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Record 1975/38

GEOLOGICAL INVESTIGATION OF TUGGERANONG DAMSITE, MURRUMBIDGEE RIVER, A.C.T. 1968

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SUMMARY

A preliminary investigation of a damsite at Tuggeranong on the Murrumbidgee River has proved hard fresh rock (rhyolitic tuff) in the river bed, and weathered rock on the abutments and in two saddles which are possible spillway locations. There are few structural defects in the foundation, which is suitable for construction of an earth and rockfill dam. The geology of the reservoir area has been mapped and there is considered to be little likelihood of leakage from, or landslips in, the reservoir. There are sufficient quantities of fill material within 12 km of the damsite.

INTRODUCTION

A preliminary geological investigation of a possible damsite on the Murrumbidgee River was undertaken between December 1967 and March 1968 by J.R. Mendum assisted by two students, R.C. Price and D.N. Carter. C.E. Newbigin carried out a detailed petrological investigation of rocks from the damsite (Appendix 1).

Geophysical traverses indicate that the rhyolite on the higher flanks of the damsite is weathered to a depth of 18 m in places, and this estimate has been confirmed by auger drilling. The deeply weathered rhyolite contrasts markedly to the strong fresh closely-jointed homogeneous rock the gorge area near river level. The few open joints and shear zones in the gorge are small and are not deeply weathered.

LOCATION AND ACCESS

The proposed site is on the Murrumbidgee River (Fig. 1), 1 km downstream from its confluence with Tuggeranong Creek. The dam embankment would extend from the spur west of Tuggeranong Creek in the north to the low undulating ridge northeast of Freshford homestead in the south (Plate 1). The axis would describe a curve, concave westwards, in the northern part (Fig. 2).

The proposed dam would have a maximum height of 70 m in the river gorge, but would only be 15 m high on the flanks of the gorge. The proposed top water level at 591 m would create a reservoir extending upstream to Angle Crossing on the Murrumbidgee River and the proposed Tennent damsite on the Gudgenby River (Fig. 1) and containing 600 million m^3 of water.

Access to the site is from the north via Kambah Road and Urambi homestead or from the south via Freshford homestead (Pl. 1).

TOPOGRAPHY

The river at the damsite flows through a cleft 6 m in the floor of a U-shaped gorge 28 m deep. The gorge is flanked by undulating grassy hills with few steep slopes (Fig. 2). About 1.5 km north of the damsite a series of small, rather conical hills reach a height of 718 m, whereas to the south the country is gently undulating for several kilometres. In the west the Murrumbidgee Fault is marked by a steep scarp rising to a height of 900 m; the scarp is deeply dissected by numerous small creeks. Small alluvial fans deposited at the foot of the scarp by the creeks could provide a source of core material for the dam. To the east of the damsite much of the area is very flat and swampy.

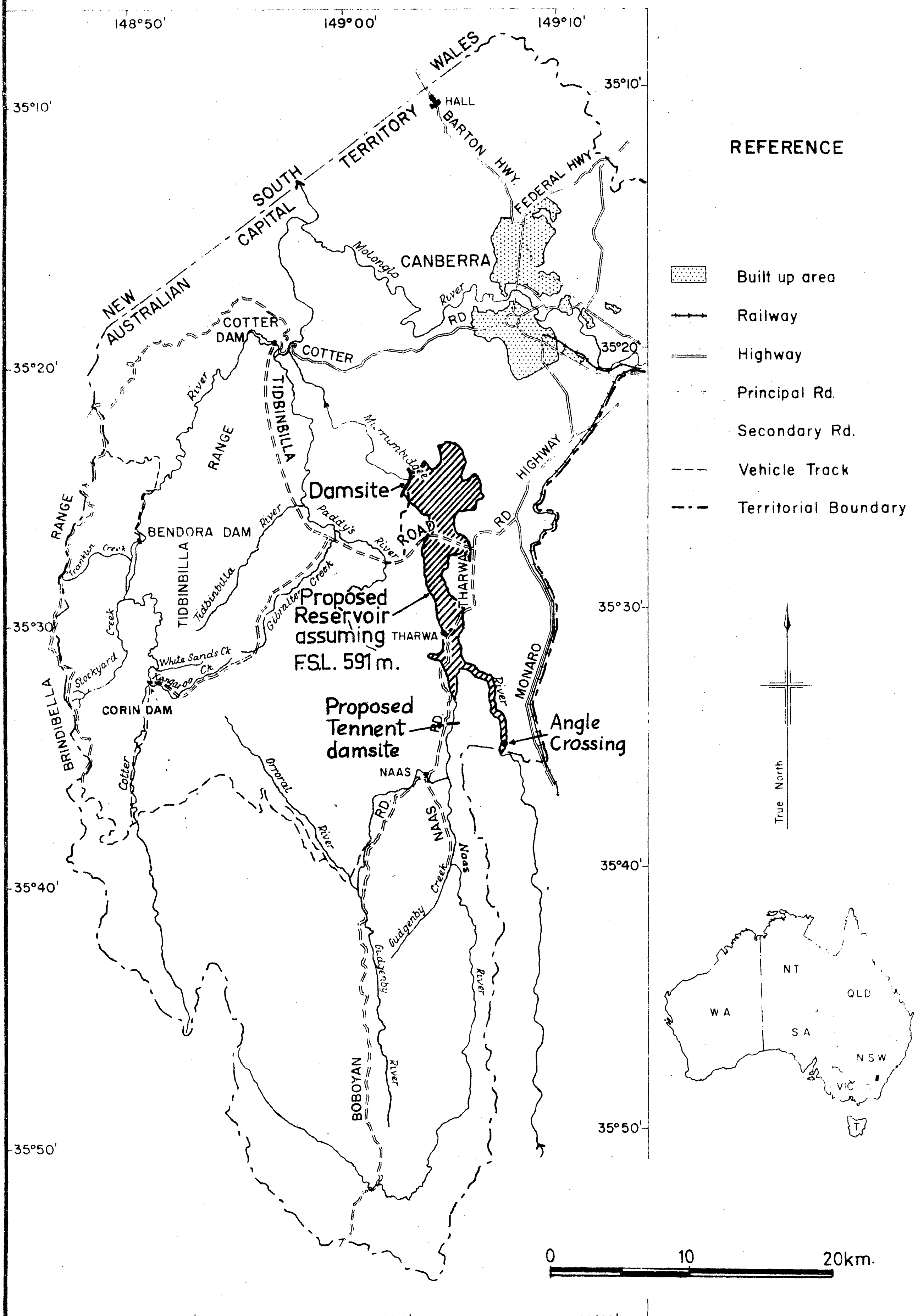
The course of the Murrumbidgee River is largely controlled by faults and dominant joints. Although many of the faults may only have a small displacement, they are characterized by wide zones of shattered and epidotized rock. The fault or shear zones have weathered deeply and have been eroded more easily than the surrounding massive rhyolitic tuff.

The creeks and major river courses show evidence of recent rejuvenation. Thick deposits of stream gravel were found several kilometres upstream in Tuggeranong Creek, indicating downcutting of at least 4 m at that point. Cross-bedding was observed in the finer gravels. Incised meanders occur in the lower reaches of the creek.

Much of the reservoir area is at present grazing land, and in the low-lying areas some crops are grown. The natural vegetation ranges from open bushland with scattered eucalypts in the east to eucalypt forests on the Murrumbidgee scarp.

Fig. 1

TUGGERANONG DAMSITE
LOCALITY MAP



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REGIONAL AND RESERVOIR GEOLOGY

STRATIGRAPHY AND LITHOLOGY

The geology of the district is divided into two major units by the Murrumbidgee Fault which separates the late Silurian-early Devonian Murrumbidgee Batholith of granitic rocks to the west from the Silurian and Devonian volcanic and sedimentary rocks to the east (Plate 1). The latter unit is of greater importance in the area considered. The geological map of the reservoir area was compiled from reports by Mackenzie (1966) and Jephcott (1966) and supplemented by detailed mapping in the north during the damsite investigation.

Silurian volcanic rocks crop out mainly in the flat-lying area east of the river. Good exposures of dark purple to dark grey welded tuff are found on residual hills including Stranger and Tuggeranong. The sequence is predominantly a dellenitic tuff and is generally of uniform lithology through the area; it consists of small quartz and altered feldspar phenocrysts set in a fine-grained dark-grey or purple matrix. The matrix is commonly stained with iron oxides and, in places contains small grains of biotite. The tuff is cut by several shear zones characterized by epidote veins 1 cm thick and, in places, by complete alteration of the rock mass to epidote. Undeformed elongate epidotized pods of dellenitic and rhyolitic tuff occur in an otherwise completely sheared rock. The sequence is thought to be Silurian in age by comparison with other similar tuffs of that age, and is unconformably overlain by Devonian volcanic rocks. Farther south, in an area west of the Murrumbidgee River and east of the batholith, is a zone of completely sheared or mylonitized tuff. This is probably a sheared equivalent of the Silurian dellenitic tuff.

Silurian sedimentary rocks crop out in an anticlinal inlier at Point Hut Crossing (Plate 1) and are also exposed south of Tharwa in association with the Silurian tuffs. At Point Hut a sequence of beds dipping steeply west is exposed in the river bed. The basal member is a thickly-bedded hard massive white to brown sandstone with small intercalations of volcanic ash. It is overlain by a concordant succession of laminated calcareous and non-calcareous dark grey slaty shale with a well defined cleavage that dips 80° southwest and strikes 346°. Volcanic ash becomes more abundant high in the succession. Slump structures occur in the shale and ash, indicating a possible northwesterly origin for the sediments. Higher in the sequence are thinly-bedded fine-grained sandstone, siltstone and a thin bed of impure limestone. The sandstone exhibits graded bedding which shows that the beds are not inverted.

Overlying this sequence at Point Hut is tuffaceous sandstone containing probably Silurian fossils including brachiopods and the corals Favosites and Cystiphyllum. A similar, but unfossiliferous, tuffaceous sandstone crops out near Pine Island, south of a prominent fault (Plate 1).

The unconformity separating the Devonian and Silurian sequence is exposed at Point Hut Crossing, where gentle east-dipping, very fine-grained grey rhyolite overlies steep west-dipping Silurian sedimentary rocks. The basal Devonian rhyolite has a maximum thickness of 3 m and is exposed from the northern extremity of the reservoir area to the southern slopes of Mount Gigerline. The contact of the rhyolite with the overlying massive coarse-grained rhyolitic welded tuff varies from a gradual change with increasing grainsize in the north, to a sharp demarcation farther south near Point Hut Crossing.

Mackenzie (1966) has established the age of the tuff sequence southeast of Tharwa, where it conformably overlies shale and sandstone of early Devonian age. The shale and sandstone wedge out northwards leaving the Devonian tuffs resting unconformably on the Silurian sequence. The massive Devonian rhyolitic welded tuff, although showing some variation in lithology near its base, is a uniform widespread rock type extending from beyond the southern slopes of Mount Gigerline to north of Kambah Pool.

The damsite is wholly underlain by the massive Devonian tuff which consists of quartz with subsidiary plagioclase and orthoclase phenocrysts in a dark grey mainly alkali-feldspar matrix. The rock is fresh except in the numerous shear zones. Quartz phenocrysts are prominent on weathered surfaces. providing a good criterion for recognition; however, some of the Silurian tuffs to the northeast and southwest also exhibit this feature. In fresh exposure many xenoliths are apparent in the rhyolitic welded tuff; most are purple and similar in composition to the host rock but some are coarse-grained and others cryptocrystalline. Chlorite blebs are common in places.

In a downfaulted basin at Pine Island is a series of thinly bedded, commonly banded, fine-grained rhyolite tuffs. The light to dark green tuffs contain turquoise, purple, and grey abraded angular fragments of volcanic material (many with large resorption rims). They also contain large agglomerate fragments. The rhyolite tuff sequence is probably the result of a late-stage explosive extrusion of glassy rhyolitic material from a nearby vent, the volcanic glass being partly resorbed into the tuff before and during extrusion. The partial rounding of the grains and the potash feldspar-rich matrix possibly indicate a diatreme explosion. This rock represents the last volcanic extrusive event in the area.

Intrusive rocks in the area range from adamellite quartz-feldspar porphyry to aplite. The quartz-feldspar porphyry is well exposed southeast of Tharwa, where it is intruded between the Silurian and Devonian sequence. There is also a small occurrence in the north near Kambah Road. The rock consists of large quartz, biotite, and feldspar phenocrysts, the latter commonly 1 cm in diameter, set in a fine-grained dark green-grey groundmass. It corresponds to adamellite in composition and may be termed a dellenite porphyry.

The Siluro-Devonian Murrumbidgee Batholith has been described by Snelling (1960) who gives a detailed petrological and petrochemical account of the various components. The age of intrusion of some of the components of the batholith has been determined as 395 ± 3 million years.

The Tharwa Adamellite, a late-stage intrusive of the Murrumbidgee Batholith, crops out in the reservoir area. It is a biotite adamellite with a primary foliation cut by a secondary shear foliation that increases in intensity towards the Murrumbidgee Fault.

Younger aplite, which occurs in the batholith, also intrudes the surrounding sediments and volcanics. The intrusions are sheared in the northern area where the outcrop is cut by faults and shear zones.

Rhyolite plugs and dykes have been noted southeast of Tharwa by Mackenzie (1966). These acid intrusions cut the Lower Devonian welded tuff sequence.

STRUCTURE

The Devonian welded tuffs occupy a regional syncline with a northwest trend. The sequence is moderately folded into a series of domes and basins. Faults and shears are common in the area and disrupt the simple fold pattern.

The major fracture is the Murrumbidgee Fault, which is a high-angle reverse fault with the eastern side downthrown. The fault was initiated in Silurian or earlier time and influenced sedimentation in the Lower Devonian and possibly Upper Silurian time. Post-Devonian normal faulting has occurred in the region and the jointing at the damsite is believed to be associated with this event.

DAMSITE GEOLOGY

The dam axis (Fig. 2) has a total length of 2010 m, but as a small rocky hill south of the river gorge reaches a height of 600 m, 122 m of its length would be above the dam crest level. The dam would have a maximum height of 68 m.

NORTH ABUTMENT

The northern abutment consists of moderately to completely weathered rhyolitic welded tuff with no variation in rook type apparent at the surface. Open joints, probably with a similar orientation to those in the gorge, occur in several small outcrops. Fresh rock occurs in some areas but weathering is more than 12 m deep in the saddle (Fig. 2, coordinates 11300E, 34200N) which is a possible spillway site.

SOUTH ABUTMENT

The south abutment of the damsite is composed of moderately to completely weathered rhyolitic welded tuff; it becomes finer-grained at the southern end of the damsite, where the bedding strikes 307° and dips 11°N. Small open folds with vertical axial planes plunge 21° towards 045°. There are several open jointed outcrops on the hill above water level. In the wide saddle south of the hill, the tuff is completely weathered to 13 m and the total depth of weathering is about

18 m. This zone probably marks the fault which forms the northern boundary of the basin containing the Devonian rhyolite tuff (Pl. 1).

RIVER GORGE

The river gorge was mapped in detail by plane table (Pl. 2). The gorge is steep-sided with a wide, level, sound rock floor. During the mapping the river was flowing in a 6 m deep cleft in the gorge, but in flood it overflows in to a higher channel to the south (Pl. 3). There is almost complete exposure in the river gorge, where the rock is a devitrified rhyolitic densely-welded ash-flow tuff with abundant xenoliths. The degree of weathering ranges from fresh in the bottom of the gorge to slightly weathered on the sides, and the rock is hard and strong.

Open folds with vertical axial planes probably occur at the damsite, but are not visible because of the uniformity and massive nature of the welded tuff. The only apparent structures are shear zones and joints.

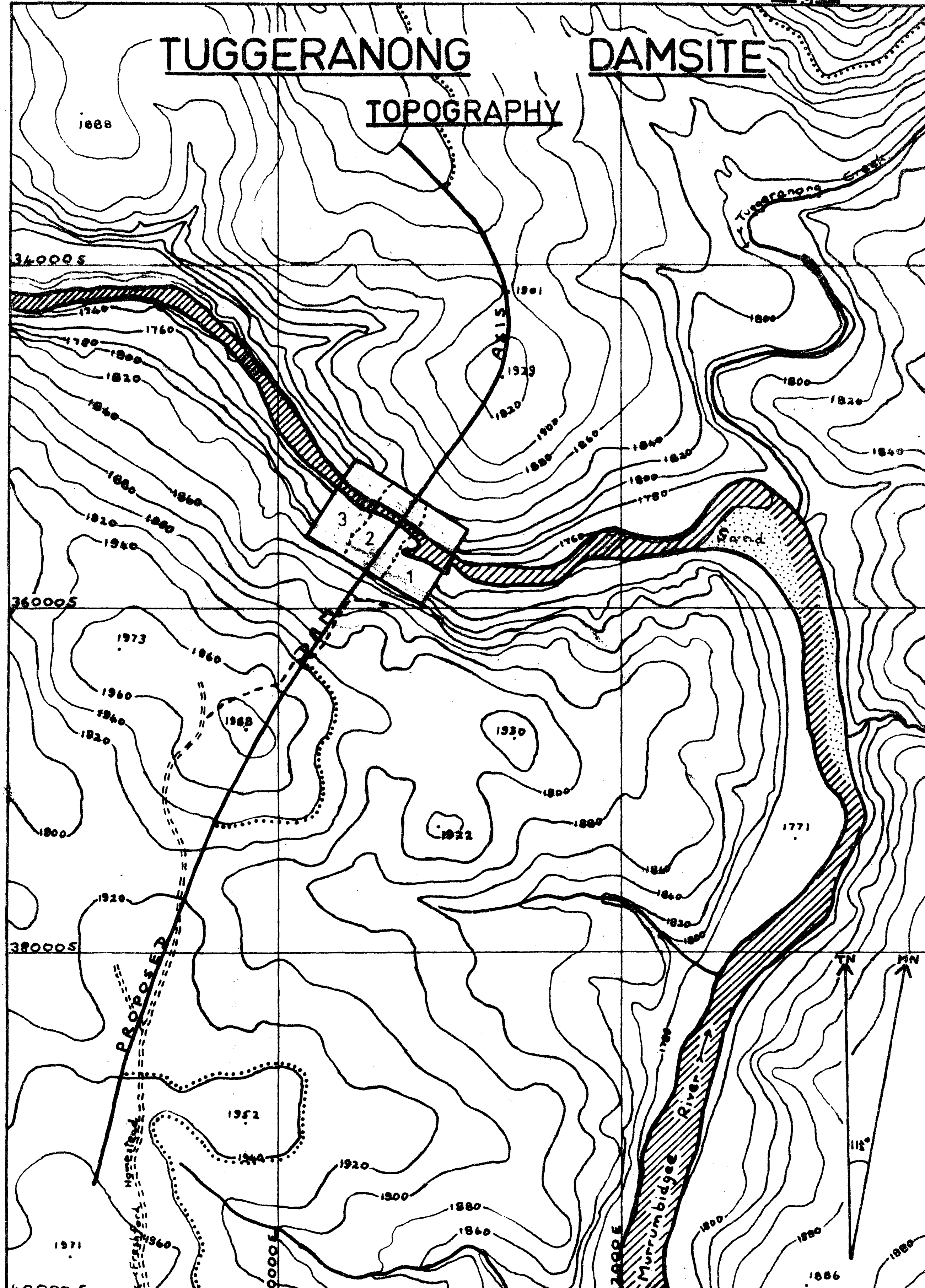
Several shear zones occur in the river gorge. Most are characterized by close vertical jointing. Recognizable crushing has occurred in the northwestern area of the gorge where there is a zone of completely sheared rhyolite 5 to 25 cm wide. A projection of this zone eastwards intersects the dam axis on the northern slope of the gorge. The shear zones generally conform approximately with the major joint direction (094^{o}), but in the southeastern area they trend north to northwest.

The distribution and orientation of jointing is illustrated in Plate 3. Plate 4 shows the joint stereograms for the total are and for the three sub-areas shown in Figure 2. Vertical and high-angle joints are the most common, intermediate angle joints being rare. The joints in

Fig. 2

TUGGERANONG DAMSITE

TOPOGRAPHY



REFERENCE

Top Water level

1952 Spot Height (feet)

1880 Contour (feet)

Established Track

Vehicle Track to Damsite

1 2 3 Areas covered by Stereograms in Plate 4.

Origin of Grid is at Mt Stromlo (Canberra Grid)

SCALE

0 200 400 600m.

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the gorge are moderately tight, and weathering does not penetrate to more than a metre or so. The high-angle joints show two distinct maxima on the stereogram for the total area; these are strike 094° and 025° respectively and are a conjugate pair.

The joint set striking 094° is dominant and controls the course of the river downstream to Kambah Pool. The joints of this set dip 80° to 90° and have an average length of 30 m with a range of 6 to 240 m. Spacing of the joints varies between 5 cm and 12 m, averaging about 2 m.

The joint set striking 025° commonly has dips of 75° to 90° northwest. The joints have an average length of 8 m and range from 2 to 35 m. Spacing varies between 0.3 and 20 m and averages 3 m. These joints are generally truncated by the set striking 094°. The strike of the minor set is more variable than that of the major set, ranging from 036° in the west to 023° in the central area.

There are not many low-angle joints, but they are widespread over the damsite; one is well exposed in the southwest part of the gorge. Strike and dip is variable but the diagram (Pl. 4) shows a concentration of joints with strike 082° and dip 9°N. These joints are not related to any depositional structure or lithological variation in the welded tuff.

The conjugate set of high-angle joints was probably formed in response to a compression with the intermediate stress direction 150°. The acute angle between the joints varies from 64° to 72°. In the relief of this stress several normal faults have formed within the reservoir area. Mackenzie (1966) noted a conjugate set of faults in the Murrumbidgee Batholith whose orientation is the same as that observed in the river gorge. In the central area of the gorge two separate sets of conjugate joints may be distinguished. The major set has the same characteristics of orientation and stress direction as the set of high-angle joints described above but the minor set results from a relief of compression with intermediate stress direction 060°. The set has an acute angle of 62° between the joints. This set possibly results from the interchanging of the intermediate and minimum stress directions present in the major system. However, this possible stress reversal can only have existed for a relatively short period, as joints of the minor set are less numerous than those of the major set. The high angle of the joints suggests that very little overburden was present at the time of formation.

ENGINEERING GEOLOGY

DAMSITE

The rhyolitic welded tuff in the river gorge would provide excellent foundations for any kind of structure. It would be necessary tb clear the sides of the gorge of soil, boulders and loose rock. Levelling of the bottom of the gorge would be required for a rockfill dam. The rhyolitic tuff situated between the flood channel and the normal course of the river (Pl. 3, Section AB) may have to be removed along the line of horizontal joints. Probably very little foundation treatment would be necessary for the river gorge area.

The abutments are deeply weathered in places, especially in the saddles and it may be necessary to excavate up to 15 m of completely weathered rock if the north and south saddles are to be used as spillway sites. The southern saddle is considered suitable for an emergency spillway whereas the northern saddle is best suited for the construction of the main spillway. These two sites would probably require extensive concrete-lined chutes.

DIVERSION TUNNEL

The line of the diversion tunnel would probably pass beneath the north flank of the river gorge. A tunnel 640 m long would be required and it would pass through fresh massive rhyolite welded tuff for almost its entire length. Close jointing similar in pattern to that seen in the river gorge would probably be encountered.

LEAKAGE

It is unlikely that leakage will occur from the reservoir as the shortest leakage path is 6 km long along the Silurian-Devonian faulted boundary near Tuggeranong to the Yarra Glen. Limestone and other porous rocks are absent from the reservoir area except for a very small outcrop near Point Hut Crossing. The faults in the northern area are probably tight, precluding leakage from the reservoir.

Deeply weathered and possibly faulted zones along the dam axis, for examples in the two saddles, need to be thoroughly examined for the possibility of leakage. The clayey weathering products of the rhyolite, however, should prevent any serious leakage along open joints, faults or shear zones.

LANDSLIPS

There is little danger of landslips occurring within the reservoir area. Most of the slopes are gentle and the rocks are usually massive.

SEISMIC AND AUGER RESULTS

The Commonwealth Department of Works carried out a seismic refraction survey and drilled several auger holes along the proposed dam axis (Walford, 1967). The following remarks summarize the results obtained.

Seismic work indicates three definable velocity layers:-

1) A layer ranging from 0 to 3 m in depth with velocities of 300 to 670 m/s. This is interpreted as soil with a composition varying between loam and clay.

2) A layer 4 to 18 m deep with velocities of 1000 to 2400 m/s. This layer is interpreted as having a composition from completely weathered rhyolitic tuff down to moderately weathered, jointed tuff.

3) A layer 18 m below the ground surface with velocities of 3400 to 5600 m/s. This is interpreted as slightly weathered rhyolite with many closed joints down to fresh sparsely-jointed massive rhyolite. The rock in the river gorge has a velocity of 4400 m/s, probably owing to the numerous joints and the slight surface weathering.

On the north side of the river gorge a step in the seismic profile occurs. Layers with a velocity of 1000 m/s drop abruptly from a depth of 7 m in the south to 17 m in the north. This material is probably completely weathered rhyolitic tuff and the step may represent a fault. Further seismic work and possibly drilling would be necessary to confirm this discontinuity.

The augering was carried out using a mobile Gemco drilling rig. Some indication of the rock hardness was gained from noting the setting of the auger, automatic settings indicating soft, easily augered rock. The results obtained are generally in agreement with the seismic work but with some discrepancies, expecially on the hill above top water level, south of the gorge. The augered material ranged from soft clayey mud to hard, gritty weathered rock. Commonly bands of differing hardness occurred within one auger hole, the softer material being found above a harder band. The minimum depth of weathered rock was 1 m of hard gritty material. In the southern saddle a maximum thickness of 13 m of soft clayey material was underlain by 5 m of harder gritty material to auger refusal. In the northern saddle 13 m of soft weathered material was underlain by 0.7 m of harder gritty material.

The combined seismic and auger work shows that maximum depth of complete weathering is about 14 m in the abutments and considerable excavation would be necessary before any structure is built there.

SEISMICITY

Earthquakes have been recorded in the Australian Capital Territory but their epicentres have commonly been in the Snowy Mountains or to the north in the Gunning area (Cleary, 1967). Shocks of magnitude 2 are occasionally felt in the Territory. Movement along the Murrumbidgee Fault occurred recently at Michelago but there is no need for a special seismic design for the proposed structure.

CONSTRUCTION MATERIALS

Sufficient quantities of construction materials for the proposed dam are probably available within a radius of 12 km of the damsite (Fig. 3).

FINE AGGREGATE

Medium to large quantities of fine aggregate occur in the bed of the Murrumbidgee River up stream of the damsite. About 9000 m^3 are available at the confluence of Tuggeranong Creek and the Murrumbidgee River. Additional sources occur near Lambrigg homestead, and at several points on the Murrumbidgee River further south towards Tharwa. Fine aggregate could also be obtained by crushing the rhyolitic welded tuff but it would be very abrasive to the quarrying equipment and crushing plant.

COARSE AGGREGATE

The massive rhyolitic tuff which crops out over much of the area near the damsite would provide an excellent source of coarse aggregate. The rock is sufficiently jointed to break into suitable blocks when quarried. The best localities for quarrying are: south of Pine Island; about 1 km up Tuggeranong Creek; the small hill east of Point Hut; and at Red Rocks 1 km downstream from the damsite where there are cliffs of massive rhyolitic tuff over 30 m high.

ROCKFILL

The rhyolitic welded tuff would also provide an adequate source of rockfill material. The rectangular jointing would possibly limit the size of the blocks obtained, but sufficient widely-spaced jointed zones could probably be found to give the necessary size. The localities of the welded tuff given above could provide sufficient rockfill material. The rhyolite breccia on the west bank of the river near Pine Island could probably provide larger blocks.

CORE MATERIAL

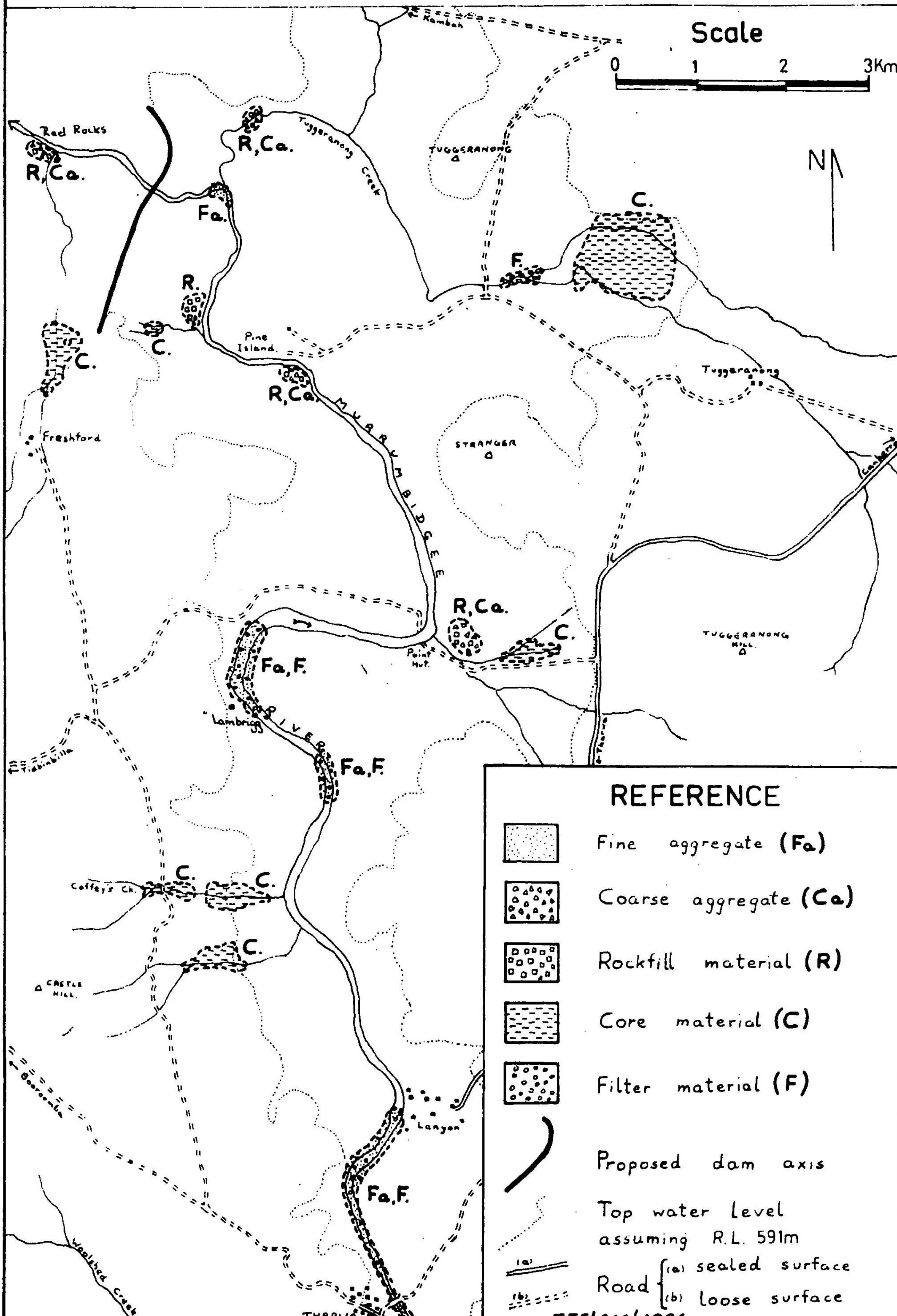
Many localities, some outside the reservoir area, would provide suitable core material but the extent and depth of this material are not accurately known. Quantities in any one area are probably limited in volume.

At Coffeys Creek east of the Tidbinbilla Road, 5 m of cohesive clayey granite wash occurs. The deposit extends downstream for 200 m and has an approximate area of 33 000 m^2. Farther downstream is an additional deposit about 130 000 m^2 in area. The depth of usable material averages 3 m.

In the creek south of Coffeys Creek is a similar deposit

Fig. 3

TUGGERANONG DAMSITE.
Construction Materials.



of granite wash of approximately 100 000 m^2 in extent which would make excellent core material. It is cohesive, yet has a good proportion of larger grains and small pebbles.

North of Freshford homestead, Freshford Creek has cut into a large deposit of weathered dacite and fluviatile detritus from the batholith. The material is sufficiently cohesive for core material. The deposit was only sampled at its southern margin, where it is 3 m thick. It is about 250 000 m^2 in area, and close to the damsite.

A small deposit of weathered dacite over 3 m thick occurs southeast of the damsite in a small creek bed. Although ideal in texture and composition, it is limited in quantity.

Probably a more important deposit, almost wholly within the reservoir area, lies northwest of Tuggeranong homestead. It covers an area of about 750 000 m^2 but the depth of usable material is unknown.

A similar, though somewhat smaller, deposit of potential core material occurs east of Point Hut, north of the road. Another deposit occurs on the upper reaches of Tuggeranong Creek near the Monaro Highway. No quantitative or qualitative information was obtained from these two sites, which are less suitable than those previously mentioned.

FILTER MATERIAL

Ungraded sand and gravel would probably be suitable for filter zone material. Medium to large quantities occur along the Murrumbidgee River especially in the region between Point Hut Crossing and Tharwa. The material contains some rounded cobbles but there may be insufficient quantities of coarse material.

A small deposit over 4 m thick occurs on Tuggeranong Creek near the Pine Island Road. This gravel may, however, have too great a clay content for use as filter material.

The quantities of material described above are only approximate estimates based on cursory inspections. Further detailed work would be necessary to determine the depth and extent of these deposits.

CONCLUSIONS

1. The proposed dam would rest on massive rhyolitic welded tuff of Lower Devonian age.
2. The Devonian rhyolitic tuff unconformably overlies folded and commonly sheared Silurian dellenitic tuffs and marine sedimentary rocks, and is conformably overlain by Devonian rhyolite breccia.
3. The Devonian welded tuffs are gently to moderately folded, but there are few structural defects in the massive beds occurring at the damsite.
4. The reservoir is underlain by: Silurian tuff and shallow-water marine and fluviatile sediments; Devonian sandstone, shale, welded tuff and breccia; the Tharwa Adamellite and other intrusives related to the Murrumbidgee Batholith.
5. Leakage from the reservoir is unlikely other than through the damsite, where some leakage may occur.
6. There is little or no risk of landslips occuring within the reservoir area.
7. Faulting has affected the whole sequence in the reservoir area, and faults are represented by thick zones of sheared and epidotized rock. Two such faults may possibly cut the proposed dam axis.

8. Earthquakes are not expected to affect the structure.

9. The proposed dam axis lies across a steep river gorge in slightly weathered rock, with moderate to completely weathered rock on the flanks.

10. Seismic and auger results show that complete weathering extends to 14 m in both the north and south spillway saddles.

11. Jointing is widespread in the river gorge but almost all the joints are closed. A few shear zones crop out but their extent and effect is merely local.

12. The proposed line for the diversion tunnel lies in massive rhyolitic welded tuff.

13. Sufficient quantities of suitable construction materials are available within a radius of 12 km of the damsite.

RECOMMENDATIONS

1. Additional seismic traverses should be carried out along the dam axis to gain more detailed information on the depth of weathering and nature of any discontinuties.

2. A core drilling program should be carried out, especially on the abutments, to determine the nature and depth of weathering, and locate any lithological or structural discontinuities. Water-pressure tests should be conducted, especially in well-jointed or possibly faulted areas.

3. Costeaning is necessary along the dam axis especially in zones of shallow weathering, where there has been no drilling, and the costeans should be geologically mapped.

4. The possible spillway sites should be geologically mapped in detail with the aid of sluicing or costeaning.

5. A detailed appraisal of possible sources of construction materials should be made by seismic surveys, augering and back-hoe pits. The construction materials should be tested and their suitability then re-assessed.

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APPENDIX 1

PETROGRAPHY

by

C.E. Newbigin

PETROGRAPHY

DAMSITE ROCKS

The following two samples were selected as representative of the many samples collected from the damsite exposure. The first is from low in the rock face, collected from just above a joint parting. It was thought that these partings were cooling planes and would distinguish separate ash flow units. There is however insufficient variation amongst the samples to divide the outcrop, and no genetic significance can be ascribed to these planes.

67360129 Devitrified densely welded rhyolitic ash flow tuff.

The hand specimen shows large phenocrysts of quartz and smaller grains of feldspar in a dark grey-green matrix; the joint surface is coated with epidote and chlorite.

In thin section the quartz (20-25%) occurs as phenocrysts and as small highly angular chips in the groundmass; the phenocrysts are anhedral, resorbed, and slightly broken. Most plagioclase grains (20-25%) are very sericitized and poorly twinned. Some small grains scattered amongst the phenocrysts are almost obscured by sericitization. Sanidine phenocrysts, slightly altered to clay, make up less than one percent of the rock.

Most biotite grains (5-8%) are altered to chlorite, but epidote, sphene, and opaque minerals including leucoxene are also common. The grains are distorted, moulded onto larger phenocrysts. Large irregular plates of chlorite in the groundmass may be pseudomorphs after biotite or former voids now filled and distorted from the original shape.

The groundmass (45-50%) consist of devitrified glassy material now consisting of potash feldspar and quartz; opaque dust is scattered throughout and secondary development of chlorite is common. Immediately around the phenocrysts, crystallization has been slight and the groundmass is cryptocrystalline. In less crystal-rich zones the texture is saccharoidal. In these zones the opaque dust is concentrated in blebs, and secondary chlorite is well developed.

67360137 Devitrified densely welded quartz rhyolitic ash flow tuff

This specimen was collected from the top of the cliff on the north side of the river. There are few phenocrysts in this rock but otherwise it is similar to the first sample; it is a dense rock dark greyish green, with large irregular shaped phenocrysts of quartz.

In thin section the quartz constitutes about 25% of the rock, and occurs as large anhedral, resorbed grains and as scattered small angular grains. Phenocryst of plagioclase (15%) are uncommon, occurring mainly as small broken and resorbed grains altered to sericite, chlorite and epidote. Rare grains are well-twinned and the approximate composition measured on these was sodic oligoclase. Sanidine (1-2%) occurs as large unaltered phenocrysts in some cases with an overgrowth of plagioclase.

As in the first slide the biotite grains are altered to chlorite, epidote and iron oxide and are moulded onto the other phenocrysts. In both slides the biotite grains contain inclusions of apatite.

Potash feldspar with subordinate quartz and accessory zircon make up the groundmass (50-55%). Opaque dust is scattered throughout, and secondary chlorite is well developed where the groundmass grainsize is greatest. The texture of the rock is similar to that of the first slide, with large irregular phenocrysts of quartz and scattered small angular grains set in a groundmass of varying grainsize. The grainsize decreases around phenocrysts, and a rough streaky texture is visible, the result of severe flattening of the former shard structures. Away from the phenocrysts this texture has been destroyed by later recrystallization, and the groundmass is saccharoidal. Although this slide is a little richer in quartz it cannot be distinguished from the first and the rocks are thus considered to be part of one ash flow.

Pumice is apparently absent, and shard structures have been smeared out. The rock is a densely welded ash flow tuff. No obviously unwelded layers were apparent in the outcrop, nor could distinction be made between different units in outcrop, although there was slight variation in phenocryst content in different slides.

RESERVOIR AREA

68360018 Banded rhyolitic tuff.

This rock comes from the reservoir area and represents the last volcanic event in this area. It crops out in the bed of the Murrumbidgee River downstream from Pine Island, where it is moulded to the underlying rhyolitic welded tuff described above. The rock is a thinly bedded, fine-grained rhyolitic tuff, light to dark green, in many places banded. It contains large tourquoise, purple, and grey xenoliths, up to 30 cm long, composed of agglomerate, acid volcanics, chert, and shale. The xenoliths may be rounded or intensely resorbed, with large resorption rims.

In hand specimen it is a fine-grained greenish grey rock, with small rounded quartz phenocrysts, and small xenoliths. Some xenoliths are rounded, others are stretched and resorbed; they are mainly acid volcanics, with subordinate shale.

Thin section shows that the quartz grains (15%) are subrounded to subangular, but are not resorbed. Many plagioclase grains are broken; most are fresh with only a few altered to sericite. Generally the plagioclase is andesine although a few grains are zoned. Potash feldspar grains (2-3%) are mostly broken and strongly disaggregated. They were identified by staining. Only a few flakes of biotite are present and most are altered to chlorite and epidote.

The groundmass consists mostly of cryptocrystalline potash feldspar, chlorite, and epidote. Nowhere is saccharoidal crystallization evident, indicating that there has been no recrystallization of the groundmass. Epidote and leucoxene, secondary after ilmenite, occur as small, rounded scattered grains. Although this unit was sampled at the very base, it contains no conclusive evidence of ash flow origin: a few small undeformed shards appear in the groundmass, but pumiceous fragments are absent.

The only xenoliths identified in thin section are igneous; the majority are very fine-grained volcanics containing small quartz phenocrysts and fragments of plagioclase. A few are strongly chloritized.

Any hypothesis explaining the origin of this rock must explain a) the partial rounding of the grains; b) the mineral partitioning between groundmass and phenocrysts which suggests partly crystallized magma; c) the lack of shard structures; d) the resorption of xenoliths and the lack of resorption of phenocrysts; e) the lack of recrystallization of the groundmass.

The rock probably represents a diatreme-type explosion which finally cleared out the volcanic vent. The partly crystalline magma in the vent bearing well developed phenocrysts of quartz and feldspar (both plagioclase and alkali feldspar) in a potash-rich liquid became fluidized by rising gases. Considerable turbulence in the vent caused the abrasion of the particles; most shards formed were destroyed; and lumps of wall rock in the vent were torn off and incorporated in the gas solid mixture. The material was finally removed from the vent by the last gas-rich eruption from the volcano, and deposited as an air-fall tuff.

This rock has been named a rhyolite breccia, but because brecciation occurred before deposition a better name would be rhyolite tuff.

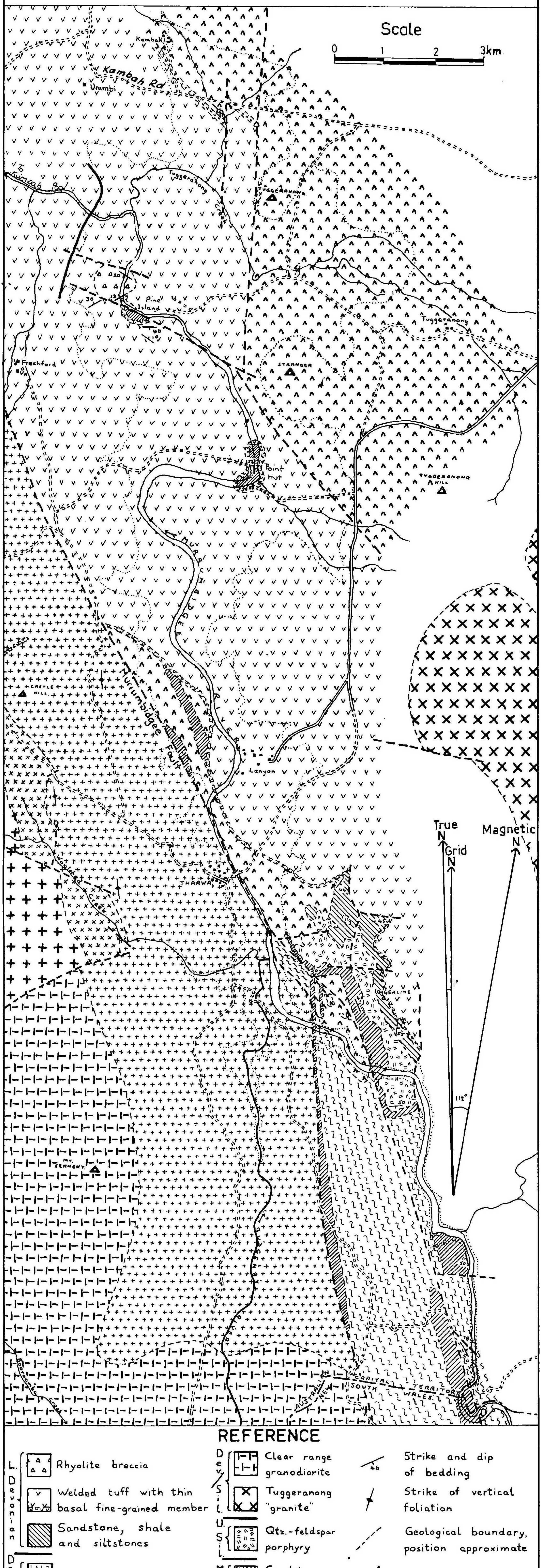
68360023 Feldspathic labile arenite.

This rock is from the reservoir area, just downstream from Point Hut Crossing on the Murrumbidgee River. In hand specimen it is a light grey banded acid volcanic rock with large crystals of quartz and mafic minerals; fragments of highly fossiliferous shale are included in the rock. The average grainsize is 0.3 mm with a maximum in thin section of 1.0 mm. Under the microscope the fabric of the rock is seen as close-packed angular to subrounded grains in an altered fine-grained matrix with authigenic quartz developed from the original glassy material. A rough graded bedding was visible, bands of scattered coarse grains in a fine matrix grading to fine-grained bands. The rock is well compacted and some deformation of the minerals has occurred. Mineralogically the sorting is good but grainsize sorting is poor. The matrix was originally glassy dust and minor amounts of micaceous material; this has been altered to chlorite and epidote and cemented by authigenic silica. The mineral detritus is comprised of quartz grains which are generally resorbed, broken plagioclase usually altered to sericite and chlorite with exsolved lamellae of potash feldspar, fresh grains of sanidine, and leached and deformed grains of biotite, some altered to epidote. There are also some large undeformed glass shards, some of which have devitrified. Fragments of biotite quartz schist,

TUGGERANONG DAMSITE

Plate 1

Reservoir Geology



REFERENCE

L. Devonian
- Rhyolite breccia
- Welded tuff with thin basal fine-grained member
- Sandstone, shale and siltstones

Devonian/Silurian
- Dolerite
- Tharwa Adamellite
- Leucogranites, aplites
- Shannons Flat Granodiorite

Dev/S.
- Clear range granodiorite

L. U. S.
- Tuggeranong "granite"
- Qtz.-feldspar porphyry

M. to U. Silurian
- Sandstone and shale
- Welded tuff
- Mylonitized tuff

- Fault, position approximate
- Strike and dip of bedding
- Strike of vertical foliation
- Geological boundary, position approximate
- Proposed dam axis
- Boundary of reservoir area, assuming R.L.1938'
- Road, sealed surface
- Road, loose surface

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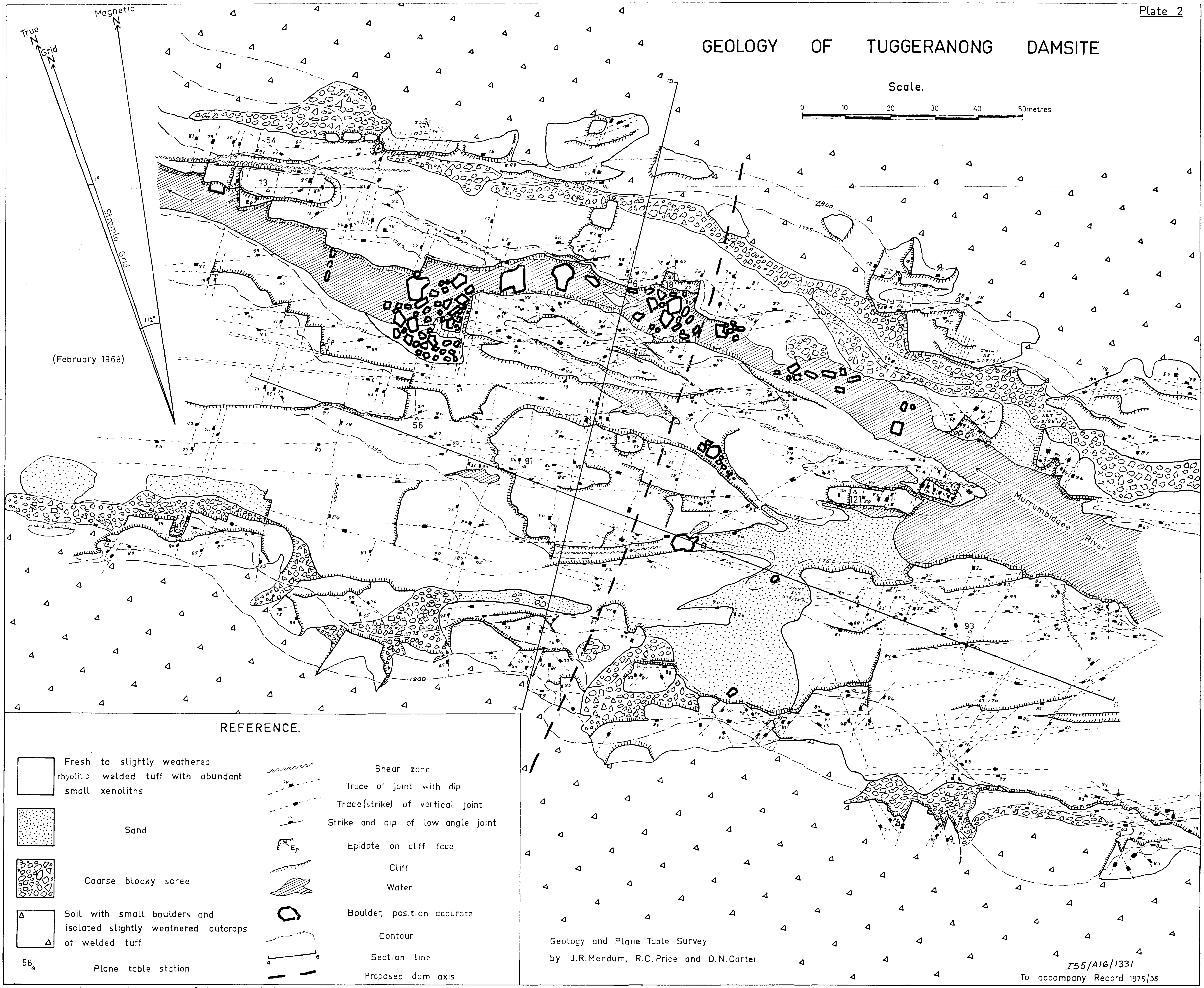

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Plate 3

TUGGERANONG DAMSITE – GEOLOGICAL SECTIONS

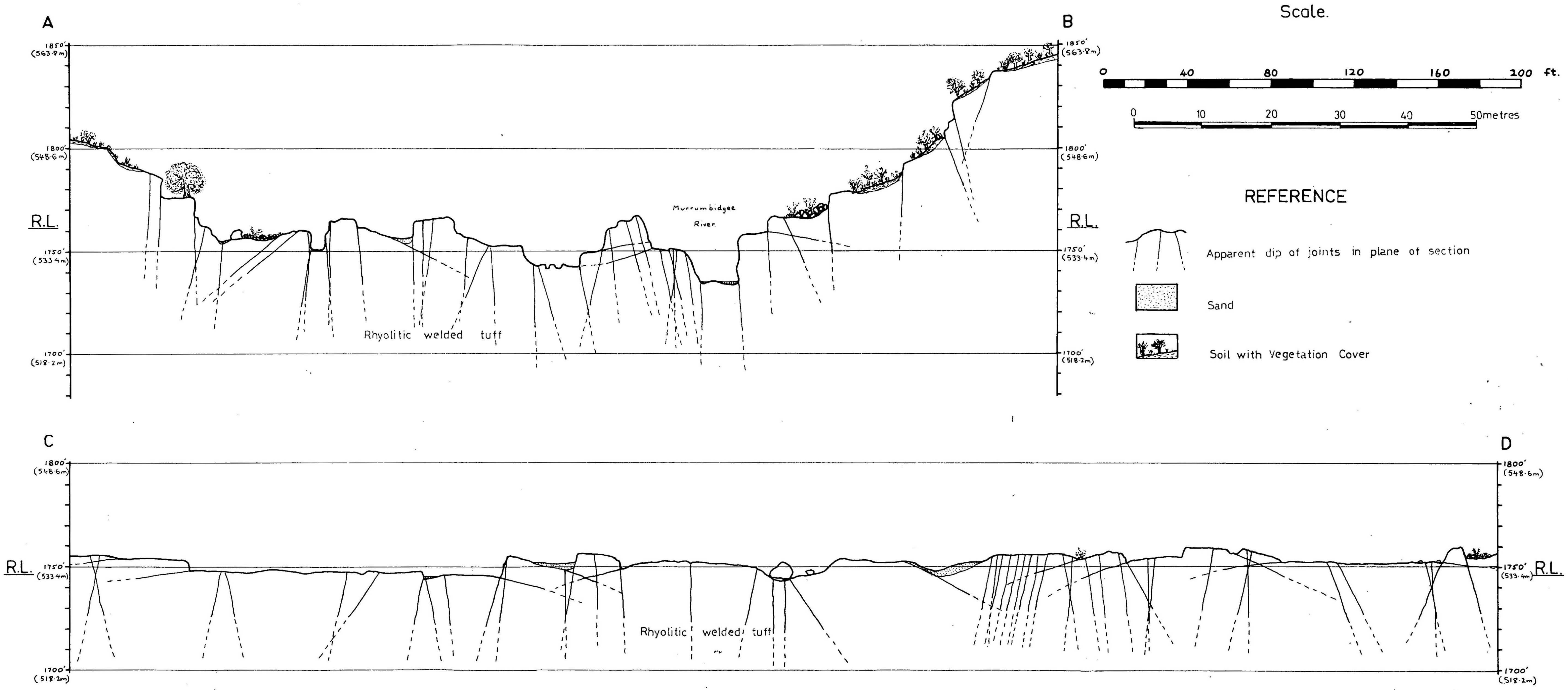

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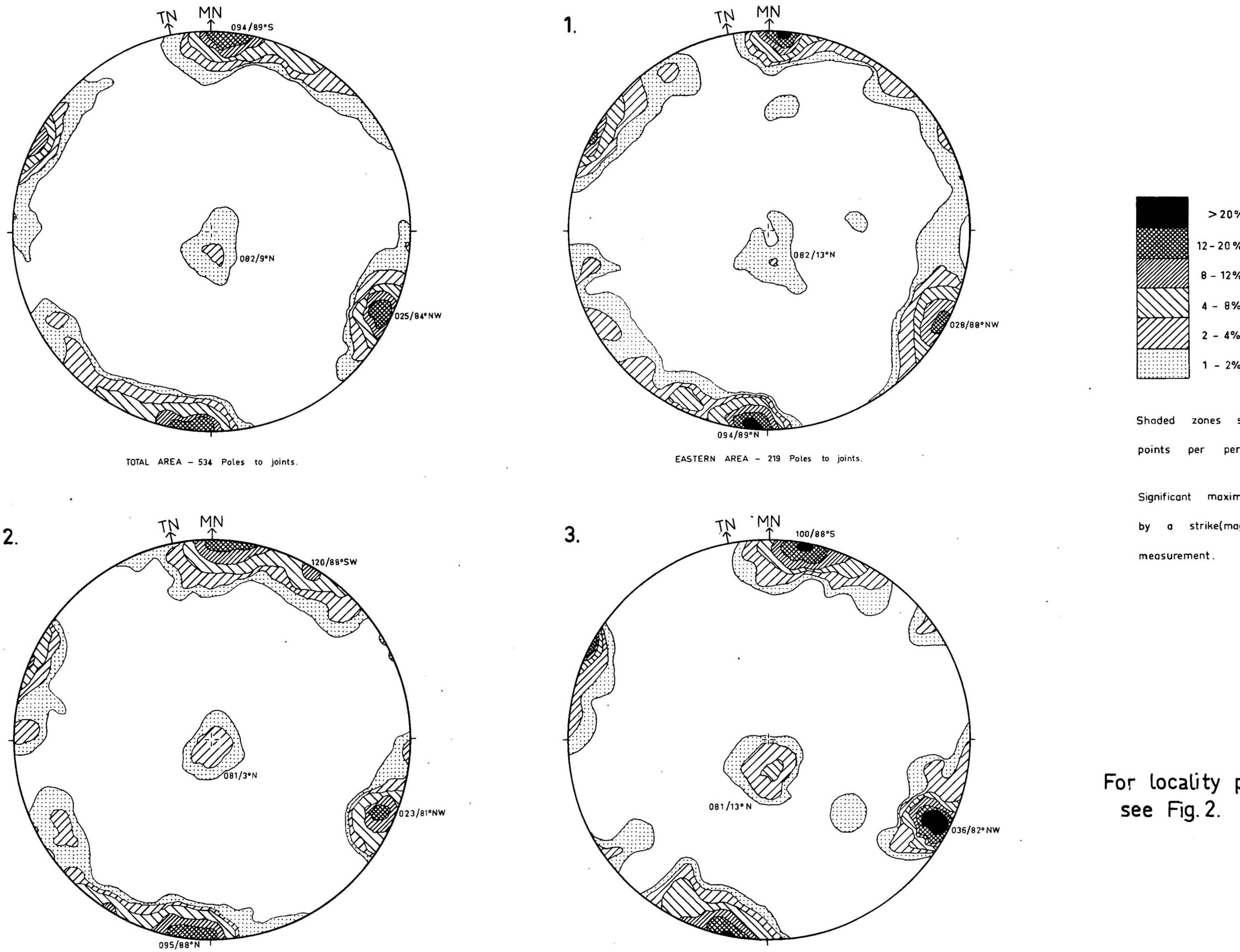
Plate 4

TUGGERANONG DAMSITE - JOINT STEREOGRAMS



TOTAL AREA - 534 Poles to joints.

1. EASTERN AREA - 219 Poles to joints.

2. CENTRAL AREA - 215 Poles to joints.

3. WESTERN AREA - 100 Poles to joints.

Shaded zones show percentage of points per percentage of area.

Significant maxima are represented by a strike(magnetic) and dip measurement.

For locality plan see Fig. 2.

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