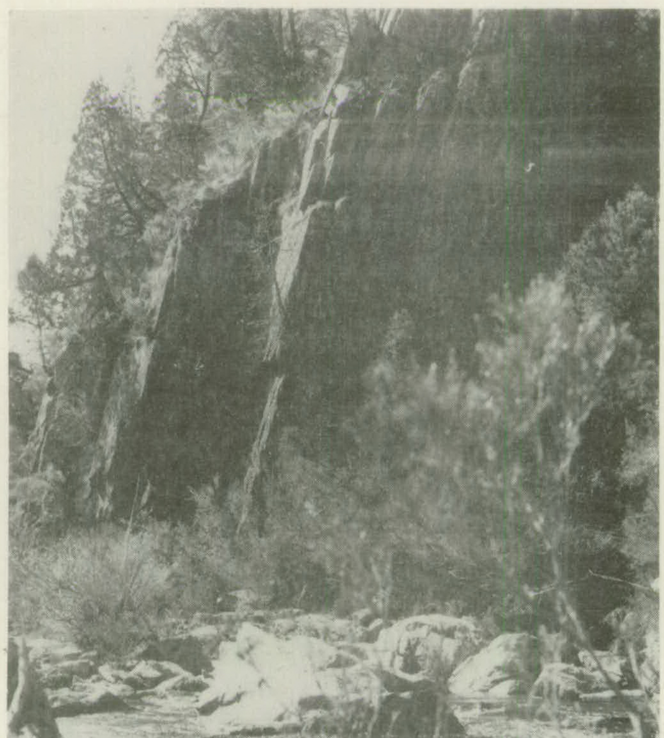


Fig. 3 Jointing in adamellite, dam site 2, right abutment
Note the curved trees on the top left-hand side.

Weathering

The degree of weathering in the adamellite is variable and is related to the presence of shearing or the intensity of the foliation, or both. Appendix 3 contains a table comparing seismic velocity with degrees of weathering.

The upper part of the right abutment (above RL 630 m) is covered by a silty, gravelly soil up to 7 m thick, containing loose blocky rock and scattered outcrops of highly weathered gneissic adamellite. Below RL 630 m the terrain steepens and moderately weathered to fresh outcrop is abundant.

The lower part of the right abutment is formed by cliffs 60 m high (Fig. 3) and a large unstable mass of rock and soil (see section on stability).

The left abutment consists of scattered outcrops of moderately weathered adamellite and 0-2 m of silty sandy soil with some quartz gravel.

Structure

Foliation. The adamellite has a primary foliation striking 345-005° and dipping 70° east defined by the orientation of xenoliths, and a superimposed secondary foliation which trends between 320-002° and dips steeply west or vertical. Aplite dykes are commonly concordant with this foliation. A gently dipping foliation striking at 330° which may be related to localised shear zones, was recognised in an outcrop on the left abutment.

Jointing. The adamellite is jointed as follows:

Set 1 - 90/345 (parallel to foliation). These joints are generally open, continuous for > 20 m, and closely spaced.

Set 2 - 90/088-096 - These are mostly tight, continuous for < 5 m, and mostly widely spaced. There are some discontinuous shallow dipping joints evident in the steeper sections of the right abutment (Fig. 3).

Close to the river, joints of all orientations are open owing to the relief of stress in the rock mass consequent on the incision of the Gudgenby River valley. Within the unstable area, some clay seams striking 090° occur.

Faulting and shearing. A number of shear zones have been delineated by field mapping, and confirmed as lower-velocity zones in the seismic profiles (Plate 4); however, a number of low-velocity zones have no surface outcrop. Quartz veins, slickensides on joint planes, and blastomylonite at the top of the right abutment indicate other displacements within the rocks.

ENGINEERING GEOLOGY

Embankment foundation conditions

Left abutment. This abutment has sound rock, free of major defects, with only minor areas of deeper weathering. Fresh rock with seismic velocities between 4550-5200 m/s occurs within 1-2 m of the ground surface. Two zones with velocities of 3450 and 3800 m/s probably represent slightly weathered and/or more jointed rock.

Outcrop covers much of the embankment area except in the gully on the south side where costeans and seismic traverses indicate much deeper weathering, with moderately weathered rock at 20 m overlain by extremely to highly weathered adamellite and alluvium (Dolan, 1972; Henderson, 1973).

The 1-2 m of soil and loose rock will have to be stripped from the abutment slopes; some additional stripping will be required in deeply weathered zones. These zones of deeper weathering and clay seams will also require grouting or dental treatment.

No stability problems are anticipated on the left abutment. The natural slope ranges from 20-35^{o}, and the major joint sets are not undercut by the slope.

River channel. Seismic traverses covered about half of the flat alluvial terrace and channel area, and relatively sound rock appears to be present at least as far east as the river. Additional seismic traverses have been shot, but results are not yet available (P. Hill, in prep.). The rock beneath the alluvium is probably strong and fresh. The 6-8 m of alluvium beneath the embankment will have to be stripped, and large boulders and deep pockets of weathering are to be expected.

Right abutment. Foundation conditions are generally poorer on this abutment, which has a deeper and more variable weathering profile than the left abutment. The highest recorded refractor (3800 m/s) is overlain by 15-25 m of highly to moderately weathered rock (1450-1600 m/s; Plate 4). Above RL

630 m the slope is covered by loose rock and soil with some scattered outcrop. Seismic refraction traverses were not continued across the lower part of the abutment as it is too steep (greater than 45^o). P. Hill (in prep.) is carrying out a survey on this lower slope.

Suitable foundation rock lies below an intermediatevelocity layer 1450-1600 m/s, and is much deeper than on the left abutment. If drilling confirms this material as highly to moderately weathered rock, then a considerable thickness of rock will have to be removed.

Stability of right abutment. The right abutment is stable from about stn 400 to 500 m but to the west of Stn 400 a 10 m cliff marks the backwall of a slip plane. A combination of toppling, and sliding failure, has resulted in an unstable zone (60 x 80 m in area) of transported material with rotated blocks of rock, scree, and soil (Fig. 4).

Evidence of movement is shown by:

a) A number of large blocks (up to 15 m^3) of adamellite show dips of the foliation ranging between $10-40^o$ to the east (Fig. 5), whereas the same foliation in undisturbed rock dips about 90^o and strikes between $345-005^o$. This indicates that these blocks have tilted (Figs 6 and 7).

b) The topography exhibits post-landslide features, with a nearvertical backwall and a lobate mass of scree and tilted blocks (Fig. 6). A highly weathered shear zone runs parallel to this backwall.

c) Cypress pines are generally younger on the displaced material on the slope than on surrounding slopes (Fig. 6). Some of the older pines have been tilted by movement, and have since straightened in growth to vertical again (Figs. 3 and 8).

d) Numerous angular blocks 2-3 m^3 lie in the river bed and lack the rounded corners and smooth waterworn features of river transport that are common elsewhere in the boulders in the river bed.

e) Open joints in outcrops at the base of the slope display a wedge mechanism for rotation of blocks to a potential toppling condition (Fig. 9).

f) Low-angle open joints dip both into and out of the rock face (Fig. 3), and facilitate the lateral movement of rocks by wedging.

The loose part of the unstable zone will have to be cleaned out to provide suitable foundation for the dam. The remaining rock will have to be grouted, and concrete poured in the depressions. The depth of loosened rock and open joints may be up to 20 m behind the slope, and may require treatment for up to 35 m. Additional failure may be induced in the backwall as the loosened material is removed.

Spillway

The proposed spillway crest lies in a saddle behind a knoll on the eastern side of the dam site, and the spillway chute will follow a gully striking 325° (Plate 2). Skeletal gravelly soil and scattered outcrops of highly weathered schistose adamellite and aplite are found on the knoll.

Seismic results (Horsfall, 1976) from near the spillway crest show an intermediate-velocity layer of 1950 m/s down to about 16 m; this velocity probably represents moderately weathered rock grading into fresh rock with a velocity of 4100 m/s (Plate 4). A lower velocity of 3250 m/s probably represents a more jointed section of rock. Suitable foundation for the spillway crest is expected at a depth of 7-10 m.

Downslope, the gully contains blocky colluvium (estimated to be up to 5 m thick), and moderately weathered adamellite crops out lower down (below RL 630 m).

River diversion

A diversion conduit could be located to the west of the river and founded in 5450 m/s velocity rock at a depth of about 5 m, or less depending on how far west of the present river channel the conduit is placed.

If a diversion tunnel were to be constructed in preference to a valley floor conduit, then tunnelling conditions in the left (west) abutment ought to be better than those in the right abutment.

DAM SITE 3

GENERAL GEOLOGY

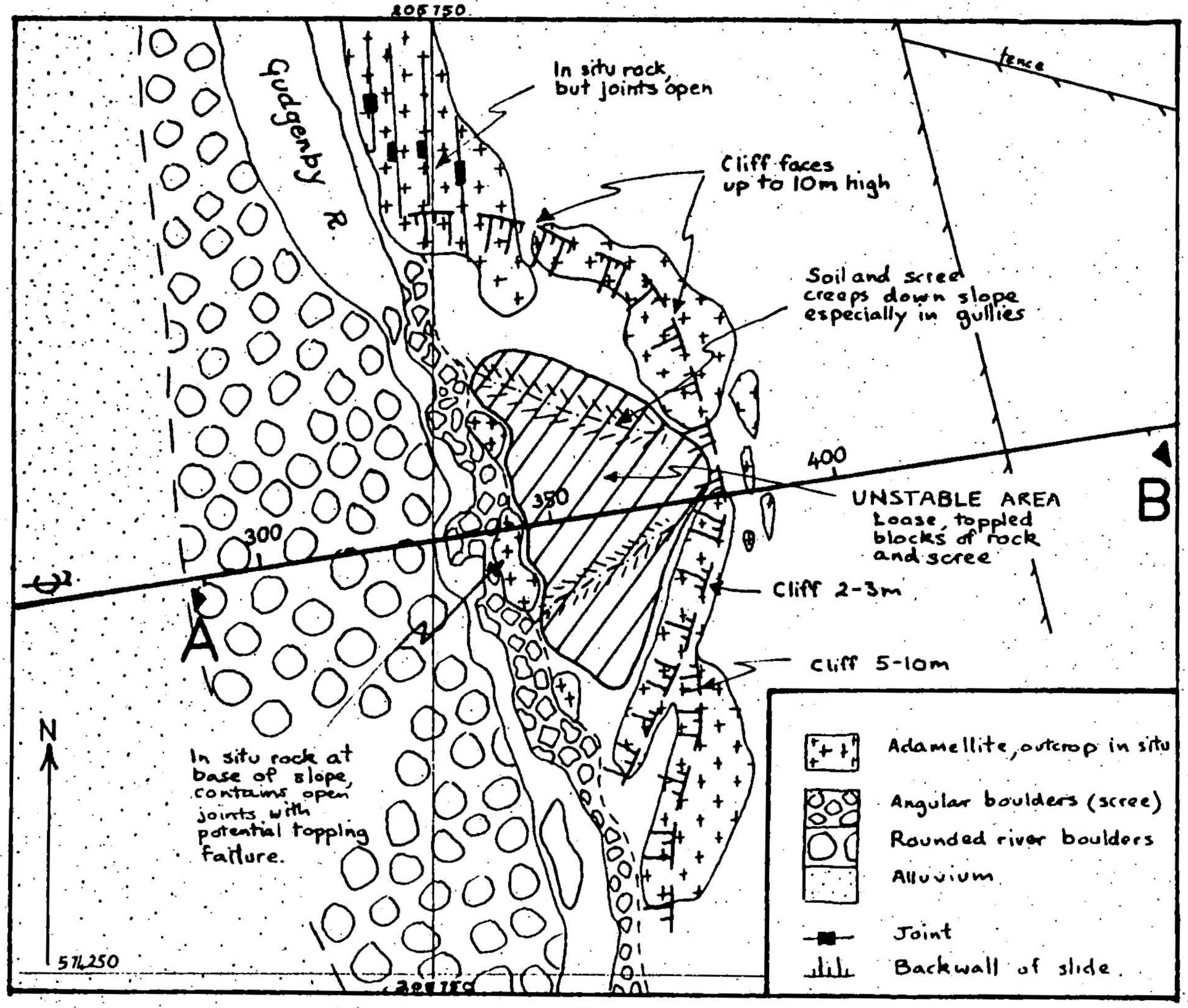
The location of this site is shown in Plate 1, and the rock distribution and geology in Plate 3. The site is asymmetric with steep slopes forming the right abutment (Fig. 10), and a long, more gentle slope which extends across the Naas Road forming the left abutment.

Tharwa Adamellite

The right abutment and river valley are underlain by fairly weak, (3500-3700 m/s) gneissic adamellite with minor aplite, quartz blastomylonite,

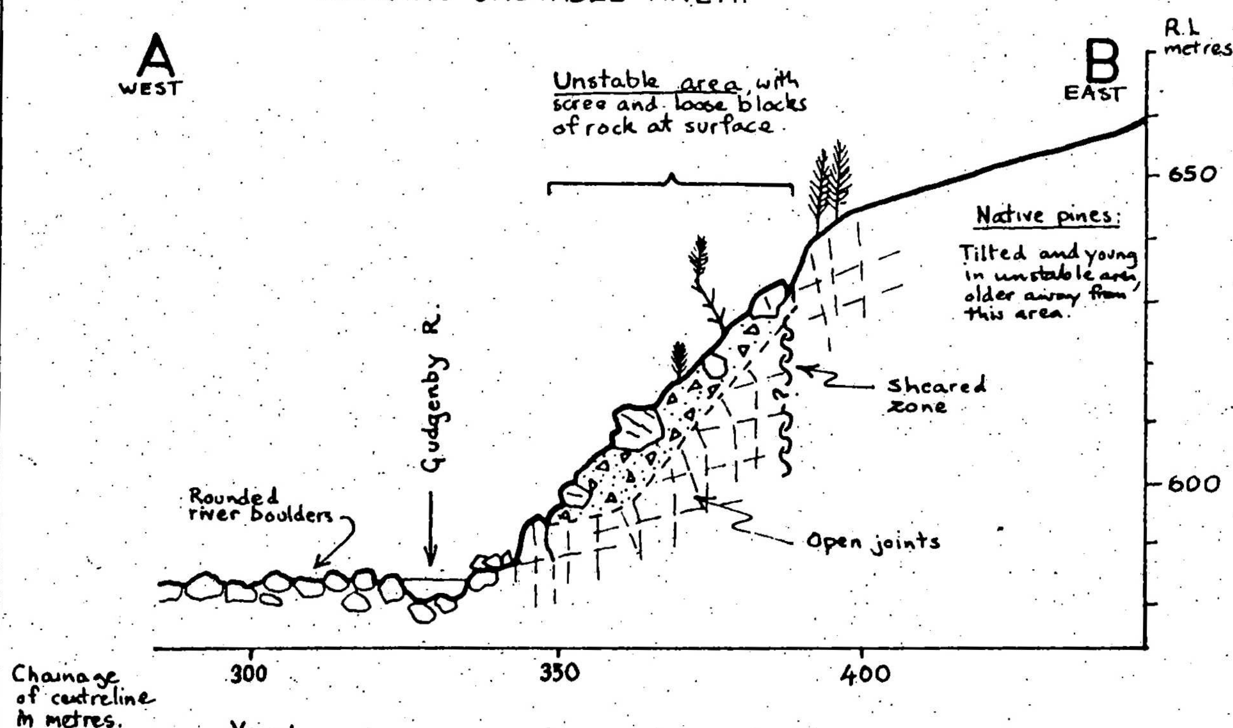
TENNENT DAMSITE 2

MAP OF UNSTABLE AREA ON THE RIGHT ABUTMENT



SCALE 1:1250 0 50 metres

SECTION OF LOWER PART OF RIGHT ABUTMENT SHOWING UNSTABLE AREA.



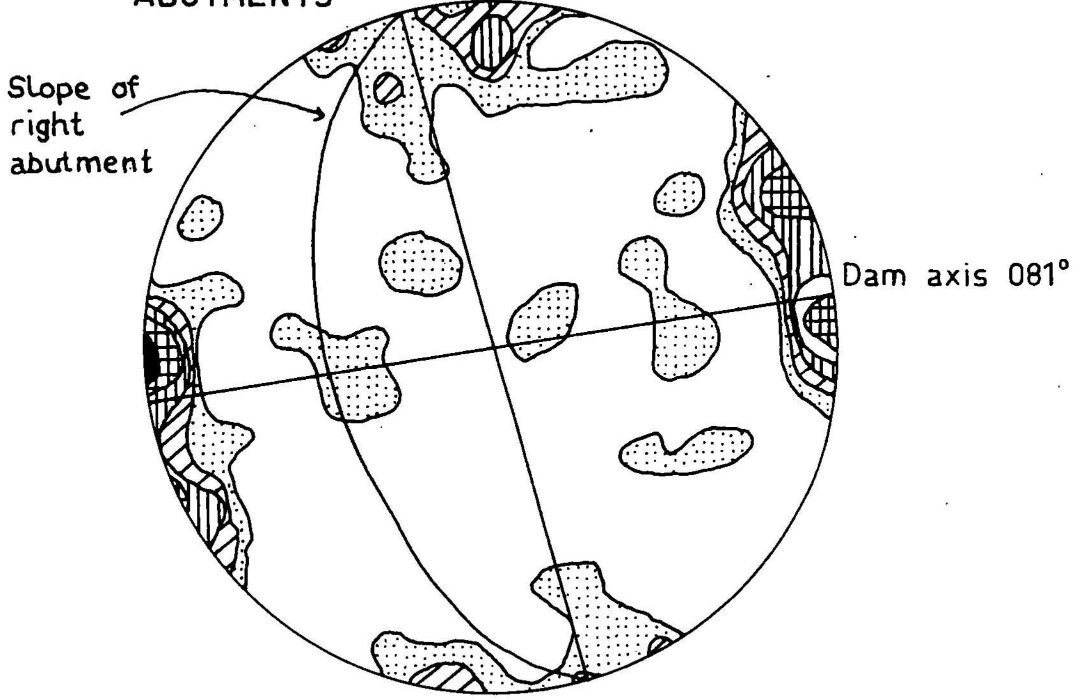
Record 1977/18

FIGURE 4

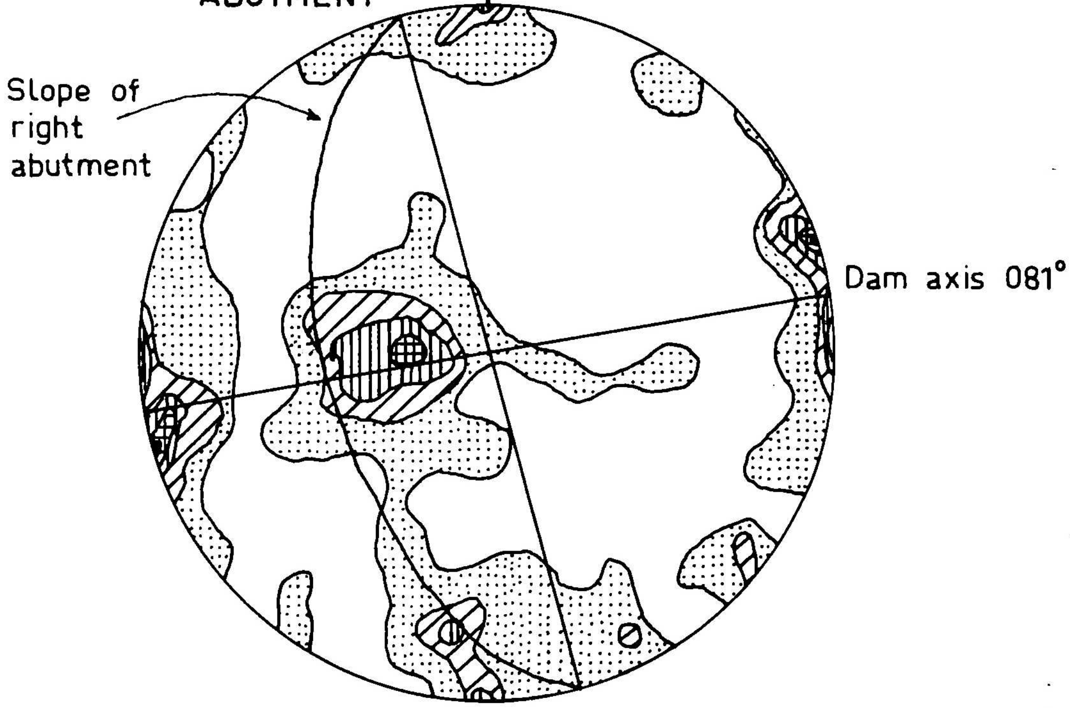
Drawn by R.Goldsmith 155/A16/1695

STEREOGRAPHIC PROJECTIONS OF JOINT POLES AT TENNENT DAMSITE 2

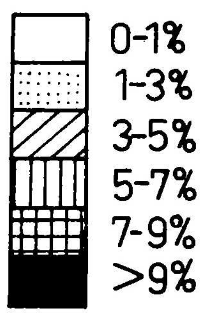
A. 95 JOINTS IN STABLE GROUND OF BOTH ABUTMENTS



B. 108 JOINTS IN UNSTABLE GROUND OF RIGHT ABUTMENT



Shaded zones show percentage of points per percentage of area



For area represented by each stereogram see figure 2

Record 1977/18

FIGURE 5

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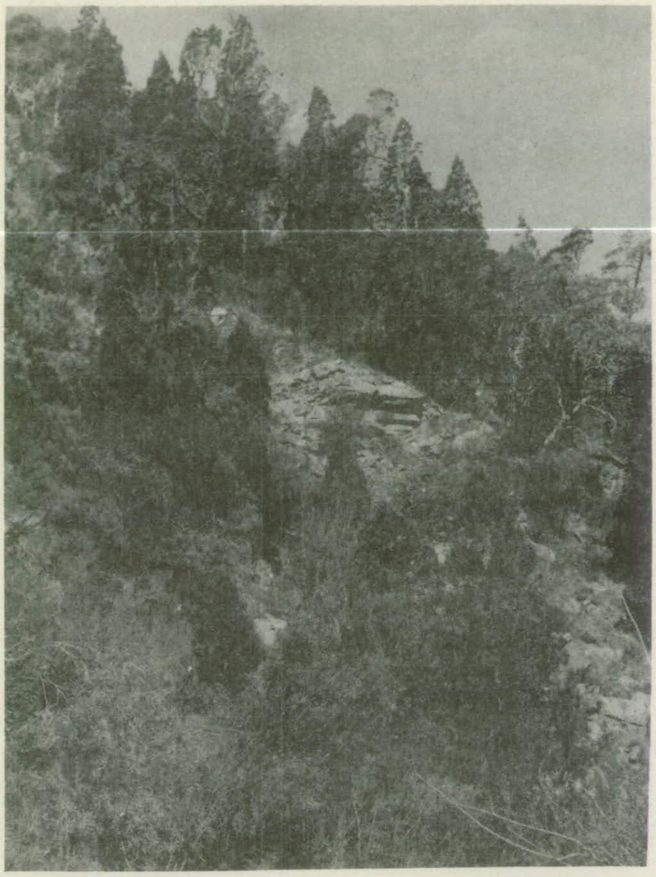


Fig. 6 View of unstable area, dam site 2

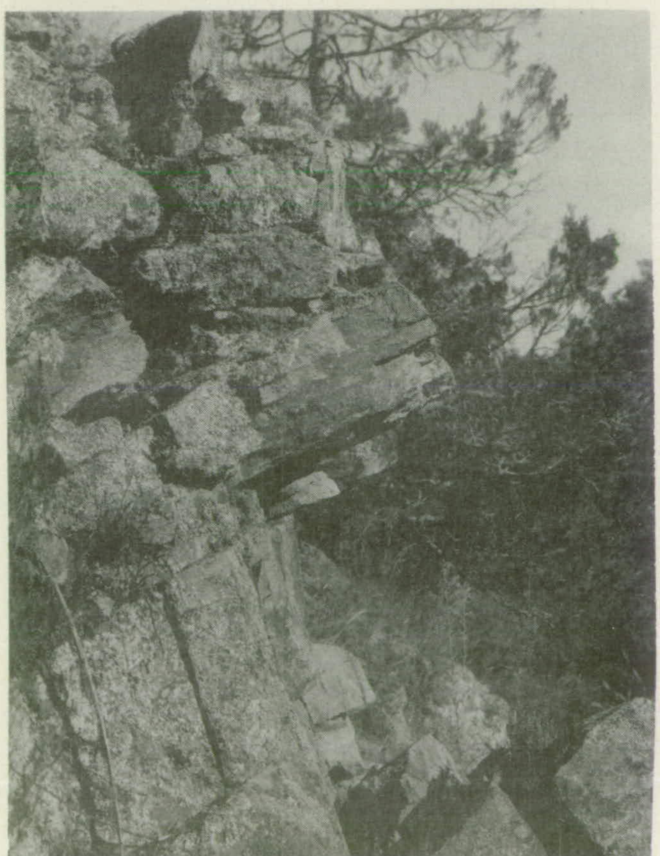


Fig. 7 Toppled blocks, dam site 2

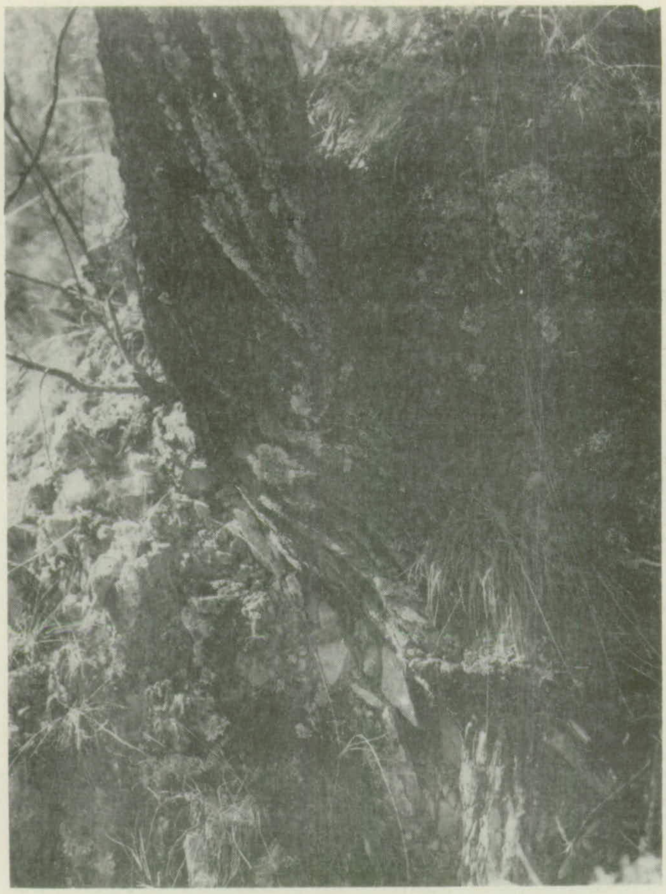


Fig. 8 Tree deformed by movement in slope, dam site 2

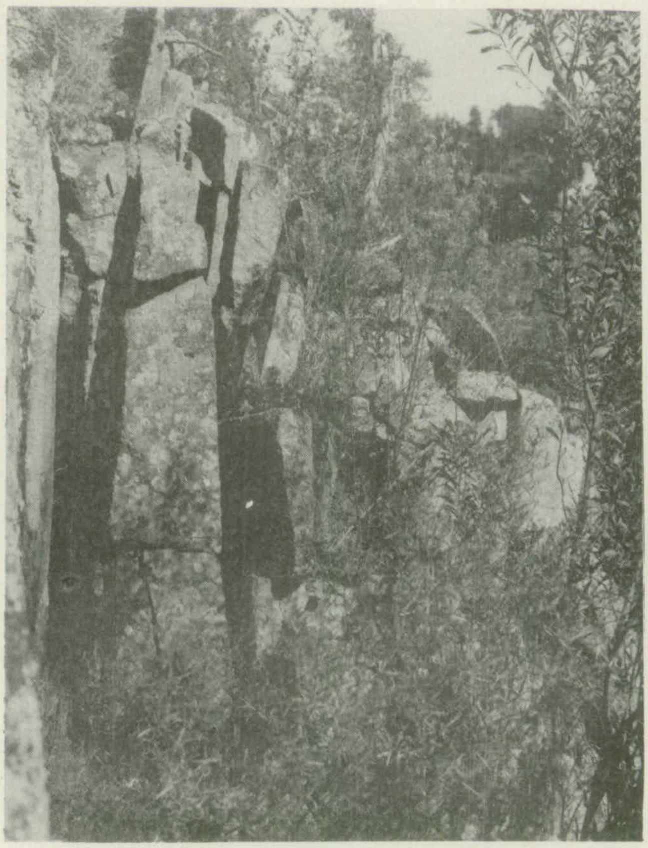


Fig. 9 Potential toppling condition, dam site 2

Fig. 10 General view of right abutment, dam site 3

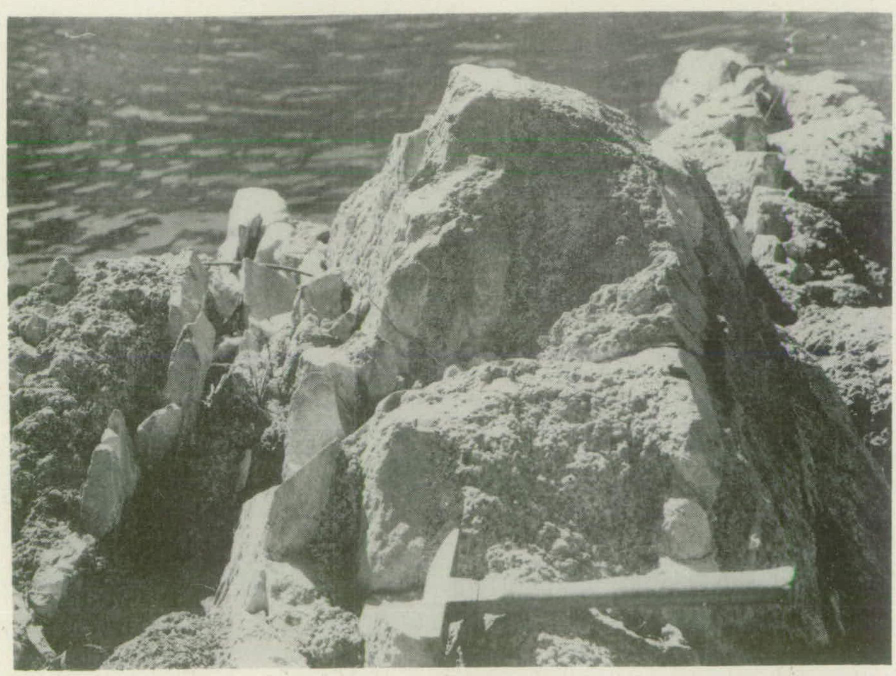


Fig. 11 Adamellite and aplite dykes cropping out in river, dam site 3

and schist. Shearing has altered and weakened the adamellite, and outcrops are highly weathered, closely jointed, and fractured. The rock is less gneissic and less sheared west of the river. A porphyritic adamellite containing unoriented plagioclase crystals up to 4 cm is widespread. Patches of rock with fine-grained dark xenoliths are common.

Dykes and veins

The more prominent outcrops are aplite dykes, quartz blastomylonite and quartz veins. Aplite dykes both parallel to foliation and discordant are abundant in the upper part of the left abutment. Crosscutting veins of aplite and quartz crop out adjacent to the river and on the left abutment (Fig. 11).

Surficial deposits

The valley floor at this site is 20 m wide and consists of sandy alluvium to a depth of about 3 m. A narrow (3-4 m) older river terrace containing silty alluvium occurs on the western side of the valley. Colluvium composed of clayey sand and fine quartz gravel covers the lower part of the left abutment.

Structure

Foliation. The foliation in the unsheared adamellite trends between 008-346^{o} and is present in some of the aplites.

Shearing. Shear zones in the right abutment and river area trend between 320-020^{o}, generally at about 000^{o}. Towards the top of the right abutment a fault zone is indicated by phyllite and blastomylonite. This fault also passes through the right abutment of dam sites 1 and 2 (Henderson, 1973).

Jointing. There are two main joint sets - one parallels the foliation, the other is steeply dipping and strikes 068-080^{o}. Joints are moderately to closely spaced on the right abutment, but on the left abutment they are fairly tight and widely spaced with smooth planar faces. Irregular discontinuous joints, including exfoliation joints, are common in the larger outcrops. A road-cutting on the Naas Road shows that there is generally a weathering zone up to 30 cm wide adjacent to joints. All joints at and near the surface are ironstained and most contain thin (1 to 2 mm) infillings of chlorite/sericite.

Weathering

The right abutment is covered by a thin silty soil with angular rock fragments and highly weathered rock outcrops. The adamellite at this dam site is more deeply weathered than at dam site 2. The left abutment has a 1 m thick silty soil cover between rounded boulders and outcrops of highly to slightly weathered adamellite. The depth to moderately or less weathered rock is from 1.0 to 5.0 m.

The seismic results (Plate 4) show progressively higher basement velocities towards the river in the right abutment. This probably represents a section through the weathering profile. Equivalent lower-velocity material (2600-3500 m/s) has probably been eroded from the left abutment by the easterly migrating river channel.

ENGINEERING GEOLOGY

Embankment foundation conditions

Left abutment. On the left abutment, fresh rock is 10 m deep, but competent rock should be between 1 and 5 m deep. The intermediate-velocity layer (Plate 4) of 1700-2350 m/s probably represents moderately weathered rock grading into fresh rock (4100-5100 m/s). The irregular margin between moderately weathered and fresh rock may reflect a very irregular profile with large residual boulders of fresh rock within more weathered material.

Right abutment. The deepest seismic refractor detected (3500-3700 m/s) is at a depth of 15-20 m and probably represents a slightly weathered gneissic adamellite.

The 1350 m/s zone at stn 810 m represents a fault zone which can be traced northwards down the spur.

The intermediate-velocity layer of 1400 to 1900 m/s probably represents highly to moderately weathered rock grading into slightly weathered foliated adamellite. Correlation of these velocities with drill core will be required before more accurate depths to rock suitable for a dam foundation can be given. Based on the seismic velocities alone, suitable foundation rock may be 5-12 m deep. Deeper excavation and more extensive foundation treatment will probably be required for this abutment than for the left abutment.

The steep slope combined with the fractured and sheared rocks on the right abutment have resulted in sheet erosion and several areas of superficial land slippage. Below a bench on the slope (at about stn 630) the gradient steepens to 35-40^{o} and slippages in soil and scree have occurred. The potentially unstable loose rock and soil is confined to the 250 to 850 m/s velocity layer. No instability occurs on the left abutment.

Spillway

A proposed spillway is located in the right abutment (Plate 1). The spillway crest traverses a small saddle and the chute will be excavated in a steep gully, entering the Gudgenby River about 250 m downstream of the embankment.

The valley of the spillway approach follows an airphoto-lineament striking 005^{o} which can be traced for 2.2 km (Plate 1). This lineament probably represents a fault or shear zone. The seismic section (Plate 4) shows a fault at station 920 m (1750 m/s), and diamond drilling is recommended to accurately locate the fault and to determine rock permeability. Considerable treatment of foundations will have to be carried out in these areas.

EASTERN WATER-TREATMENT PLANT SITE

The treatment plant (Plate 1) is located on a gently undulating plateau to the east and southeast of dam site 2. The installations will include a clear-water storage reservoir, a treatment plant building, and an area of sludge beds.

GENERAL GEOLOGY

Plate 2 shows the geology of the site. The area is underlain by coarse-grained Tharwa Adamellite, with some minor aplite, quartz, and blastomylonite. The adamellite is foliated parallel to the regional structural trend, and quartz and blastomylonite zones are similarly aligned.

A ferricrete hardpan may be present in the soil, especially below low-lying areas.

Structural information from this site is limited to the scattered moderately weathered outcrops to the north and west. Joint orientations are not known in the area, but they are likely to be similar to those mapped elsewhere on the right abutment (Fig. 5).

ENGINEERING GEOLOGY

Excavation and foundation conditions

Hand augering in soil-covered areas (for location see Plate 2) indicates that up to 2-3 m of gravelly clay and extremely weathered rock overlie highly to moderately weathered adamellite. Figure 12 shows the logs of the hand auger holes.

Seismic results indicate that 10 m of highly weathered rock (seismic velocity 800-1400 m/s) and 15-20 m of moderately weathered rock (2200 m/s) overlie slightly weathered rock at 25-30 m. The seismic section indicates that a series of parallel shear zones intersect the area (Plate 4).

For the treatment plant and clear-water storage reservoir, excavation to rock suitable for foundation at 3 m depth will be possible with a minimum of blasting. The seismic velocity of the overlying silty, sandy gravel and extremely weathered adamellite is 350-400 m/s. The highly to moderately weathered adamellite is strong enough to support the planned structures (1200-1400 m/s).

Groundwater

Several small swampy seepage areas were noted in the field (Plate 2). These areas would probably be saturated after periods of heavy rain owing to perched water-tables forming on the clay or hardpan layers in the soil.

WESTERN WATER-TREATMENT PLANT SITE

The treatment plant site covers two rocky hills and an adjoining saddle on the western side of the Naas Road northwest of dam site 2 (Plate 1).

GENERAL GEOLOGY

Lithology

The site (shown on the left-hand side of Plate 2) is underlain by foliated, medium to coarse-grained adamellite which has a variable composition and texture. The compositional variation is due to the amount of biotite in the rocks. Textures vary from porphyritic with unoriented plagioclase phenocrysts up to 3 cm in length, to foliated and gneissic. The gneissic varieties are found on the northern hill, while adamellite with poorly defined foliation is found to the south.

Outcrop covers at least 40 percent of the upper part of the hills, and comprises large, rounded to elongate moderately to slightly weathered boulders projecting up to 3 m above ground surface. Downslope, the outcrops are flatter and more scattered with occasional loose blocks and flat soil-covered benches. Steeper areas are generally rocky.

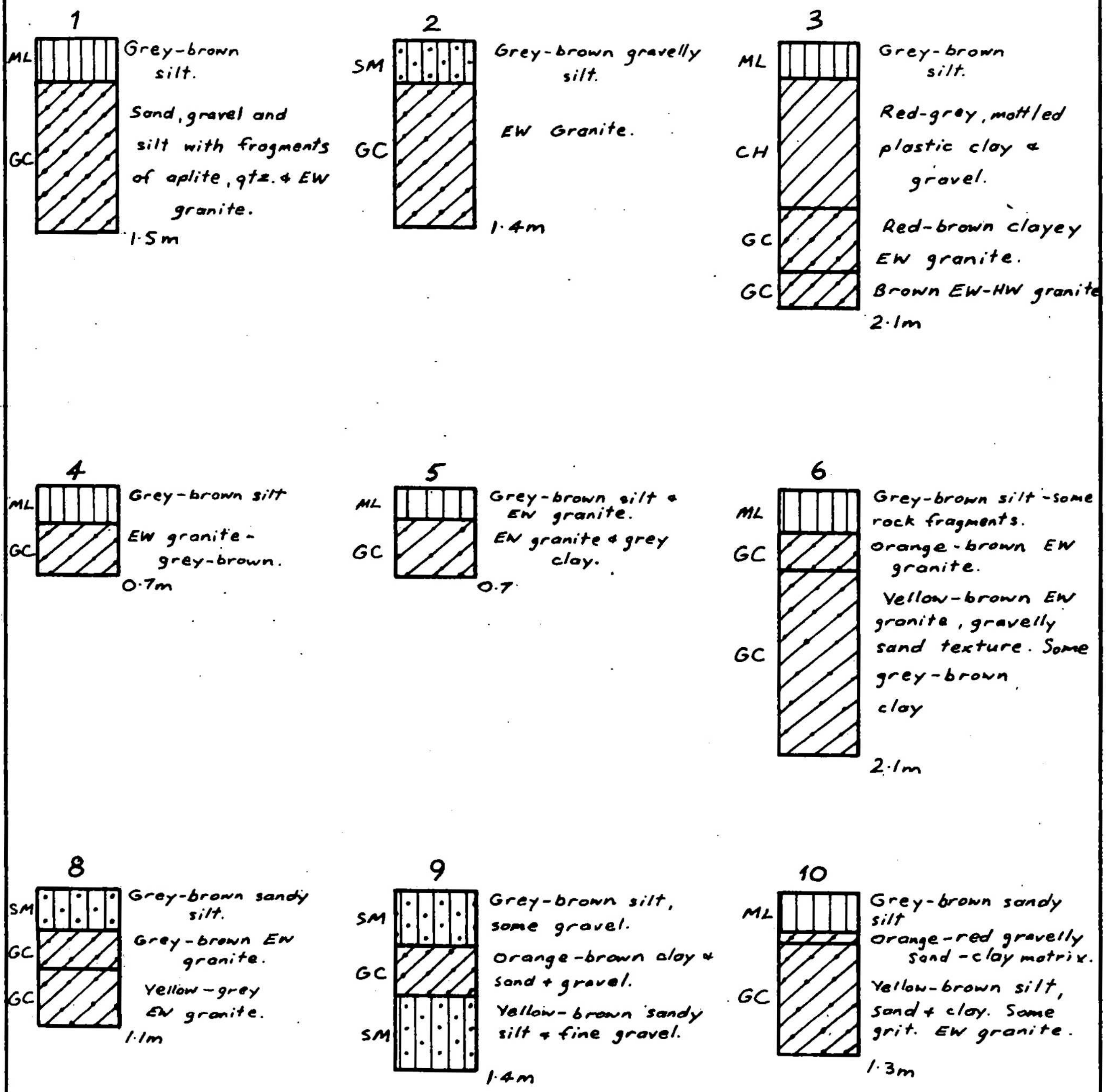
Structure

Foliation in the adamellite dips vertically and trends at 322-356^{o}. Joints are widely spaced and continuous with smooth planar to curvilinear surfaces; most are tight with no infillings. There are two main joint directions: one parallel to the foliation along which the rocks tend to weather; and an east-west near-vertical set. Subhorizontal joints occur but are not commonly exposed. Closer jointing parallel to the foliation on the northwestern side of the southern hill may indicate a shear zone in the saddle. A small northwest trending shear zone associated with aplite and quartz veins occurs to the east of the site near the Naas Road.

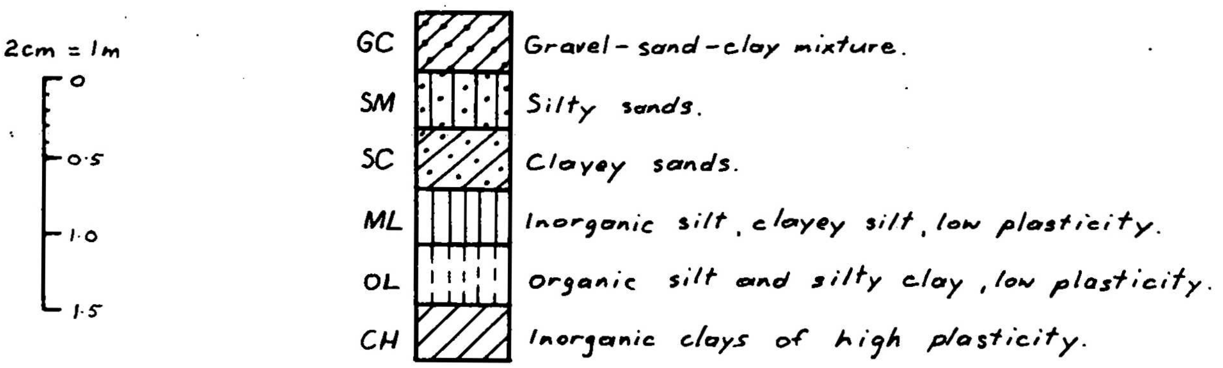
Weathering

Rock at the surface is commonly moderately to slightly weathered, with the more weathered rock in closely jointed or sheared areas. The weathering profile is expected to be most irregular at this site, with fresh adamellite core stones surrounded by soil and extremely weathered rock. Deeper weathering is expected in the saddle area and along shear-zones.

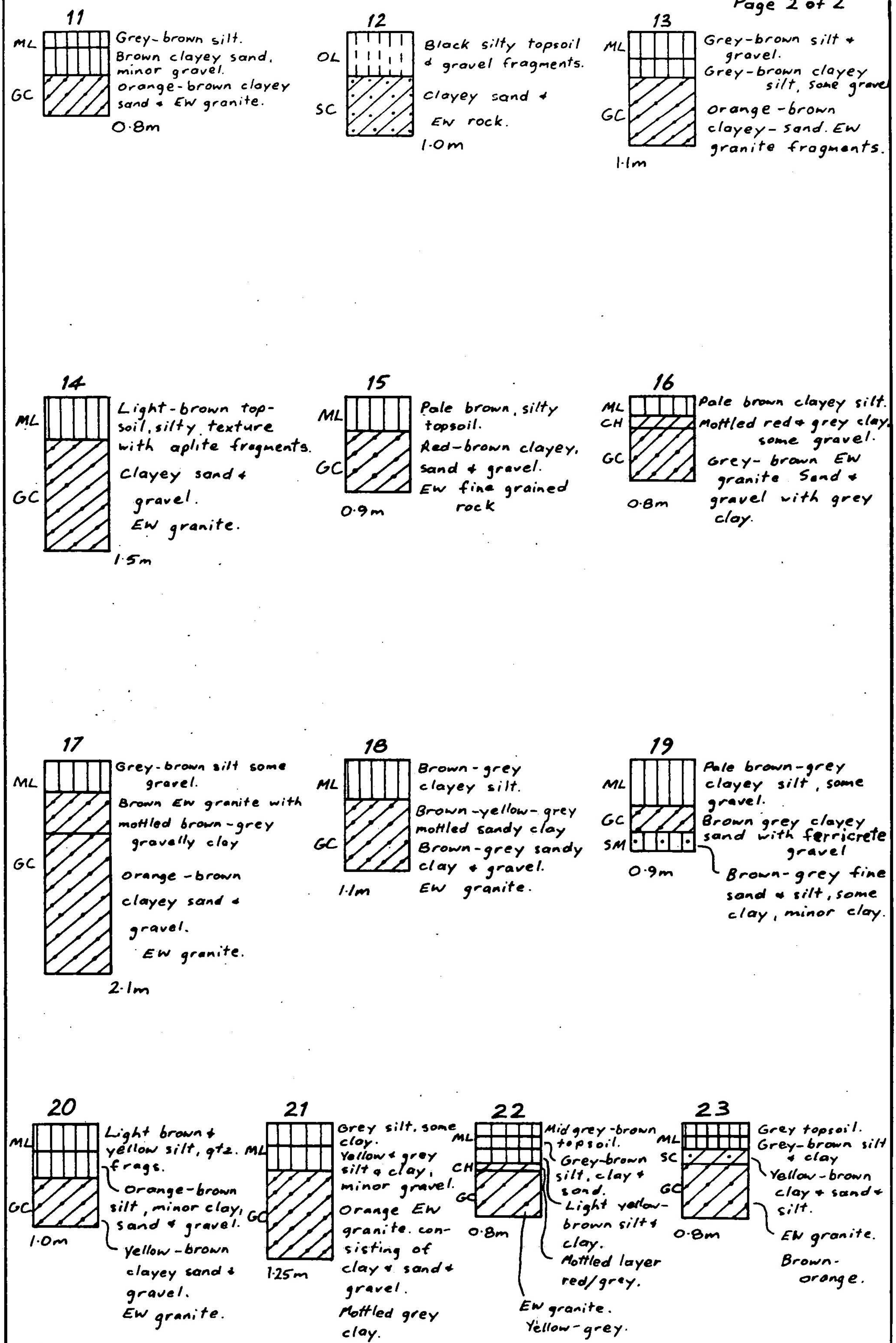
TENNENT DAMSITE
WATER TREATMENT PLANT SITE
LOGS OF AUGER HOLES



SOILS ARE CLASSIFIED ACCORDING TO THE UNIFIED SOIL CLASSIFICATION SYSTEM



For location of auger holes see Plate



EW Extremely weathered

HW Highly weathered

Record 1977/18

155/A16/1691

FIGURE 12b.

ENGINEERING GEOLOGY

Excavation and foundation conditions

Treatment plant construction would necessitate an excavation of up to 20 m, and blasting would be required; however, the material would be suitable as rockfill for the dam.

Treatment conditions should be adequate to support the planned structures, although the deeper weathering of material in the saddle may cause problems of differential settlement; the depth of highly weathered rock and soil in the saddle should be ascertained by seismic traverses or drilling, or both.

Groundwater

The only area likely to have a groundwater drainage problem lies on the northeastern side of the saddle. The organic clays in this area are saturated after heavy rain. The problem would be a minor one, as excavation would remove much of the soil anyway.

CONSTRUCTION MATERIALS

The investigation of Tennent dam site 1 (Henderson, 1973) included an assessment of nearby sources of construction materials. Suitable quantities of rock fill (Henderson, 1973) and earch core material (McDevitt, 1970) were found for this proposed dam of 68 m height, but additional sources of construction materials will be required for the proposed dam sites 2 and 3 as their embankments are larger than the original site 1.

Locations of potential quarry sites and earthfill borrow areas are shown in Plate 1.

ROCKFILL

For the dam construction, a quarry site upstream of the proposed embankment is favoured, so that subsequent filling of the reservoir will submerge the excavation. Unfortunately there is insufficient volume of rockfill in the reserves so far investigated below the proposed reservoir level of 680 m. A quarry must be sited on the western side of the Gudgenby

River as the rock quality is much better than in the more sheared rock to the east.

Quarry sites A, B, and C could provide about 1.4 million cubic metres (m^3) of rockfill for dam site 2 but the suitability of the material should be confirmed by drilling. Additional reserves of rockfill are available from quarry sites D and E.

Quarry sites D and E, totalling about 750 000 m^3 of rockfill are the only ones below 680 m near dam site 3.

Quarry site F could provide 1.1 million m^3 of rockfill from excavations for the water-treatment plant. Site G, downstream of the dam sites, could provide a further 400 000 m^3 of rockfill, and could provide a source for rockfill for future extensions of the dam.

A number of sites on the lower slopes of Mount Tennent and above the existing road would certainly yield sufficient quantities of rock. Another source of rockfill would be from the excavation for the spillways if they could be located west of the river. At dam site 2, a spillway in the saddle skirting the area west of the water-treatment plant site could provide much of the 2.6 million m^3 of rockfill. This solution is not possible for the west abutment of dam site 3 as excavation would be greatly increased.

EARTH CORE MATERIAL

The materials sampled and tested for earth core material were found to be suitable in four areas (McDevitt, 1970). Area 1 about 1.2 km east of the dam sites contains about 400 000 m^3 of alluvium and decomposed adamellite; a disadvantage of this area is that it is outside the reservoir area.

Area 4, the extensive area adjacent to quarry site A, contains thin deposits of suitable material, but the volume is small. Other possible borrow areas, all within the bounds of the reservoir, lie 3-6 km upstream of the dam sites; however, the deposits are thin and a considerable area would have to be stripped to obtain the 600-700 000 m^3 required.

FILTER ZONE MATERIAL

The main source of filter zone material could be the deposits of sand and gravel in the flood plains and beds of the Gudgenby and Naas Rivers, particularly at the confluence of the two rivers. Crushed rock from the rockfill quarry could also provide satisfactory filter zone material.

SEISMICITY

The seismic activity of the Canberra region is low, with magnitude readings rarely exceeding 3 on the Richter scale (Table 2). The Dalton-Gunning area, 90 km to the north, is a more seismically active area with frequent minor tremors associated with faults along the margins of the Murrumbidgee Batholith. Epicentres have been located close to the Murrumbidgee Fault Zone in the vicinity of the proposed dam sites.

Filling of the dam reservoir is likely to create an initial slight increase in seismicity for the area, but the expected accelerations can be allowed for in design and will not be a constraint on development.

TABLE 2. RECENT EARTHQUAKES*

Date	Lat.	Long.	Magnitude (Richter)	Depth (km)
2/7/60	36.610S	149.100E	2.30	8
9/8/60	35.770S	149.120E	2.80	1
28/4/62	35.460S	149.010E	2.30	10
3/4/68	35.430S	149.030E	1.80	1
11/9/68	35.550S	149.200E	2.50	1
1/3/71	35.490S	149.010E	2.10	1
11/3/75	35.500S	149.060E	5	3
21/5/75	35.610S	149.050E	5	12

* To 30/6/76

CONCLUSIONS

1. Both of the dam sites would be geologically suitable for construction of an earth and rockfill dam; from investigations to date, the more suitable site appears to be dam site 2.

2. Extensive excavation and foundation treatment will be necessary.

(a) Dam site 2 requires the removal of only 1 to 2 m of soil and loose rock from most of the left abutment, except where deeply weathered rock occurs in the gully on the upstream side of the left abutment and where open-jointed rock occurs on most of the right abutment. In these areas stripping to depths of up to 20 m will be necessary.

(b) Dam site 3 will also need extensive stripping on the right abutment.

(c) Grouting and dental treatment required to provide sound foundations and a smooth profile will be considerable on the right abutments at both sites.

(d) The river channel of dam site 2 will require stripping of 6-8 m of alluvium and boulders.

Abutments

3. (a) The stability of the left abutments of both dam sites is satisfactory. (b) The right abutment at dam site 2 contains an unstable zone of loose rock and soil to a depth of 10-15 m. (c) Sheet erosion and numerous small superficial slides characterise the right abutment of dam site 3, but do not indicate a stability problem.

Spillways

4. Suitable sites for the construction of a spillway exist in gullies to the east of each dam site; however, subsurface information is only available from the spillway crest areas, and the investigation of spillway foundations will require diamond drilling.

Diversion

5. Dam site 2 has a wide alluvial terrace within which to construct a diversion conduit. Dam site 3 will require a diversion tunnel which could be constructed on either abutment; tunnelling conditions are expected to be less favourable in the right abutment, but would be good in the left abutment if the tunnel is in rock within the 4100 m/s layer.

6. The two water-treatment plant sites have rock suitable for plant foundation within 3 m of the surface. The eastern water-treatment plant requires the least excavation, and the material is suitable for mechanical excavation. The western site will involve an excavation of about 20 m to conform to design water-levels; most of this rock will require blasting, but rock fill for the dam could be obtained from here.

7. Deposits of sand and gravel suitable for filter material and deposits of clay for core material, are located upstream of the proposed dam sites.

8. Sufficient rockfill should be available from quarry sites on the western side of the Gudgenby River; however, no single quarry site has enough rock for the dam construction.

9. Additional rock could be derived from quarries on the slope of Mount Tennent, or by the extension of quarries A-C to the west. Additional drilling would be required to prove the quality and quantity of material. If the spillway were to be placed on the west abutment the excavation for the spillway would provide all the rock fill for the dam embankment.

RECOMMENDATIONS

It is recommended that :

(1) The final choice between dam sites 2 and 3 be deferred until the results of diamond drilling are available from both sites, particularly the right abutments.

(2) Seismic refraction surveys of the rock fill quarry sites be carried out to enable more accurate assessments of rock quality and quantity.

(3) Seismic refraction surveys be carried out at the proposed treatment plant sites.

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APPENDIX 1

GLOSSARY OF GEOLOGICAL TERMS

(summarized from Gary et al., 1972)

Blastomylonite. A mylonitic rock (see below) in which some recrystallisation and/or neomineralisation has taken place.

Exfoliation. A process by which thin (from less than a centimetre to several metres), concentric sheets of rock are successively broken loose from the outer surface of a larger rock mass.

Foliation. A general term for a planar arrangement of textural or structural features in any type of rock.

Hardpan. A general term for a relatively hard, impervious, and often clayey layer of soil lying at or just below the surface. It comprises soil particles cemented by relatively insoluble, precipitated materials such as silica, iron oxide, calcium carbonate, and organic matter.

Mylonite. A compact chert-like rock without cleavage, but with a streaky or banded structure, produced by the extreme granulation and shearing of rocks that have been pulverised by the action of intense, dynamic metamorphism.

Pegmatite. An exceptionally coarse-grained igneous rock, with interlocking crystals, usually found as irregular dykes, lenses, or veins, especially at the margins of batholiths.

Slickenside. A polished and smoothly striated surface that results from movement along a fault plane.

Xenolith. An inclusion in an igneous rock that is not genetically related to the surrounding material.

APPENDIX 2

DEFINITION OF SEMI-QUANTITATIVE DESCRIPTIVE TERMS

Grain size	
Coarse-grained	1 mm to 4 mm in diameter
Medium-grained	¼ mm to 1 mm in diameter
Fine-grained	Less than ¼mm in diameter
Hardness of rock	
Hard to very hard	Impossible to scratch with a knife blade
Moderately hard	Shallow scratches with a knife blade
Soft	Deep scratches with a knife blade
Joint spacing	
Very close	Joints spaced less than 5 cm
Closely spaced	Joints spaced between 5 cm and 30 cm apart
Moderately spaced	Joints spaced between 30 cm and 1 m apart
Widely spaced	Joints spaced between 1 m and 3 m apart
Very widely spaced	Joints spaced more than 3 m apart
Percussive strength of rock	
Strong to very strong	Rock abrasive, rings when struck (by hammer)
Moderately strong	Rock abrasive; dull ring when struck
Weak	Rock deformed and/or split when struck firmly
Very weak	Rock deformed and/or split when struck gently

Weathering of rock

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

APPENDIX 3

WEATHERING OF GRANITIC ROCK TYPES

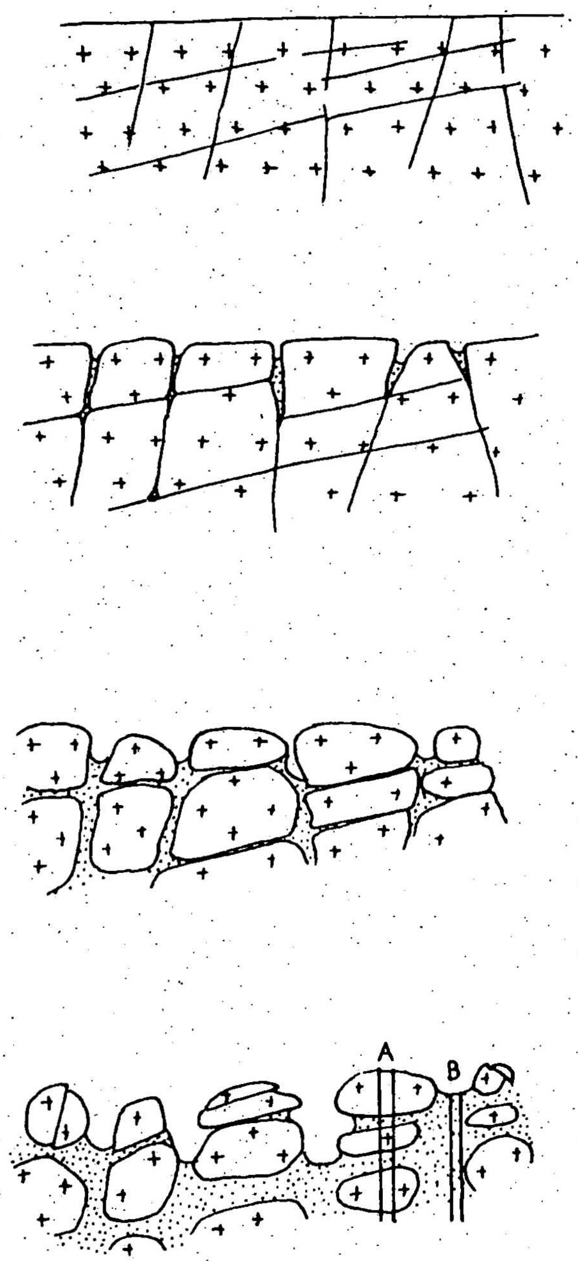
Granitic magmas form and cool at high pressures deep within the Earth's crust. Joints develop as the magma cools, and subsequent uplift and erosion brings these rocks close to the ground surface, where unloading joints develop to form granite blocks. Chemical weathering proceeds along these joint planes, leaving boulders of unaltered granite surrounded by extremely weathered rock.

Figure A is a cross-section through a typical granite outcrop which shows the stages of weathering and the formation of core stones. Quartz is not altered in the weathering process, but feldspars and mica decompose into clay minerals.

As illustrated also in Figure A, it is difficult to determine the depth to suitable foundation rock and to predict excavation conditions. The seismic refraction technique can only give an approximate depth to rock as the method averages out minor velocity differences, and drilling is likely to give an inaccurate picture of the general subsurface conditions, as shown in Figure A. The seismic technique and drilling are, however, useful indicators of general rock conditions.

Comparison of seismic velocity with degree of weathering

Seismic velocity, m sec-1	Material
200-1000	Soil or slopewash
850-1100	Extremely to highly weathered
1000-1400	Highly weathered
1350-2350	Highly to moderately weathered, irregular zone with less weathered core stones surrounded by more weathered zones. Velocity also depends on the extent of jointing
1650-2700	Highly to moderately weathered faults or sheared zones bounded by fresh rock at depth
3250-3800	Slightly weathered
4100-5800	Fresh or fresh stained



1. Fresh, jointed granite.

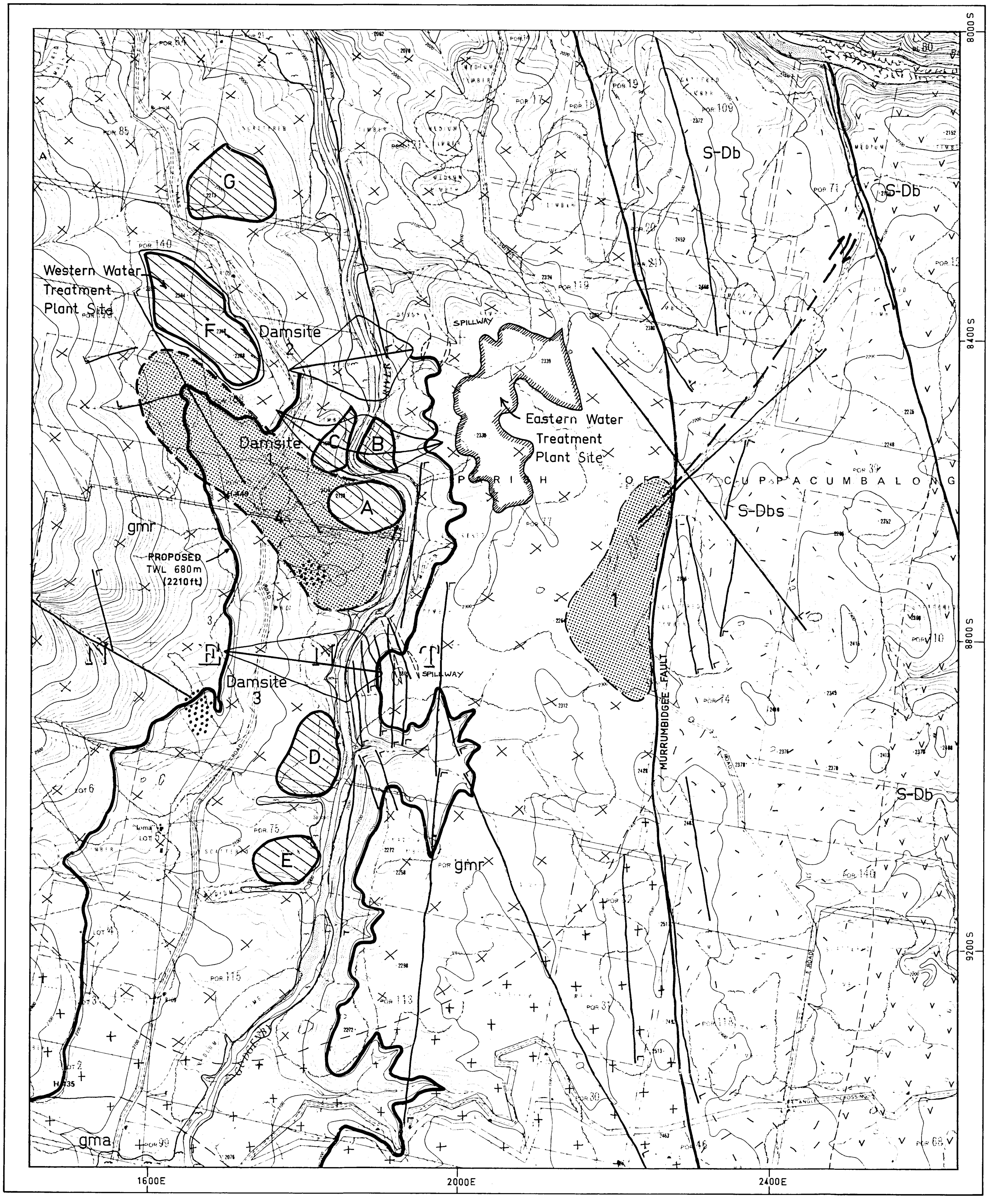
2. Water percolates into joints where weathering takes place.

3. Weathering advances along joint planes, and soil is washed away at the surface with resulting tor development.

4. Tors are well developed and residual fresh rock is surrounded by weathered material Drill holes A and B show how investigations in granite can be misleading.

WEATHERING IN GRANITIC ROCKS

REGIONAL GEOLOGY
SHOWING PROPOSED TENNENT DAMSITES
GUDGENBY RIVER, A.C.T.



LEGEND

S-Db	Bransby Beds; rhyolitic tuff
S-Dbs	Bransby Beds; siltstone, sandstone
× gmr	Tharwa Adamellite
+ gma	Clear Range Granodiorite

- - - - Geological boundary

Fault showing movement

Air-photo lineament

SCALE

0 100 200 300 400

METERS

N MN

(A) Quarry site

(1) Earthfill borrow area

Gravel deposit (weathered granite)

PLATE 1

AMENDMENTS			
No.	Description	Author	Checked
A1			
A2			
A3			
A4			
A5			

SCALE

Base map/survey A.C.T. PLANNING SERIES No P73

Geology by Henderson, Richardson, Briscoe, Goldsmith

Compiled and checked G. Briscoe and R. Goldsmith, Project geologist

Checked and approved D.C. Purcell, Senior geologist

E.G. Wilson, Supervising geologist

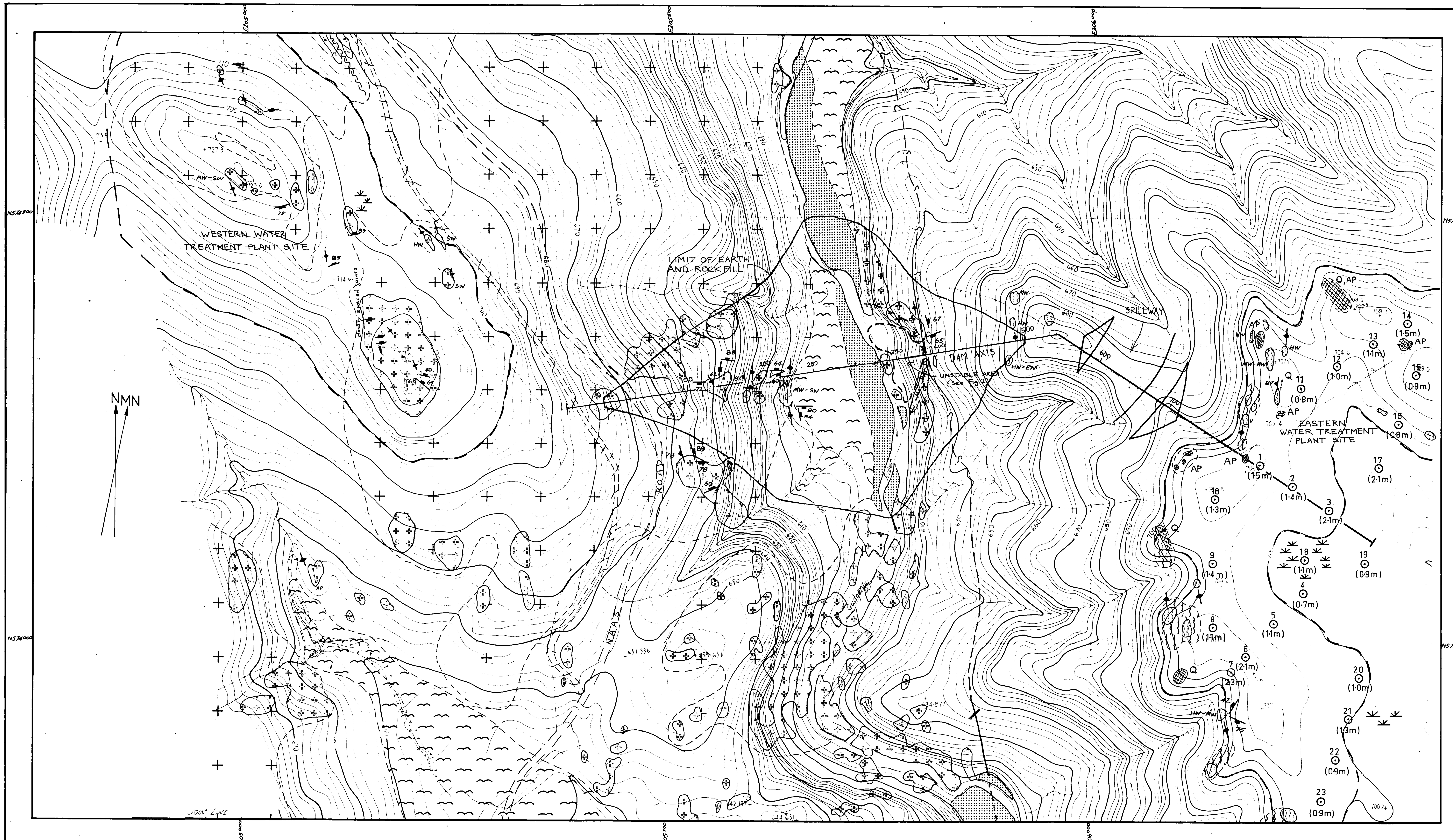
COMMONWEALTH OF AUSTRALIA
BUREAU OF MINERAL RESOURCES
CANBERRA, A.C.T.

TITLE Regional Geology

PROJECT Tennent Damsites

To accompany	Drawn by	Drawing No.
Record 1977/18	M.E.	155/A6/1692

TENNENT DAMSITE 2 GEOLOGICAL MAP OF PROPOSED SITE



LEGEND

- sand and gravel
- terrace alluvium
- adamellite, >50% outcrop
- adamellite, scattered outcrops and rubble
- sheared adamellite, >50% outcrop
- sheared adamellite, scattered outcrops, rubble and colluvium
- dykes; Q=quartz, AP=aplite
- outcrop
- geological boundary, position accurate
- geological boundary, position approximate
- fault, position accurate
- fault, position approximate
- fault, position inferred
- unstable zone
- shear zone
- foliation, showing dip
- foliation, vertical
- joint, showing dip
- joint, vertical
- vein, Q=quartz, AP=aplite
- 4 (0·7m) hand auger hole, showing depth to refusal
- seismic traverse
- -650- contour, in metres above sea level
- +634 877 spot height, instrument levelled
- road
- track
- fence
- creek
- poorly drained area

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

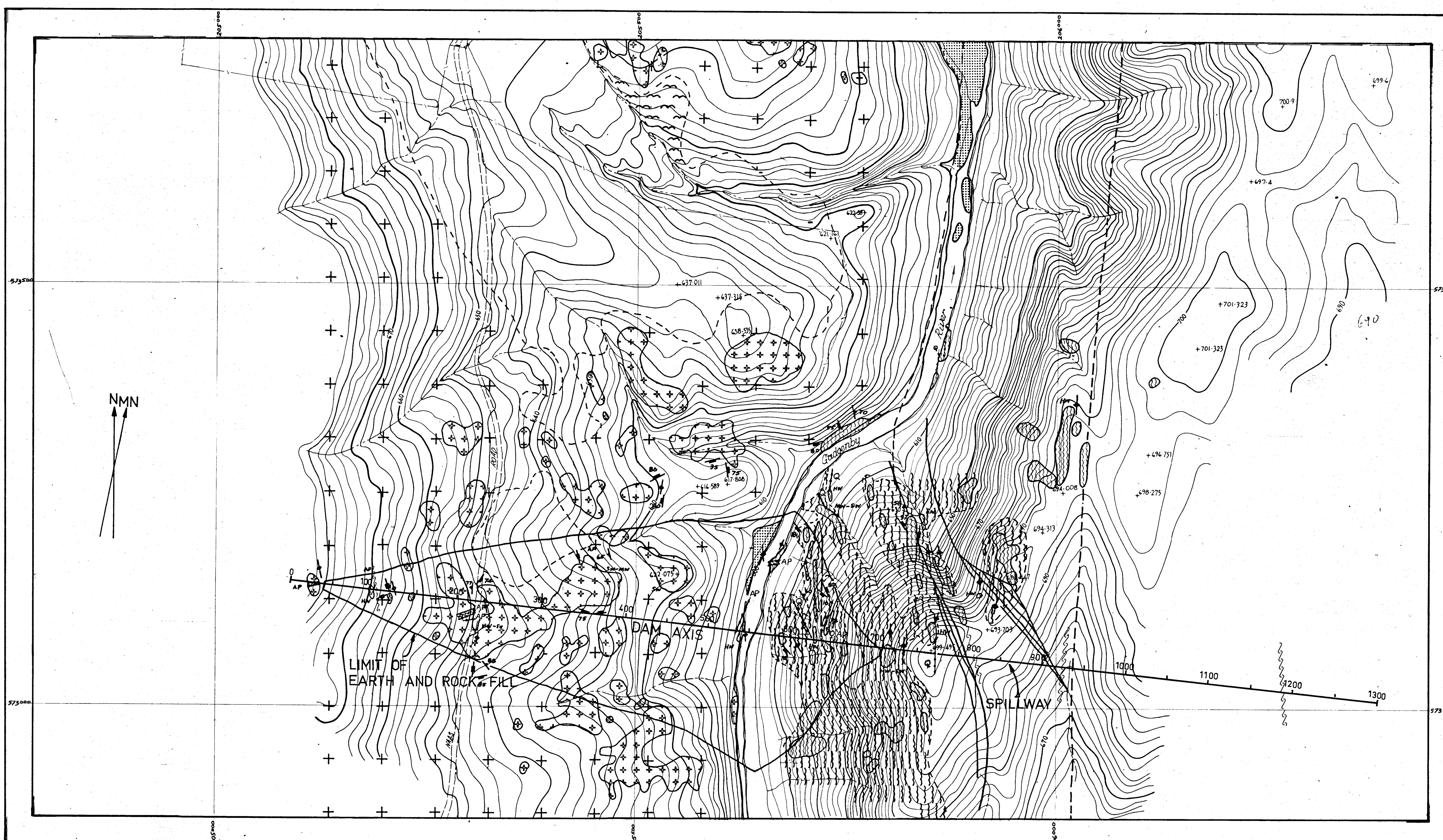
50 0 50 100 150

SCALE 1:2500

PLATE 2

AMENDMENTS		
Dep. Serv. Prop. No. L638	COMMONWEALTH OF AUSTRALIA **BUREAU OF MINERAL RESOURCES** CANBERRA, A.C.T.	
R.C.M.G & G.B.	Preliminary investigations of Tennent damsite 2 Gudgenby River	
R.C.M.G. G.B. / D.C.P.	TENNENT DAMSITE	
E.G.W.	To accompany record 1977/18	Drawn by M.Elliston / Drawing number 155/A16/1693

TENNENT DAMSITE 3 GEOLOGICAL MAP OF PROPOSED SITE



LEGEND

- sand and gravel
- terrace alluvium
- adamellite, >50% outcrop
- adamellite, scattered outcrops and rubble
- sheared adamellite, >50% outcrop
- sheared adamellite, scattered outcrops, rubble and colluvium
- dykes; Q=quartz, AP=aplite
- outcrop
- geological boundary, position accurate
- geological boundary, position approximate
- fault, position accurate
- fault, position approximate
- -?- fault, position inferred
- unstable zone
- shear zone
- foliation, showing dip
- foliation, vertical
- joint, showing dip
- joint, vertical
- vein, Q=quartz, AP=aplite
- 4 (0·7m) hand auger hole, showing depth to refusal
- seismic traverse
- -650- contour, in metres above sea level
- +634·877 spot height, instrument levelled
- road
- track
- fence
- creek
- poorly drained area

DEGREES OF ROCK WEATHERING

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

50 0 50 100 150

SCALE 1:2500

PLATE 3

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

SCALE

BASE MAP/SURVEY: Dep. Serv. Prop. No. L638/1

GEOLOGY BY: R.C.M.G & G.B.

COMPILED AND CHECKED: R.C.M.G. G.B. PROJECT GEOLOGIST

CHECKED AND APPROVED: D.C.P. SENIOR GEOLOGIST

E.G.W. SUPERVISING GEOLOGIST

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

TITLE: Preliminary investigations of Tennent damsite 3, Gudgenby River

PROJECT: TENNENT DAMSITE

TO ACCOMPANY RECORD: 1977/18

DRAWN BY: M.Elliston

DRAWING NUMBER: 155/A16/1694

TENNENT DAMSITES 2 AND 3

SECTIONS SHOWING SEISMIC DATA AND INTERPRETATIONS

SEISMIC DATA

5200 Seismic velocity in m/s

Seismic refractor boundary

Seismic discontinuity

GEOLOGY

Alluvium

Adamellite

Foliated adamellite

Geological boundary

SS 5 Survey station

SCALE 1:1000 $V/H=1$

0 50 100

METRES

PLATE 4

AMENDMENTS			
No.	Description	Author	Checked
A1			
A2			
A3			
A4			
A5			

SCALE

Base map/survey

Geology by R.C.M.G. & G.B.

Compiled and checked R.C.M.G. & G.B. Project geologist

Checked and approved D.C.P. Senior geologist

E.G.W. Supervising geologist

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

TITLE SECTION SHOWING SEISMIC DATA AND INTERPRETATION

PROJECT Tennent Damsites 2 and 3

To accompany Record 1977/18 | Drawn by M.E | Drawing No. 155/A16/1695