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## GOOGONG DAM SITE - QUEANBEYAN RIVER N.S.W.
## REPORT OF INVESTIGATIONS : MAY 1961 - AUGUST 1962.

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## GOOGONG DAM SITE - QUEANBEYAN RIVER, N.S.W.


### SUMMARY.

The Googong Dam Site is on the Queanbeyan River five miles south of Queanbeyan, in south -eastern New South Wales. The Site is being considered by the National Capital Development Commission as the third storage dam to supplement the existing water supply for Canberra.

The Googong site had been examined briefly previously by several geologists. It has been re-examined in greater detail for a larger structure than those previously considered; diamond drilling and seismic surveys were included in the re-examination.

A low saddle a quarter of a mile north-east of the site was surveyed; its lowest point corresponds with the proposed height of storage and will require treatment to remove the risk of overflow and leakage.

The storage overlies shale, slate, fine sandstone, lenticular limestone and tuff, mainly of Middle Silurian age. The sediments and tuff were strongly folded, faulted and intruded by acid igneous rocks in epi-Silurian time.

The dam site lies on strongly jointed, massive dacitic tuffs and flows which dip downstream at about 40°. The volcanics are bounded by a younger granite intrusion that crops out two hundred feet downstream from the site and by the Googong Fault and older sediments two hundred feet upstream.

The rocks in the environs of the dam site are considerably sheared but a suitable axis line for design investigation has been chosen; it is considered that the rocks about this line have no major structural weakness or major permeable zone, and present no grouting problem.

It was not possible to determine accurately the probable depth of excavation for the dam because of the complexity of weathering and jointing in the dacite and the small amount of testing done. It is expected to average about 8 feet on the right bank, 5 feet in the river section and 15 feet on the left bank. These depths are maxima and are based on excavation to a very firm foundation for the most delicate of the masonry-type structures; other types of dams would require proportionally less excavation.

No major difficulty is expected in protecting the saddle against overflow or sub-surface leakage. The depth of weathering is considerable and the weathered rock will require treatment. A fault may cross the axis of the saddle at right angles; it would also need treatment to prevent water leakage. Further testing is required.

The Queanbeyan Fault lies one half mile east of the dam. It is a major regional fault and separates the Silurian sediments and volcanics of the storage area from the Ordovician rocks of the Cullarin Horst (Plate 11). Geological and recent seismological evidence indicate that the fault is possibly still subject to minor movements.

Major leakage is not expected from the storage area.

Some leakage may occur along the Queanbeyan Fault and major shears but this would not be excessive. It is expected that the sediments under the storage will not provide appreciable leakage paths because of their lenticularity and interruptions by intrusions and faults.

Firm proposals are not made for the type of dam to be built. It is understood that the profile of the gorge is not well suited on engineering grounds to a thin-arch dam; the foundations of a thin arch dam would also be in part on sheared rocks associated with the Googong Fault; this is undesirable. In view of the fairly small area of very sound ground one of the thinner type structures such as a buttressed or cable-anchored type is favoured if a gravity masonry dam is desired. An earth or rock fill dam would require far less excavation than a masonry dam but would require considerable care in grouting over the much larger and thicker zone of shallow open jointed rock. The spillway location for an earth or rock fill dam would need careful consideration because of depth of weathering in the main possible spillway areas on both abutments.

Adequate construction materials are in sight: aggregate and rock fill from granite, limestone, silicified sandstone or dacite; impermeable core material from weathered granite or slope wash; and sand from the Queanbeyan River.

## INTRODUCTION

The Googong dam site is eight miles by road and five miles in a straight line due south of Queanbeyan, N.S.W. Its military grid reference is: Canberra 1-mile, 274259 and the elevation of the gauging weir on the Queanbeyan River at present occupying the dam site is 2020 feet above sea level.

The site lies in a small gorge below Beltana Crossing on Googong Station. Access is gained by travelling 5 miles south along the Queanbeyan-Burra road and then 3 miles east along the Googong Homestead track to Beltana Crossing.

The Department of Works early in 1961 was asked by the National Capital Development Commission to prepare a feasibility study of the Googong site as part of the Commission's search for a site for a third dam for the Capital. The Department of Works in turn asked the Bureau to examine the geology of the site and provided finance for drilling and costeaning.

### PREVIOUS INVESTIGATIONS

Two dam sites on the Queanbeyan River, one at Googong and the other at London Bridge six miles farther upstream, were selected by the Federal Capital Commission, which was the early Government constructing authority for the Capital. The sites lie in N.S.W. but under the Seat of Government Act the Federal Government is entitled to obtain its water and electricity supplies from land outside the Capital Territory.

The Googong site was prospected extensively by many shafts, adits and auger holes some time in the 1920's. Twelve shallow shafts and one adit were mined on the left bank and six adits were driven on the right bank. Also, thirty shallow auger holes were drilled along or near the axis of the proposed dam. The location of the more important excavations is shown on Plate 1; more complete details of these excavations are given in the plan and table of Plate 2.

Dr. W.G. Woolnough, formerly Commonwealth Geological Adviser, visited the site briefly in July, 1929 and reported favourably on it (B.M.R. file: 170ACT/3, Part 1, folios 11 and 12).

In 1954 the Department of Works requested the Bureau of Mineral Resources to gather more geological information on the site and to make any further comments considered necessary on the feasibility of the site so that the Department could compare more accurately the merits of the Googong site and a site on the Cotter River (Cotter Site A). The writer, assisted by Geologist M.A. Randal, mapped the immediate site in detail in 1954; the work was done under the supervision of L.C. Noakes then officer-in-charge of the Bureau's Engineering Geology Group. Noakes and the writer reported on the investigation early in 1955 (B.M.R. File 170 ACT/3, Part 1, Folios 31-33). The investigation revealed that the geology was more complex than originally thought. A major fault had been discovered immediately upstream and parallel to the proposed axis of the dam and the writers recommended further exploration including diamond drilling.

The Public Works Committee subsequently decided on a site in the Upper Cotter Valley and no further exploration was done at Googong. The writer of this report, however, assisted sometimes by University students, continued regional mapping of the catchment as time and other duties permitted.

PRESENT INVESTIGATIONS

In May 1961 the Department of Works asked the Bureau to undertake the additional exploration suggested in 1955 by Noakes and Burton, and to prepare a preliminary drilling programme. The specified height of the wall was increased to approximately 150 feet; this introduced considerable additional geological problems.

The writer, assisted by Field Assistant P.A. Stolz, mapped in greater detail by plane-table both abutments and paid particular attention to the higher sections. Additional costeaning was undertaken to define more accurately the Googong Fault.

Subsequently, when a survey of Phalaris Saddle, a quarter of a mile north-east of the dam site, showed that it was at about the same elevation as the proposed top water level, the saddle was geologically mapped and a report written (Burton, 1962).

A seismic survey to determine depth of weathering in the dam site area was carried out by W.A. Wiebenga and M. Kirton of the Bureau's Geophysical Branch between the 7th and 15th September 1961; the results were issued as a Bureau Record (Wiebenga and Kirton, 1962).

From 13th April - 2nd May 1962 the saddle area was similarly tested by M. Kirton and J.E. Gardiner and additional work was done on the dam site. A report is being issued.

Four diamond drill holes of total length 727 feet were drilled by a team from the Snowy Mountains Authority from the 20th July to 28th October 1961; the holes were water pressure tested.

Joint rosettes (Plate 4) were used to design drill holes to intersect the main joint systems at the most favourable angles. Logs of the four drill holes are given in Appendix 3. All core from the diamond drill holes was photographed while still in the split inner core barrel and each full core box was photographed before its removal to Canberra. Complete sets of these photographs are held by the Bureau's Engineering Geology Group and by the Department of Works, Canberra.

The results of water pressure testing of drill holes are given in Appendix 4 and results are illustrated graphically in Plate 5.

Cores from all four holes are stored at the Department of Works' Hydraulic Laboratory at Kingston, Canberra.

Some shallow costeans were also sunk but weathering on the left bank and the instability of the higher costean walls on the right bank limited the use of costeaning to defining the Googong Fault.

A report covering the geological investigations and the drilling of the first three diamond drill holes was prepared in September 1961 (Burton, 1961).

## PHYSIOGRAPHY

Within the area between London Bridge and Googong the Queanbeyan River and its tributaries have developed a broad, gently to strongly rolling, valley in soft Middle, and possibly Lower, Silurian sedimentary rocks.

The valley is bounded on the east by flat-topped hills of the Cullarin Horst (which is a fault block of strongly folded Ordovician sediments) and on the west by the Googong Plain (elevation about 2450 feet), which is underlain by hard dacite of Middle, and possibly Upper, Silurian age (Plates 7 and 11).

Noticeable benches have been developed in the valley at elevations of about 2150 and 2300 feet. The river is at present degrading and rapids are found above and below the dam site.

The hills of the Cullarin Horst rise sharply as a scarp along the line of the Queanbeyan Fault. The fault is a high-angle reverse fault with a throw of about 3,000 feet. A visual comparison of the benches of the valley with those on the Cullarin Horst (also apparent from the contour on the Bungendore 1:50,000 Military Sheet) shows a difference in elevation of about 300 feet; this may have been produced by a geologically recent vertical movement or movements on the fault. Relatively recent movement is also evidenced by the V-shaped valleys and bevelled facets on the scarp face. The northerly displacements of Bradleys and Valley Creek at the fault further indicate the possibility of considerable horizontal movement along the fault. The writer considers that strain-slip cleavage near the fault provides evidence for horizontal movement in Palaeozoic time.

At the dam site the physiography of the left abutment differs significantly from that of the right abutment. The left abutment is a rather isolated ridge; it shows the steps of the valley's well-developed benches. The lower 60 or 70 feet of the profile is sharp where a more recent and rapid cycle of erosion has cut the main section of a gorge. The two benches between 2080 and 2200 feet and 2300 and 2350 feet are gentle slopes;the 2080 to 2200 bench appears to be a multiple bench with two steps, a small one about at 2080 and another about 2170 feet.

In contrast, the right abutment is abrupt and shows little sign of the 2080-foot bench. It is on the outside part of the bend in the river, where erosion is more active than on the left bank. The stronger erosion resulting from this is aided by a favourable system of jointing and has produced the steep face which is almost free of scree and deeply jointed surface rock. The very steep face at the axis of the dam may however, be partly due to the presence of granodiorite porphyry which is harder and less-jointed than the more widespread dacite (Appendix 3, Log of Diamond Drill Hole 4). The two rock-types cannot be differentiated in the field because of their mineralogical similarity.

The form of the left abutment is conducive to a deeper piezometric surface, to more open joints and a heavier overburden of soil and weathered rock. Weathering may extend to as deep as 25 feet near Plane Table Station E and the piezometric surface may be as deep as 30 feet. The right abutment is likely to carry little overburden except in shear or fracture zones near the Googong and other Faults. The piezometric surface may be at 25 feet at Plane Table Station SA.

## GENERAL GEOLOGY

### CATCHMENT AREA

The Queanbeyan River (see Plate 7) rises in a belt of Siluro-Devonian granite and Ordovician sedimentary rocks to the south of Captains Flat and then runs east through the Cullarin Horst, (which is composed of Ordovician fine-grained and strongly folded sedimentary rocks) to London Bridge. Near London Bridge the river crosses the Queanbeyan Fault on the western margin of the horst and then flows northwards for about seven miles mainly through Lower(?) and Middle Silurian sedimentary rocks and in a few places through Middle and possibly Upper Silurian igneous rocks to Googong Station and the dam site. No Lower Silurian rocks have been identified; the regional geology suggests they may be present and probably are shale and fine sandstone with thin limestone lenses. The Middle Silurian sedimentary rocks are commonly lenticular and consist of shale, tuff and minor limestone and sandstone or greywacke; they have been described in detail by J.J. Veevers (1951, 1953a, 1953b).

The Silurian rocks were strongly folded meridionally during the Bowning Orogeny in late Silurian time (for more detail see, Noakes 1954, Opik 1954 and 1958). The folding and faulting appear to be more intense near the Queanbeyan fault. In the later stages of the Orogeny and early in Devonian time granite and granodiorite porphyry were intruded into the folded and faulted Silurian rocks.

Shearing and jointing in the granite near the Queanbeyan Fault indicates the probability of strong local faulting some time after Lower Devonian time.

Considerable geological mapping has been carried out in other nearby areas of the Middle and possibly Lower Silurian volcanics and sediments and this work provides much information on the sequence at Googong, which is difficult to map because of the soil cover and strong folding and faulting. The references to the mapping are tabulated below:

| Area | Reference |
|---|---|
| Immediately south and west of Queanbeyan | Phillips (1956) |
| Googong to Bredbo | Veevers (1951, 1953a and b) |
| Immediately north-east of Queanbeyan. | Moore (1957) |
| Immediately north of Captains Flat. | Oldershaw (Manuscript) |
| Queanbeyan - Burbong - Googong. | Stauffer (Mapping in progress - post graduate study, Australian National University). |

Little palaeontological evidence of the Silurian age of the rocks in the Googong Catchment is available, Veevers (1953a) attributes a Wenlock (possibly Lower Wenlock) age to his London Bridge Formation which runs through the Googong Catchment; this is Middle Silurian (possibly lower Middle Silurian). Also Joyce Gilbert-Tomlinson, who assisted the regional survey of the dam in an inspection of a fossiliferous zone immediately west of the Queanbeyan Fault and on Valley Creek 2¼ miles north of the dam site, attributes a Silurian age only to the zone.*

STORAGE

The storage area and dam site lie almost entirely within the belt of Lower (?), Middle and Upper Silurian rocks (Plate 11). Lower Silurian rocks have not been identified but they could be concealed between the outcropping Middle Silurian and the Ordovician basement or be part of the very disturbed sequence that crops out along the Queanbeyan Fault and contains extensive Middle Silurian sediments. If Lower Silurian rocks occur they are probably sandstone and shale but they possibly include thin limestone lenses.

One of the best sections in the storage area is immediately south of the Googong Homestead over an east-west distance of 3 miles. The stratigraphic succession there is approximately as follows:

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* "The hornfels at Canberra 1-mile Military Grid Reference 273295 yielded fragmentary shelly fossils, including simple rugose corals, brachiopods, and trilobites. The state of preservation does not permit generic identification, but a Silurian age is obvious." (Personal communication).

TABLE I.

| UNIT | THICKNESS | LITHOLOGY | PERMEABILITY | AGE |
|---|---|---|---|---|
| A | ± 2000' | Dacite | Low- in joints and fractures | Middle to Upper Silurian |
| B | 50' | Tuff & shale | " " " " | |
| C | 150' | Dacite | " " " " | |
| D | 150' | Tuff & shale | " " " " | |
| E | 10 - 40' | Limestone (lenses) | Probably very low, unlikely to be cavernous | |
| F | 300' | Shale & limestone lenses | Almost impermeable | |
| G | 50'? | Limestone and shale bands | Probably low- probably not cavernous. | (?) |
| H | Unknown | Fine-grained sandstone, greywacke, shale and slate | Low - joints and fractures | Lower ? to Middle Silurian |
| I | Basement | Fine-grained sediments | Almost impermeable | Ordo-vician |

(Units A - C probably are part of or equivalent to the Keewong Foliated Porphyry (Sharp, 1949), Gladefield Volcanics of Moore (1957), and Kohinoor Volcanics (Oldershaw, in preparation). Units D - H are Veever's London Bridge Limestone).

The succession has a general westerly dip. Folding, including overfolding, faulting and igneous intrusions are common and become particularly pronounced in the area between the Queanbeyan River and the Queanbeyan Fault. These features, together with the widespread soil cover, prevent the accurate reconstruction of the stratigraphic succession and the table must be regarded as a rough approximation only.

A considerable part of the northern storage area is bounded in the east by the scarp along the Queanbeyan Fault. East of the fault sediments are probably of Middle Ordovician age. They consist of at least 1200 feet of isoclinally folded greywacke and siltstone-greywacke which commonly contain thin interbeds, rarely more than 6 feet thick, of black and grey slate. Some basic igneous rocks - quartz dolerite and diorite - occur near Taliesin Homestead.

Specimens collected on a Traverse from Taliesin Homestead along Valley (Jumping) Creek to the scarp are described in Appendix 1.

DAM SITE

The dam site lies in a gorge (Plate 11) cut through a belt of blue-grey Middle Silurian dacite (Unit A of Table 1) which dips to the west at about 40° - 60°. Few dips are visible and possibly the structure is more complex than mapping has indicated: the configuration of strong outcrop west of the northern end of the proposed axis of the dam indicates a possible decrease or a reversal of dip in the dacite there.

Immediately upstream from the gorge lies a belt of a sediment and tuff (probably Units B, C and D) which are thought to be older than the dacite but have been faulted up against them by a major meridional reverse fault - The Googong Fault. The sediments are mainly slate, shale, greywacke, sandstone, calcareous and non-calcareous tuff and thin beds of limestone. As they are older beds they may also underlie the dacite at the dam site.

Immediately downstream from the proposed dam the river crosses a wide belt of granite which intruded the dacite in Upper Silurian to Middle Devonian time; this took place after the dacite had been strongly folded and faulted during the late Silurian Bowning Orogeny. The order of events established during field mapping and examination of drill core is supported by detailed petrological examination (Appendix I, Remarks).

## ENGINEERING GEOLOGY

### DAM SITE

#### General

The dam site is on massive blue-grey dacite of Unit A (see above). The dacite is closely jointed and considerably sheared. The granite has thermally metamorphosed the dacite and in places has altered the feldspar. Many of the joints and shears are infilled with veins of quartz, quartz and epidote, calcite, and pyrite. The pyrite, however, is not restricted to fracture planes but is disseminated through the groundmass of the rock.

The dacite is probably a mixture of tuffs, ignimbrites and lavas; it varies considerably in grain size but it was found impossible to subdivide the sequence in the field. The sequence has been affected considerably by later tectonic events and most of the original textural features have been destroyed (see Appendix 1).

On the northern and eastern parts of the right abutment and in Diamond Drill Hole DDH4 some slightly more massive and coarse rocks described as granodiorite porphyry were encountered (Slide No.7177, Appendix 1). It was not possible to map these as separate bodies and it is not known whether they are coarser phases of the dacite sequence, dacite metamorphosed by the granite, or fine-grained apophyses of the main granite body.

The silicification and change in the lithology of the dacite in the lower section of Diamond Drill Hole 2 and the upper section of Diamond Drill Hole 1 also indicate the possibility of a granodiorite porphyry intrusion between these two holes.

Immediately upstream from the dam site the northerly trending Googong Reverse Fault has brought beds of the lower Units B, C and D up into juxtaposition with the dacite of Unit A. The Googong Fault is thought to dip about 80° east and the throw is considered to be of the order of 200 feet.

The Googong area, particularly between the Queanbeyan River and the Queanbeyan Fault, is an area of major faulting, shearing and close jointing. The strikes of the main joints and cleavage at the dam site are shown in rosettes on Plate 4. The strongest system of shearing and jointing strikes about 010 degrees magnetic. The 010 system is the oldest and corresponds to the regional cleavage; it is parallel to the Googong Fault. As the granite shows no sign of this joint system (see also Remarks in Appendix 1) it is considered to be younger than the jointing. Two other directions of jointing or shearing strike about 080 degrees and 340 degrees and have affected the granite. Small crushed zones occur in the dacite in some places where major joint systems intersect.

A careful examination of the area during the mapping failed to reveal any major plane of weakness along the river at the site. Diamond Drill Hole 2 (Plate 5) showed fracturing under the river but pressure testing suggests this is not serious. The Googong Fault appears to be offset in the concealed section in the river and mapping of the spur east of the fault indicates the possible presence of several small faults parallel to, but not in line with, the course of the river through the gorge; in the gorge near the north-eastern end of the gauging weir there is also some strong jointing on the right bank parallel to the river.

The main problems which might be expected at this site are:

Bedding and Stratigraphic Weaknesses:

The dacite over much of the site is massive and no evidence was found of any well developed bedding-plane joint system which could act as glide planes dipping downstream under the proposed dam.

Regional mapping of the Middle Silurian rocks has shown that interbedded dacite tuff, shale, and other sediments are common but drilling proved that the dacite is without sedimentary inter-beds to 120 feet below and that the dam foundations would therefore be free of weak or porous zones of sedimentary origin.

It will be noted in the logs in Appendix 3 that the term 'blotchy' has been used to describe the apparently enlarged and possibly distorted feldspar phenocrysts in considerable sections of the dacite.

These feldspars have been altered by contact and/or regional metamorphism (see also Appendix 1). The altered phenocrysts commonly are less strong than the unaltered feldspar; however, these rocks when occurring below the weathered zone will not possess appreciably different elastic properties. They may however be responsible for some of the deeper zones of weaker weathered rock. Tests should be carried out on a fairly large suite of specimens from the preliminary drilling to examine this question. Laboratory ultrasonic testing, seems to be a suitably rapid method of testing the core while still preserving it for later inspection.

Beds of the lower units, B, C and D, probably exist at depth but under most of Section abc on Plate 1 they must lie at more than 110 feet (as proved by Diamond Drill Hole 1) below the surface (Plate 10). At this depth they will not endanger the stability of the structure. Their permeability is discussed in the next section.

Permeability:

None of the dacite mapped showed intergranular porosity and none is expected because much of the dacite is ignimbrite and all of it has been regionally metamorphosed. Mapping did not reveal any columnar jointing or any other depositional structure likely to result in leakage. The main problem is permeability due to fractures and joints of the dacite or permeability of any porous sedimentary beds underlying Unit A.

The nature of the jointing and fracturing is quite important. The dam site lies within a wide belt of strong shearing extending at least from the Queanbeyan Fault to a probable fault along the Burra Road at the Googong Roadside Mail Box. This belt is probably a continuation of the belt of strong shearing between the Queanbeyan Fault and Sullivan's Line east of Canberra.

The Silurian rocks at the dam site are very closely jointed. The nearby granite, however, has filled many of the original fracture planes with thin veins of calcite, epidote and quartz-epidote. This has produced two different effects above and below the piezometric surface. Below the piezometric surface the rocks are generally at sufficient depth and under sufficient load not to have sprung open and hence are still sealed by vein material or otherwise tight. The results of water pressure testing confirmed this.

In the shallower zone above the water table the joints have sprung as a result of unloading and permitted air and water to dissolve and oxidise the pyrite; the resulting acid has dissolved the calcite. The quartz-epidote and quartz veins however are more common than calcite veins and, as they are highly resistant to weathering, they have preserved the faces of most joint blocks and prevented strong weathering. The fresh open-jointed rock in this zone may be suitable for grouting thereby reducing the amount of excavation required.

Water pressure testing (Plate 5) showed that the dacite is almost impermeable below the piezometric surface and should present no great problem of leakage. Some localized shears can be expected and these will require careful grouting. Soil and weathering have prevented mapping of all shears but several striking at about 340° are expected to be encountered in the lower 60 feet of the left abutment.

Although the dacite is almost impermeable there is a possibility that water could leak from the storage through sedimentary beds which may occur beneath the dacite. This possibility is illustrated in Plate 10; the presence of the sediments in this diagram is hypothetical; they have not been encountered in any drill hole. If the beds exist some water could enter them through outcrops upstream, through the Googong Fault or through subsidiary shears. If the beds are permeable the water would pass along them beneath the grout curtain and up any major shears downstream from the dam; the less-fractured granite would act substantially as a bar to continued flow in bedrock. Flow up through the shears would be very low; Diamond Drill Hole 1 (Plate 5) shows that even strong shears in the dacite have a very low permeability at more than 100 feet below river level: in fact the dacite because of its great thickness would act as an aquiclude or cap over the sedimentary rocks. A 200-foot vertical hole is recommended on the upstream side of the dam to check whether any deep leakage path exists below the dam site and to determine more accurately the depth of grouting that would be required.

In Diamond Drill Hole 3 a quartz reef (probably the continuation of the reef cropping out 10 feet south of DDH 3) was encountered. The permeability in the zone of the reef appears to be high (0.3 gallons per minute per foot length of drill hole under 21 pounds per square inch pressure, Plate 5), but the reef was encountered close to the piezometric surface where joints are commonly open and permeable. On the other hand quartz reefs are commonly fairly permeable and it will be advisable to watch this point in further testing.

Immediately north of the right abutment geological and geophysical work has indicated an east-west fault, Fault A, and a concomitant deeply weathered zone in the dacite. The depth of weathering as shown in the geophysical work indicates that a spillway in this area, as was envisaged in one of the tentative designs, would require considerable excavation and replacement by concrete and would be very costly; the material removed would not be suitable for rock-fill in an earth dam. Further testing of the permeability of the postulated fault will be necessary.

Piezometers should be installed on the abutments, particularly immediately downstream of the dam site during design investigation, and should be read at regular intervals from the time of installation.

<u>Clay Seams</u>:

No major clay seams were observed on shears during diamond drilling. Some thin seams of less than ⅛" were seen. These should not create any great difficulty during construction as most are probably nearly vertical. Care should be taken during grouting to wash these out as thoroughly as possible. A strict watch however should be kept for thicker clay seams during further drilling, excavation and grouting.

<u>Breccia</u>:

Some small zones of crush breccia were seen in Diamond Drill Holes 1 and 2; they apparently were formed at the junction of joint and shear systems of different ages. The crush zones should not be a serious problem during design and construction but a small amount of 'dental work' may be expected. One crush zone was mapped and is shown on the right bank in Section abc (Plate 1).

<u>Reactivity</u>:

The possibility of the dacite being reactive with cement has not been checked. This should be investigated; if the dacite is reactive allowance should be made for the possible weakening of the bond between the dacite of the foundations and the masonry of a concrete dam.

Depth of Excavation

Three indicators (Plate 3, Section abc) are available for determining the depth of excavation. The first, geological evidence, is restricted to a few shallow shafts and drill holes. This limited evidence, particularly in an area with many shears, is poor and probably underestimates depth to sound rock.

Additional evidence is from the depth to the piezometric surface, above which rock tends to be weathered. The piezometric surface, even though only determined in a few places, tends to act as a bulk sample and indicates the overall depth to very sound rock. At Googong these observations are confirmed by the pressure testing of drill holes, which show a sharp reduction in permeability below the present piezometric surface.

The third evidence is from seismic investigations. This again is a bulk sample and subject only to the accuracy of the measurements in the particular geological environment. In this regard the geophysicists state (in a personal communication relative to the Googong survey) 'that due to the relative insensitivity of our seismic technique when applied to shallow depths of bedrock the uncertainty in the depths shown along traverse P is about 5 ft. Allowing for a similar uncertainty in the depths along traverses B, C and D, and the fact that the cross-over points were not precisely located, the average depths should agree with (your) geological estimates to within the above limits of accuracy.' Further, the 'bedrock' as determined by geophysical work on the main part of the site, is rock having a velocity of 15,000 to 18,500 feet per second and some of the overburden to this "bedrock" is undoubtedly sufficiently sound to provide suitable foundation rock.

In view of the complexity of jointing and shearing insufficient testing has been done at Googong so far to provide reliable figures for the probable depth of excavation for a concrete thin arch type structure. The figures in Table II, based on all available evidence, are considered to have an accuracy of about plus or minus 2 feet; the error is more likely to lie on the side of an overestimation of excavation. Small shear zones which will require additional excavation and filling must be expected. The figures allow for the levelling of sharp bedrock ridges as the actual firm bedrock will probably be a very uneven surface.

TABLE II

Depth of Excavation (measured vertically)

(a) Right bank: 5 to 15 feet
Average about 8 feet.

(b) River Section: 4 to 9 feet
Average about 5 feet.

(c) Left bank: 8 to 25 feet
(Small areas near granite on western end 25-32 feet)

Average about 15 feet.

The figures given above are for Section abc. Depths of excavation may increase away from this line.

Location and design:

The best site for the dam appears to be along and slightly west of Section Line abc on Plate 1. The approximate area suitable for detailed design investigation has been outlined around the Section abc on Plate 1. Farther east there is considerable shearing, associated with the Googong Fault, and lower bedrock velocities were encountered in the seismic traverses. If sited much farther west the southern end of the wall would rest on granite, and this granite is expected to be deeply weathered on the higher ground, where the piezometric surface has been deep. Site abc has the following features:

1. It is sufficiently close to the granite to benefit from hardening and sealing of the dacite by the granite but far enough away from it to avoid the danger of deeply weathered granite.

2. It is sufficiently far from the Googong Fault to avoid most of the worst shearing.

3. It is close enough to the granite to reduce to a minimum the possibility of water escaping beneath the dam through any sediments that may occur beneath the dacite.

4. The site has a tested section of at least 110 feet of dacite beneath much of its axis line.

It should be kept in mind that much of the top permeable zone with moderate seismic velocities may be fresh material with open or slightly sprung joints, and that this material, although possibly not suitable for foundations for a thin arch dam, will be amenable to grouting and may provide suitable foundation rock for gravity-type dams, including earth and rock dams.

In view of the limited area of sound foundation near the axis line abc consideration may have to be given to the possibility of a thin section gravity dam of the buttress-type, or the stressed-type anchored by prestressed cables. The very fractured nature of the rock in the foundations is unlikely to prevent the use of pre-stressed cables but depth and anchorage of the cables will need considerable care. The presence of considerable quantities of pyrite in the dacite of the foundation and the possibility that the pyrite would act as a corroding agent on the cables must be considered.

An earth or rock fill dam will require very much less excavation than a gravity dam but will require considerable grouting of the upper jointed zone over the large area of foundations. The possibility of some seismic activity near the area must be considered when deciding between these two main types of dam.

The Department of Work's engineers state that the topography of the gorge is not suited to a thin arch dam and that the foundations of such a dam would extend over the Googong Fault.

RIDGE

Between the dam site and the scarp at the Queanbeyan Fault a long ridge consisting of Browns Spur, Phalaris Saddle and Beltana Hill (Plate 8) forms a natural continuation of the proposed dam. The ridge can be considered to be water-tight except within 50 or 60 feet of the surface, and in zones of major shearing.

Much of the ridge is composed of Units A, B, C and D and smaller areas of Units E and F. A large granite intrusion occupies much of the eastern end of the ridge around Beltana Hill. Units A to F have all been considerably sheared and probably some are overturned. In addition several faults probably cut the ridge almost at right angles.

The lowest and narrowest part of the ridge is Phalaris Saddle a quarter of a mile north-east of the dam site which, at its lowest point is at 2160 feet elevation.

Appreciable leakage before grouting for a dam about 150 feet high (i.e. top water level 2160 feet) would be restricted to the low area about 1200 feet long at Phalaris Saddle and to the major faults, including the Googong and Queanbeyan Faults. It is considered that the water loss through these two faults would be small.

SADDLE

The saddle has been formed in a sequence of slate, tuffaceous shale, and dacite tuff (probably Units C and D) which dip at about 80° north-east.

The slate has been intruded at the eastern end of the saddle by a biotite granite of Upper Silurian to Middle Devonian age similar to the granite at the dam site. The granite appears to have also intruded and replaced a limestone and shale sequence (probably Units E to G).

A strong cleavage, of strike about 170° dip about 70° east, is developed in the sediments and volcanics. The granite is not cleaved but is strongly jointed.

The boundary between slate and dacitic tuff appears to be gradational over a very short interval. No dips were seen in the dacite tuff, which is assumed to be conformable with the slate. One rather doubtful dip measurement on a graded silicified arenite or tuff near the granite indicates, if valid, that the sequence has been overturned and that the slates, which are the older beds, now overlie the dacite.

The dacite that crops out strongly midway between Plane Table Stations B and C is possibly silicified; silicification could signify the presence of a small granite intrusion beneath the area. Low velocities obtained in the course of the seismic testing suggest that the boundary between the dacite and slate may be a fault. Little geological evidence for a fault was found except some strain-slip cleavage several hundred feet south of the saddle. Other possible explanations of this low velocity zone would be caving around an undiscovered limestone lens high in the saddle or deep weathering and opening of joints, caused by considerable ground water movement along the boundary of the less permeable slate.

The results of the seismic survey suggest that the boundary of the granite at the "bedrock" lies at least 100 feet farther east than mapped by the writer at the surface;

the discrepancy is probably accounted for a postulated easterly dip of the boundary (Section, Plate 6). Dip would similarly cause the small difference in the geological and geophysical assessment of the boundary between dacite and slate.

On geological evidence decomposed rock is likely to extend to a depth of about 10 feet in the tuff, 8 feet in slate and up to 30 feet in granite, and is likely to be highly permeable. Weathered rock is expected to extend 5 - 10 feet below the piezometric surface (see Section, Plate6) and to be very permeable (comparable to DDH 3, Plate 5); weathered dacite and granite are probably more permeable than weathered slate. Permeability at greater depths is expected to be slight except in major shears or faults such as the one, indicated by the seismic work, at the contact of the dacite and slate.

Despite the marked permeability of the weathered rock, treatment may not be necessary because of the width of the saddle. However the matter requires testing by permeability tests. As a preliminary opinion it is suggested that allowance should be made for grouting to fresh rock (and deeper in any shear zone) and for a thin concrete cut-off wall of average depth 10 feet to seal the decomposed rock. Soil cover, which is negligible will need to be stripped off.

As only a 10-20 foot high earth embankment will be required in the saddle, strength of both the decomposed and weathered rock should be adequate.

During the early part of this investigation consideration was given to using the saddle as a possible spillway area. This plan was rejected when it was found that the creek immediately north of the spillway area, which would act as the race, contained 20 feet or more of unconsolidated sediments and that there would be a serious problem in removing these and stabilizing the sides of the spillway race. However, as discussed in the section on materials, the unconsolidated sediments in this area may be suitable as an impermeable core for an earth and rock dam; if they are it would be possible to remove most of the loose material and consideration could be given to stabilizing the sides. Should this be possible the main problem will lie in the probable need to excavate the deeply weathered material revealed by the seismic survey at the crest of the Saddle itself.

STORAGE

It can be seen in Plates 7 and 8 that much of the Googong storage is underlain by sediments, including limestone and sandstone. It is considered, however, that the danger of major leakage through permeable beds is negligible.

The limestones are known from regional surveys to be lenticular and have rarely been observed to extend more than one or two hundred yards. Wynn (1962) however, mentions a limestone about 80 feet thick and 1600 feet long near Sunset Homestead immediately north-east of the entrance to Googong Station (Plate 8). The limestone lenses are commonly cut by faults and igneous intrusions and many are thinly bedded and contain shale bands. With the exception of the London Bridge cave, which is probably the result of abrasion rather than solution, no major cavities have been observed in the limestones in or near the critical area of the storage; at the ridge east of the dam site any limestones that may exist would have been below the piezometric surface for most of the time since deposition and are therefore probably free of solution joints and caves.

The sandstone is fine-grained and metamorphosed, and no permeable beds have been observed in it. A more detailed examination of outcropping sandstone,is, however, recommended.

Veevers (1953 - a and b) writes of the sediments of Units A to H (which he called the London Bridge Limestone after mapping them in detail at London Bridge and inspecting them at various points from Googong Homestead to Bredbo, 40 miles farther south) 'the lithology of the London Bridge Limestone is interbedded normal marine limestone, both massive and bedded types, calcareous sub-greywacke, sandstone and siltstone and calcareous slates. The beds are lenticular in shape and when followed along the strike change imperceptibly in lithology say from limestone to a calcareous slate'. Also, 'the maximum thickness of this London Bridge Formation is approximately 1500 feet at London Bridge and about 100 feet thick one mile to the south. At places this formation cannot be recognised due to extreme stratigraphic thinning and/or adsorption by the quartz feldspar porphyry'.

The whole storage has not been mapped in close detail. To do this is a long and difficult process because of soil cover, the weathered nature of many outcrops, the complicated structure due to faulting and shearing and because of difficult access to much of the area south-east of the dam site.

As limestone and shale of Units D to G mark the line of the Queanbeyan River and its right bank immediately east of Googong Homestead this area and that nearer the ridge were examined in detail.

Detailed outcrop mapping should however be carried out during any design investigation until the storage area is covered by mapping at a scale of 400 feet to the inch, using the detailed topographic map of the storage recently prepared for the Department of Works by the Snowy Mountains Authority.

The use of a power auger would assist mapping of the boundary between the granite, and slate and limestone near the Queanbeyan Fault and Beltana Hill (Plate 8). Thick soil and scree prevented accurate mapping in this area of possible leakage. Although sufficient was seen to indicate that no major problem of leakage exists it would be advisable to investigate the area further.

It should be noted that the top water level of storage corresponds to the top of an old bench in the erosion cycle of the valley. A short distance above this bench a steep slope begins. This is particularly noticeable on Feagan Trig. If top water level is raised to 2150 feet the piezometric surface would rise to just above the level of the old bench and would probably produce a series of springs that would tend to undermine the thin soil cover on the steep slope. Some vegetative cover may therefore have to be established to stabilize slopes and prevent discolouration of the water. The surface of the water would be more exposed to wind than it is in the present storages in the steep Cotter Valley and wave action would assist in the undercutting of any bordering slope.

RUN-OFF

The water received at Googong gauging weir is reported by officers of the Department of Works to be only about 7 to 8 per cent of the annual rainfall in drought years; this very low catchment efficiency has prompted the query whether or not limestones in the storage area are diverting part of the flow past the Googong Weir. Geological evidence, however, suggests that such low yields are normal and in keeping with the geology and physiography.

Granite, which occupies much of the higher parts of the catchment, weathers deeply in the Canberra region. The weathered granite acts as an excellent host for water which has percolated to the water table but has a rather low permeability. The granite also commonly develops rolling slopes and a cover of permeable wash, which are conducive to good infiltration. The presence of the granite in the higher country of the catchment where the precipitation is greater also results in greater infiltration; the precipitation includes both rain and snow in the high country.

The hydrological effect of the granite on the stream flow of the Queanbeyan River is probably to take into storage large quantities of water in periods of above normal rainfall and normal rainfall. This water is released as part of normal underground water depletion flow into the Queanbeyan River with a considerable time delay. Hence in periods of long-continued high rainfall the flow of the Queanbeyan River benefits considerably from earlier infiltration into the granite; this effect continues for some time into periods of below normal rainfall. However, if the dry period is prolonged the yield from the granite may diminish greatly and even when rainfall returns to normal discharge of groundwater may increase only slowly because of the low permeability of the granite. The overall effect of the granite is to retard considerably the transfer of much of the precipitation to the Queanbeyan River.

Much of the remainder of the catchment is covered by soils and weathered rock having good porosity but very low permeability; the topography is a combination of gentle plains in the high country and gentle/steep rolling slopes with several benches in the lower country. Infiltration on the gentle slopes is great but the low permeability results in a very high evapo-transpiration loss. The benches commonly result in both diminished run-off and loss of soil water and deeper underground water through springs that are subject to evaporation. These conclusions are confirmed by studies, over four years, carried out on the recharge of underground water in fractured rocks around Canberra. The studies suggest that recharge (percolation as distinct from infiltration) is much lower than originally thought and that except in late winter to early summer and in very favourable areas (such as the areas of granite in the headwaters of the Queanbeyan River) most infiltration is lost by evapo-transpiration. This loss will probably increase with increasing pasture improvement and the introduction of phraetophytes, including clover.

In an effort to see if there was any loss of river flow through limestone, officers under Mr. J. Edwards of the Department of Works undertook, after discussion with the writer, trial river gaugings above and below points where the river intersects the main belt of limestone. The preliminary tests were inconclusive and will probably be repeated.

CONSTRUCTION MATERIALS

Numerous sources of aggregate, sand and rock and earth-fill are available within a radius of six miles of the dam site. Each requires considerable exploration before it can be assessed. Owing to dissection in the area some deposits would require circuitous access routes.

Brief notes on the various materials are given in the following sections.

Aggregate for concrete.

There is one major quarry, the Queanbeyan Quarry, near the area. It supplies granite and several other types of aggregate.

The haulage distance, however, from the Queanbeyan Quarry is about six miles; there should be little difficulty in developing a suitable quarry in granite or dacite nearer the dam. Other possible rock types near the dam which may be suitable for aggregate are limestone, greywacke, quartzite and sandstone and river gravels.

1. Australian Blue Metal Limited operates the Queanbeyan Quarry, a large quarry about 5 miles north-west of the dam site (Locality 1, Plate 7). The quarry has mainly yielded granite aggregate but small faces have also been developed into hornfelsed greywacke, limestone and dolomite. The geology of the Company's area is complicated by major and minor faults and the granite shows considerable contamination near its boundary with neighbouring sediments. Considerable pyrite is present in places. Consequently when first grade aggregate for structural concrete is drawn from this source strict quality control should be maintained. In the early stages of development of the quarry granite samples were appraised as unsuitable for the construction of the Woden dam. Adequate reserves are available.

2. Granite or granodiorite crops out immediately downstream from the dam site. Adequate quantities of sound granitic rock are available. The granite is poorly jointed in many places and like most granites would probably be hard to crush. Weathering is pronounced where depth to ground water has been or is great: the soundest rock probably occurs within about 90 feet of river level and wherever the river has removed most of the thin weathered cover. One of the best sites for a quarry may be near the former alternative dam site, about 250 yards downstream from the present site.

Another possible site is a coarse intrusive rock which crops out on a small hill immediately behind (i.e. south of) Googong homestead and by the river. It should be easy to develop a sound quarry face there and the resulting quarry would be covered by water when the dam is complete.

The granites probably contain rather less pyrite than the dacite.

3. Dacite crops out extensively in the Googong area and if deeply weathered areas are avoided there should be little difficulty in selecting a quarry site close to the dam. The main problems with the dacite are: it commonly contains considerable pyrite; it may be reactive; and it is severely stressed and sheared.

4. Limestone occurs at numerous places in the area. Most of the deposits occur as steeply dipping lenses, many of which are sheared; some are faulted and some which are near granite are possibly intruded at depth. Each deposit needs careful exploration. The most promising deposits are near 'Sunset' 2 miles west-north-west of the dam site (Locality 4, Plate 7) and at London Bridge about 6 miles due south of the dam (Locality 6, Plate 7). Wynn (1961) investigated the 'Sunset' deposit as a source of concrete. He indicated reserves of 1,260,000 tons of limestone, marble, and dolomite. Some unfavourable features noted were: thin shaly partings were present in one specimen which was examined, another showed prominent bedding planes which would yield a tabular aggregate, and another specimen was too weak to provide suitable aggregate.

4. The hills that lie beyond the Queanbeyan Fault, 4 miles to the east of the dam site, are composed of hard Ordovician siltstone-greywacke (similar to a very fine hard sandstone) with interbeds of black slate. It is very doubtful if a sufficiently thick section of greywacke free of slate could be found for quarrying.

5. Quartzite, silicified sandstone and sandstone occur in small areas on the right bank of the river about 1 mile south of the dam site (Locality 7, Plate 7) in Unit H. These beds have not been investigated in detail for quarry sites but are worth prospecting. Sites which would be beneath top water level may be found. Material similar to the aggregate used at Bendora Dam may be available although the Googong sandstones are likely to be more silicified.

6. Outwash gravels of hard greywacke and hard slate occur on Bradley's Creek (Plate 8) and other major eastern tributaries of the Queanbeyan River for some distance after they debouch on to the lower country. Some of these deposits, particularly those on Bradley's Creek, may be suitable for working but they need careful investigation.

<u>Sand for Concrete</u>

Sand supplies seem assured from banks in the Queanbeyan River but considerable testing is required.

The Queanbeyan River is strongly degrading. Sand and gravel banks are probably thin and variable; sufficient reserves should however be available. In view of the variety of rocks in the catchment the quality of the sand should be examined carefully. Main danger lie in excessive amounts of flaky rock fragments from the Ordovician rocks, weathered feldspar and possible high mica content near granite sources, and reactive and flaky material from the Silurian dacite.

The nearest suitable deposit is probably on the big bend of the Queanbeyan River ½ mile south-east of Googong Homestead. Only a rapid visual inspection has been made of this bank.

Rock-fill

Rock for earth and rock-fill dams appears to be readily available. The sources would be the same as for concrete aggregate; the best for rock-fill is likely to be the dacite.

Filter materials for earth dams

Adequate supplies appear to be available in the bed of the Queanbeyan River (see section on Sand) and in the outwash gravels near Bradley's Creek (see Section 6, Aggregate). Another possible source is screenings from the Queanbeyan Quarry or any quarry developed for rock fill in the sources mentioned above.

Impermeable core material

A considerable range of prospects for impermeable core material have been delineated but the most suitable still require extensive testing.

Two quarries or borrow pits lie about 5 miles north of the dam. These are too distant to be useful but give some idea of the weathering pattern in the area.

The first of these is a very small quarry or borrow pit/that has been worked on the opposite side of the Queanbeyan - Burra Road from the A.B.M. Quarry (Locality 2, Plate7). This quarry was developed by an unknown operator in deeply weathered granite. The site is high and the water table would have been very deep (about 50 feet). Decomposed granite (granite so deeply weathered that it shows very little of the original granitic texture) forms only about the top 1½ ft of the profile. Beneath this lies more permeable weathered granite. Much of the original decomposed material probably has been removed from this steep exposed ridge by both wind and rain. Similar conditions probably apply on steep slopes near Googong.

The material from the quarry was used apparently for base course of roads.

The Queanbeyan Council developed the other small quarry, (Locality 3, Plate 7) beside the road at Barrack Creek, about one mile north of the A.B.M. quarry. The quarry yields a mixture of weathered and decomposed granite. Reserves appear to be small.

The main possible sources lie quite close to the dam site. Some of these deposits were visited with Messrs. A.D. Hosking, and A.D. McConnell, engineers of the Snowy Mountains Hydro-Electric Authority and their comments are given in Appendix 2. The deposits which were inspected had been delineated by J.K. Hill from the larger areas selected by the writer. The deposits were augered by Hill prior to the visit of the Snowy Mountains Authority officers and Hill's comments are given in Appendix 2.

The main prospects are as follows:

1. Weathered granite and dacite occur extensively through the area in topographical situations which are conducive to both weathering and retarded erosion. The granite weathers more easily and for this reason is the more likely prospect. J.K. Hill investigated several

deposits (Plate 8). Of these the most interesting appear to be A,D and C. Messrs. Hosking and McConnell, of the Snowy Mountains Authority, drew attention to the importance of keeping quarries within the storage area and below top water level; as a result further prospecting was carried out and a possible new prospect at Beatty's Spur (Locality 8, Plate 7), three quarters of a mile south of Googong Homestead was located. The deposit consists of two sharp hills which possibly have shed most of their weathered mantle; they require careful examination including some preliminary augering.

2. Weathered shale. Seismic velocities obtained on the slate and shale at Phalaris Saddle suggest that deposits of this material could be sufficiently weathered on ridges to be usable in an impermeable core. The shale two hundred yards west of Locality 7, Plate 7, may be worth investigating: it would lie below top water level.

3. Soil. Banks of wasted soil up to 20 feet thick occur along the valleys of non-perennial creeks immediately downstream from the dam. The banks are stratified and the material has a wide range of permeability and plasticity. If carefully worked these could yield a suitable mixture. The most promising area is shown at Station Creek, Locality E, Plate 8.

4. Alluvial material in river flats. Large alluvial flats occur on the lower reaches of Bradley's Creek near its junction with the Queanbeyan River. Their composition is unknown; they are probably a mixture of soil containing considerable organic material, fine sediments and thin gravel beds.

SEISMICITY

No epicentres of major earth tremors have been reported from within the proposed Googong dam storage area. Some strong tremors however have been reported on the Southern Tablelands and Snowy Mountains (Joklik, 1951; Taylor 1910; Burke-Gaffney, 1952).

The Snowy Mountains Authority and the Department of Geophysics of the Australian National University in 1958 began a detailed study of this seismicity. Seismographs were installed at Wambrook, Jindabyne, Geehi, Cabramurra, and Canberra. Collation of the results from these instruments has commenced and is yielding useful information on the Canberra region (Cleary, Doyle, Moye, Manuscript). Records include numerous minor shocks near Sutton, 18 miles north of the dam site.

Hence past information does not indicate any major seismic hazard in the Googong area. When design of the final dam structure commences however, the evidence then available from the Australian National University and the Snowy Mountains Authority should be obtained and studied to see what allowance for seismicity should be made. Particular attention should be paid to evidence suggesting recent movements of the Queanbeyan Fault or Sullivan's Line.

## CONCLUSIONS

1. The site selected is suitable for a dam 150 feet high of yet undetermined design. The site is known to be underlain by over 110 feet of strong massive dacite.

2. A thin arch dam is not favoured but the site lends itself to either a prestressed concrete structure or a rock-fill dam.

3. The axis line recommended for design investigation lies approximately mid-way between the granite intrusion downstream from the dacite and the Googong Fault upstream.

4. The dacite is closely jointed and is cut by several important faults and shears. The Googong Fault is bounded by extensive shears and produces lower bedrock seismic velocity than most of the dacite.

5. Weathering and open-jointing are more pronounced on the left bank than on the right bank because of the geomorphology and depth to the piezometric surface.

6. The granite weathers deeply on higher ground and in such positions the weathered rock is weak and has high permeability.

7. The intrusion of the granite has filled many of the joints in the adjoining dacite and has sealed many of the joint planes with veins which resist weathering.

8. The main factors on the site to be considered are the depth of excavation to sound rock and permeability of fractures and shears.

9. The depth of excavation has not been fully determined but is expected to average about 15 feet on the left bank, 5 feet in the river section and 8 feet on the right bank.

10. Pressure testing has shown that the permeability beneath the piezometric surface is low and that grout takes will not be great. Grouting however will need careful supervision because of the abundance of narrow joints and the presence of thin clay seams.

11. Fault A, on the right bank, needs careful testing because of possible leakage along it.

12. The presence of considerable areas of deep weathering on both banks downstream from the site will require careful siting and design of the spillway.

13. Considerable further testing is needed during design investigation.

14. Phalaris Saddle, north-east of the dam, would readily support a low retaining embankment but needs testing to define the permeability of the upper jointed and weathered rock and the possible fault between the dacite and slate.

15. If the saddle is chosen as a spillway site the depth of excavation will have to be examined carefully and the use or removal of unconsolidated wash in the area of the race investigated.

16. The storage area contains fine sandstone and limestone but they are not expected to provide leakage paths.

17. Some loss of water from storage is expected to occur along the Queanbeyan, Googong and other faults but the total loss will not be excessive.

18. The Queanbeyan Fault may still be subject to minor movement and may provide seismic disturbance.

19. Sufficient construction materials are in sight but require considerable testing.

## RECOMMENDATIONS

1. The site is considerably sheared and it is impossible to delineate and study all shears and broken zones at the surface. Consequently most of the site should be covered adequately by diamond drilling and pressure testing. The following holes will probably be required in the course of design investigation:

(a) A 200-foot vertical hole on the right bank on the upstream side of the axis line to test further the beds below the axis.

(b) A second hole under the river from the right embankment to supplement information from the left bank hole (D.D.H. 1) and to intersect the crush zone on the right bank.

(c) One or two holes totalling about 300 feet on the right abutment below Diamond Drill Hole 4 to supplement information in the adits there.

(d) A hole about 100 feet long between Diamond Drill Holes 1 and 2 to test the low bedrock velocities reported in Seismic Traverse K.

(e) One or two holes totalling about 300 feet to test Fault A (Plate 1).

(f) Two holes totalling about 300 feet to test the Phalaris Saddle Area.

All holes ~~were~~ should be water pressure tested.

2. Diamond drilling may need to be supplemented by visual inspection of foundations to determine accurately depth of excavation; this is most important in the upper sections of the abutments where the piezometric surface is deep. If the holes recommended above fail to provide sufficient information on the strength & water-tightness of the abutments a shaft at about R.L. 2110 to 2120 feet on both banks should be considered to permit inspection.

3. It was not possible to determine fully the elastic properties from the seismic work done to date and at the Googong site this is important if a masonry structure is to be built because of the degree of jointing and nature of the weathering. It is important to determine the elastic properties on bulk samples in situ rather than on small excavated samples. Accordingly detailed seismic testing of the foundations should be undertaken. This should be supplemented by laboratory ultrasonic testing of drill cores

of existing and new drill holes. During the core testing attention should be paid to core showing saussuritisation and kaolinisation of the feldspar.

4. In the final stage of investigations a small number of 20-40 feet deep drill holes may be needed to define bedrock over the whole axis line.

5. Outcrop mapping of the storage area should commence immediately after a decision to proceed with further work at Googong. This mapping should commence in the north where the presence of permeable beds would be more critical than in the south.

6. Liaison should be maintained with seismologists of the Australian National University in order to keep abreast of the latest information on the seismicity of the Googong area.

7. Prospecting and testing of materials should be undertaken as required. This should include testing of the dacite in the foundations for reactivity.

8. Piezometric studies of the site should be planned and maintained.

9. In view of the importance of accurately referring shears, located in past testing and mapping and future testing, to design it is advisable to establish a grid and several major survey control points at the beginning of the next stage of investigation.

10. Power augering or diamond drilling to assist mapping of the Queanbeyan Fault east of the saddle area should be considered.

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# APPENDIX I.

## PETROLOGY

by

W.R. Morgan

## INTRODUCTION

The rock descriptions are arranged in three parts: first, descriptions of specimens collected from outcrops in the vicinity of the dam site; second descriptions of core samples from Diamond Drill Holes 1 and 2 at the dam site (the petrographic descriptions in these two parts are followed by a few remarks on their petrology); and third. descriptions of a group of specimens from the Ordovician rocks to the east of Queanbeyan Fault.

## OUTCROP SPECIMENS

One group of outcrop specimens was collected in 1954, and the thin sections were submitted for examination in 1960; the hand specimens were not available for examination. The localities are shown on Plate 1.

R.9327. Silicified dacite porphyry.

The thin section (7395) shows phenocrysts, ranging in size from 0.2 mm. to 3.5 mm., enclosed in a fine-grained groundmass that has an average grain-size of 0.08 mm. The quartz phenocrysts are embayed, and are strained and cracked. Tabular albite phenocrysts are moderately sericitized. Porphyritic crystals of ferro-magnesian minerals (possibly hornblende) are replaced by sericite, chlorite, and nontronite. The groundmass is composed of finely intergrown quartz grains that enclose numerous minute flakes of sericite. Very thin anastomasing veins of sericite material cut the rock. Accessory zircon and leucoxene were noted.

R.9328. Silicified dacite porphyry.

In thin section (7396) this specimen is seen to be fairly similar to R.9327. The main differences are the finer grain-size of the groundmass (0.02 mm.) and that the ferro-magnesian minerals (biotite and possible hornblende) are pseudomorphed by epidote and small amounts of leucoxene. Some accessory apatite was noted. The rock is cut by thin anastomosing veins of sericite material.

R.9329. Silicified and sheared dacite porphyry.

The thin section (7397) shows phenocrysts of quartz and albite enclosed by a fine-grained groundmass of finely intergrown quartz. The rock is cut by a thick shear zone composed of intergrown quartz grains that show strong strain patterns; a vein containing quartz and small amounts of euhedral tabular epidote has been emplaced along the shear zone.

R.12830. Veined dacite porphyry.

The thin section (5025) shows phenocrysts, ranging in size between 0.1 mm. and 5.0 mm. enclosed in a fine-grained granular and flow-textured groundmass that has an average grain-size of 0.03 mm.

The anhedral quartz phenocrysts are embayed and have pseudo-inclusions: some of the smaller quartz grains are angular, and may be pyroclastic. Andesine phenocrysts are tabular to anhedral, and are commonly sericitized; some crystals are strained and micro-fractured. Sub hedral amphibole and biotite are pseudomorphed by epidote, leucoxene, nontronite, and chlorite.

The groundmass is formed of granular quartzo-feldspathic material, and leucoxene, and flaky sericite and nontronite. The flaky minerals are strung out in flow trails which swirl around the coarse grains. Octahedra of black iron ore, and prisms of accessory zircon and apatite are present.

The phenocrysts and the groundmass are cut by thin veins containing sericite, nontronite, and rare zeolite. In places, the veins occupy microfractures in the phenocrysts.

In groundmass the veins occur as very narrow diffuse zones in which the flaky minerals are oriented parallel to the flow-texture. The vein minerals commonly form narrow fringes around quartz and andesine phenocrysts.

A visual estimate of the percentage of minerals present is :- andesine: 54, quartz: 25, pseudomorphed ferro-magnesian minerals: 10, sericite and nontronite: 10, black iron ore: 1.

Certain of the angular quartz grains appear to be tuffaceous, although the shapes of most of the phenocrysts, and the presence of the flow-texture suggest that the rock is a lava. It is probable that the rock is a <u>dacite porphyry</u> containing some tuffaceous material.

## <u>R.12831. Devitrified dacitic crystal tuff.</u>

In the thin section (5026), coarse grains of quartz, feldspar, and rare rock fragments and altered ferro-magnesian minerals are enclosed by a fine-grained, dominantly felsitic groundmass.

The coarse grains of quartz are angular, and commonly corroded: they frequently show strained extinction. Somewhat saussuritized oligoclase forms tabular to anhedral crystals that, in some places, occur as interlocking clusters. Rare intergrowths of epidote, leucoxene, and chlorite may represent altered ferro-magnesian minerals. The groundmass is composed mainly of finely intergrown quartz that encloses minute flakes of muscovite and chlorite, and grains of leucoxene. Accessory apatite and zircon were observed. A rounded rock fragment, probably trachyte, or andesite was observed to be composed of medium-grained tabular plagioclase crowded into a fine-grained felsitic and leucoxenic groundmass. The rock is cut by irregular veins containing fine opaque dust.

## <u>R.12832. Dacite porphyry</u>

The thin section (5027) shows coarse, anhedral to subhedral phenocrysts ranging between 0.3 mm. to 3.0 mm. in size, enclosed in a fine to medium-grained xenomorphic-inequigranular groundmass whose average grain-size is 0.05 mm.

The phenocrysts are composed of quartz, plagioclase and rare ferro-magnesian minerals. Rarely, quartz occurs as euhedral prisms, but more commonly it forms anhedral, strongly corroded crystals. Tabular anhedral grains of plagioclase are somewhat saussuritized and silicified. Rare pale green chlorite forms anhedral flakes.

The groundmass is composed of fine to medium-grained somewhat intergrown grains of quartz and plagioclase. The intergrown nature of these two minerals seems to be granoblastic, suggesting that some contact metamorphism has taken place. Granular epidote and leucoxene, and flakes of green chlorite are present.

The rock is cut by thin diffuse zones of granular epidote.

R.12835. Sheared and granulated dacite porphyry, or dacite tuff.

In this section (5030), coarse shattered and granulated grains of quartz and oligoclase are enclosed in a fine-grained groundmass. The groundmass is composed of quartz which forms granular, commonly elongated and intergrown grains that show a shear fabric, although the present form of the intergrowths suggest that recrystallization has taken place after the shearing. Subhedral to tabular crystals of epidote that are present appear to have been formed subsequently to the shearing.

R.12836. Dacitic tuff.

The thin section (5031) is seen to contain medium to coarse grains of quartz and feldspar, whose sizes range between 0.1 mm. and 2.0 mm., enclosed in a fine-grained groundmass. The coarse grains of oligoclase are anhedral to tabular, and many show micro-fracturing. Quartz forms angular anhedral grains that sometimes show corroded margins. The groundmass is composed of granoblastic, somewhat intergrown grains of oligoclase and quartz. Small amounts of calcite occur in granular aggregates and rare veins.

R.12837. Veined and saussuritized dacite porphyry.

The thin section (5032) has coarse phenocrysts of andesine, quartz, and pseudomorphed amphibole, and their sizes range between 0.2 mm. and 4.5 mm. They are enclosed in a fine-grained granular groundmass whose average grain-size is 0.05 mm.

Quartz phenocrysts are anhedral, and have embayed margins; several show strained extinction. Andesine forms tabular to anhedral, often strongly saussuritized crystals that are commonly microfractured. Amphibole is now pseudomorphed by intergrowths of nontronite, black iron ore, and uncommon epidote.

The groundmass is composed of fine, intergrown quartz grains enclosing minute flakes of sericite and grains of epidote. Accessory black iron ore and zircon are present.

The groundmass is cut by numerous thin and irregular veins containing fine flakey nontronite. A few thicker veins of yellow epidote cut the rock.

W.B. Dallwitz in 1961 briefly examined a second group of three slides made from field specimens. The locations are shown on Plate 1; Dallwitz named the rocks as tabulated below:

| Specimen Number | Slide Number | Name |
|---|---|---|
| R. 8808 | 7176 | Sheared acid ashstone |
| R. 8807 | 7175 | Dacitic crystal tuff |
| R. 8809 | 7177 | Granodiorite porphyry (thick flow or intrusion). |

## CORE SAMPLES

These samples are from Diamond Drill Holes 1 and 2 at the dam site; their thin sections were examined in September, 1962.

### D.D.H. 1.

R. 9213. (Depth, 2 feet 9 inches): The thin section (7343) shows that the rock is silicified vitric and crystal dacitic tuff. The crystals range in size from 0.15 mm. to 5.0 mm., and are enclosed in a fine groundmass that has an average grain-size of 0.02 mm. The crystals consist of embayed and strained quartz moderately sericitized tabular albite, and a small amount of biotite that is now completely pseudomorphed by granular epidote and some leucoxene. Some of the albite forms multiple grains. The groundmass is composed of finely intergrown quartz grains.

R. 9330. (Depth, 30 feet): The thin section (7398) shows that the rock is a silicified vitric and crystal tuff. Angular to sub-angular grains of moderately strained quartz, roughly tabular crystals of albite and potash feldspar, and somewhat distorted flakes of biotite are enclosed by a very fine-grained groundmass composed of finely intergrown quartz grains and minute sericite flakes. The feldspar and quartz grains have embayed margins, and the biotite is pseudomorphed by sericite, epidote, and chlorite. The crystals and grains range up to 4.5 mm. in diameter, and the groundmass has an average grain-size of 0.01 mm.

R. 9331 (Depth, 133 feet 3 inches): In thin section (7399) the specimen is seen to be silicified tuffaceous dacite porphyry. The phenocrysts range from 0.15 to 4.5 mm., and are enclosed in a fine groundmass that has an average grain-size of 0.03 mm. The phenocrysts consist of embayed quartz, tabular, somewhat sericitized albite and slightly distorted biotite that is completely pseudomorphed by sericite, leucoxene, and nontronite. The groundmass consists mostly of finely intergrown quartz grains enclosing numerous minute flakes of sericite. Two or three xenoliths that are present are rounded, and have a diameter of about 3 mm.; they consist of dioritic material and contain granoblastically intergrown stumpy laths of sodic plagioclase 0.5 mm. in length. The rock is cut by thin, diffuse anastomosing veins containing sericitic material.

### D.D.H.2

R.9396. (Depth, 109 feet 6 inches): The thin section (7436) shows the rock to be a silicified tuffaceous dacite, or ignimbrite. The phenocrysts range from 0.2 mm. to 3.2 mm. diameter, and consist of embayed and strongly strained quartz, rounded albite crystals and embayed crystals of somewhat kaolinised potash-feldspar. The rare ferro-magnesian minerals are replaced by leucoxene and epidote. The groundmass has an average grain-size of 0.02 mm., and consists almost entirely of fine intergrown quartz grains; rare leucoxene and epidote were observed. In places there is a faint relict flow texture in the groundmass around a few of the phenocrysts. The rock is cut by two veins, 1 and 2 mm. thick, composed of fine granular epidote.

R.9404. (Depth, 187 feet 9 inches): In thin section (7465) the rock is seen to be a divitrified and silicified albite dacite porphyry. The phenocrysts range from 0.3 mm. to 5.0 mm. in size, and are enclosed in a fine-grained groundmass (forming 60% of the specimen) that has an average grain-size of 0.01 mm. The phenocrysts of tabular, strongly sericitized albite (20%), strained and embayed quartz (10%), subhedral biotite (5%), and strongly kaolinised potash feldspar (5%). Biotite is pseudomorphed by leucoxene, sericite, and nontronite. The groundmass consists of irregularly intergrown quartz grains that enclose numerous minute flakes of sericite. Besides the phenocrysts, the groundmass encloses a xenolith of altered andesitic material that measures 3 mm. across. The irregular veins range from 0.03 mm. to 0.5 mm. in thickness, and mostly consist of calcite; some contain, in addition, fine green chlorite, and fragments of quartz and feldspar that are derived from the porphyry.

## REMARKS

All the specimens described are dacitic lavas and tuffs, although in some of them small xenoliths of intermediate igneous rocks were noted; it is possible that these are cognate. The groundmass of most of the specimens is silicified; this may be due to diagenesis, but other evidence which will be mentioned shortly suggests that it may be due to contact metamorphism or metasomatism. Some of the specimens have been sheared; in these the sheared material appears to have recrystallized to a granoblastic texture, suggesting reheating subsequent to the shearing. In one specimen (R.12834) veining by epidote occurred after the shearing took place. This evidence suggests that the volcanic succession in this locality has been intruded, resulting in slight contact metamorphism and some metasomatism. Prior to this, some of the volcanics were sheared or faulted.

## SAMPLES FROM ORDOVICIAN EAST OF QUEANBEYAN FAULT.

These seven specimens were collected by G.M. Burton during a traverse down Valley Creek from Taliesin Homestead. Valley Creek is approximately 2½ miles north-east of the dam site.

The localities and thin section numbers of the specimens are:

| Field Number | Military Grid Reference | | | | Laboratory Reference | | | |
|---|---|---|---|---|---|---|---|---|
| T. 1: | Canberra | 1-mile | Sheet | 324286 | ,thin | section | number | 5020 |
| T. 5: | " | " | " | 319286 , | " | " | " | 5009 |
| T. 8: | " | " | " | 313282 , | " | " | " | 5021 |
| T. 9: | " | " | " | 313281 , | " | " | " | 5022 |
| T. 11: | " | " | " | 304279 , | " | " | " | 5023 |
| T. 18: | " | " | " | 288276 , | " | " | " | 5024 |
| G. 59/1 | | | | 327278 , | | | | 5005 |

Specimens T.1, T.9, T.11, and T.18.

All the hand specimens are dark grey or greyish-brown, medium-grained but inequigranular micaceous sandstones that show some apparent shearing and lineation of the mica. Specimen T.18 has a phyllite-like sheen on some surfaces.

In thin section, all the specimens are seen to be inequigranular, the grain sizes ranging between 0.02 mm. and 0.5 mm. All specimens contain angular grains of quartz and subordinate albite that are enclosed in a finer groundmass composed of granular quartz and feldspar, and flakes of sericite and subordinate chlorite. Some perthite grains were noted in specimen T.9 and chlorite seems to be more abundant in specimen T.11 than in the others. The sericite in specimen T.1 is stained by hydrated iron oxide. Black ore is present in specimens T.1 and T.9, and in T.8 and T.11, it is seen to be partly altered to leucoxene. Leucoxene only is present in specimen T.18. Prismatic zircon, and prismatic to anhedral, pale green tourmaline may be found in all the specimens. Sub-prismatic apatite is present in specimens T.9, T.11, and T.18, and sub-rounded grains of sphene in all specimens except T.1. In specimen T.9, euhedral sphene is enclosed in some of the quartz grains.

The textures of the specimens all show the effects of shearing, but it is more pronounced in some (e.g., T.18) than in others (e.g., T.1). The mica and chlorite in specimens T.1 and T.9 tend to be wrapped around the coarse quartz and feldspar grains and show only slight lineation. In specimens T.8. and T.11 the lineation is more pronounced. Quartz and feldspar show some strain and have somewhat ragged margins in specimens T.1, T.8, and T.9. These features are seen to be more pronounced in T.11. Specimen T.18 is definitely more schistose than the others, as it has a pronounced lineation and foliation of sericite and chlorite, and commonly the grains of quartz and feldspar have been strained and elongated, and, in places, rotated parallel to the cleavage.

All these specimens may be termed <u>greywacke</u>, although from the large amount of quartz present, the name <u>quartz greywacke</u> might be better. Specimen T.18 is an <u>albite - sericite - quartz schist</u>.

<u>G.59/1</u>. Thin section number 5005.

The hand specimen is seen to be a medium-grained hypidiomorphic-inequigranular basic igneous rock.

In thin section the rock is hypidiomorphic inequigranular, the grain sizes ranging between 0.15 mm. and 1.0 mm.; rare phenocrysts attain a size of 2.5 mm. Some ophitic intergrowth and (rarely) slight fracturing of the crystals may be seen.

Labradorite ($An_{68}$) forms slightly saussuritized subhedral tabular crystals that, in places, contain replacement veins of albite. Rarely inclusions and veins of chlorite are present in labradorite. Augite forms colourless subhedral to anhedral grains that are sometimes ophitically intergrown with labradorite. It commonly has a rim of pale green fibrous actinolite, and in places, augite is almost entirely replaced by this mineral. Actinolite also occurs as small euhedral crystals, and is pleochroic with X=nearly colourless, Y=pale olive green, and Z= pale green;

the colours tend to be rather more dark than those of the actinolite replacing augite. Pale green fibrous chlorite, and more rare epidote, zoisite and quartz, are interstitial. Anhedral grains of leucoxene and black iron ore may be seen, and accessory apatite occurs as fine acicular crystals enclosed in labradorite.

The rare phenocrysts are formed of tabular labradorite and prismatic, somewhat uralitized augite whose margins are sometimes ophitically intergrown with groundmass labradorite.

A visual estimate of the percentages of minerals present is : labradorite: 55, augite: 20, actinolite: 20, chlorite, epidote and quartz: 2, black iron ore and leucoxene: 3. The rock is a partly uralitized quartz-dolerite.

T.5. Thin section number 5009.

This specimen was collected in 1955, and only the thin section was available for examination. The rock is seen to be hypidiomorphic-inequigranular, and coarse-grained, the grain sizes ranging between 0.3 mm. and 3.5 mm. The mineralogy is fairly similar to that seen in G.59/1: labradorite ($An_{65-70}$) forms slightly saussuritized anhedral to tabular crystals that show some fracturing; the fractures are filled with fine fibrous actinolite. Augite forms colourless subhedral to prismatic crystals, of which many are partly or wholly replaced by pale green fibrous actinolite. Actinolite is also found interstitial to labradorite crystals. Anhedral leucoxene and fine acicular apatite are present.

A visual estimate of the percentage of minerals present is:- labradorite: 55, actinolite and augite: 42, leucoxene: 3. The rock is a uralitized gabbro.

APPENDIX 2

CONSTRUCTION MATERIALS

Reconnaissance surveys for impermeable core and filter material for the proposed dam were carried out in April 1962 by J.K. Hill. Five prospective sources of impermeable core material were found and briefly tested by hand augering. In May, the sites were inspected by officers of the Snowy Mountains Hydro-electric Authority. Discussions were held in the field at each site; notes made by both a Bureau geologist (J.K. Hill) and the Authority's officers (A.D. McConnell and A.D. Hosking) are given in this appendix.

The following approximate figures for construction materials for an earth and rock dam at Googong were supplied by A. Fokkema of the Department of Works prior to the reconnaissance survey:

| | | | |
|---|---|---|---|
| Impermeable core | 90,000 - 120,000 | cubic | yards |
| A filter ($<\frac{1}{2}$" sand) | 70,000 | " | " |
| B filter ($\frac{1}{2}$" - 3") | 47,000 | " | " |
| C filter (3" -10") | 23,000 | " | " |
| Rock fill, class I (downstream) | 325,000 | " | " |
| Rock fill, class II(upstream) | 280,000 | " | " |

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INSPECTION OF IMPERMEABLE CORE MATERIALS NEAR GOOGONG DAM SITE

by

J.K. Hill

On 2.5.62 two officers from the Snowy Mountains Hydro-electric Authority inspected proposed sites for borrow pits in weathered granite and slope wash material near the Googong Dam Site. The following conclusions were reached with regard to each particular borrow area site:-

SITE A. (Plate 8)

This area was regarded as a likely prospect in view of the lack of outcrop and its situation on the crest of a ridge. Material from a shallow (4') auger hole was examined and cursory examination showed its properties to be favourable for impermeable core. Provided at least 10 ft. of "rippable" material is present, this prospect will probably yield a sufficient volume of material (120,000 cu. yds.).

SITE B.

Site B was briefly inspected, and although material from auger holes was pronounced suitable, it was generally agreed that insufficient material was present to warrant further investigation. However, enough material probably exists to form a core for the levee bank in the nearby low saddle. The site is the crest of a narrow, steep sided ridge.

SITE C.

This site is gently sloping hill-side which may be covered with a considerable thickness of granitic slope-wash. The material itself appears to be suitable, and should it persist to a depth of 10 ft. or more, it is almost certain that more than 120,000 cu. yds. can be obtained. The hillside is traversed by a tongue of granite (with boundaries near the crest and foot of the slope respectively); which extends for a considerable distance in either direction along the contour. The ground is quite stony in places, but it is thought that these fragments are either "floaters" in the profile or else are derived from outcrops higher up the slope, and therefore do not indicate that fresh granite is near the surface.

SITE D.

This site is on the crest of a broad spur and is completely devoid of outcrops; this was considered favourable . Material obtained from shallow auger holes was thought to be suitable on the basis of a quick field examination. Should about 8 or more feet of weathered rock be present, there will be no difficulty in obtaining the volume required.

SITE E.

This prospect is located in a small valley, the floor of which has been filled with up to 20 feet of alluvium and/or slopewash. The material is roughly stratified in many places and has become quite hard through leaching and cementation. There are also numerous layers of coarse blocky rock debris present. The conclusion reached after a cursory inspection was that, provided the properties of the clay, silt and sand components are suitable, the material would make a satisfactory core if it can be mixed thoroughly during excavation, laying, and compaction. A suitable excavation method would be to work a full face with a power shovel in vertical strokes. Ample material is present for impermeable cores for both dam and levee bank.

General Comments

The S.M.A. officers said that experience at the Authority in proving weathered granite sources has shown that material readily drilled by truck-mounted or portable power engine augers is not necessarily capable of excavation by bull-dozers or ripping machines. They emphasised that it would not be wise to test any prospective source by power augering, and that hand augering with 4" post hole augers is a much more reliable indicator; i.e. if the material can be hand augered to say 10 feet, then it can also be excavated by ripping etc.

However, they felt that material at sites A,C and D would best be tested by a tractor-powered back hoe to determine its excavation properties, since hand augering already attempted at these sites usually failed to penetrate more than 3 to 4 ft. The S.M.A. officers felt that the weathered granite encountered could well be an exception to the rule and be capable of excavation by ripping.
Pitting with a back hoe would check this. The back hoe should be capable of digging to about 10 ft. They suggest that the next step in investigating the most favourable sites should be to hand auger or pit with a back hoe on a rectangular grid with 200 to 300 ft. spacing, followed up by additional auger holes or pits at half this distance where necessary.

Further investigation of a proposed borrow pit site by seismic survey was considered unnecessary since the auger holes and pits provide positive and sufficient information. However, geologists working on road surveys in the Snowy Mountains report that percussion (Hammer) seismic methods have given reliable results in determining the depth of "rippable" material in weathered granite. All material with a seismic velocity of less than 4,600 ft/sec. has been found to be capable of excavation in this manner.

Any deposit less than about 8 to 10 feet deep is uneconomic to work because of the large area required to supply the necessary volume and the consequent expense of soil conservation works.

As a general conclusion, it was decided that sites A and C were to be preferred at this stage because of their proximity to the dam site. Site D appears to have the greatest potential for large volumes but the distance from the dam site is greater. Site E is near the dam site but the material will require thorough testing as to its suitability before further investigation by drilling is carried out. (About 200 lbs of sample are required). It was considered that sites A,C and D were sufficiently favourable to render further reconnaissance unnecessary at this stage.

## NOTES ON FIELD INSPECTIONS FOR POSSIBLE CONSTRUCTION MATERIALS SOURCES

by

A.D. Hosking and A.D. McConnell, S.M.H.E.A.

On Wednesday 2nd May 1962 a site inspection was made of possible materials deposits in the vicinity of Googong Dam Site on the Queanbeyan River with Messrs. G.M. Burton, E.G. Wilson and J.K. Hill of the Bureau of Mineral Resources.

### General Geology of Damsite Area

The damsite, some seven river miles upstream from Queanbeyan, lies in dacite in a generally complex geological area. At the site itself both abutments consist of dacite, which forms part of a belt of Silurian shales, sandstones, greywackes, limestone and igneous rocks some two miles wide in this area. This belt is abruptly bounded by the Queanbeyan Fault on the eastern side, beyond which Ordovician metamorphosed sediments form the country rock. To the west the mainly sedimentary belt passes into sheared porphyry and tuffs of Silurian age. Immediately upstream of the dacite at the damsite there is a fault, beyond which there are limestones, shales and related rocks. Downstream from the damsite, and very prominent on the ridges east and west of the river, there are considerable areas of granite, mostly very weathered at the surface.

### Sources of Dacite for Rockfill

Although the visit was primarily concerned with exploration for impervious materials a brief inspection was made of the outcropping dacite on the right abutment of the dam. It is understood that the excavation of a spillway through the right abutment of the site is planned for use as rockfill for the dam. The fresh dacite will yield excellent rockfill material but the presence of zones lacking in outcrop would indicate that special sub-surface exploration of the spillway area would be required to establish the relative quantities of suitable and unsuitable material which could be expected to become available from that area. Deliberate extension of excavation beyond the limits of the spillway proper would be quite feasible as a source of additional rockfill material if required. (Results of seismic traverses L,M,N and O since to hand show that the dacite in this spillway area is very jointed and weathered, G.M.B.).

Sources of Impervious Material

In all, 5 prospective sources of impervious material were visited and inspected.

(i) Slope wash (Site E) - The lower end of a gently sloping and shallow valley which enters the river approximately a mile downstream from the dam site contains slope wash to a depth of up to 20 ft. This material is well exposed to a depth of at least 15 ft in a narrow vertically-sided gully which has been formed by erosion in the valley floor. The deposit consists of stratified gravels, sands, silts and clays with few cobbles and gives the impression that if well mixed it would yield a satisfactory impervious core material. It appears that the deposit is large enough to yield the required quantities. Preliminary composite samples (at least 150 lb. weight and preferably 200 lb. weight for a basic range of tests) can readily be obtained by channelling the vertical faces of the erosion gully to depths equivalent to face shovel cuts. Initially a limited amount of exploration will be required such as augering (although the presence of stones may make this method impracticable) or test pitting to establish the lateral limits of the deposit, to confirm the available quantities and to assess variability. The area is at a relatively low elevation and haul roads to the dam site would be straightforward and little affected by ruling grades.

(ii) Weathered Granite (Site B)

This area is situated on the southern end of a ridge which runs generally parallel to the river, approximately ½ mile east of the dam site.

This material had been easily augered to a depth of 5 ft (limit 3 in. auger used) and appeared to be satisfactory core material. However the area is very restricted (rock outcrop occurs on the ridge both north and south of the area), the side slopes of the ridge are relatively steep and it is very doubtful that sufficient quantities of material would be available from the source to fulfill the requirement for the main dam. It could give useful material for the saddle dam but Site C is much closer and more convenient.

(iii) Weathered Granite (Site C)

This area is on the western slope of the ridge referred to under (ii) above and is north of the ridge top area. It forms the right abutment of the saddle dam. There appears to be no reason why this area should not yield sufficient quantities of suitable material. Subsurface exploration, initially by hand augering at broad intervals, will be required to obtain preliminary samples for index testing and to establish the approximate quantities available. The area is approx. 300 feet above the river level and the haul road to the dam site could be fairly direct.

(iv) Weathered Granite (Site A)

This area is on the upper level of ridge which forms an extension of the left abutment of the dam. At this location the ridge is broad and gently sloping. Hand augering with a 3 in. auger had been stopped by hard material at 3 ft depth and the material removed by the auger appeared suitable for an earth core. Subsurface exploration initially by hand augering at broad intervals will be required to obtain preliminary samples for index testing and to establish the workable depth and therefore the approximate quantities available. The area is approximately 600 ft above the river level and although quite close to the dam site would require at least a one mile haul road to reach the lower levels of the dam site with reasonable grades.

(v) Weathered Granite (Site D)

This area is approximately ¾ mile from and to the north west of the dam site and is situated on a gently sloping ridge which joins the river ¾ mile downstream from the dam site. The area is quite similar to but more extensive than that at Site A; hand augering with a 3 in. auger produced similar results and additional exploration should be on the same basis.

Although it is further from the dam site than Site A it is at approximately the same elevation and the haul road would be comparable in length with that required for Site A.

Sources of Filter Material

Inspections were not made of possible sources of this material except in the floor of Bradleys Creek where a limited quantity of suitable material is available. However, along the Queanbeyan River there appear to be fairly extensive deposits of sands and gravels which should be explored as possible sources of filter zone material.

General

Although it would be desirable to locate borrow areas within the reservoir area if possible (thus avoiding disfiguration of permanently exposed areas and consequent regeneration costs) there appears, from the general geology of the area, little chance that suitable, sufficiently large deposits will be found upstream within reasonable distance of the site. However, this possibility should be examined further.

Required quantities are not large and consideration should be given only to areas which contain the total requirements in one deposit, with adequate margin for contingencies (the proved volume should be at least twice the required volume). It is doubtful how far the exploration for impervious materials should proceed at this stage. It is considered that in each of the more likely areas a minimum of exploration should be carried out now to establish the workable depth of material, the general extent of the area, the available quantity of material and its general properties. To achieve this it will in general be necessary to drill hand auger holes at broad intervals to check on depth and extent and to obtain samples. It may also be necessary to excavate a very limited number of pits (by hand or by back hoe) where hand augering is unsuccessful.

It is doubtful if any additional work should be carried out until the design has reached the stage where it becomes necessary to have more detailed information about a particular area or areas.

General Comments on Exploration and Sampling

During discussion some reference was made to the possible use of power augers for exploration for impervious materials. In the Snowy Mountains Area power augers provide a false indication both of material properties and of the workable depth of material (due to the grinding action of the bit in hard material). Experience has also shown that, in general, material which can be removed by hand auger will present no problems with normal excavation equipment. It is therefore strongly recommended that power augers be not used in explorations for fill materials by the Bureau.

Samples of completely weathered granite for laboratory testing should be obtained by methods which will ensure a minimum amount of material breakdown.

Although exploration of impervious materials deposits by seismic methods gives an excellent indication of extent and depth of available material, it must be supplemented by other forms of subsurface exploration to obtain a clear picture of the extent of workable material contained in a prospective borrow area.

APPENDIX 3.

LOGS OF DIAMOND DRILL HOLES 1 – 4.

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT GOOGONG DAM-SITE HOLE NO 1. R.L. 2019·5'

LOCATION Queanbeyan River N.S.W ANGLE FROM HORIZONTAL 45° DIRECTION 38°30'M.

| ROCK TYPE & DEGREE OF WEATHERING | DESCRIPTION | DEPTH & SIZE OF CORE | LOG | LIFT & CORE RECOVERY | STRUCTURES JOINTS VEINS SEAMS FAULTS CRUSHED ZONES | |
|---|---|---|---|---|---|---|
| | | 0' | | | | |
| Sand | | 1'6" | | 100 | | |
| G.diorite porph. | Unweathered 7349⊗ | 3'9" NMLC | | 100 | Joint vert. Joint 40° | Qtz epidote veins 3'10"-4'6" |
| Dacite | Unweathered | 4'9" | | 100 | Joints 55°+80° | |
| G.diorite porph. | | 6'0" | | 90 | | Large qtz. epidote veins 7'4"-8'5" dip 50°. |
| Dacite | Some g.diorite porph? Pyrites on veining at 11'. Joints strongly iron stained. | 12'4" | | 100, 100, 100, 100, 100 | Joint 50°. Joints horiz. | Thin calcite veins on joints. Fine tuff at 7' dipping at 10° |
| Dacite | Contains ⅙" tuff band, dip 10°. Silicified, Joints little iron stained | 14'4" | | 100, 100, 100 | Joints 40°+60° | |
| G.diorite porph | Joints almost free of iron staining | 16'6" | | | | Small, Qtz. epidote veins at 17'-19' Dip 50° |
| Dacite | Silicified. | 20'7" | | 100, 100 | Joint 80° | Cut by thin calcite veins at acute ang. Qtz. veins 20'4"-23' dip 50° |
| Granodiorite-porphyry + silicified dacite | Core appears silicified + hybridised in part. Feldspars zoned + "blotchy." * | 30', 40', 47'3" | | " | No open joints - core breaks on veins. Pug + oxidised copper on joints at 29'. Little clay on joints dipping 60° at 38'. Veins dipping at 50°+80°, intersected at 120°. | Numerous q.-epidote + † aplite veins 3" to 1' apart. Also very thin later calcite veins. ½" q. epidote veins at 21'8" dip 45°. Calcite veins at 35'6" dip 60°. † Note. "Aplite" is a field description only + requires further examination in the laboratory. |
| Dacite | 7398 ⊗ Fine to coarse; "blotchy" feldspar. Steep incipient shearing increasing towards base. | 50', 60' | | " | Joints dip at 45°, 60°+80°. Joints from 51'-60' have clay films. Fracture zone with q. epidote veins at 53' - 57'6" | Veins of q. epidote + aplite. Some pyrites at 47'6" on 80° shears. |
| Dacite + possibly some Granodiorite porphyry | Mainly coarse but some fine. Small ⅛" masses of pyrites common mainly in fine dacite. Pyrite also disseminated along tight shear joints dipping at about 75°. Feldspar is "blotchy." | 70', 81' | | " | Joints from 62'-72' about 5" apart, dip 45-60°; from 72-80' dip about 60° + 20°. Many tight shear planes some slickensiding, dip about 75°. Crush zone at 69' contains 1-2" soft dacite + veins. Crush zone 75-76'6" contains about 6" very soft rock. | Aplite veins ⅛-¼", mainly in coarse dacite about 6-9" apart + dip about 20°+60°. |
| Dacite | Mainly fine, some coarse. Pyrite common. Feldspar is "blotchy" in part. | 92'6" | | " | Joints well spaced. 5"-12" apart, dip at about 30°+70°. Slickensides on some 70°. | Calcite veins with some quartz common at 86-91'. |
| Dacite. | Medium to fine grained. Pyrite common. Feldspar "blotchy" in part. Dacite is strongly stressed. | | | " | Joints 3-6" apart dip 30°, 40°+70°. Joints 1-2" apart between 95-96'. | Heavy quartz veining 97'6"-99'3", dip at about 80°. Slickensided + sheared zone 95'-96'. |

DRILL NO 6-A-15

TYPE BOYLES

DRILLER R. Grech

COMMENCED 28·7·61

COMPLETED 18·8·61

*The adjective "blotchy" is used to describe feldspar which appears to be strongly saussuritized, + distorted?, probably resulting from contact + low grade dynamic metamorphism.

⊗7343 B.M.R. petrological slide + reference number.

LOGGED G. M. Burton

VERTICAL SCALE 1" = 10 feet.

# BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

## GEOLOGICAL LOG OF DRILL HOLE

PROJECT: GOOGONG DAM SITE HOLE NO: 1. R.L.: 2019·5'

LOCATION: Queanbeyan River N.S.W ANGLE FROM HORIZONTAL: 45° DIRECTION: 38°30' M

| ROCK TYPE & DEGREE OF WEATHERING | DESCRIPTION | DEPTH & SIZE OF CORE | LOG | LIFT & CORE RECOVERY | STRUCTURES (JOINTS, VEINS, SEAMS, FAULTS, CRUSHED ZONES) | |
|---|---|---|---|---|---|---|
| Dacite. | | 100'<br>110'<br>116' | | 100<br>100 | Joints 100-108', 4" to 10" apart, dip about 30°+60°<br>Joints 108-112', 1" apart or broken.<br>Joints 112'-116' 2" to 4" apart dip at 40° + 70°.<br>Crush zone 108'3" to 111'6" has calcite veins | Occasional thin calcite veins usually on 70-80° joints or shears bearing slickensiding.<br>Quartz or aplite veins at 107'6" dip about 60°.<br>Steep incipient shearing increases from about 107'. |
| Dacite | Medium to fine grained Feldspar, "blotchy" Strongly stressed | 120' | | | Joints 4-6" apart, dip at 65° 40-50° + 30° clay + slickensiding on shears. | Thin calcite veins common. Pyrites common. |
| Dacite | Medium to Coarse grained. Feldspar "blotchy."<br>Disseminated pyrite common.<br>Dacite is considerably stressed. 7399⊗ | 130'<br>140' | | | Joints 4" to 6" apart. Many about 70°. incipient shear planes.<br>Some thin quartz - epidote? veins are sheared. | Thin ½" aplite veins at 127'6" + 135'6"; also others very thin. Also some very thin calcite veins.<br>Aplite veins post-date shearing + dip at 50°. |
| Dacite | Medium to coarse grained, Feldspars "blotchy".<br>Considerable disseminated pyrite. | 150'<br>161'5" | | | Joints 2"-6" mainly dip at 40°+70° + mostly slickensided.<br>Clay pug on shears dipping at 60-70°, particularly at 142'6" 147' + 160-161'.<br>Incipient shears common, dipping at 40° + 60-70° are common. | Aplite veining 159-160'.<br>Little calcite on some shears. |
| Dacite | Fine to medium grained. Feldspars smaller but white.<br>Dacite is considerably stressed | 170'<br>176' | | | Joints 2" to 9" apart. mainly dip 25° + 60-70°<br>Incipient shearing common. | Numerous veins mainly aplite, dipping at 25° + 70°; heavy at 161'5"-163'1", 173'5"-174' and 176'9"-177'.<br>Thin calcite coatings on some joints + shears. |
| Dacite | Medium grained, Feldspar "blotchy" | 178'3" | | | Joints ½" to 4" apart, incipient shearing. | Pyrite present. |
| Dacite | Fine to medium grained. | 180'6" | | | Joints about 3" apart. | Incipient shears. |
| Dacite or Granodiorite porphyry | Feldspar fresher but zoned. | 188'6" | | | Joints ½-3" apart. dip at 60° + 40-50°<br>180-183'2" core broken | Thin aplite? veins. |
| Dacite | Feldspar white + "blotchy."<br>Dacite is considerably stressed. | 190'<br>201' | | | Joints mainly 2-6" apart 70° + 40°<br>Thin veins 197'6"-198'6" broken.<br>Shears + incipient shears present.<br>Clay + Calcite on shears. | |

DRILL NO: 6-A-15
TYPE: BOYLES
DRILLER: R. Grech
COMMENCED: 28·7·61
COMPLETED: 18·8·61

LOGGED: G.M. Burton

VERTICAL SCALE: 1" = 10 feet.

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT GOOGONG DAM SITE HOLE NO. 2. R.L. 2116·9"

LOCATION Queanbeyan River N.S.W. ANGLE FROM HORIZONTAL 40° DIRECTION 38°M

| ROCK TYPE & DEGREE OF WEATHERING | DESCRIPTION | DEPTH & SIZE OF CORE | LOG | LIFT & CORE RECOVERY | STRUCTURES JOINTS, VEINS, SEAMS, FAULTS, CRUSHED ZONES | |
|---|---|---|---|---|---|---|
| Soil + decomposed rock. | | 2'9" | | 100 | | |
| Dacite | Weathered | 4'9" | | 100 | Fragments only | |
| Dacite | Weathered, silicified + epidotised. | 7'3" | | 65 | Core | |
| Dacite | Weathered | 11'6" | | 50 | Sludge only recovered to 9'9"; then broken core. | |
| Dacite | With some quartz veins. | 14'9" | | 15 | Sludge only. | |
| Dacite ? | | 18'5" | | 12 | Sludge + decomposed fragments only. | |
| Dacite | Medium – fine, weathered + decomposed. | 21'2" | | 90 / 100 | Mainly fragments Joints ironstained dip at | 20°, 55° + 75° |
| Dacite | Weathered. | 24'0" | | 100 | Joints 1' apart dip at 30° + 45-50°; joints are ironstained. | |
| Dacite | Med. – fine grained, fresh. Epidotised and silicified for most part. | 36'6" | | " | Joints ironstained; 24'-33', 1'-3' apart 33'-36'6", 1' apart. Joints, open + carrying limonite + clay, dip at 30°, 45° + 80°. | Thin veins, 1"-3" apart mainly aplite but some quartz + epidote, dip at 30°, 45° + 75°. |
| Dacite | Weathered to fresh, chloritised. | 39'0" | | " | Joints 1"-2" apart, ironstained. | Quartz veins |
| Dacite | Fine grained, fresh. Feldspar zoned. | 50'0" | | " | Joints, 4"-6" apart, are iron + clay strained but appear tight. Joints dip at 20°, 40°, 60° + 70°. | Few thin veins of quartz + epidote. |
| Dacite | Fine – medium grained, lightly weathered. | 54'0" | | " | Joints ½"-5" apart; ironstained, dip at 20° + 55°. | |
| Aplite dyke | Fresh, but missing core may have been decomposed | 56'6" / 57'8" | | 90 / 100 | Core fragments. Well jointed. | Joints ½"-1" apart. dip at 35° to 50°. |
| Dacite | Weathered + stressed | | | | Joints 2" apart and ironstained dip at 35°, 50° + 60°. | |
| Dacite | Fine-grained, very heavily veined with thin quartz - epidote veins. Dacite has pink feldspar. | 65'9" | | " | | |
| Dacite | Fine – medium grained. Fresh, silicified + epidotised. | 77'0" | | " / 95 | Joints 2"-1' apart. | |
| Dacite | Ditto. | 79'9" | | | ⅛" veins of drilling sludge? in joints. | |
| Dacite | Fine – medium grained, partly silicified. Feldspar zoned. | | | 100 | Joints appear open; heavily clay + iron stained. Core is stressed and shows incipient shearing. Joints ½"-2" apart + dip at 30°, 60° + 80°. | Thin veins of quartz; possibly aplite + quartz - epidote common. Fracture zone 81'7" – 83'1". |
| Dacite | Fine – medium grained silicified + epidotised. | 88'0" / 91'0" | | " | Joints well developed + clay + iron stained, 1"-4" apart dip at 20°, 35°, 45°, 50° + 60°. | |
| Dacite | Fine – medium grained, strongly stressed. | 91'8" | | " | Joints well developed + ironstained 1"-4" apart. | |
| Dacite | Fine – medium grained, silicified + epidotised. Feldspar zoned. | | | " | Joints tighter 2"-4" apart iron + clay stained dip at 20°, 35°, 45°, 55°, 75° + 85°. | Veins of quartz common dip at 50°. Aplite? dip at 65°. Quartz-epidote dip at 45°. |

DRILL NO. 6 - A - 15
TYPE BOYLES

DRILLER R. Grech
COMMENCED 21·8·61
COMPLETED 15·9·61

LOGGED G.M. Burton

VERTICAL SCALE 1" = 10'

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT: GOOGONG DAM SITE — HOLE NO: 2 — R.L.: 2116·9'

LOCATION: Queanbeyan River N.S.W. — ANGLE FROM HORIZONTAL: 40° — DIRECTION: 38°M

| ROCK TYPE & DEGREE OF WEATHERING | DESCRIPTION | DEPTH & SIZE OF CORE | LOG | LIFT & CORE RECOVERY | STRUCTURES JOINTS VEINS SEAMS FAULTS CRUSHED ZONES | |
|---|---|---|---|---|---|---|
| Contd. | | ⊗7436<br>118' | | 100 | 106'-108'3" Crush zone<br>110'-110'4" Fractures common.<br>111'9"-113'3" Crush zone with silica + epidote | Veins as above 1"-6" apart becoming less common with depth. |
| Dacite | Fine - medium grained. Silicified + epidotised. Stressed. Feldspar zoned. | 127' | | | 121'-122' Fracture zone<br>123'6-124'2" Strong fracture zone<br>Joints common ½"-4" apart some heavily iron stained<br>Joints dip at 35°, 45°, 60°, 75° + 85°. | Quartz epidote and aplite(?) or felsite(?) veins very common |
| Dacite | Darker in colour. Fine - medium grained. Appears epidotised or chloritised. | 151' | | | Joints well spaced + much tighter. Mainly 2"-2' apart dip mainly at 25°, 45°, 60° + 70°<br>Pyrite on joint at 139'9" | Very thin calcite veins commence at 135' and iron staining disappears at 145'. Veins common + usually thin about 1"-6" apart. Veins appear to be felsite + some quartz-epidote. |
| Dacite breccia | Silicified + epidotised | 152'6" | | | | Strongly veined with anastomosing epidote veins. |
| Dacite | Medium grained. Feldspar commonly zoned and tending to "blotchy" with depth. Strong oxidation of pyrite on joints. | 160'<br>172'5" | | | Joints 2"-2' apart and dipping at 10°, 15°, 20°, 30°, 50° + 70°<br>Joints dip at 20°, 30°, 40°, 50° + 75°. Zones of closer jointing are iron stained. | Very thin calcite veins on joints or incipient joints. Little iron staining on joints. Some thin epidote veins.<br>Thin veins of epidote cut zoned feldspar but not saussuritised feldspar. |
| Dacite | Fine - medium grained. Feldspar zoned. | 180'4" | | | Joints 1"-5" apart dip at 20°, 25°, 40° + 65°. Closer joints are iron stained | Numerous ⅛"-½" veins of quartz- and epidote? dip at 35°, 60°, 75° + 80°. |
| Dacite or granodiorite porphyry | Appears hybridised in part. Medium grained. Feldspar zoned. Some feldspar saussuritised + not cut by epidote. Some pyrite. Iron staining on joints rare. | ⊗7465<br>199'7" | | | Joints 4"-1'6" apart and dip at 20°, 30°, 40°, 45°, 50° + 80°. | Bedding (??) dip at 30° + 35°. Thin veins of quartz-epidote? + very thin veins of calcite. Calcite cuts quartz-epidote. Calcite also probably cuts blotchy feldspar. Calcite occurs also on slickensided joints. |

DRILL NO.: 6-A-15 — TYPE: BOYLES

⊗7436 Indicates B.M.R. petrological slide with reference number

LOGGED: G.M. Burton

DRILLER: R. Grech — COMMENCED: 21·8·61 — COMPLETED: 15·9·61

VERTICAL SCALE: 1" = 10'

# BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

## GEOLOGICAL LOG OF DRILL HOLE

PROJECT: GOOGONG DAM SITE — HOLE NO: 2 — R.L. 2116·9'

LOCATION: Queanbeyan River N.S.W. — ANGLE FROM HORIZONTAL: 40° — DIRECTION: 38°M

| ROCK TYPE & DEGREE OF WEATHERING | DESCRIPTION | DEPTH & SIZE OF CORE | LOG | LIFT & CORE RECOVERY | STRUCTURES JOINTS, VEINS, SEAMS, FAULTS, CRUSHED ZONES | |
|---|---|---|---|---|---|---|
| Dacite or granodiorite | Fine-medium grained. Hybridised probably by numerous thin veins of quartz-epidote. Feldspar commonly zoned. | 205'8" | | 100 / " | Joints 2"-6" apart dip at 20°, 25°, 30°, 35°, 50° + 55°. | Very thin calcite veins. Quartz-epidote veins ⅛"-½" thick dip at 30°, 55°, 70° + 85°. |
| Dacite | Fine-medium grained. Feldspar zoned. Blobs of pyrite common. | 211' | | " | Joints 2"-1' apart dip at 20°, 25°, 30° + 50°. No iron staining. | Very thin calcite veins. Quartz-epidote vein. |
| Aplite | Zone thoroughly hybridised by thick quartz-epidote veins. | 212'8" / 215' | | " | Few joints 6" apart 25° + 35° | |
| | | | | | Joints common 1"-6" apart dip at 26°, 35°, 40°, 45° + 65°. | Numerous thin quartz-epidote veins. |
| Dacite | Fine grained, partly hybridised | | | " | Joints 3"-1' apart dip at 30°, 48° + 55°. | Numerous veins of quartz-epidote irregular + anastomosing |
| Dacite | Mainly fine grained. Feldspar zoned + slightly "blotchy." | 220'7" | | " / 100 | | |

DRILL NO: 6-A-15
TYPE: BOYLES
DRILLER: R. Grech
COMMENCED: 21·8·61
COMPLETED: 15·9·61

LOGGED: G.M. Burton

VERTICAL SCALE: 1" = 10'

# BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

## GEOLOGICAL LOG OF DRILL HOLE

PROJECT: Googong Dam Site — HOLE NO. 3 — R.L. 2125.0'

LOCATION: Queanbeyan River N.S.W. — ANGLE FROM HORIZONTAL: 20° — DIRECTION: 218°M

| ROCK TYPE & DEGREE OF WEATHERING | DESCRIPTION | DEPTH & SIZE OF CORE | LOG | LIFT & CORE RECOVERY | STRUCTURES: JOINTS VEINS SEAMS FAULTS CRUSHED ZONES | |
|---|---|---|---|---|---|---|
| Soil + decomposed dacite | | 3'2" | | 15 | Core fragments only | |
| Dacite | Fine grained, partly silicified + epidotised | 4'6" | | | Joint dipping 90° | |
| Dacite | Fine grained light to heavily weathered. | 8' | | 100 | Joints 3" to 6" apart dip at 40°, 45° + 60°. | Few thin quartz epidote veins dip at 40°. |
| Dacite | Fine grained; heavily silicified, weathered in part. | 10' | | 100 | Joints 2" to 9" apart dip at 30°, 40°, 55°, 60° + 70°. | 6" quartz vein at 14'8". |
| Dacite | Fine grained; chloritised? | 16'3" | | " | | |
| Dacite? | Heavily weathered + decomposed | 17'7" | | " | Few fragments only | |
| Dacite | Lightly to strongly weathered. | 19'7" | | 55 | Core broken. | |
| Dacite | | 20' | | | No Core | |
| Dacite | Fine grained; lightly weathered, joint planes heavily weathered + iron stained. | 31'6" | | 100, ", " | Joints 2"-1'3" apart dip at 0°, 30°, 45°, 55°, 65° + 70°. | Quartz veins ½"-1" at 28'-29' dip at 75° + 80° |
| Dacite | Fine to medium grained. Feldspars zoned. Joints heavily ironstained but lightly weathered. | 40' | | ", " | Joints 2"-1'3" apart dip at 30°, 40°, 45°, 60° + 75°. | Thin quartz + quartz-epidote veins dip vertical, 35° + 75°. |
| Quartz | Reef. Little dacite lightly weathered, fine grained. Quartz strongly iron stained | 45'0" | | ", ", " | Joints 1"-2" apart dip at 35°. | |
| Dacite | Fine-medium grained, fresh. Some feldspar is zoned. Joints heavily iron stained but only lightly weathered. | 54'1" | | ", ", " | Joints 2"-1'3" apart dip at 30°, 35°, 40°, 45° + 60°. Strong jointing 52'-53'3". | Few thin quartz + quartz-epidote veins dipping at 45°. |
| Dacite | Fine to medium grained. Feldspars are zoned. Joints fresh + only lightly iron stained. | 60' | | ", ", " | Joints fairly tight, 1"-2" apart. | Few thin veins of quartz + quartz-epidote dip at 40° + 70°. |
| Granitised dacite | Medium-fine grained; fresh. Feldspars range from 'blotchy' to small idiomorphic crystals. Pyrite common on joints + in ground mass. Joints appear tight; light iron staining on joints decreasing. | 80' | | ", ", ", ", ", ", " | Joints common 1"-1' apart dip at 20°, 25°, 50°, 55°, 60°, 65°, 70° + 75°. Broken zone 65'9" to 66'3". Slight slickensiding + pug on some joints. | Major quartz-epidote vein at 70'6"-71'6" dip at 80°. Quartz-epidote also dips at 45°. Quartz veins dip at 55° + 70°. Thin calcite veins common. |
| Dacite | Lightly to strongly granitised. Fine-medium grained; fresh. Feldspars commonly zoned to idiomorphic. Pyrite mainly on joints, partly oxidised. | 100' | | ", ", ", ", ", ", " | Joints common 1" to 6" apart (average 4") dip at 0°, 15°, 20°, 35°, 45°, 50°, 60°, 65°, 70° + 85°. Joints tight to open, clay stained + pyrites oxidised. Broken zone 95'6"-96'3", clay stained. Broken zone 97'3"-98', heavily clay stained, some core lost. | Thick vertical quartz-epidote vein at 82'-85'. Thin calcite veins filling numerous thin minor joints 80'-88' |

DRILL NO. 6-A-15
TYPE BOYLES

DRILLER E. Sclabas
COMMENCED 18.9.61
COMPLETED 5.10.61

LOGGED G.M. Burton

VERTICAL SCALE 1" = 10'

# BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

## GEOLOGICAL LOG OF DRILL HOLE

PROJECT Googong Dam Site HOLE NO. 3 R.L. 2125·0'

LOCATION Queanbeyan River N.S.W ANGLE FROM HORIZONTAL 20° DIRECTION 218°M

| ROCK TYPE & DEGREE OF WEATHERING | DESCRIPTION | DEPTH & TYPE OF CORE | LOG | LIFT & CORE RECOVERY | STRUCTURES JOINTS VEINS, SEAMS FAULTS CRUSHED ZONES | |
|---|---|---|---|---|---|---|
| Dacite silicified + granitised. | Fine-medium grained. Feldspars zoned + some idiomorphic. Pyrite on joints mainly oxidised | 120' | | 100 | Joints very close. Clay stained, tight? average 2" apart. Broken zones 100'11" - 103' 107'3" - 108'7" 115' - 119' Joints dip in usual directions. | Thin quartz veins + quartz-epidote veins common. |
| Dacite | Medium grained, silicified or granitised. | 122' | | | Joints 1"-2" apart dip at 35°, 55° + 75° Joints are lightly stained with clay + weathered pyrite. | |
| Dacite | Fine-medium grained; is silicified + epidotised. Stressed with incipient shearing + light slickensiding Feldspar slightly "blotchy" The epidotisation probably preceded some shearing. Pyrite common. | 131' | | | Joints 1"-6" apart common dip at 15° 30°, 35°, 40°, 50°, 55°, 70° + 75°. | |
| | | 133'10" | | | Joints 3"-1' apart dip at 40°, 45°, 55° + 70°. | Thin calcite veins on joints. |
| Dacite | Fine grained. | | | | | |
| Granite | Greatly contaminated: some silicified dacites. Fresh. Large idiomorphic pink feldspar crystals in granite. Pyrite on joints | 141'5" | | | Joints common 1"-1' apart dominent dip at 45°. dip also at 20°, 50°, 55° + 60° Joints also have light clay stain + weathered pyrites | Major quartz vein at 137'2" - 138'5" dipping at 45°. |
| Granite | Less contaminated. Fresh. Large pink feldspar crystals. Little lightly oxidised pyrites on joints. | 149'7" | | | Joints 1"-1' apart (average about 6") + dip at 25° 45° 50° 55°, 60°, 65°, 70° + 80°. | Few very thin quartz veins on joints. Few thin epidote veins. |

DRILL NO. 6-A-15
TYPE BOYLES
DRILLER E. Sclabas
COMMENCED 18·9·61
COMPLETED 5·10·61

LOGGED G.M. Burton

VERTICAL SCALE 1" = 10'

# BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

## GEOLOGICAL LOG OF DRILL HOLE

PROJECT: Googong Dam Site HOLE NO: 4 R.L.: 2150.9'

LOCATION: Queanbeyan River, N.S.W. ANGLE FROM HORIZONTAL: 45° DIRECTION: 222° M.

| ROCK TYPE & DEGREE OF WEATHERING | DESCRIPTION | DEPTH & SIZE OF CORE | LOG | LIFT & CORE RECOVERY | STRUCTURES (JOINTS VEINS SEAMS FAULTS CRUSHED ZONES) | |
|---|---|---|---|---|---|---|
| Soil | | 1'3" | | 100 | | |
| Dacite | Fine grained. Medium weathering | 7'2" | | | Core fragments mainly probably due to weathering on joints. Joints 2" to 6" apart dip at 55°, 60°, 65°. | Some incipient shearing dipping at 70°. Also a thin quartz-epidote vein. |
| Dacite | Fine grained. Weathering light. Joints heavily stained with iron + manganese. | 17'3" | | | Joints 3" to 1' apart dip at 20°, 50°, 55°, 60°, 70° + 80°. Broken zones 9' - 10'3", 11' - 11'5" | Few very thin aplite and quartz-epidote veins. |
| Dacite | Fine grained. Weathering medium. Joints iron + manganese stained. | 18'6" | | | Joints 1" to 3" apart. | |
| | | 21'3" | | 0 | Sludge only | |
| Dacite(?) | Weathered + iron stained. | 23'3" | | 95 | Joints ½" to 9" apart. | |
| Dacite | Light to heavily weathered. Joints iron stained. | | | 100 | Closely jointed dipping at 30°, 55° + 90° with dominant dip of 65°. | |
| Dacite | Fine grained. Lightly weathered. Joints iron stained. | 27'6" | | | | |
| Dacite | Partly metamorphosed(?). Fine to medium grained. Some Feldspar "blotchy", some slightly zoned. Fresh. Joints appear tight but heavily iron stained + lightly clay-stained. | 50' | | | Joints well spaced. About 9"-12" apart dip at 15°, 30°, 40°, 45°, 50°, 65° + 85°. Thin clay seam (1/10") at 45'9" dipping at 65°. Broken zones at 39'3"-39'6" + 45'6"-46'6" | Some pyrite, mainly in veins. Vein at 38'8" probably lightly auriferous. Few thin veins of aplite? dip at 50° + 65°. |
| Granodiorite porphyry + metamorphosed dacite. | Some silicification. Medium to coarse grained. Fresh. Feldspar commonly zoned. Pyrite common, particularly on joints. | 67' | | | Joints well spaced 3"-18" apart. Joints appear tight but heavily iron stained. Joints dip at 0°, 10°, 25°, 35°, 40°, 50°, 60°, 65° + 70° | |
| Dacite | Silicified + epidotised. Fine to coarse grained. Joints lightly clay + iron stained. Some pyrite, mainly on joints. | 78' | | | Strongly jointed; joints 1"-1' apart dip at 25°, 35°, 40°, 45°, 75° + 85°. Joints dipping at 40° are prominent. Quartz vein strongly jointed at 72'11" to 73'11" | Mainly epidote veins up to ¾" thick dip at 50°. |
| Granodiorite porphyry or partly metamorphosed dacite | Fine to medium grained. Fresh. Joints tight + lightly clay and iron stained. | 81'8" | | | Joints 3"-18" apart dip at 40°, 55°, 75° | Little pyrite on joints. Some thin epidote veins dip at 75°. |
| | | 83'6" | | | Joints 3"-9" apart dip at 30° + 40°. | |
| Dacite | Fine grained. Breccia zone filled with quartz | | | | Joints 3"-18" apart dip at 20°, 35°, 40°, 50°, 60°, 65°. (40° common) | Some pyrite on joints |
| Metamorphosed dacite or granodiorite porphy | Fine grained. Feldspar zoned. Fresh. Joints lightly clay + iron stained. | 90' | | | | |
| Dacite | Fine to medium grained. Strongly epidotised + silicified. Joints tight + lightly clay + iron stained. | | | | Joints 2"-12" apart dip at 35°, 40°, 50°, 55°, 65° + 70°. (55° common) Some incipient shearing. | Epidote veins common dip at 45°, 55° + 75°; large veins between 97'7" - 98'1" + 98'9" - 99'6" contnd. → |

DRILL NO: 6-A-15
TYPE: BOYLES
DRILLER: E. Sclabas
COMMENCED: 11.10.61
COMPLETED: 28.10.61

LOGGED: G. M. Burton

VERTICAL SCALE: 1" = 10'

# BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

## GEOLOGICAL LOG OF DRILL HOLE

PROJECT: Googong Dam Site — HOLE NO: 4 — R.L.: 2150·9'

LOCATION: Queanbeyan River, N.S.W. — ANGLE FROM HORIZONTAL: 45° — DIRECTION: 222°M

| ROCK TYPE & DEGREE OF WEATHERING | DESCRIPTION | DEPTH & SIZE OF CORE | LOG | LIFT & CORE RECOVERY | STRUCTURES JOINTS, VEINS, SEAMS FAULTS, CRUSHED ZONES | |
|---|---|---|---|---|---|---|
| contnd. | | 102'9" | | 100 | | |
| Dacite or granodiorite porphyry | Silicified + epidotised. Fine to medium grained. Lightly weathered. Heavy clay + iron staining on joints. | 110' | | " | Joints common + dip at 35°, 55°, 85° (mainly 55°) Core is fragmentary between 103'6" - 104'2" 104'9" - 105' 105'10" - 107'11" | |
| Dacite | Silicified(?). Fine to medium grained. Fresh. | 115' | | " | Closely jointed; joints dip at 45°, 50°, 55°, 60°, 70°, 75° + 80°. | Epidote vein dips at 50°. |
| Dacite | Silicified (?) + epidotised(?) Fresh. Fine to medium grained. Joints tight + lightly clay + iron stained. | 120' | | " | Joints common 1" to 9" apart + dip at 25°, 30°, 45°, 60°, 65° + 90°. | Epidote vein dips at 50° |
| Dacite & granodiorite | Fine - medium grained. Fresh. Probably silicified & epidotised. Some pyrite. | | | " | Joints 3"-1' apart. Mainly tight. Some have light clay + iron stain. | Well veined. Mainly epidote + quartz. Major quartz-epidote zone 134'9" - 136'0" |
| Dacite | Strongly silicified & epidotised. | | | " | Closely jointed, 1"-2" apart. | |
| Dacite | Silicified & epidotised? Some pyrite. | 155'7" | | " | Closely jointed, 1"-6" apart. | Well veined, mainly epidote + quartz. |

DRILL NO: 6 - A - 15
TYPE: BOYLES
DRILLER: E. Sclabas
COMMENCED: 11·10·61
COMPLETED: 28·10·61

LOGGED: G.M. Burton

VERTICAL SCALE: 1" = 10'

## APPENDIX 4.

### WATER PRESSURE TESTING

Pressure testing was carried out in accordance with standard Snowy Mountains Hydro-Electric Authority practice. Mechanical packers were used. Gauge pressures for testing were calculated beforehand so that the maximum effective pressures used did not exceed one pound per square inch for each foot of rock overburden.

Copies of the drillers testing results are available at the Department of Works in Canberra or at the Bureau in Canberra. Copies of the reduction tabulation of results are held in the Bureau also.

Effective pressure, that is nett water pressure acting on the rock in the section tested and causing the water loss, is calculated in accordance with the following formula :

Effective pressure = gauge pressure + water column pressure - pressure due to groundwater level - friction head loss.

Diamond Drill Hole No. 1 Inclination: 45°

| Section Tested From Ft. | To Ft. | Length of Section Ft. | Depth to Standing Water (measured along slope of Hole.) Ft. | Effective Test Pressure P.S.I. | Water Loss Gals/Min/Ft. NX hole |
|---|---|---|---|---|---|
| 31.0 | 46.0 | 15.0 | 6.0 | 12.7 | 0.00 |
| 46.0 | 61.0 | 15.0 | 7.0 | 13.0 | 0.027 |
| 46.0 | 61.0 | 15.0 | 7.0 | 23.0 | 0.06 |
| 61.0 | 76.0 | 15.0 | 9.0 | 13.2 | 0.00 |
| 61.0 | 76.0 | 15.0 | 9.0 | 23.2 | 0.00 |
| 61.0 | 76.0 | 15.0 | 9.0 | 33.2 | 0.00 |
| 79.3 | 94.3 | 15.0 | 9.0 | 23.2 | 0.01 |
| 79.3 | 94.3 | 15.0 | 9.0 | 33.2 | 0.01 |
| 79.3 | 94.3 | 15.0 | 9.0 | 53.2 | 0.01 |
| 94.3 | 111.2 | 16.8 | 14.5 | 24.1 | 0.01 |
| 94.3 | 111.2 | 16.8 | 14.5 | 44.1 | 0.01 |
| 94.3 | 111.2 | 16.8 | 14.5 | 64.1 | 0.02 |
| 61.2 | 81.2 | 20.0 | 15.8 | 25.3 | 0.01 |
| 61.2 | 81.2 | 20.0 | 15.8 | 35.3 | 0.01 |
| 61.2 | 81.2 | 20.0 | 15.8 | 45.3 | 0.01 |
| 81.2 | 101.2 | 20.0 | 15.8 | 25.2 | 0.01 |
| 81.2 | 101.2 | 20.0 | 15.8 | 55.2 | 0.01 |
| 81.2 | 101.2 | 20.0 | 15.8 | 75.2 | 0.01 |
| 101.2 | 121.2 | 20.0 | 15.8 | 25.2 | 0.01 |
| 101.2 | 121.2 | 20.0 | 15.8 | 65.2 | 0.01 |
| 101.2 | 121.2 | 20.0 | 15.8 | 85.2 | 0.01 |
| 121.2 | 141.2 | 20.0 | 15.8 | 25.6 | 0.01 |
| 121.2 | 141.2 | 20.0 | 15.8 | 65.6 | 0.01 |
| 121.2 | 141.2 | 20.0 | 15.8 | 105.6 | 0.01 |
| 141.2 | 161.2 | 20.0 | 15.8 | 25.1 | 0.00 |
| 141.2 | 161.2 | 20.0 | 15.8 | 65.1 | 0.01 |
| 141.2 | 161.2 | 20.0 | 15.8 | 105.1 | 0.00 |
| 158.5 | 198.5 | 40.0 | 11.0 | 23.5 | 0.01 |
| 158.5 | 198.5 | 40.0 | 11.0 | 43.5 | 0.01 |
| 158.5 | 198.5 | 40.0 | 11.0 | 83.5 | 0.01 |
| 158.5 | 198.5 | 40.0 | 11.0 | 124.7 | 0.02 |

Diamond Drill Hole No.2 — Inclination: 40°

| Section Tested From Ft. | To Ft. | Length of Section Ft. | Depth to Standing Water(measured along slope of Hole.)FT. | Effective Test Pressure P.S.I. | Water Loss Gals/Min/Ft. NX hole |
|---|---|---|---|---|---|
| 30.6 | 40.6 | 10.0 | 26.6 | 8.1 | 0.04 |
| 39.2 | 49.2 | 10.0 | 26.6 | 8.3 | 0.00 |
| 39.2 | 49.2 | 10.0 | 26.6 | 18.3 | 0.01 |
| 47.7 | 57.7 | 10.0 | 26.6 | 7.7 | 0.26 |
| 47.7 | 57.7 | 10.0 | 26.6 | 17.5 | 0.50 |
| 59.5 | 69.5 | 10.0 | 57.0? | 15.8 | 0.00 |
| 59.5 | 69.5 | 10.0 | 57.0? | 25.8 | 0.02 |
| 69.8 | 89.8 | 20.0 | 63.0? | 18.4 | 0.02 |
| 69.8 | 89.8 | 20.0 | 63.0? | 28.4 | 0.03 |
| 90.9 | 110.9 | 20.0 | 63.0? | 18.3 | 0.01 |
| 90.9 | 110.9 | 20.0 | 63.0? | 23.3 | 0.01 |
| 90.9 | 110.9 | 20.0 | 63.0? | 33.3 | 0.01 |
| 111.5 | 131.5 | 20.0 | 69.0? | 19.7 | 0.00 |
| 111.5 | 131.5 | 20.0 | 69.0? | 29.7 | 0.01 |
| 111.5 | 131.5 | 20.0 | 69.0? | 39.7 | 0.01 |
| 129.8 | 149.8 | 20.0 | 65.0 | 18.5 | 0.00 |
| 129.8 | 149.8 | 20.0 | 65.0 | 33.5 | 0.00 |
| 129.8 | 149.8 | 20.0 | 65.0 | 38.5 | 0.00 |
| 149.0 | 189.7 | 40.0 | 104.0 | 39.4 | 0.01 |
| 149.0 | 189.7 | 40.0 | 104.0 | 49.3 | 0.02 |
| 149.0 | 189.7 | 40.0 | 104.0 | 59.1 | 0.03 |
| 190.8 | 215.8 | 25.0 | 104.0 | 29.3 | 0.01 |
| 190.8 | 215.8 | 25.0 | 104.0 | 49.1 | 0.02 |
| 190.8 | 215.8 | 25.0 | 104.0 | 64.1 | 0.03 |

Diamond Drill Hole No. 3 — Inclination: 20°

| Section Tested From Ft. | To Ft. | Length of Section Ft. | Depth to Standing Water (measured along slope of Hole.) Ft. | Effective Test Pressure P.S.I. | Water Loss Gals/Min/Ft. NX Hole |
|---|---|---|---|---|---|
| 9.1 | 19.1 | 10 | - | 1.8 | 0.32 |
| 9.1 | 19.1 | 10 | - | 11.8 | 0.54 |
| 21.5 | 31.5 | 10 | - | 3.2 | 0.50 |
| 30.3 | 40.3 | 10 | - | 14.8 | 0.22 |
| 30.3 | 40.3 | 10 | - | 19.9 | 0.30 |
| 30.3 | 40.3 | 10 | - | 29.8 | 0.46 |
| 39.1 | 54.1 | 15 | 39.4 | 16.0 | 0.29 |
| 39.1 | 54.1 | 15 | 39.4 | 21.0 | 0.34 |
| 54.8 | 64.8 | 10 | 39.4 | 16.2 | 0.03 |
| 54.8 | 64.8 | 10 | 39.4 | 31.2 | 0.04 |
| 54.8 | 64.8 | 10 | 39.4 | 41.2 | 0.05 |
| 65.3 | 85.3 | 20 | 39.4 | 16.3 | 0.02 |
| 65.3 | 85.3 | 20 | 39.4 | 41.3 | 0.05 |
| 65.3 | 85.3 | 20 | 39.4 | 66.3 | 0.06 |
| 85.5 | 105.5 | 20 | 40.5 | 16.3 | 0.01 |
| 85.5 | 105.5 | 20 | 40.5 | 51.3 | 0.03 |
| 85.5 | 105.5 | 20 | 40.5 | 86.3 | 0.04 |
| 104.3 | 134.3 | 30 | 40.5 | 15.9 | 0.02 |
| 104.3 | 134.3 | 30 | 40.5 | 55.9 | 0.03 |
| 104.3 | 134.3 | 30 | 40.5 | 95.8 | 0.05 |
| 134.6 | 149.6 | 15 | 52.0 | 17.5 | 0.01 |
| 134.6 | 149.6 | 15 | 52.0 | 57.4 | 0.02 |
| 134.6 | 149.6 | 15 | 52.0 | 107.5 | 0.03 |
| Retest: | | | | | |
| 13.0 | 23.0 | 10 | 40.5 | 4.3 | 0.68 |
| 23.0 | 33.0 | 10 | 40.5 | 4.0 | 0.18 |
| 23.0 | 33.0 | 10 | 40.5 | 14.0 | 0.38 |

Diamond Drill Hole No.4.   Inclination: 45°

| Section Tested From Ft. | Section Tested To Ft. | Length of Section Ft. | Depth to Standing Water (measured along slope of Hole.) Ft. | Effective Test Pressure P.S.I. | Water Loss Gals/Min/Ft NX hole |
|---|---|---|---|---|---|
| 12.9 | 22.9 | 10 | - | 9.4 | 0.22 |
| 12.9 | 22.9 | 10 | - | 13.4 | 0.28 |
| 26.3 | 46.3 | 20 | 28.7 | 10.9 | 0.06 |
| 26.3 | 46.3 | 20 | 28.7 | 19.9 | 0.09 |
| 44.5 | 64.5 | 20 | 28.7 | 10.8 | 0.03 |
| 44.5 | 64.5 | 20 | 28.7 | 19.8 | 0.03 |
| 44.5 | 64.5 | 20 | 28.7 | 24.8 | 0.03 |
| 62.8 | 82.8 | 20 | 38.5 | 12.2 | 0.01 |
| 62.8 | 82.8 | 20 | 38.5 | 27.2 | 0.01 |
| 62.8 | 82.8 | 20 | 38.5 | 37.2 | 0.01 |
| 84.7 | 104.7 | 20 | 38.0 | 12.3 | 0.01 |
| 84.7 | 104.7 | 20 | 38.0 | 27.3 | 0.01 |
| 84.7 | 104.7 | 20 | 38.0 | 42.3 | 0.02 |
| 106.0 | 136.0 | 30 | 38.0 | 12.3 | 0.01 |
| 106.0 | 136.0 | 30 | 38.0 | 37.3 | 0.02 |
| 106.0 | 136.0 | 30 | 38.0 | 62.3 | 0.03 |
| 135.6 | 155.6 | 20 | 38.0 | 12.2 | 0.00 |
| 135.6 | 155.6 | 20 | 38.0 | 47.2 | 0.01 |
| 135.6 | 155.6 | 20 | 38.0 | 82.2 | 0.03 |

## APPENDIX 5.

## WATER ANALYSES

During the survey a prolonged dry spell occurred; only 60 points of rain (compared to the normal 300 points) fell in the six weeks preceding 20th July, 1962.

It was decided on 20th July that the Queanbeyan River and its tributaries were flowing only because of seepage from the main bodies of underground water. The river and several tributaries were sampled to check the difference in quality of the yield from different rock types in the catchment. Jerrabomberra Creek was also sampled the same day because the rocks in its catchment are dacites similar to those of Googong and the geomorphology is almost the same as between London Bridge and Googong.

The water samples were analysed by S. Baker in the Bureau's Geological Laboratory.

| SAMPLE: | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| River | Queanbeyan | Tributary of Bradley's Ck. | Bradley's Creek | Spring in Granite | Jerrabomberra Creek |
| Canberra 1-mile Military Grid reference: | 277256 | 293246 | 278256 | 270241 | 190305 |
| Flow | 36 cusecs | 1 cusec? | 1 cusec? | very small | 0.25 cusecs. |
| Calcium p.p.m. | 17 (0.85) | 33 (1.64) | 28(1.40) | 55(2.74) | 36(1.79) |
| Magnesium " | 12 (0.99) | 42 (3.45) | 15(1.23) | 75(6.17) | 18(1.48) |
| Sodium " | 20 (0.87) | 69 (3.0) | 36(1.56) | 134(5.83) | 50(2.17) |
| Potassium " | 1.5(0.04) | 2 (0.05) | 1(0.02) | 2(0.05) | 1(0.02) |
| Strontium " | $<$ 0.05 | $<$ 0.05 | $<$ 0.05 | 0.8(0.17) | 0.05 |
| Iron $^{3+}$ " | $<$ 0.1 | $<$ 0.1 | $<$ 0.1 | $<$ 0.5 | $<$ 0.1 |
| Aluminium " | $<$ 0.1 | $<$ 0.1 | $<$ 0.1 | $<$ 1 | $<$ 0.1 |
| Manganese $^{2+}$ " | $<$ 0.002 | $<$ 0.002 | $<$ 0.002 | N.D. | $<$ 0.002 |
| Silica " | 8 | 10 | 9 | $<$ 1 | $<$ 7 |
| Bicarbonate" | 85 (1.39), | 218 (3.57), | 101(1.69), | 790(12.9), | 160(2.62) |
| Sulphate " | 18 (0.37) | 25 (0.52) | 30(0.62) | 7(0 .14) | 12(0.25) |
| Chloride " | 35 (0.99) | 130 (3.67) | 60(1.69) | 83(2.34) | 80(2.26) |
| Phosphate " | $<$ 0.01 | $<$ 0.01 | $<$ 0.01 | N.D. | $<$ 0.01 |
| Total dissolved salts at 180°C | 150 | 454 | 250 | 740 | 280 |
| pH | 7.2 | 7.6 | 7.0 | 8.0 | 7.4 |
| Conductivity in micromhos per cm at 25°C | 218 | 714 | 310 | 1190 | 240 |

Figures in brackets refer to milliequivalents per litre.
N.D. indicates not determined.

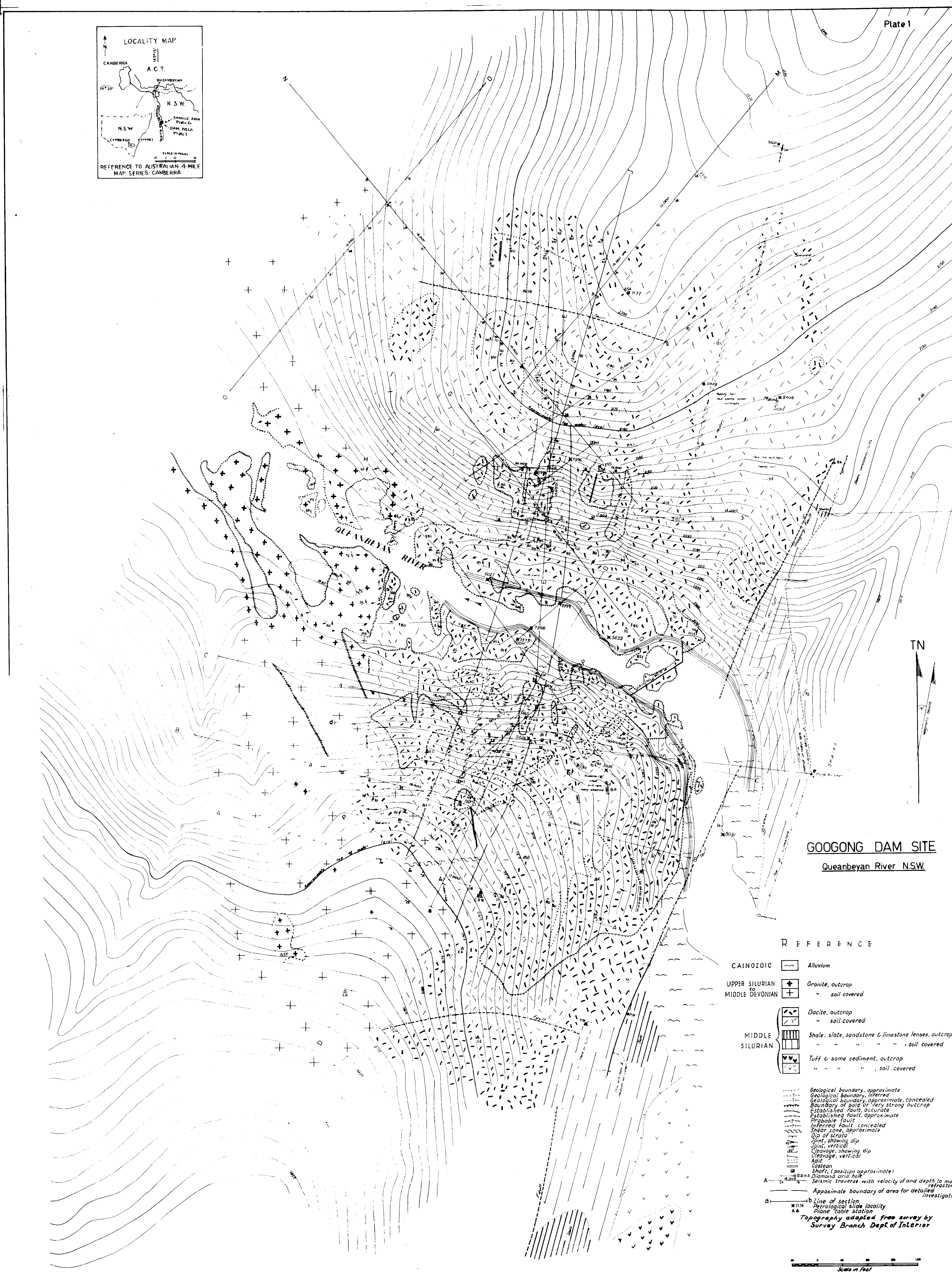
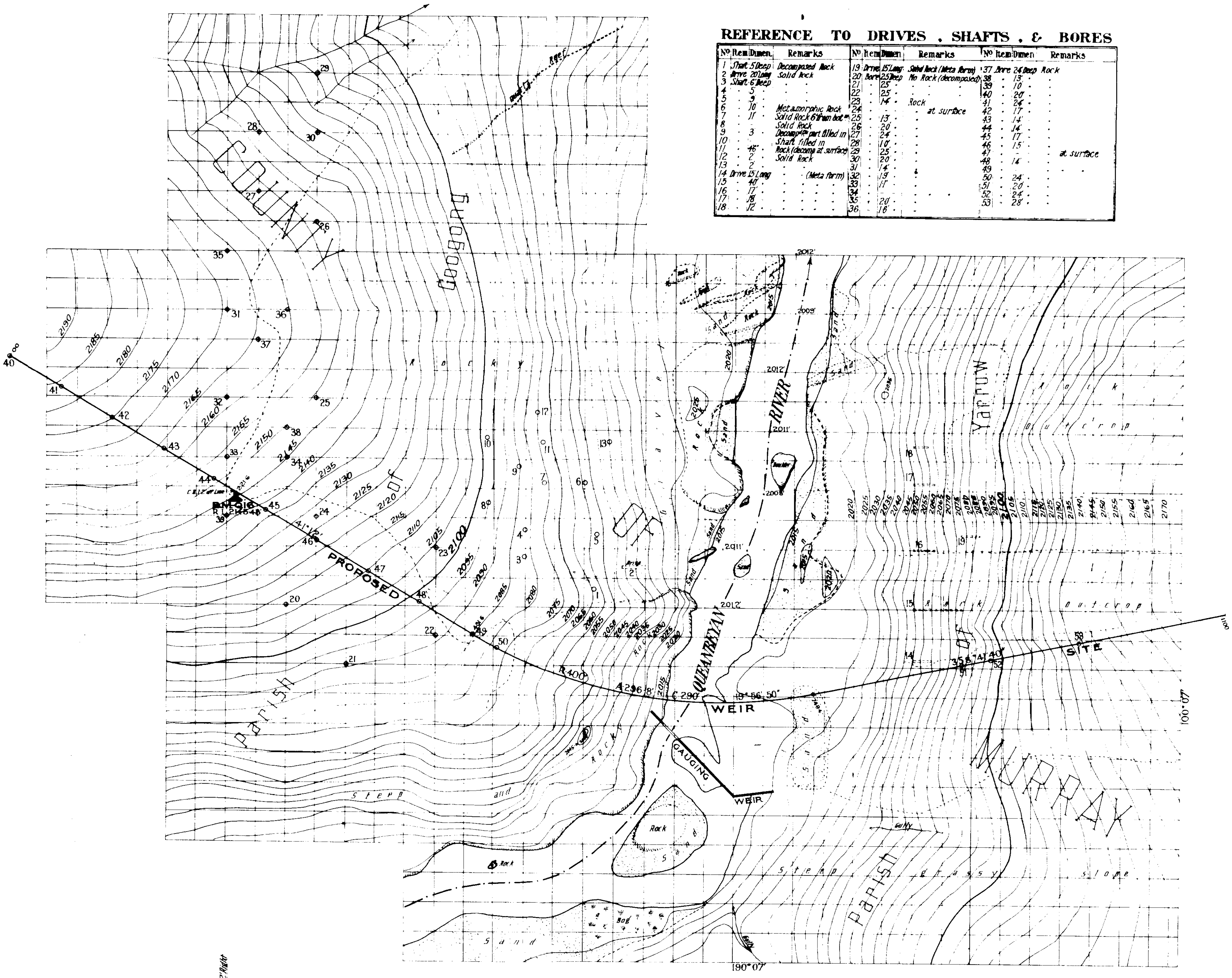


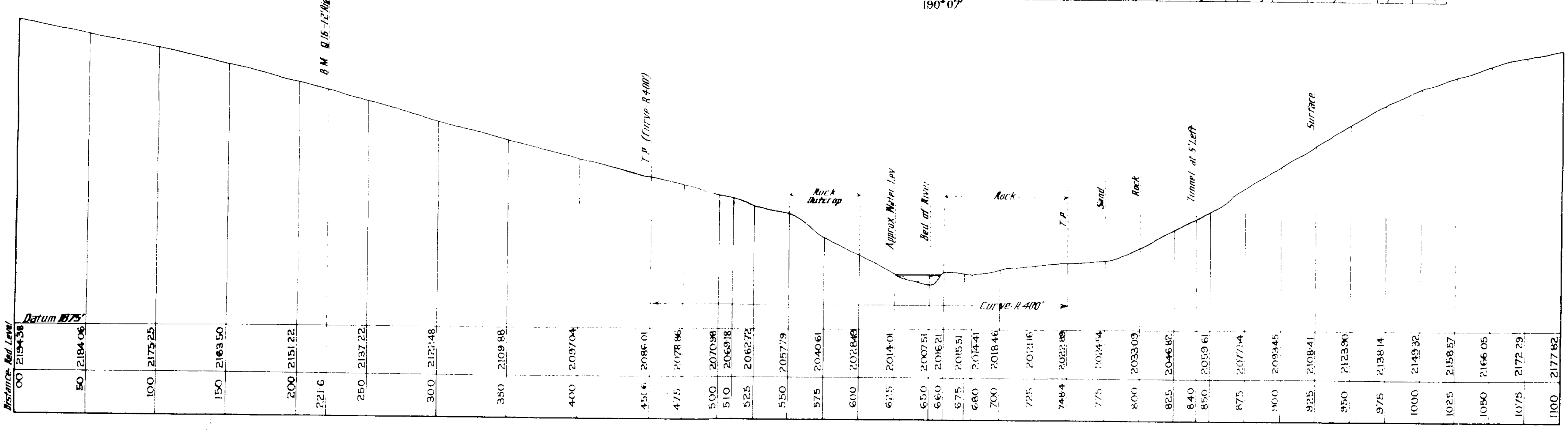
Plate 1
LOCALITY MAP
N
149°15'
CANBERRA
A.C.T.
QUEANBEYAN
35°20'
N.S.W.
QUEANBEYAN RIVER
SADDLE AREA Plate 6
DAM AREA Plate 1
N.S.W
CANBERRA
SYDNEY
SCALE IN MILES
REFERENCE TO AUSTRALIAN 4-MILE MAP SERIES: CANBERRA
QUEANBEYAN RIVER
TN
GOOGONG DAM SITE
Queanbeyan River N.S.W.
REFERENCE
CAINOZOIC
Alluvium
UPPER SILURIAN TO MIDDLE DEVONIAN
Granite, outcrop
" soil covered
MIDDLE SILURIAN
Dacite, outcrop
" soil covered
Shale, slate, sandstone & limestone lenses, outcrops
" " " " " , soil covered
Tuff & some sediment, outcrop
" " " , soil covered
Geological boundary, approximate
Geological boundary, inferred
Geological boundary, approximate, concealed
Boundary of bold or very strong outcrop
Established fault, accurate
Established fault, approximate
Probable fault
Inferred fault, concealed
Shear zone, approximate
Dip of strata
Joint, showing dip
Joint, vertical
Cleavage, showing dip
Cleavage, vertical
Adit
Costean
Shaft, (position approximate)
Diamond drill hole
Seismic traverse with velocity of and depth to main refractor
Appoximate boundary of area for detailed investigation
Line of section
Petrological slide locality
Plane table station
Topography adapted from survey by Survey Branch Dept. of Interior
Scale in feet
Mineral Resources, Canberra. Nov 1963.
To accompany Record No 1963/65

# FEDERAL CAPITAL COMMISSION

### REFERENCE TO DRIVES, SHAFTS, & BORES

| Nº | Item | Dimen. | Remarks | Nº | Item | Dimen. | Remarks | Nº | Item | Dimen. | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Shaft | 5' Deep | Decomposed Rock | 19 | Drive | 15' Long | Solid Rock (Meta form) | 37 | Bore | 24' Deep | Rock |
| 2 | Drive | 20' Long | Solid Rock | 20 | Bore | 25' Deep | No Rock (decomposed) | 38 | · | 13' · | · |
| 3 | Shaft | 6' Deep | · · | 21 | · | 25' · | · · · | 39 | · | 10' · | · |
| 4 | · | 5' · | · · | 22 | · | 25' · | · · · | 40 | · | 20' · | · |
| 5 | · | 9' · | · | 23 | · | 14' · | Rock | 41 | · | 24' · | · |
| 6 | · | 10' · | Metamorphic Rock | 24 | · | – | · at surface | 42 | · | 17' · | · |
| 7 | · | 11' · | Solid Rock 6' from botm | 25 | · | 13' · | · | 43 | · | 14' | · |
| 8 | · | – | Solid Rock | 26 | · | 20' · | · | 44 | · | 14' · | · |
| 9 | · | 3' · | Decompd Rk part filled in | 27 | · | 24' · | · | 45 | · | 17' · | · |
| 10 | · | – | Shaft filled in | 28 | · | 10' · | · | 46 | · | 15' · | · |
| 11 | · | 46" · | Rock (decomp at surface) | 29 | · | 25' · | · | 47 | · | – | · at surface |
| 12 | · | 2' · | Solid Rock | 30 | · | 20' · | · | 48 | · | 14' | · |
| 13 | · | 2' · | · · | 31 | · | 14' · | · | 49 | · | | · · · |
| 14 | Drive | 15' Long | · (Meta form) | 32 | · | 19' · | · | 50 | · | 24' · | · |
| 15 | · | 40' · | · · · · | 33 | · | 11' · | · | 51 | · | 20' · | · |
| 16 | · | 17' · | · · · · | 34 | · | – | · · · | 52 | · | 24' · | · |
| 17 | · | 18' · | · · · · | 35 | · | 20' · | · | 53 | · | 28' · | · |
| 18 | · | 12' · | · · · · | 36 | · | 16' · | · | | | | |




**SECTION OF PROPOSED WEIR SITE**

**Scale:- 80 feet to an inch (Natural)**

(from original ... )

## CONTOUR SURVEY
## PROPOSED WEIR SITE
## GOOGONG
## N. S. W.

Scale - 80 feet to an inch

Drawn by [signature] 23.10.'28
Exd by [signature] 23.10.28.
F.B.-S.461 : L.B.-L.424, 425, & 481
Date of Survey 23.8.'28.
Datum-Railway-C.B.-B.M. Q16 (R.L. 2145.45')

[signature]
Senior Staff Surveyor
Date 23 10 28

[signature]
for Surveyor in Charge
Date 23 - 10 - 28

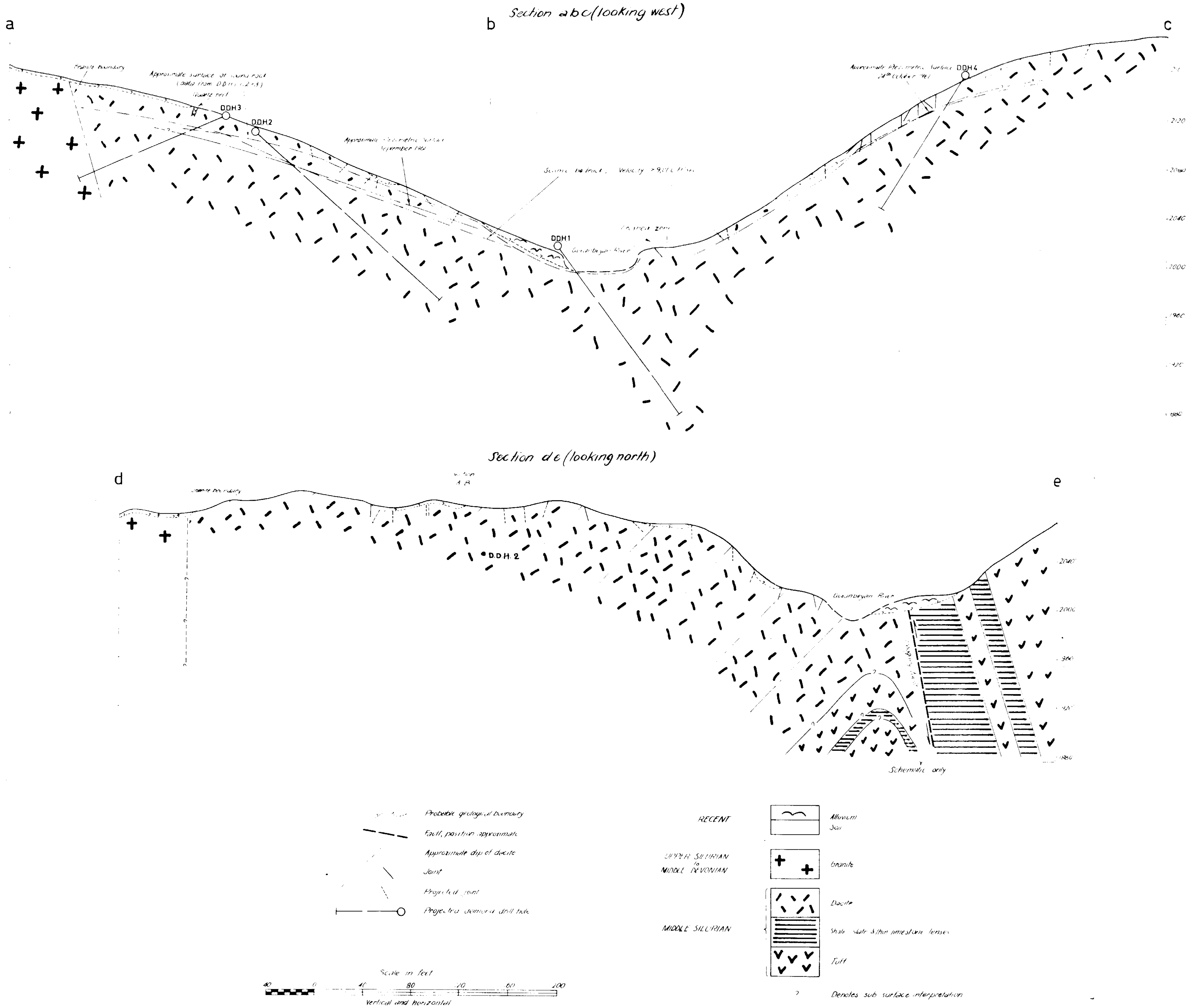
[signature]
a/Chief Engineer
Date 24.10.28

155/16/49

# GOOGONG DAM SITE
## N.S.W.
### Sections

showing projections of diamond drill holes

*See Plate 1 for location of sections*




Bureau of Mineral Resources, Geology & Geophysics, Canberra December 1962

To accompany Record 1965/68

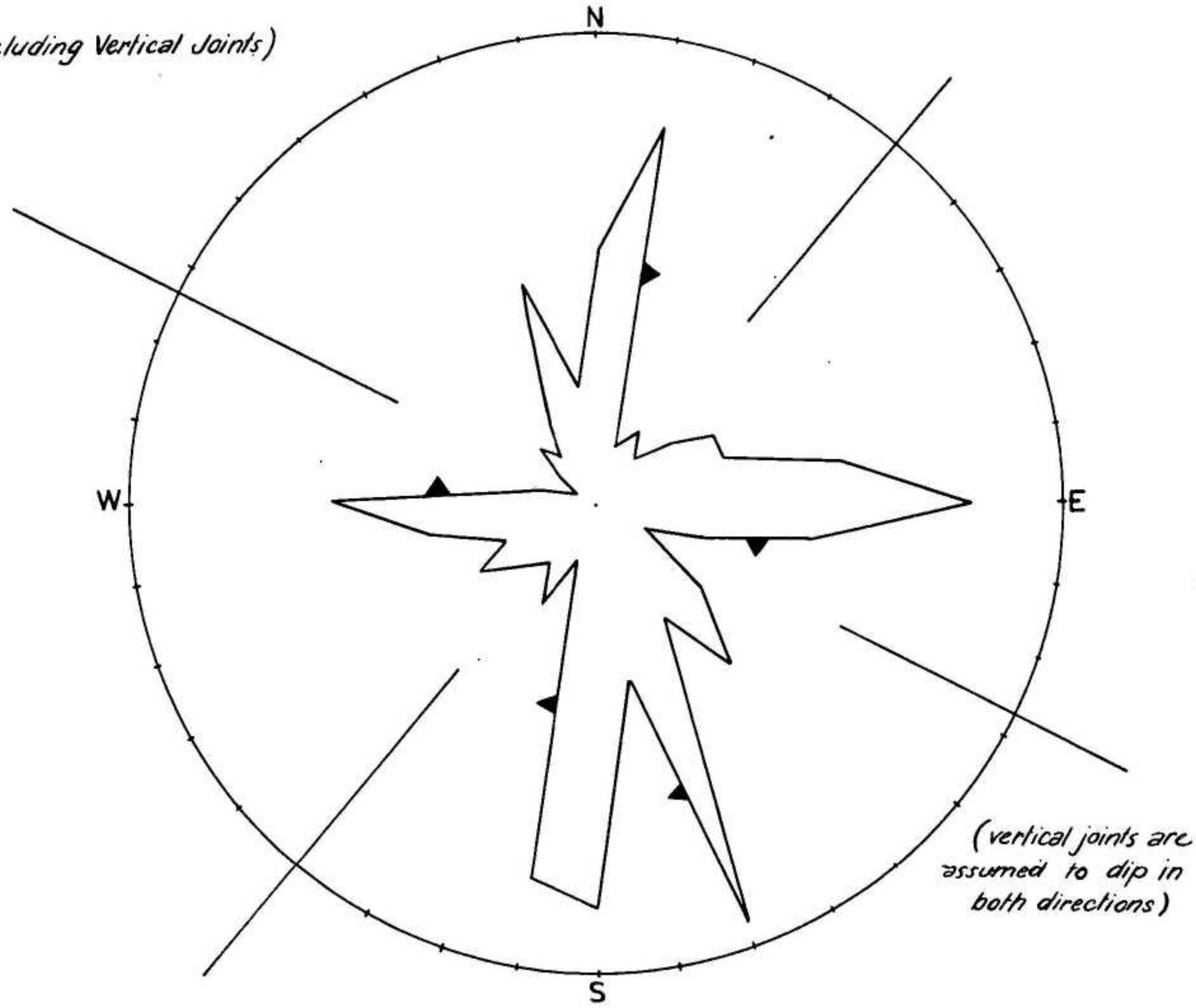
PLATE 4

# GOOGONG DAM SITE

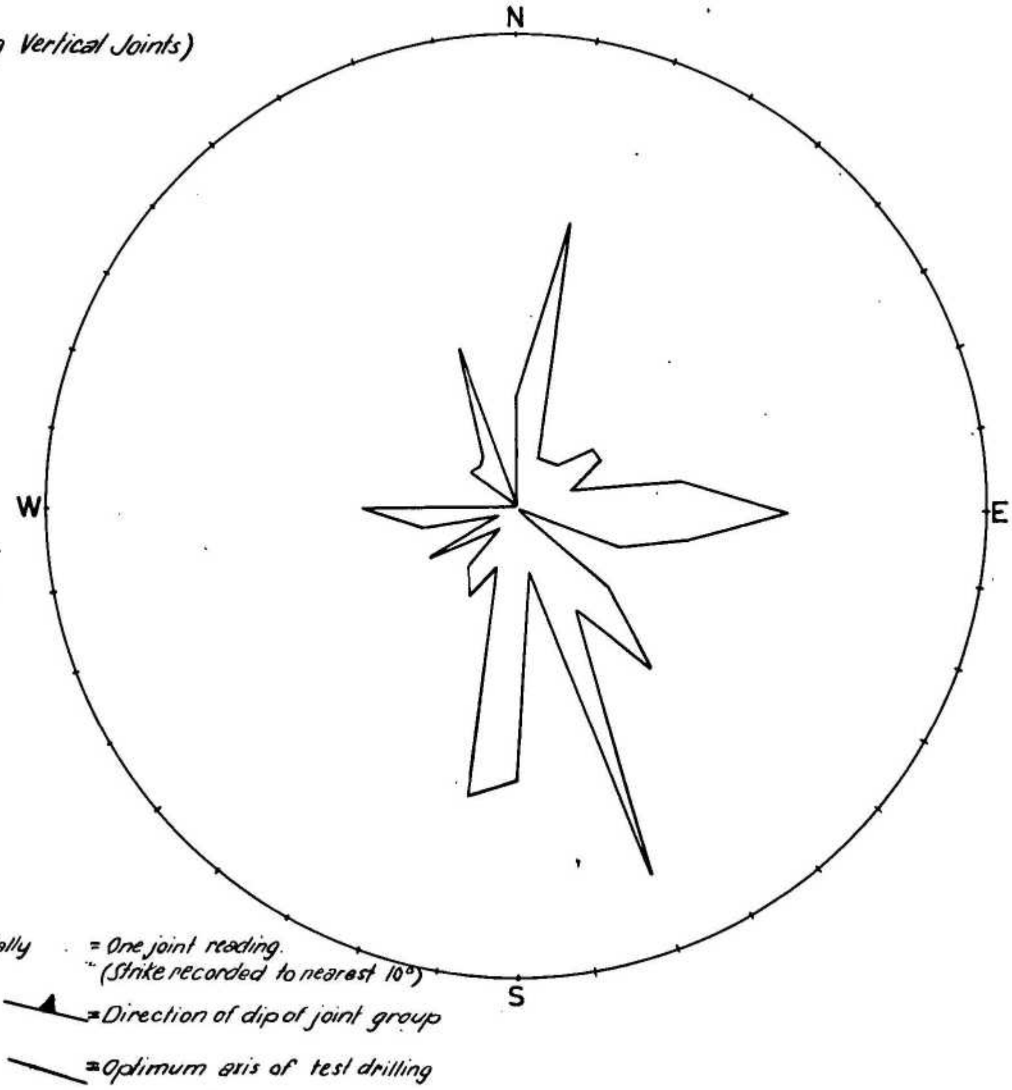
## JOINT ROSETTES

*Showing Frequency of Strike*

*A. (Including Vertical Joints)*




*B. (Excluding Vertical Joints)*




1/10" radially = One joint reading.
(Strike recorded to nearest 10°)

= Direction of dip of joint group

= Optimum axis of test drilling

Bureau of Mineral Resources, Canberra, Dec. 1962. To accompany Record 1963/68

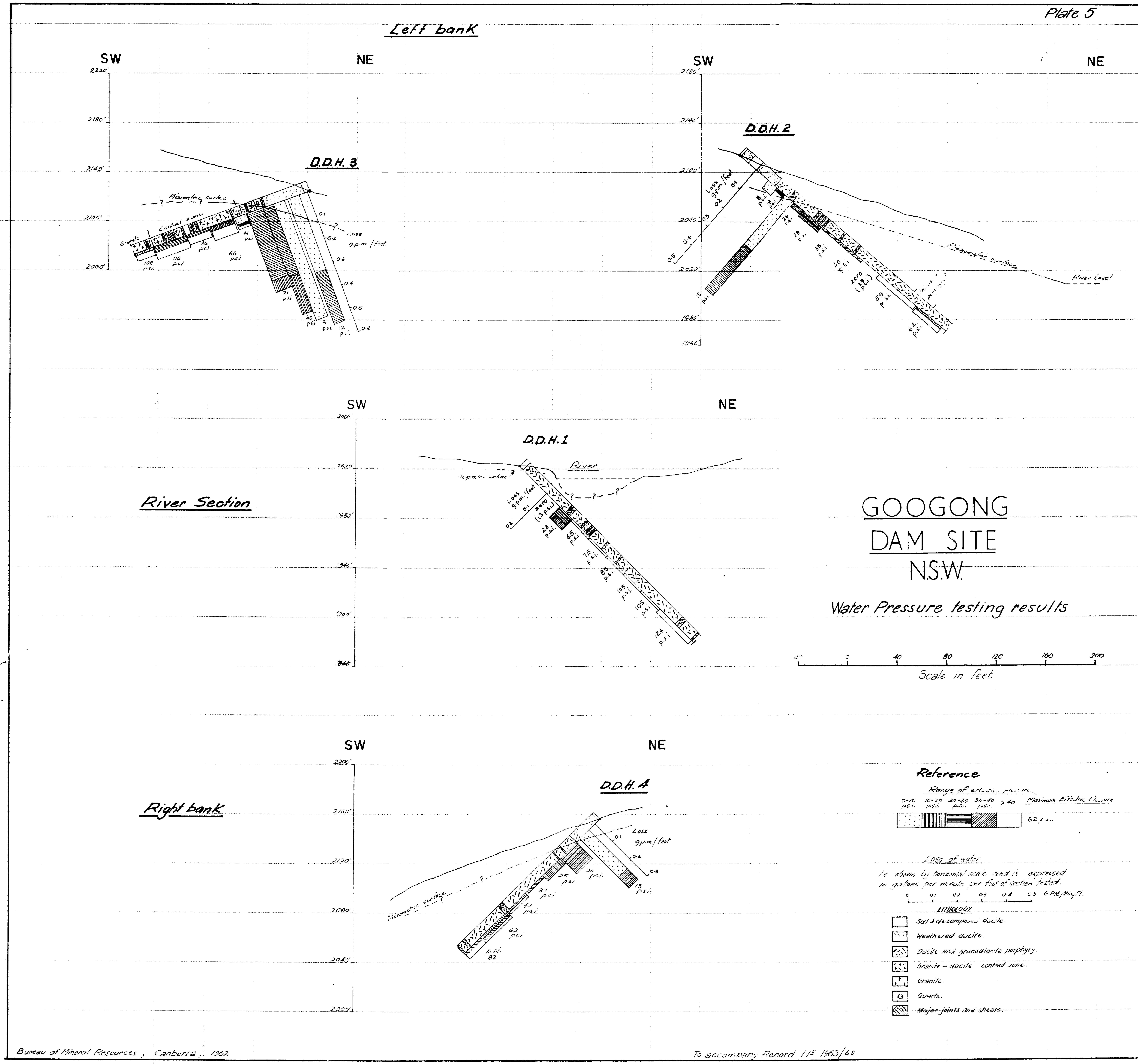
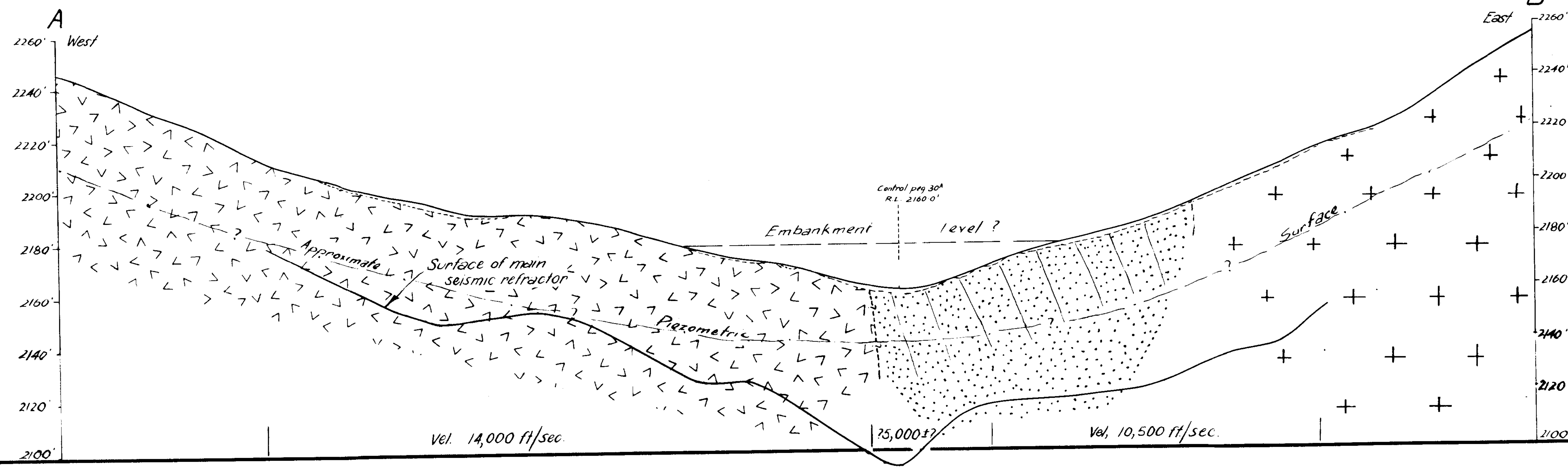


Plate 5
Left bank
SW
NE
D.D.H. 3
Piezometric surface
Contact zone
Granite
Loss
g.p.m./foot
108 p.s.i.
96 p.s.i.
86 p.s.i.
66 p.s.i.
41 p.s.i.
21 p.s.i.
30 p.s.i.
3 p.s.i.
12 p.s.i.
D.D.H. 2
Piezometric surface
River Level
zero (38 p.s.i.)
59 p.s.i.
64 p.s.i.
River Section
D.D.H. 1
River
zero (13 p.s.i.)
23 p.s.i.
45 p.s.i.
75 p.s.i.
85 p.s.i.
105 p.s.i.
124 p.s.i.
Right bank
D.D.H. 4
Piezometric surface
25 p.s.i.
30 p.s.i.
13 p.s.i.
37 p.s.i.
42 p.s.i.
62 p.s.i.
GOOGONG
DAM SITE
N.S.W.
Water Pressure testing results
Scale in feet
Reference
Range of effective pressure
0-10 p.s.i.
10-20 p.s.i.
20-30 p.s.i.
30-40 p.s.i.
>40
Maximum Effective Pressure
Loss of water
is shown by horizontal scale and is expressed in gallons per minute per foot of section tested.
G.P.M./ft.
LITHOLOGY
Soil & decomposed dacite
Weathered dacite
Dacite and granodiorite porphyry
Granite - dacite contact zone
Granite
Quartz
Major joints and shears
Bureau of Mineral Resources, Canberra, 1962
To accompany Record No 1963/68

# GEOLOGY OF GOOGONG SADDLE AREA

## Queanbeyan River N.S.W.


Interpretative Section A-B
Scale $\frac{V}{H} = 2.5$



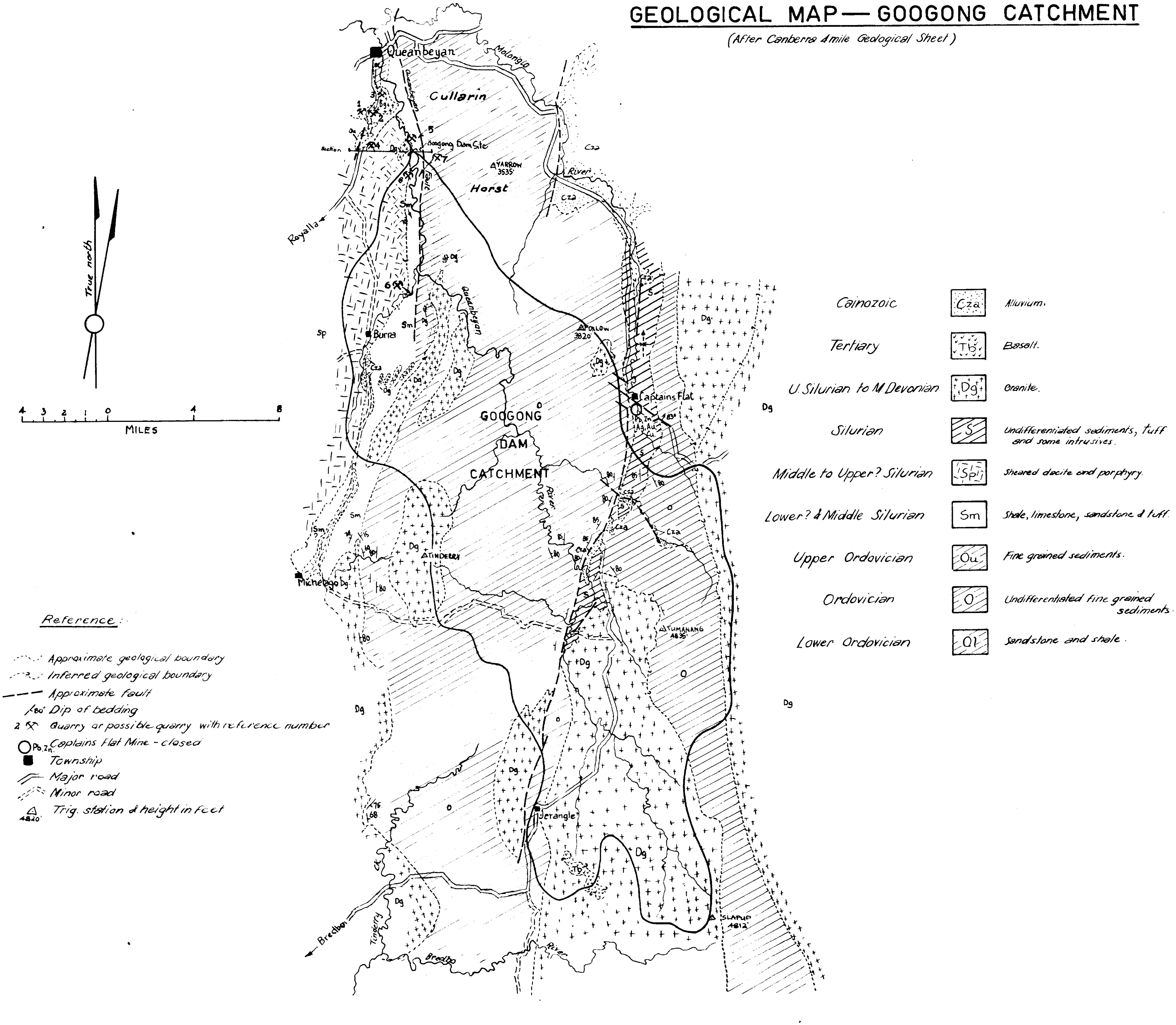

To accompany Record 1963/68

Bureau of Mineral Resources, Canberra.

Plate 7

# GEOLOGICAL MAP — GOOGONG CATCHMENT

(After Canberra 4 mile Geological Sheet)

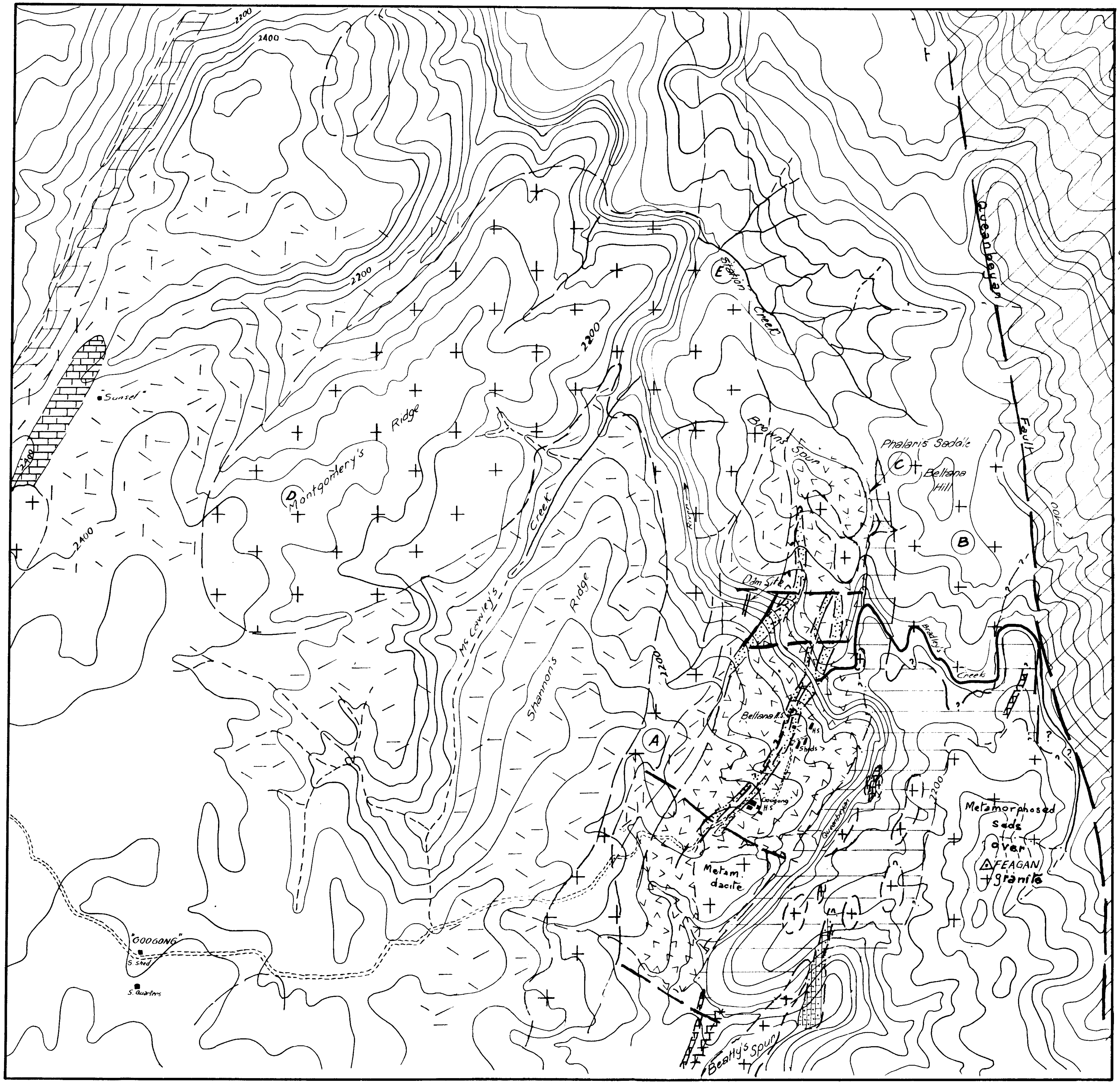



Bureau of Mineral Resources, Canberra, Nov. 1962.

To accompany Record 1963/68

Plate 8

## GOOGONG DAM SITE
**Northern Storage Area**
**Queanbeyan River N.S.W.**




| | | |
|---|---|---|
| UPPER SILURIAN to MIDDLE DEVONIAN | + | Granite, granodiorite, quartz & metamorphics overlying granite. |
| SILURIAN | | Dacite (Unit A) |
| | | Tuff, calcareous + non-calcareous. (Mainly Units B, C+D) |
| | | Slate, shale interbeds |
| | | Sediments, mainly shale, minor sandstone, limestone, some tuff. (Units E+F) |
| | | Limestone beds |
| | | Limestone. (Unit G) |
| ORDOVICIAN | | Greywacke & slate. |

Geological boundary approximate.

Geological boundary inferred

Fault, approximate.

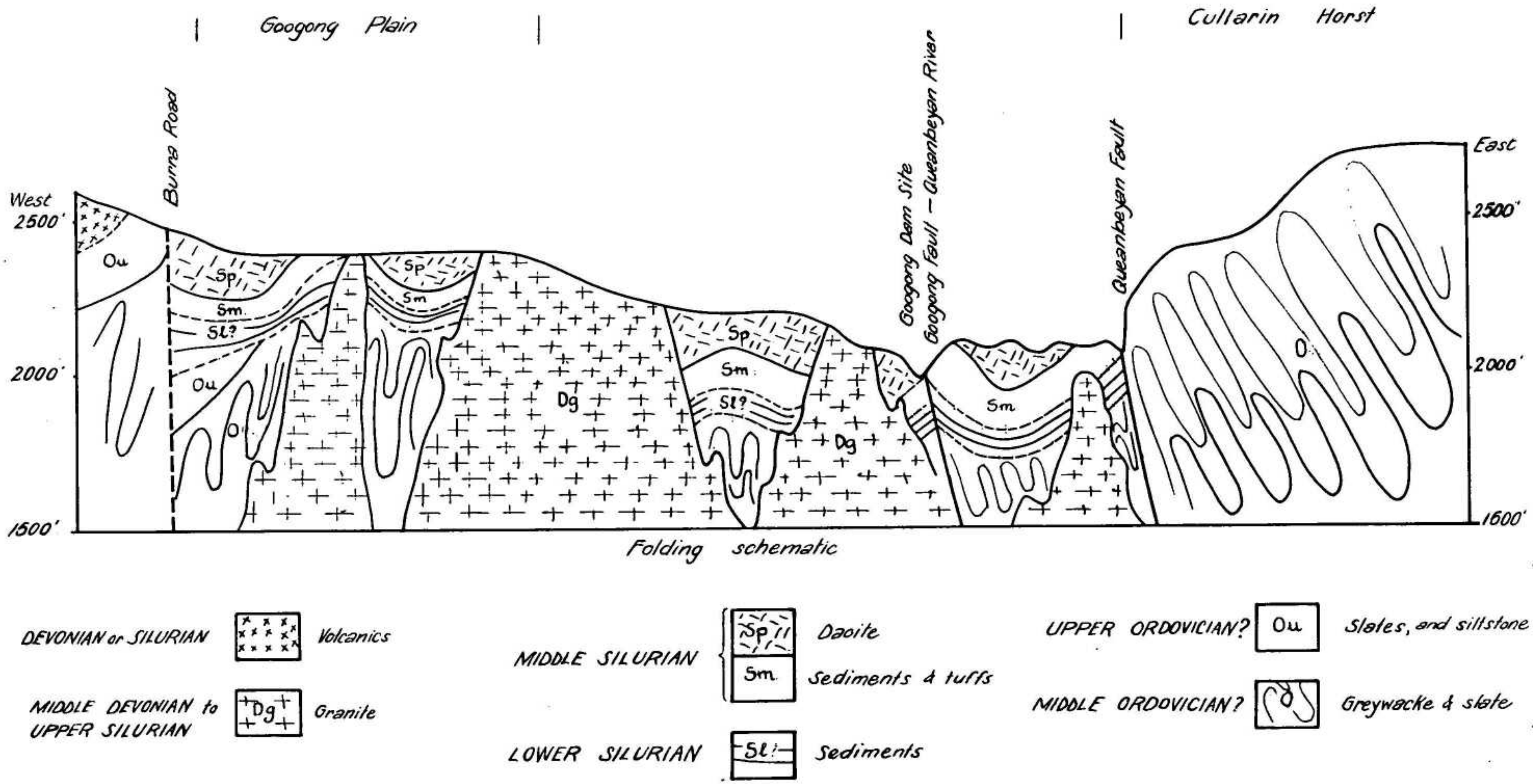
(A) Source of material, with text reference.

SCALE.
5 inches = 1 mile approximate.
Contour interval 25'.

TRUE NORTH

B.M.R. 1962

To accompany Record No 1963/68

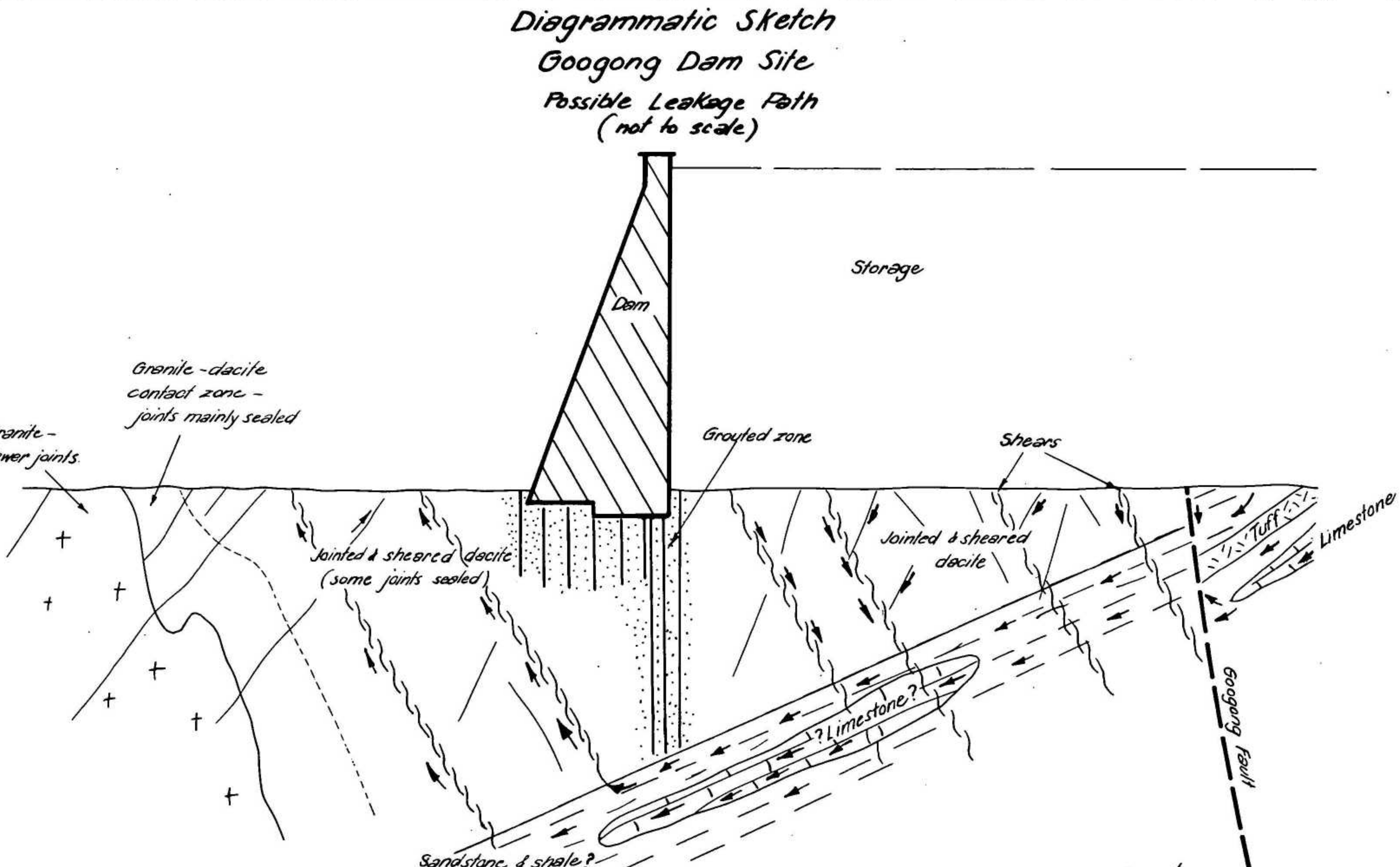



Scale :- H 1" = ½ mile
V 1" = 500 feet

# Geological Section

## GOOGONG AREA

*Queanbeyan River, N.S.W.*




Bureau of Mineral Resources, Geology & Geophysics, Canberra, Dec. 1962

To accompany Record Nº 1963/68

PLATE 10

# GOOGONG DAM SITE

PLATE II


MAIN STORAGE AREA
(Looking south-east from a point about 200yds south of southern end of proposed dam axis line)


PROPOSED DAM SITE
(looking upstream)

M(A)/6

PLATE11

A. Stereo-pair — left abutment
B. Right abutment
C. Stereo-pair — right abutment


A


A


B


C

C