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Engineering Geology of the Tuggeranong West Urban Development Area, A.C.T.

by

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ENGINEERING GEOLOGY OF THE TUGGERANONG WEST

URBAN DEVELOPMENT AREA A.C.T.

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Records 1970/68

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SUMMARY

The Tuggeranong West Urban Development Area is composed of granites in the west and volcanic and minor sedimentary rocks in the east. The granites are separated from the volcanics by the northwesterly trending Murrumbidgee Fault which is one of the major faults of the Canberra region. The volcanic and sedimentary rocks give rise to undulating plains that are broken up by rounded, rock-strewn hills. These rocks should in general have similar engineering properties to the volcanics and sediments in the Woden Valley, Weston Creek, and Belconnen areas. The granitic rocks, however, probably have significantly different engineering properties compared with those of the volcanics, because of the distinctive mineralogy, texture, weathering profile, and joint pattern in the granite local engineering practices may require some modification.

In much of the area the bedrock is covered by an irregular thickness of unconsolidated, but weakly cemented, soil, colluvium, and alluvium. The unconsolidated soils are thickest in the east and gradually thin to the west.

Shallow excavation for urban development will take place largely in soil and weathered bedrock using normal plant and machinery. Ridges of fresh bedrock, isolated corestones of fresh rock and tors of granite will require drilling and blasting. Excavation for heavy buildings will normally require careful subsurface investigation.

Adequate foundations for most buildings will be found at shallow depth, but deeper foundations may be necessary for large commercial or industrial buildings situated on alluvial soils. In the later case, careful subsurface investigation should be made to determine the engineering properties of the soils at the site. Existing small cut-slopes along the roads in the area are stable, but deep cuts or high embankments should include adequate drainage to reduce the cost of maintenance to a minimum.

Good supplies of coarse aggregate can be made by crushing selected volcanics. Suitable quarries could be established inside, or a short distance outside, the urban development area. Adequate

supplies of good quality sand appear to be lacking. The sand and gravel resources in the Murrumbidgee River will probably need to be supplemented from outside the area.

The northerly flowing Murrumbidgee River is the main and central river draining the area. It is fed by a number of small streams that adequately drain the soils of the area. Concentrated urban development will considerably alter the natural drainage system and could produce some drainage problems. It is recommended that a hydrological investigation be started early so that valuable quantitive information can be collected and used to assess and predict the possibility of drainage and groundwater problems.

The area can be expected to experience minor earth tremors from time to time (see under Seismicity).

INTRODUCTION

In response to a request from the National Capital Development Commission, a preliminary geological survey of the proposed Tuggeranong West Urban Development Area was carried out in August and September, 1969. The report is accompanied by a locality map (Pl. 1), a bedrock geology map (Pl. 2), a soil map (Pl. 3), and a diagrammatic cross-section (Pl. 4).

D.E. Gardner (1968) has written a preliminary geological report on the Tuggeranong Urban Development Area that lies to the east of the area described in this report.

LOCALITY

The Tuggeranong West Urban Development Area lies to the southwest of Canberra, about 17 road miles (27 km) from Canberra. The area lies mainly to the west of the Murrumbidgee River and stretches northwards from near Thwarwa to the Kambah Pool Road (Pl. 1). The area mapped is elongated in a north-south direction, and has an area of approximately 24 square miles (60 sq km).

The main Canberra-Cooma road (Monaro Highway) passes close to the eastern edge of the area. Access into the area, from the Monaro Highway, is via a sealed road through Tharwa and an unsealed road via Point Hut crossing. Unsealed roads and tracks are present throughout the area and provide relatively good access.

TOPOGRAPHY

The area is situated astride the Murrumbidgee Fault which separates the rugged Tidbinbilla Ranges of the Cotter Horst from the gently rolling plains and residual hills (e.g. Black Mountain, Mount Stromlo) of the Canberra Rift (White, 1955). The landscape changes, within a few miles, from a flat-lying alluvium floodplain, 1800 feet (550 m) above sea level (A.S.L.), broken by rocky residual hills up to 2300 feet (700 m) A.S.L. in the east, to the rock-strewn steeper slopes of the dissected foothills of the Tidbinbilla Ranges in the west.

The Murrumbidgee River is the main and central river controlling the drainage of the area. The Murrumbidgee flows northerly, following the structural grain of the country; it is fed by a number of small streams flowing off the Murrumbidgee batholith in the west, and from the residual hills south of Tuggeranong to the east. A large valley (Sawyers Gully) to the west of Tharwa is drained by the southeasterly flowing Woolshed Creek which flows into the valley of the Gudgenby River close to the southern boundary of the area. The Gudgenby then joins the Murrumbidgee River 1 mile (1.6 km) south of Tharwa.

GEOLOGY

The geological map showing bedrock (Pl. 2) is based on the maps of Mackenzie (1966) and Mendum (1968), supplemented by field mapping where necessary. Bedrock is exposed along the Murrumbidgee River, in some of the creek channels, and on the hills and ridges in and around the area; the geological boundaries have been extrapolated where bedrock is not exposed.

Sedimentary, volcanic, and plutonic rocks are found in the area. The Murrumbidgee Fault, a major geological feature in the A.C.T., which runs through the area from ¼ mile east of Tharwa northwestward to close to Freshford homestead, separates the granitic rocks of the Murrumbidgee Batholith to the west from the volcanic and sedimentary rocks of the Canberra Plains to the east (Pl. 2).

Granitic Rocks

Although granitic bedrock covers about one-third of the area it only occurs to the west of the Murrumbidgee Fault. The granite forms part of the Murrumbidgee Batholith which has been described in detail by Snelling (1960). The granite is well exposed on the top and along the flanks of Castle Hill and Tharwa Hill where it commonly occurs as tors* or as large rounded boulders. Four types of granite have been distinguished on Plate 2, of which the Tharwa Adamellite is the most important and widespread. The following notes refer mainly to the Tharwa Adamellite, but further detailed work may reveal significant differences in weathering between the four types of granite. The granite consists of large well formed crystals (phenocrysts) of white and pink feldspar, clear quartz, gleaming plates of black mica and dark green stumpy crystals of hornblende set in a greyish finer-grained matrix. The deep tor like weathering of the granite is due to the presence of relatively unstable minerals such as feldspar and mica, the coarse-grained porphyritic texture, and close jointing. The variations in texture, composition, and jointing from place to place can be related to the depth of weathering and irregular soil development.

Urban development in Canberra has not, as yet, taken place to any great extent on granite terrain so some variation in current local engineering practices will probably be required. The granites weather in a different way to the volcanics and sediments commonly

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* Tors are defined by Gardner (1968) as 'under certain conditions of topography, rock jointing, groundwater level and drainage the bedrock weathers, over a long period of time, downwards along joints to depths of many feet, leaving cores of fresh, hard rock. Such hard cores are exposed, as tors if the decomposed rock is removed by rain and wind.'

found around Canberra. Weathering of the granite commonly extends to greater depths than in the volcanics, and it is generally very irregular and commonly tor-like. These tors or cores of hard fresh rock may occur loose on the surface; partially submerged in a sandy soil of weathered granite; or submerged, tens of feet below ground surface, and surrounded by bedrock weathered to various degrees. Under the influence of gravity the tors may move downhill and become incorporated in hillwash and scree, later, to be partially exposed above ground by erosion, or to remain buried and covered by further unconsolidated deposits (Pl. 4). The tors along the top of Castle Hill range from a few feet to 20 to 30 feet (6-10 m) in diameter.

Determination of excavation methods and costs could, therefore, be very difficult if based on surface inspection alone. The material to be excavated can change abruptly from a weakly cemented incoherent sandy soil into a mass of fresh hard bedrock. Adequate subsurface investigation and allowances for these difficulties should be made in the testing, design, and costing of major engineering works (e.g. tunnels, underground sewers, deep trenches). To a lesser extent variation in the degree of weathering may also be a nuisance in minor excavations (e.g. basement garages, stormwater channels, large building foundations). Some of the problems associated with granitic terrain have been encountered along the Tidbinbilla road, south from Tharwa, where fresh bedrock alternates irregularly with pockets of highly weathered granite.

Volcanic and Sedimentary Rocks

Volcanic and sedimentary rocks occur to the east of the Murrumbidgee Fault and cover the remaining two-thirds of the area. The Devonian(?) dacite and rhyolite tuffs, are a continuation of those found in the Tuggeranong area (Gardner, 1968). The volcanics are exposed along the tops of small hills and ridges and along the Murrumbidgee River. Because they are generally finer-grained than the granites and have a much stronger interlocking welded texture, they are generally fresher, harder, and stronger than the granites.

The volcanics of the Tuggeranong West area are a southerly extension of those found in the Woden and Weston Creek areas, and local engineering practices would appear to be applicable to this area. However, the Tuggeranong West area has had a different geomorphological history during geologically recent times, and some modifications to local engineering practices may be required. The area which lies at the foot of the Tidbinbilla Range and close to the Murrumbidgee River, has had a complex geomorphological history, involving irregular weathering of the bedrock, soil formation by scree and hillwash accumulation, and dissection and partial stripping of the unconsolidated mantle by the Murrumbidgee River. In the Belconnen and Woden Valley areas the soil grades downwards gradually into fresh bedrock, but in the Tuggeranong West area an irregular surface of hard volcanic bedrock is covered by an irregular thickness of weakly cemented soil and scree.

Five irregular discontinuous areas of sedimentary rocks (mainly sandstone, siltstone, and shale) crop out along, or close to, the Murrumbidgee River. These Upper Silurian sediments have steep dips and their relationship within the Devonian(?) volcanics suggests that they are folded or faulted inliers. The siltstone and shale are generally closely jointed or cleaved, but they appear to be of very limited distribution. Geological advice should be sought if these rocks are to form the foundations of major engineering structures.

Faults

A number of faults were mapped in the area (Pl. 2), and there are undoubtably others. The faults were initially recognized as lineaments on air-photographs, and were then examined in the field. Four of the faults are filled with quartz and form small resistant ridges, 10 to 20 feet (3-6 m) high, running through the countryside. Numerous angular pieces of milky quartz are scattered about on the crests of the ridges. The quartz reefs appear to be lenticular, but careful examination of faults should be made if excavation across them is to be made.

The Murrumbidgee Fault is a fundamental geological feature in the Canberra region and can be traced through the Tuggeranong West area either as a strong quartz reef or as a 10 to 20-foot (3-6 m) scarp separating granite outcrops from volcanic. No evidence of a spring line or impedence of drainage at the fault was found. Earth tremors have been recorded along the fault (see under Seismicity).

SOILS

In much of the area the bedrock is covered by a variable thickness of soil. In this report the term soil refers to the unconsolidated mantle of mineral and rock fragments which rests on bedrock. Plate 3 shows the main groups of soils. The map was made by estimating the thickness of the soil and its probable origin; four groups have been recognized.

Thin Soils and Rock Outcrop

The soils forming this group are normally found above 2300 feet (700 m) and are confined to the tops and upper slopes of hills and ridges. Semi-continuous rock outcrop separated by shallow irregular pockets of coarse rock debris and hillwash material is the characteristic land form found in these areas. As most foundations will be on bedrock at or very close to the surface, excavation or earthmoving is likely to be costly, especially where the bedrock is fresh. Blasting will frequently be required. The area stretching northwards from Castle Hill along the western boundary of the area falls largely into this soil group. It is anticipated that residential or similar urban development would not be encouraged in this area. In fact, with the excellent exposures of granite, the difficulty of access produced by the steep slopes and the outstanding views in all directions this area would be well suited for development as a nature reserve (c.f. Black Mountain and Red Hill).

Thicker Soils, Colluvium and Scree

The thicker soils, colluvium and scree include a mixture of in situ soil, colluvium, and scree commonly about 10 to 20 feet (3-6 m) thick, with numerous rock boulders on the surface. Small discontinuous patches of outcrop also occur. This group is fairly widespread (Pl. 3) and occurs mainly on the lower slopes of the hills between about 2000 and 2300 feet (600-700 m). The soil is composed of a heterogeneous mixture of fresh to highly weathered bedrock boulders, weathered and decomposed in situ bedrock, and scree and hillwash which has accumulated at the foot of the steeper slopes. The material is poorly sorted and graded so the physical and chemical properties of the soil may be variable.

The depth to fresh or slightly weathered sound bedrock will be variable throughout this area, but about 15 feet (4.5 m) is an estimated mean value. The variation in depth to bedrock is well illustrated in the small creeks that flow eastwards off Castle Hill and underneath the Tidbinbilla Road. In these creeks the thickness of soil ranges from 0 to 20 feet (0-6 m).

Foundation support will be adequate for most structures, but augering or geophysical surveys may be required if very strong or uniform foundation conditions are required for heavy loadings. Excavations less than 10 feet (3 m) deep will commonly be in a material with the properties of a soil rather than rock so that light machinery will normally be adequate. Blasting or heavy machinery will be required where buried ridges or corestones of fresh bedrock are found close to the surface, and where excavations in excess of about 20 feet (6 m) are made. The soils of this group are generally permeable and are adequately drained, at present, by small streams.

Thick Soils, Hillwash and Alluvium

The thick soils, hillwash, and alluvium form flat-lying or gently undulating ground that covers about one-half of the urban development area. The soils are layered deposits of clay, silt, sand, and pebble beds formed largely by the deposition of material from the lower courses of the streams crossing the area. In comparison to the previous group, there is a marked lack of boulders on the surface, although some boulders are present in the pebble beds. Soil thicknesses of about 20 feet (6 m) have been observed in some stream sections, but accurate determination of the depth to sound bedrock in many areas will require subsurface exploration. Sawyers Gully, in the southwest of the area and Barnes Creek, 1½ miles (2 km) southwest of Point Hut crossing, contain well developed beds of dark brown organic peaty soil. These organic soils are indicative of areas where waterlogged ground has existed for long periods of time, and they should provide a warning to engineers that adequate drainage facilities should be installed if urban development is to take place.

The soils of this group occur as alternating layers with various proportions of clay, silt, sand, and pebbles. Rapid changes both laterally and vertically were observed in a number of creek beds and the effect of post-depositional cementation was also variable. Foundations for heavy buildings should be thoroughly examined and consolidation and swelling tests should be carried out so that the possibilities of differential compaction of silty or clayey layers, or swelling in hygroscopic clays, can be avoided.

Recent Alluvium

The only large areas of recent alluvium are those in the flood-plain of the Murrumbidgee and those along Sawyers Gully (Pl. 3). The alluvium along the Murrumbidgee River is described in the section on Construction Materials. Along Sawyers Gully the alluvium consists of irregular deposits of silty sand and pebble beds, generally less than 10 feet (3 m) thick, which overlie older alluvium and colluvium. These recent deposits will have essentially the same engineering properties as the bedded older alluvium and hillwash, described in the preceeding section, except that post-depositional cementation will generally be weaker in the recent alluvium.

EXCAVATIONS

The effect of soil type upon excavation conditions has already been discussed. Excavation in areas 2 and 3 on Plate 3 will generally be possible using light machinery with only small areas requiring blasting or heavier earth-moving equipment. Most of the excavations for residential and commercial buildings in these two areas will be in soil and highly weathered bedrock rather than in fresh hard bedrock. In contrast, excavations proposed in area 1 of Plate 3 are likely to be difficult and costly, as fresh to slightly weathered, hard, strong bedrock will normally be found at, or close to, the surface. Fresh or slightly weathered bedrock can only be excavated by drilling and blasting. Moderately weathered bedrock ranges in strength, hardness, and toughness from a rock that needs blasting to one that can be readily excavated by jack hammers and bulldozers. Highly weathered bedrock can easily be removed by a trenching machine.

FOUNDATIONS

Fresh to slightly weathered bedrock will provide strong foundations, but shaping of the foundations will require blasting and will, therefore, be expensive. Foundations in most parts of area 1 on Plate 3 will consequently be strong, but difficult and costly to prepare. In most cases moderately weathered bedrock will provide foundations that are satisfactory for large buildings. Highly weathered bedrock will provide suitable foundations for small buildings. Most of the urban development should be sited in areas 2 and 3 (Pl. 3) where soils, colluvium, hillwash, and scree of variable thickness, but generally less than 20 feet (6 m), cover bedrock. The depth of weathering in the bedrock will be difficult to determine without subsurface investigation, but this will only be required where heavy loadings are considered.

SLOPE STABILITY

Natural slopes throughout the area are generally low and evidence of important landsliding was not found, either on the air-photographs or during ground inspections. Steeper slopes occur along the western boundary of the area where deep dissection in the granite terrain has occurred. These steeper slopes are commonly covered by large boulders or tors of granite. Instability of some of the tors is suggested by their occurrence on the lower slopes near the

Tidbinbilla road. A close examination of these tors is warranted before development on the lower slopes east and northeast of Castle Hill takes place. Early inspection and remedial action should be cheap and easy to carry out.

The alluvium and colluvium deposits are weakly cemented, but most vertical faces in erosion gullies, up to 10 feet (3 m) high, are stable, except when undercut.

Existing cut-slopes in the area are stable, even where they are excavated into unconsolidated soils. However, groundwater was seen seeping through the small cut-slopes along the Tidbinbilla road, after heavy rains in August 1969. Suitable drainage of cut-slopes should be installed, especially in areas of permeable soils and weathered bedrock. This precaution will largely eliminate gullying and fretting of cut-slopes, so that costly maintenance and repair will be avoided.

CONSTRUCTION MATERIALS

No detailed search was made for construction materials in the Tuggeranong West Urban Development Area. The following notes, based on observations made during the survey, outline what resources of materials can be reasonably expected.

Aggregate

The main source of all kinds of aggregate will be from crushed rock. The river and stream gravels are irregularly distributed and variable in thickness, and are probably of little value.

The fresh volcanic rocks are predominantly strong, sound and tough, and not closely jointed. Variations in texture and composition were observed in the field, and were confirmed by petrological inspection. Some of the specimens contained devitrified volcanic glass while others contained prominent ironstaining; detailed field and petrological examinations of the rocks will be required before suitable quarry sites can be located. However, the rounded hill (capped by a monument) north of Barnes Creek appears to be a promising area for aggregate. The rock forming the hill is a massive coarse to medium-grained quartz-hornblende porphyry. In outcrop it has a thin (2 cm) weathered crust and seems to be uniform in character over much of the hill. In hand specimen the rock is very hard, very strong, and tough. A thin section shows that the rock is a welded dacite tuff with prominent quartz, feldspar, and hornblende crystals set in a finer-grained welded matrix of the same minerals. The quartz is fresh, but the felspar and hornblende are markedly altered throughout the slide. Secondary chlorite is common. Subject to the normal reactivity tests this rock would appear to be a suitable source of aggregate. Unfortunately, this area may be unsuitable for quarry siting due to its position in the urban development area. Tuggeranong hill, 3 miles (5 km) east of Point Hut crossing, is composed of a similar welded tuff.

Although granite generally has low resistance to abrasion and is not well suited for use as road aggregate, it is commonly used for aggregate in concrete. The granites were not examined in detail, but variations in the mineral composition and texture were noted in many areas. Detailed examination will be required before its suitability for aggregate use can be determined. Two specimens from Castle Hill show evidence of post-formational tectonism with fracturing and bending of the platy minerals, together with recrystallization and alteration of other minerals. These textural weaknesses would probably render these granites unsuitable for structural concrete.

The sedimentary rocks shown on Plate 3 would not be suitable as aggregate. The sediments are generally highly weathered, closely jointed, and argillaceous, as well as being of limited distribution.

Sand and Gravel

The main supply of sand from within the area will be from the recent deposits along the Murrumbidgee River. The areas of recent alluvium, sand, and gravel shown on Plate 3, excluding those along Sawyers Gully, are probably the only significant supplies in the area.

The deposits along Sawyers Gully consist of silty sand and pebble beds which are probably too impure for use as fine aggregate. The deposits along the Murrumbidgee consist of coarse-grained micaceous sand and pebble beds. The deposits have been worked at several places along the river, but most rely on replenishment during periods of higher flow. No extensive areas of good-quality sand or gravel are known within the area, therefore, development of the small deposits along the Murrumbidgee must be supplemented from outside the area.

Highly weathered and decomposed granite forms a material that can be used as a general purpose fill (e.g. trenches and embankments) and as a subgrade material for roads. The granite weathers to a mixture of coarse sand and weathered rock fragments in a matrix of silty sand and clay. This material will be cheap and easy to excavate and should economically replace sand for many purposes.

General

From the brief examination carried out both the granites and Devonian(?) volcanics would appear to be suitable for use as dimension or facing stone. Specimens of suitable rock types are attractive in polished sections and are generally composed of durable minerals. Further testing, however, will be necessary before any development is considered.

Boulders of volcanics have been used, to good effect, to construct a small wall at the Point Hut picnic ground. Suitable sized and shaped rock boulders will probably be in demand for such purposes when residential development commences.

GROUNDWATER AND DRAINAGE

The northerly flowing Murrumbidgee River is the main and central river draining the area. It is fed from the west and east by a number of small streams with gradients that are normally sufficient to adequately drain the soils and prevent waterlogging. Two small areas showed evidence of poor drainage. Small discontinuous patches of saturated soils are present in the upper reaches of

Sawyers Gully. These are probably formed by small ridges of bed-rock impeding the shallow subsurface groundwater flow. Beds of organic peaty soils, that are indicative of periods of waterlogging, occur in the lower reaches of Barnes Creek. The slope gradient in this section is very low and in prolonged wet periods is probably the cause of the waterlogging.

Providing normal care is taken when installing artificial drainage, during urban development, no serious waterlogging problems should occur. Methods used in the Canberra area will be applicable in the Tuggeranong West area, but hydrologists should be consulted where abnormal conditions or special problems are met.

To fully assess the effect of urban development on the natural drainage of the area, and to predict what type of problems can be expected with the unavoidable impedence of groundwater, would require a well planned, systematic, hydrological investigation of the drainage regime of the area over a number of years. However, the installation of a number of piezometers and the subsequent regular measurement of groundwater level fluctuations over a 2 to 3 year period, together with the information obtained by studies in other parts of the A.C.T., will enable hydrologists to predict some of the more important problems that are likely to be met, and to suggest early solutions. Areas where shallow groundwater tables are common or where groundwater is under pressure will require the careful installation of a well designed drainage system; they are also areas in which deep basements or deep foundations should be avoided. An early understanding of the ground-water regime can offset design and construction costs as well as simplify construction methods.

SEISMICITY

The Tuggeranong West Urban Development Area is approximately 60 miles (100 km) southwest of a minor seismic zone that occurs close to Gunning (N.S.W.). Seismic activity has been felt in the Gunning area since the early settlements and some damage to homes has occurred. The Tuggeranong West area is also close to a minor seismic zone in the

Snowy Mountains, where an earthquake of magnitude 5 occurred at Berridale, 65 miles (100 km) south-southwest of the Tuggeranong area, in 1959.

Three small earth tremors, with magnitudes between 2 and 3 on the Gutenberg-Richter scale, were recorded along the Murrumbidgee Fault between October 1958 and August 1961 (Cleary, 1967). The epicentre of one of the tremors was 20 miles (32 km) north of the Tuggeranong West area, the epicentres of the others were 8 and 20 miles (13 & 31 km) south of the area. These tremors were probably confined within the upper 10 km of the crust.

There is no record of damage caused by earthquakes in the Canberra-Tharwa area. If Tennent Dam is built near Tharwa new minor strains could be imposed on the earth's crust in the surrounding area. However, experience indicates that a dam as small as this is unlikely to cause more than very minor increased seismic activity.

CONCLUSIONS

The Tuggeranong West area lends itself to urban development.

The geological and geomorphological environment (as described in the text) of a major part of the area is significantly different from that encountered in the development of Canberra to date: an intricate land surface and bedrock pattern exists. The engineering geologist with a knowledge of preliminary development plans will be able to foresee possible difficulties that could arise. He will be able to plan suitable early testing and use the results to advise the planners and engineers how the difficulties can be eliminated or by-passed.

Geological advice is likely to influence, more than in many other areas of Canberra, the alignment of arterial roads and services, neighbourhood design patterns and the feasibility of major areas of cut and fill.

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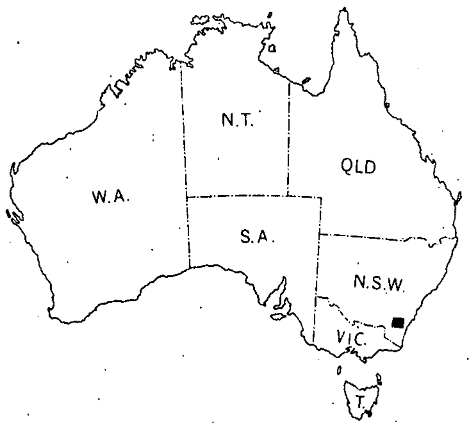
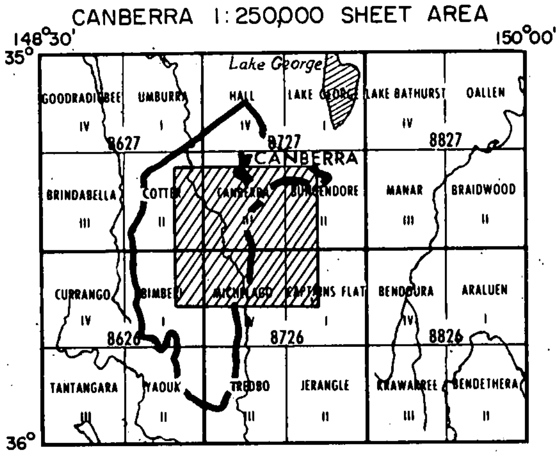
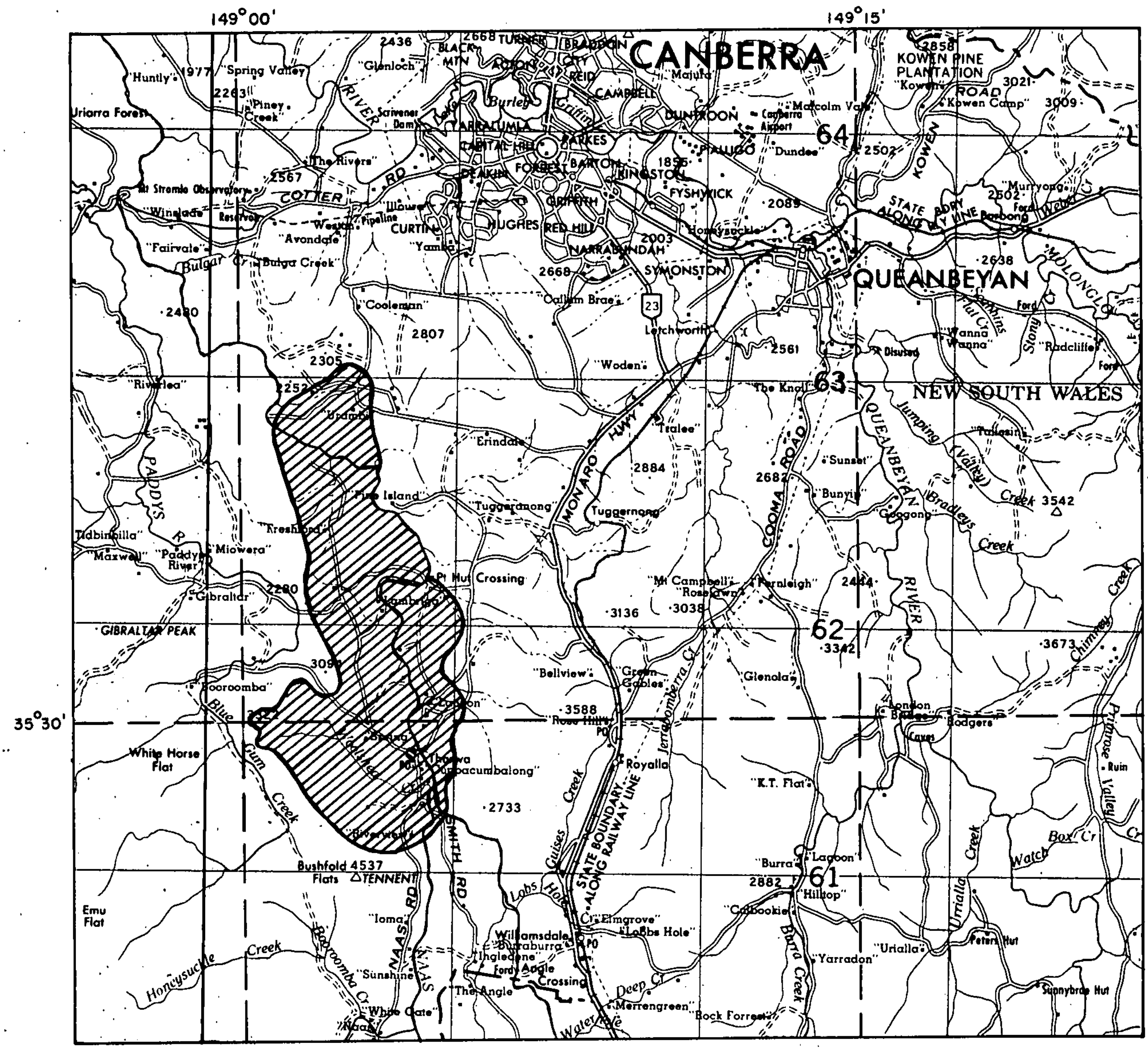
LOCALITY MAP



CANBERRA 1:250,000 SHEET AREA





0 5 10 MILES

Proposed Tuggeranong West urban development area

To Accompany Record 1970/68.

I55/A16/717

PLATE 2

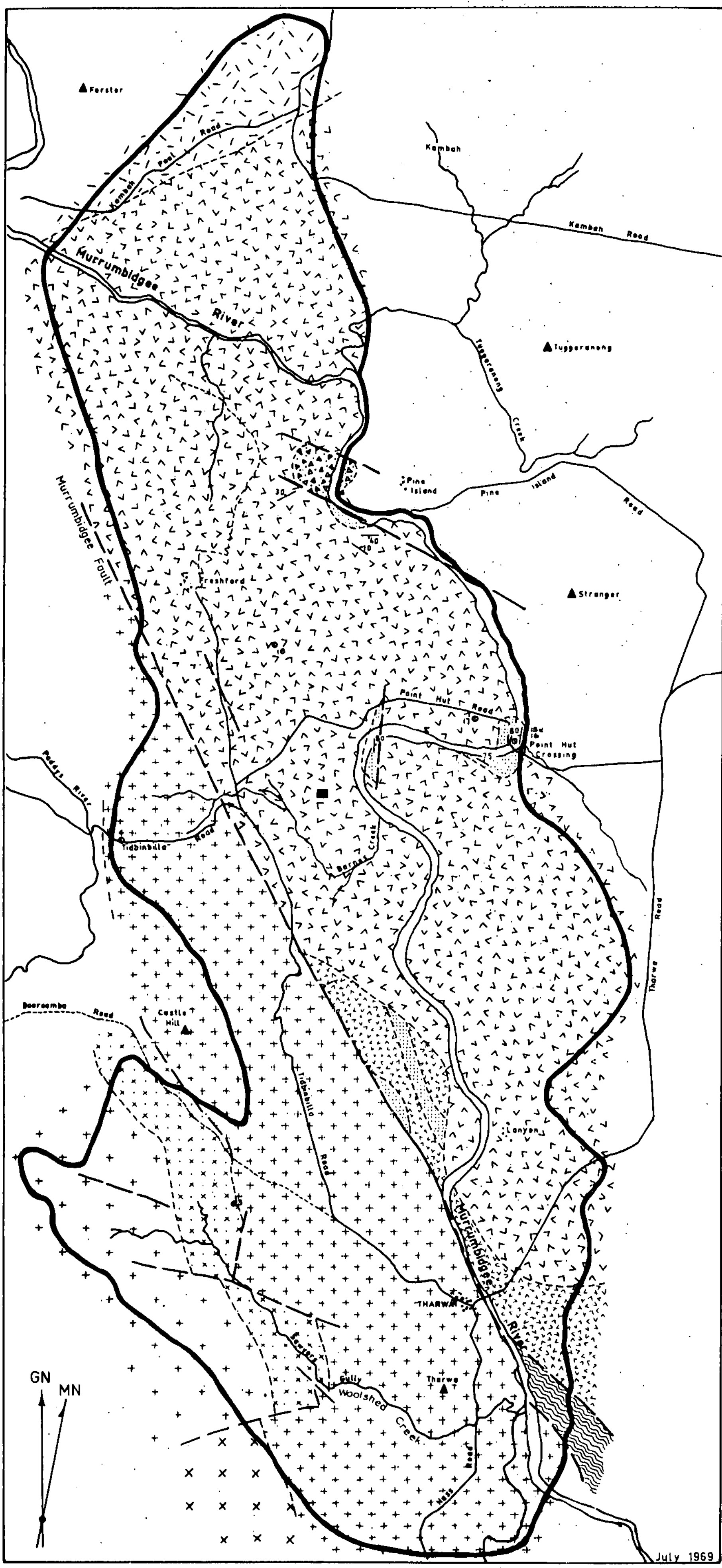
TUGGERANONG WEST

PRELIMINARY GEOLOGICAL MAP SHOWING BEDROCK

SCALE 1:64,000

0 1 2 MILES

0 1 2 3 KILOMETERS



REFERENCE

DEVONIAN
- Rhyolite tuff
- Volcanics, mainly tuffs

DEV/SIL
- Tharwa Adamellite
- Leucogranites, aplites
- Shannons Flat Granodiorite
- Clear Range Granodiorite

SILURIAN
- Sandstones & shales
- Tuff
- Mylonitized tuff
- Porphyry (based on Canberra 1:250,000 Geological sheet SI 55-16)

- Geological boundary, position approximate
- Fault, position accurate
- " " approximate
- Strike & dip of bedding
- Road, track
- Trig. station
- Monument
- Boundary of urban development area (approximate)
- Thin section locality

Geology by: M.J. Jackson, J.R. Mendum, D.E. Mackenzie.

Compiled & drawn by: M.J. Jackson.

Base map: N.C.D.C. map, scale 1:32,000

To Accompany Record 1970/68

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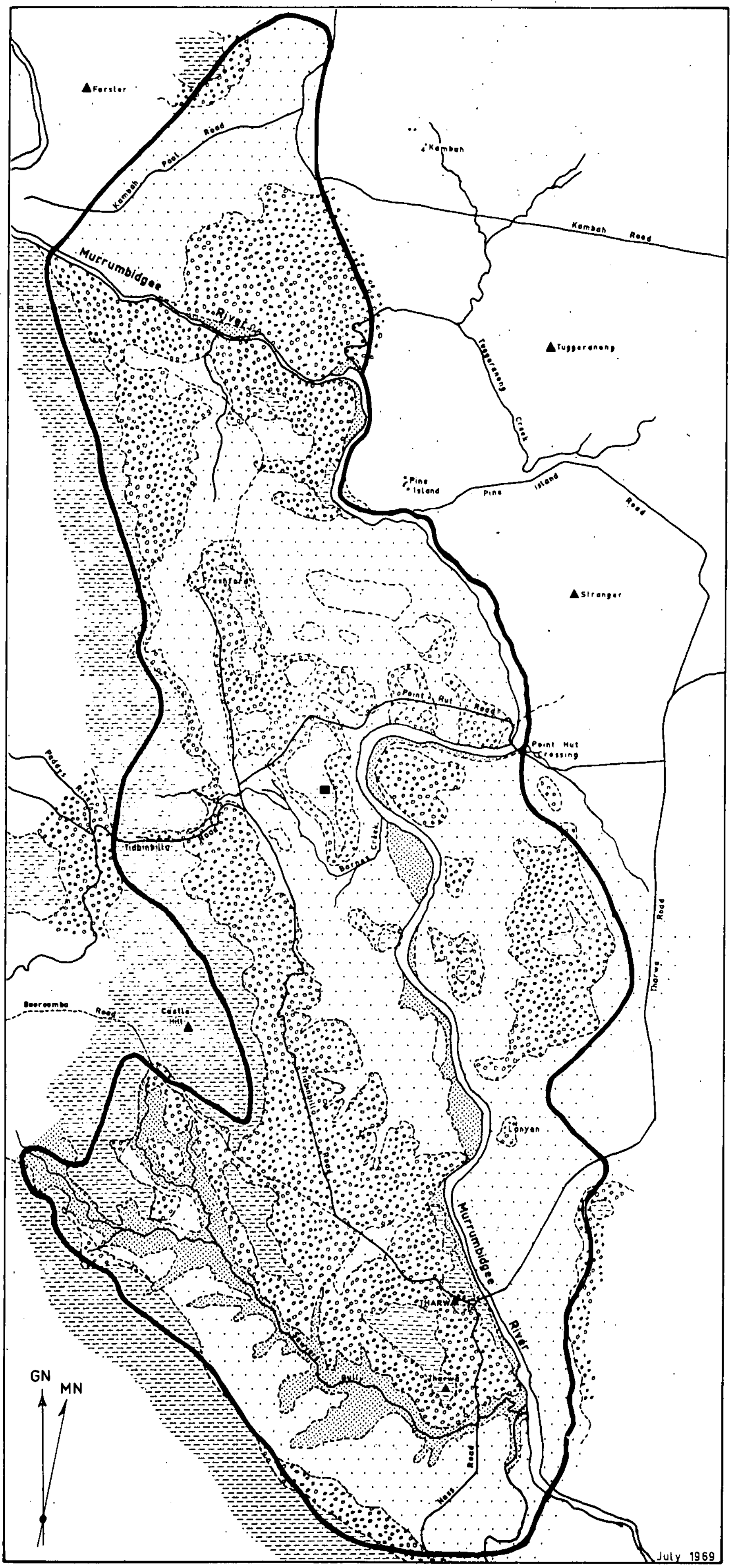
TUGGERANONG WEST

PRELIMINARY MAP SHOWING DISTRIBUTION OF SOILS



SCALE 1:64,000

0 1 2 MILES

0 1 2 3 KILOMETERS

REFERENCE

4 Recent alluvium mainly sand & gravel

3 Thick soils, colluvium, and alluvium

2 Soils, colluvium, and scree; commonly 10–20ft thick; numerous boulders on the surface

1 Thin soils (<10ft) and rock outcrop

Soil boundary

Road, track

▲ Trig station

■ Monument

Boundary of urban development area (approximate)

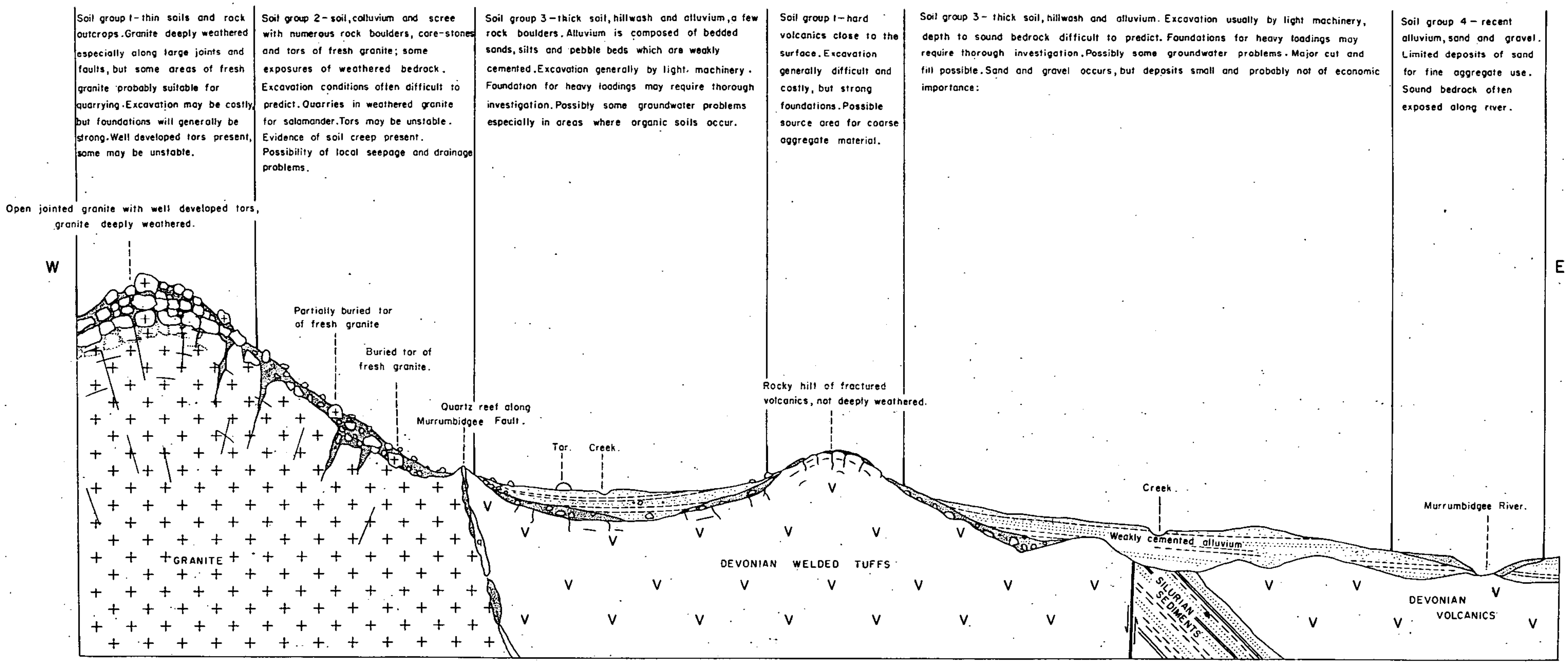
Soils mapped by: M. J. Jackson

Compiled & drawn by: M. J. Jackson

Base map: N.C.D.C. map, scale 1:32,000

To Accompany Record 1970/68.

PLATE 4.



GENERALISED DIAGRAMMATIC SECTION THROUGH THE TUGGERANONG WEST AREA.

This is a simplified, schematic cross-section, from west to east across the area.
The major landforms and soil features are illustrated and comments on the engineering geology of these are included. The cross-section is not to scale.

To accompany Record 1970/68

I 55/A16/720.