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COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES

GEOLOGY AND GEOPHYSICS

RECORD 1961 No. 53

MOUNT MORGAN GEOPHYSICAL SURVEY FOR UNDERGROUND WATER, QUEENSLAND 1959

by

E. E. JESSON and C. J. Bamber

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ABSTRACT

At the request of the Mount Morgan Shire Council, a geophysical survey was made to determine the extent and interconnexion of alluvial deposits from which the town of Mount Morgan pumps its domestic water supply. The object of the survey was to provide data for further development of the underground water resources.

The seismic and resistivity methods were used to determine the thickness of the alluvial deposits and to give information about its constituent materials.

The results outlined three zones which may be suitable for development either because of the great thickness of alluvial deposits there or because of other factors which influence the rate of yield of water.

1. INTRODUCTION

The town of Mount Morgan draws its domestic water from bores operated by the Mount Morgan Shire Council. The Shire Council pumping reserve, approximately 9 miles south of Mount Morgan, is near the mouth of the alluviated valley of Fletcher Creek (Plate 1), and its tributaries the McBride and Nine Mile Creeks. Proposed developments by the mining company, Mount Morgan Limited, will require a much larger quantity of water than is at present available.

On the recommendation of Mr. S.R.L. Shepherd, Consultant Geologist to Mount Morgan Limited, a request was made by the Mount Morgan Shire Council to the Bureau of Mineral Resources to carry out a geophysical survey to determine the extent and interconnexion of the potential water-bearing beds along Fletcher and McBride Creeks. This survey was undertaken by the Geophysical Branch of the Bureau. While the survey was in progress, a request was made by the Shire Council to extend the survey to three smaller areas on Nine Mile Creek. It was later found by geological observations that two of these areas were unsuitable, and surveys of them were cancelled except for seismic shooting of a single control spread to compare the geophysical measurements with visual observation.

The geophysical party consisted of E.E. Jesson (party leader and geophysicist), B.J. Bamber (geophysicist), and J.P. Pigott (geophysical assistant). Field hands were supplied at first by the Irrigation and Water Supply Commission of Queensland and later by Mount Morgan Limited. The topographical surveying was carried out by Mount Morgan Limited, which also provided office space for the party.

Field operations took place between 26th October and 27th November 1959. During this period there were several heavy rain storms; these afforded an opportunity to carry out resistivity surveying, because good electrical contact could then be made with the ground.

2. METHODS

Seismic method

In the seismic method an explosive charge is detonated on or near the surface of the ground at what is known as the "shot-point", to produce artificial seismic waves which are reflected and refracted by boundaries between different rock formations beneath the surface. The reflection and refraction of seismic energy depend on a contrast between the elastic properties of the rock on each side of a boundary. The physical laws involved closely resemble those associated with optical phenomena.

For this survey the refracted energy only was considered. If energy strikes a boundary at the critical angle it will travel along the boundary, continuously transmitting energy back to the surface at the critical angle. This energy is recorded at the surface by special detectors (geophones) which are set up in line (geophone spread) at a specific spacing. The arrival time (measured from shot instant) of this refracted energy is plotted against distance from the shot-point, for each individual geophone. The resulting curve is known as a "time-distance curve". The slope of each section of this curve is a measure of the velocity of seismic waves in each of the successive rock layers, and from these data it is possible to compute the depth to these layers.

The computation method used is the "Method of Differences" (Heiland, 1946, p. 548). In this method, if A is the shot-point at one end of a spread, the time taken for the energy to reach a point B within the spread is T_{AB} and the time to a point C beyond the spread is T_{AC}. Similarly, when shooting from C, the time for the energy to reach B is T_{CB}, and from C to A is T_{CA}. The energy paths from C to A and A to C are identical and the times T_{AC} and T_{CA} (the reciprocal times) should be identical.

The depth is computed from the vertical travel time T_D which is defined as -

$$T_D = \frac{1}{2} (T_{AB} + T_{CB} - T_{AC})$$

The depth D, is then given by -

$$D = V_a T_D$$

where V_a = apparent velocity of seismic waves in the material between the surface and the boundary under consideration, and allows for the inclined energy path.

Two types of spread were used :-

(1) Normal spreads in which the geophone spacing was generally 100 ft, shots being fired at points 100 ft beyond each end of the spread. This type of spread is used to give values of T_D to the unweathered bedrock.

(2) Weathering spreads in which the geophone spacing was 10ft, and shots were fired at points 10 ft, 75 ft, and 150 ft beyond each end of the spread. In some places an additional shot was fired at 500 ft beyond each end. This type of spread is used to give information relating to velocity and thickness of the layers at shallow depths, from which an apparent velocity (V_a) between the surface and unweathered bedrock may be calculated.

The seismic method was used to trace unweathered bedrock, to measure the thickness of the alluvial deposits, and to indicate places where drilling might reveal an abundant water supply.

Resistivity method

In the resistivity method, an electric current is applied to the ground through two current electrodes, and the potential difference is measured between two additional electrodes at points between the two current electrodes. The ratio of the measured potential to the applied current is a measure of the ground resistivity. For the purpose of this survey the "Wenner" configuration (electrodes equally spaced) was used with an electrode spacing of 100 ft.

It is generally considered that the effective depth of penetration of the current is approximately the same as the electrode spacing. However, the current penetration depends on the relative resistivity values of the various sub-surface layers through which the current passes to complete the electrical circuit.

If the electrode spacing, and thus the depth penetration, is kept constant and the electrode arrangement is progressively moved as a whole, then lateral variations in resistivity of the near-surface layers can be determined. Generally, if the bedrock rises, the resistivity will increase owing to the introduction of high-resistance material into the circuit.

On this survey, resistivity traversing was used to detect structural changes and these were used as a guide to the best location for seismic weathering spreads.

3. EQUIPMENT

For the seismic work a Midwestern 12-channel Portable Reflection/Refraction Seismograph was used with Brush 20-c/s geophones for the normal spreads and Midwestern 6.5-c/s geophones for the weathering spreads.

For the resistivity work either a "Geophysical Megger Earth Tester" or a "Low-Resistance Megger Earth Tester" was used. The Geophysical Megger was found to give the more consistent results on this survey.

4. GEOLOGY

The geology of the Mount Morgan Shire Council Water Reserve (Plate 1) is known from surface surveys (Staines and Shepherd, unpublished) and from the logs of water bores.

The alluvial deposits, which occur as in-fillings of former valleys, consist of gravel, sand, and clay approximately 60ft thick, and overlie a bedrock of metamorphosed shale, tuff, and chert. The underground stream, which is the source of water, flows within the alluvial deposits. In the earlier bores, at approximately 30 ft, a band now identified as coarse gravel was believed to be bedrock until a recent bore (Plate 8) penetrated it and entered decomposed bedrock at 70 ft.

The hardness of this band of coarse gravel suggests it is highly consolidated. Because an isolated consolidated band overlying unconsolidated sand and gravel is unlikely, it is probable that all the alluvial materials below this hard band are also highly consolidated.

Pump tests on the new bore showed no appreciable increase in the amount of water drawn from the bore as a result of it penetrating sand and gravel beds deeper than the nearby bores. This fact combined with the seismic data tends to confirm that the deep alluvial beds are highly consolidated.

Observation of the level of the water table at various locations near the Water Reserve suggested that rock bars may exist across the creeks.

For the purpose of this report, it is necessary to distinguish between the conventional term "bedrock" which includes weathered bedrock, and "unweathered bedrock" which is the formation mapped in a survey of this type as is discussed in Section 5.1 below.

Over much of the survey area outside the Water Reserve the boundary of the alluvial deposits was mapped by Mount Morgan Limited (Plate 1).

5. DISCUSSION OF RESULTS

5.1 Objectives and General Discussion of the Survey

The Fletcher, McBride, and Nine Mile Creeks are surface expressions of a system of subsurface streams which flow through alluvial deposits occurring as in-fillings of former valleys.

The objective of the geophysical survey was to determine the extent and interconnection of potential aquifers within the alluvial deposits. In particular if the existence of rock bars across the subsurface streams could be established, which effectively serve as subsurface dams, then an abundant supply of water could be expected from bores situated upstream of these "dams".

In a survey of this type the interpretation of results is often dependent on associating a rock type with a seismic velocity. As a guide to the interpretation, rock types and expected longitudinal seismic velocities are tabulated below: the figures are based on general experience.

Velocity in ft/sec	Rock Type
700 to 1200	Soil, unconsolidated surface deposits.
1200 to 4000 ±	Unconsolidated clay, silt, unsaturated sand and gravel.
4000± to 5500	Saturated sand and gravel, compact clay and silt, completely weathered rocks.
5500 to 8000±	Consolidated and cemented sediments, probably water-saturated; weathered metamorphic and igneous rocks.
8000± to 12,000	Highly consolidated or cemented sediments, weathered or sheared metamorphic and igneous rocks.
12,000 to 20,000	Metamorphic and igneous rocks, either unweathered or only slightly weathered. Those with velocities in the lower part of this velocity range may also be somewhat fractured.

Applying these data to the seismic weathering spreads of this survey we see that basically the following sequence of rock types is found :-

(a) unsaturated and unconsolidated alluvial deposits above the water table.

(b) saturated unconsolidated alluvial deposits below the water table. This includes the main sand and gravel aquifers.

(c) partially consolidated and saturated alluvial deposits and possibly very weathered bedrock. These also may include useful sources of water.

(d) highly consolidated (or cemented) and saturated alluvial deposits or partially weathered bedrock. Small quantities of water may be available from this group of rocks.

(e) unweathered bedrock.

Regions where rock types (d) and (e) are close to the surface may serve as rock bars, provided they are orientated so as to block the subsurface streams. Therefore the obvious way in which to locate rock bars on the Fletcher and McBride Creeks would be to trace the partially weathered bedrock and the highly consolidated alluvial deposits. This is rarely practicable, as explained below.

If there are three rock layers with velocity contrasts such that it is expected the three layers can be identified, the intermediate layer must have a certain minimum thickness before its presence can be detected by first-arrival seismic events (Leet, 1950). In addition, unless the intermediate layers are very thick, short seismic spreads would have to be used; otherwise, at the geophones remote from the shot-point, energy from the deeper high-velocity layer would mask energy from the intermediate layer.

For these reasons the unweathered bedrock is the most reliable and simplest formation to map by the seismic method, because there is nearly always a marked contrast between its seismic velocity and that of the overlying materials and it is extensive enough to be a good transmitter of seismic energy.

It is known from experience in other areas that the depth of weathering is fairly constant in areas like the Fletcher and McBride Creeks. In other words, structural features in the weathered bedrock are likely to be indicated by similar features in the unweathered bedrock.

Thus the practical way in which to locate rock bars on the Fletcher and McBride Creeks is to map the unweathered bedrock and then try to detect anomalous zones of unusually thin or unusually thick weathered bedrock, and zones where the alluvial deposits are highly consolidated.

5.2 Unweathered bedrock, Fletcher and McBride Creeks

Plate 1 shows the location of the traverses, Plates 2 and 3 show the seismic sections, and Plates 5 and 6 show unweathered bedrock contour plans constructed from the seismic data.

Generally it is seen that over this area the depth to unweathered bedrock ranges between 50 and 70 ft at the western end of the area and between 40 and 60 ft at the eastern end of the area and south-east along McBride Creek.

Features of interest are :-

(a) a rock bar at the extreme western end of the area, blocking Fletcher Creek where it enters the River Dee. This feature is shown on Traverse A, the western end of Traverse B and D, and the southern end of Traverse C. The unweathered bedrock is between 10 and 20 ft deep. This is the only rock bar detected.

(b) a broad ridge on Traverse F between its western end and centre (Plate 5). This ridge causes a constriction in the creek. The depth to unweathered bedrock is about 18 ft.

(c) a trough on Traverse C about 200 ft north of the existing water bores (which are grouped around Konara No. 11 Bore). The depth to unweathered bedrock is about 100 ft.

(d) a trough on the north-western end of Traverse J. The depth to unweathered bedrock is about 125 ft.

(e) minor troughs near the northern ends of Traverses G and N. The depths to unweathered bedrock are about 65 and 80 ft respectively.

The depth to unweathered bedrock is computed from the product of the time depth (T_D) and the apparent velocity (V_a). The accuracy of T_D values is limited to about $\pm$ 1 millisecond, which for an average value of 15 milliseconds for T_D is about 7 per cent. The error in V_a is difficult to evaluate but a value of 10 per cent seems reasonable from a consideration of the consistency of values of V_a within type groups (deep areas, shallow areas, normal intermediate depth areas).

Thus the error in the values of depth to unweathered bedrock is about $\pm$ 20 per cent.

5.3 Unweathered bedrock, Nine Mile Creek

The Nine Mile Creek seismic sections are shown on Plate 4 and an unweathered bedrock contour plan, for Area "A" only, is shown on Plate 7.

The depth to unweathered bedrock is generally between 50 and 70 ft on the western part, and between 45 and 55 ft on the eastern part of Area "A".

On Area "B" Traverse W shows depths to unweathered bedrock between 46 and 56 ft.

There is no indication of rock bars on the Nine Mile Creek areas.

5.4 Weathered bedrock

Unfortunately the information relating to weathered bedrock is very inconclusive. In some zones of the survey a material with a seismic velocity of between 10,000 and 12,000 ft/sec was detected; this could be partially weathered bedrock, but on the evidence available is not necessarily so. In other zones the highest seismic velocities observed, apart from that of unweathered bedrock, are between 4000 and 7000 ft/sec.

To gain more information on weathering, Traverse W was shot on Area "B" of Nine Mile Creek. In this area the creek has cut a channel about 20 to 25 ft deep through the alluvial deposits exposing hard rock in the creek bed. This exposed rock is accepted as bedrock in the conventional sense. There are two wells about 25 ft deep in this area; one very close to the creek and the other some 800 ft away. The cuttings dug from these wells indicate that they also enter bedrock.

Traverse W, which is situated between the two wells, shows that the depth to unweathered bedrock is between 46 and 56 ft. The quality of the seismic records is good and the discrepancy (about 20 to 25 ft) between the two forms of observation is attributed to the existence of a layer of weathered bedrock that is too thin to be recorded as a "first event" on the seismic records (Leet, 1950). This layer would be shallower than the computed depth to unweathered bedrock and must be the material observed in the creek and the two wells.

Assuming a velocity of 8000 ft/sec for the weathered bedrock, a theoretical consideration of the problem indicates that the minimum thickness of this layer to enable it to be recorded is about 40 ft; assuming a velocity of 10,000 ft/sec, the minimum thickness is about 25 ft. These values are of equal or greater magnitude than the discrepancy mentioned above.

Similar theoretical considerations show that, for an area where the unweathered bedrock is overlain by about 20 ft of material having a characteristic velocity of about 1100 ft/sec such as on Traverse F, from F4 to F24, an intermediate layer of weathered bedrock would have to be at least 10 ft thick for it to be detected.

Because it is highly improbable that weathered bedrock is entirely absent, up to 10 ft of it may be expected beneath the shallow areas and up to 40 ft on the deeper areas. On the very deep areas such as Traverses C and J, an even greater thickness of weathered bedrock may exist.

As mentioned at the beginning of this Section (5.4) a material having a seismic velocity between 10,000 and 12,000 ft per second has been detected in several places which can be grouped as below :-

(a) zones where the unweathered bedrock is deepest, namely the troughs on Traverses C, J, G, and N which are filled with a thick layer of high-velocity material.

(b) some zones where the traverses are close to the edge of the alluvial deposits, as on Traverses M and U. This is probably because the partially weathered bedrock is thicker there, where mechanical erosion is less severe than near the centre of the creeks.

(c) the junction of Traverses Q and R. Presumably there is a localised thickening of high-velocity material, but because of its depth (33 ft) and the overall width of the channel in this region, it is not likely to constitute an important rock bar.

It was originally thought that this material with a seismic velocity between 10,000 and 12,000 ft/sec was composed entirely of weathered bedrock. However, a comparison of the seismic results for Traverses B and C with the log of the Konara No. 11 Bore (Plate 8) shows that part of this material must be highly consolidated alluvial deposits. An exact comparison of the bore log and seismic results is not possible because the bore is not on the traverse line, and the depth to bedrock varies rapidly.

Detailed information on the composition of this high-velocity material is in fact not relevant to the objectives of this survey. Whether it be partially weathered bedrock or a highly consolidated alluvial deposit, if it were present as a rock bar it would constitute an effective subsurface dam. However, there is no evidence of a rock bar composed of this high-velocity material.

5.5 Alluvial deposits

The previous discussion has shown that apart from the rock bar across the mouth of Fletcher Creek, which effectively dams the whole creek system, there are no rock bars which could influence the selection of sites for new water bores. However, the composition of the alluvial deposits can influence the selection of sites for new bores. For example, a bore penetrating sand and gravel beds would be expected to produce greater quantities of water than one penetrating clay beds.

A water-saturated rock consists of a framework and voids, within the framework, which contain water. When seismic energy is transmitted through this rock two types of wave, a frame wave and a type of water wave, may exist. The faster wave generally masks the slower one. Under certain conditions where the water wave travels faster than the frame wave, it is possible to detect the water table. This is generally the case in sands and gravels which are good aquifers.

Plates 2, 3, and 4 show at many places near-surface layers having a velocity of 4000 to 5000 ft/sec, characteristic of water-saturated materials below the water table. The elevation of the water table computed from weathering spreads is shown on the contour plans (Plates 5, 6, and 7). It should be remembered, however, that the water table is subject to considerable change from season to season. It was reported orally by Mr. S.R.L. Shepherd that at the time of the survey the water table was unusually low. It will be seen from the water table elevations on the contour maps that, in the Fletcher and McBride Creeks area, the water table dips gently from 528 ft above sea level in the east to 478 ft above sea level in the west. A similar slope to the north-west is indicated by two points along McBride Creek. The bore log, however, (Plate 8) shows the water table at 473 ft above sea level at the western end of the area. This difference is probably explained by the water table having an indefinite boundary owing to capillary action.

A few anomalous water table elevations are seen on the plates. The low value of 481 ft at the junction of Traverses G and H suggests that at this place there may be a layer of unconsolidated plastic clay overlying a bed of gravel. Such a clay bed, saturated with water between 481 ft and the water table at about 496 ft, would have a characteristic velocity between 2000 and 2500 ft/sec; the measured velocity was 2400 ft/sec.

Some of the water table elevations seem anomalously higher than nearby ones; e.g. at C10, J11, and L14. These may represent an elevated water table due to recent rain; more probably, the approximately 5000-ft/sec velocity at these places is due to a layer of partially cemented or consolidated sand, gravel, or clay, or even to highly weathered bedrock. Such a layer, above the water table, would mask the true water wave and would itself be mistaken for the water wave.

In Area "A" of Nine Mile Creek, the water table is seen to slope down towards the north-west from 558 ft to 542 ft above sea level.

In Area "B", a 5000-ft/sec layer may be interpreted as the water table at 655 ft above sea level. Because no water is evident at a level lower than this in the creek, and the water is seen to be lower than this in two nearby wells, this 5000 ft/sec velocity is probably caused, as in the Fletcher and McBride Creeks area, by either an elevated water table or a rock formation with a chracteristic velocity of 5000 ft/sec.

The resistivity profiles, which are shown on Plates 2 and 3, generally confirm the configuration of the bedrock. As explained under "METHODS", if the bedrock is close to the surface, the resistivity is greater owing to the introduction of high-resistance material into the circuit. An example of this is Traverse D where from west to east, the depth to unweathered bedrock increases and resistivity decreases.

All the anomalies are associated with changes in the character of the alluvium, with the exception of the anomaly on Traverse F between F19 and F22, which is attributed to a change in character of the weathering in the bedrock.

Generally clay shows a lower resistivity than gravel. In this survey, resistivity peaks associated with detection of the water table, are interpreted as water-saturated sand or gravel. Conversely, resistivity troughs where the water table was not detected, are interpreted as clay.

6. CONCLUSION AND RECOMMENDATIONS

Apart from the ridge across the mouth of the underground channel of Fletcher Creek, no rock bars were detected within the alluvial deposits. It is thus concluded that in the survey area, the alluvial beds in the Fletcher and McBride Creeks are interconnected.

The detection of water-saturated beds in many parts of the survey area indicates the possibility of obtaining new water supplies.

The survey revealed a few areas of clay. Although clay has a high porosity it has a low permeability, and clay areas will not provide appreciable water supplies. Such areas are the north-western half of Traverse E; the junction of Traverse Q with R and S; the junction of Traverse L with P, and the region of L47 on the Fletcher and McBride Creeks area; and the junction of Traverse U with V on the Nine Mile Creek area.

Three zones on the Fletcher and McBride Creeks area should be of special interest :-

(1) The deep zone on the northern part of Traverse C.

(2) The deep zone on the north-western part of Traverse J.

(3) The junction of Traverse G with H.

The first two of these zones are deep basins (approximately 100 ft), but below about 30 ft their permeability may be reduced owing to consolidation of the alluvium.

The third zone, at the junction of Traverse G and H, is not as deep as the first two zones but, because the depth to the consolidated gravels is greater (approximately 45 ft), it may well prove to be the best for providing water supplies. A further advantage of this zone is that the shallow bedrock on the southern edge of Fletcher Creek restricts the width of the infilled valley and thus directs the underground water flow into this zone. Because the water table is indicated as having a gradual slope down-stream, the restricted width of the valley cannot be having any damming effect on the underground water. This suggests that the permeability of the beds may be somewhat higher in this zone; if so, it would be advantageous to bores in this zone. Owing to the lower surface elevation of this third zone the depth to be bored would be less than on other sites.

A test bore in the region of a bedrock shear zone on Traverse L, at L14 (Plate 2), may also yield appreciable quantities of water.

The region of the junction of Traverses Q and R appears, from the contour plan, to be of interest because it is the centre of a wide area with depths of 60 to 70 feet. However, as described above, the presence of clay beds (which overlie consolidated materials) would probably restrict the flow of water in this region.

It is recommended that to obtain full value from the survey several test bores should be sunk in regions of both thick and thin alluvial deposits to obtain some indication of the thickness of the unweathered bedrock which undoubtedly must exist over some if not all of the survey area. Suggested sites are A7, E6, E18, F10, H6, J2, Q22 and V5. A consideration of the total available water is included in Appendix I.

7. ACKNOWLEDGEMENTS

The authors wish to acknowledge the assistance given the party by the Irrigation and Water Supply Commission of Queensland by providing field hands and vehicles, by Mount Morgan Limited for providing office space, field hands, and general assistance, and by the Mount Morgan Shire Council for general assistance.

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APPENDIX

AVAILABLE UNDERGROUND WATER ON THE FLETCHER, McBRIDE, AND NINE MILE CREEKS

In this Appendix an attempt is made to calculate the order of magnitude of the quantity of water available from the valley system. It is important to realise that this estimate is only a guided guess which may serve to stimulate further research on the problem.

An examination of the relevant 1-mile military maps of Queensland shows the catchment area of these creeks to be approximately 100 square miles.

The average rainfall (measured for 33 years) for the Mount Morgan area is about 31 inches (2.6 feet) per annum (Bureau of Meteorology).

Hence the average total water that falls as rain is :

$$100 \times 5280^2 \times 2.6 \times 6.25 \text{ gallons per year}$$

or

$$4.5 \times 10^{10} \text{ gallons per year}$$

The losses due to evaporation are extremely difficult to evaluate on theoretical grounds but weather records show (Bureau of Meteorology) that from a free surface -

(a) Rockhampton has an annual evaporation of 52.71 ~~points~~ INCHES (measured for 26 years).

(b) Biloela has an annual evaporation of 79.45 ~~points~~ INCHES (measured for 13 years).

Rockhampton is about 25 miles from Mount Morgan and Biloela about 70 miles. Averaging these evaporation rates, and using the resulting value at Mt. Morgan, the annual rainfall lost from a free surface by evaporation is about 2 per cent. However, apart from any pools in the creeks, free surface conditions do not exist and allowance has to be made for the effects of vegetation and type of surface. Such evaporation losses vary considerably from area to area, and a value of 10 per cent is taken as a maximum. Hence the water available over the catchment area being considered will be about

$$4 \times 10^{10} \text{ gallons a year.}$$

As not all the water passing the bores can be recovered, particularly after rain when the flow rate of the underground streams is higher than normal and may even cause the creeks to flow, the bores need to be placed carefully to give best yield; in line across the stream, for instance, rather than in line along the stream. Assuming that only 25 per cent of the available water is recoverable, this should amount to about 1×10^{10} gallons per year.

If the future annual requirements for Mount Morgan are only a small fraction of 1×10^{10} gallons, no difficulty should be experienced in obtaining the water. If however, the requirements are of the order of 1×10^{10} gallons, it will be necessary either to develop other productive areas or to reduce the 75 per cent losses - by construction of a dam, for example.

PLATE I

LOCALITY MAP
TO ROCKHAMPTON
MOUNT MORGAN
DEE RIVER
RAILWAY
DAWSON VALLEY
ROAD
VALLEY
SCALE IN MILES
Walmul
DAWSON
Nine Mile Creek
SURVEY AREA
Fletcher Creek
McBride Ck
True North
Magnetic North
REFERENCE TO 4 MILE MILITARY MAP SERIES
QUEENSLAND
MACKAY
ROCKHAMPTON
MOUNT MORGAN
ROCKHAMPTON 4 MILE SHEET
BRISBANE
NINE MILE CK. AREA B
TRAV. W
Well (Approx)
PARISH OF CULLIUNGAL
PARISH OF GELOBERA
N
Adopted County Meridian
LEGEND
TRAVERSE
PARISH BOUNDARY
FENCE
ROAD
GEOLOGICAL LEGEND
DYKE
ALLUVIAL BOUNDARY
Aggl AGGLOMERATE
Tf grit TUFFACEOUS GRIT
Tf sst TUFFACEOUS SANDSTONE
Chty sst CHERTY SANDSTONE
Gwke GREYWACKE
Congl CONGLOMERATE
Brec BRECCIA
STRIKE AND DIP OF STRATA
Note :- Surface Geology of Shire Council Water Reserve after H.R.E. Staines (11/11/52) and S.R.L. Shepherd (7/4/55)
Nine Mile Creek
NINE MILE CREEK AREA A
TRAV. U
TRAV. V
TRAVERSE T
Fletcher Creek
TRAVERSE L
TRAV. P
TRAV. N
TRAVERSE R
TRAVERSE Q
TRAV. A
TRAV. B
TRAV. C
TRAV. D
TRAV. E
TRAV. F
TRAV. G
TRAV. H
TRAV. J
TRAV. K
TRAV. M
TRAV. S
DEE RIVER
Alluvium
Pump Well
Konara Well Bore
Mt. Morgan Shire Council Water Reserve
Greywacke
Chert
Chty sst
Grit
Congl
Shale
Tuff
Mc Bride Creek
FLETCHER — Mc.BRIDE CREEKS AREA
SCALE IN FEET
GEOPHYSICAL INVESTIGATIONS OF UNDERGROUND WATER AT MOUNT MORGAN, QUEENSLAND, 1959
FLETCHER — McBRIDE AND NINE MILE CREEK AREAS
LOCALITY MAP, LAYOUT OF TRAVERSES, AND GEOLOGY
(AFTER MOUNT MORGAN LTD.) PLANS Nos. 25-46A & 25-51
Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics.
G 59-3-2
To accompany Record 1961, No.53


PLATE 2
TRAVERSE B
TRAVERSE C
TRAVERSE D
TRAVERSE E
TRAVERSE F
TRAVERSE G
TRAVERSE J
TRAVERSE L
TRAVERSE L
TRAVERSE M
OHM-METRES
SHEAR ZONE ?
DATUM 00'
DATUM 100'
STATION No
SURFACE R.L.
DEPTH TO BEDROCK
GEOPHYSICAL INVESTIGATION OF UNDERGROUND WATER
AT MOUNT MORGAN, QUEENSLAND, 1959
FLETCHER-McBRIDE CREEKS AREA (PART I)
SECTIONS SHOWING DEPTH TO UNWEATHERED BEDROCK
AND APPARENT RESISTIVITY PROFILES
(AFTER MOUNT MORGAN LIMITED, PLAN No 25-49)
LEVELS ARE ON STATE DATUM
HORIZONTAL SCALE IN FEET
VERTICAL SCALES AS SHOWN
LEGEND
(15,000) SEISMIC VELOCITY IN FT./SEC.
RESISTIVITY PROFILE
UNWEATHERED BEDROCK BOUNDARY
TOPOGRAPHY
Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics.
G59-5-1

PLATE 3

LEGEND

(16,000) SEISMIC VELOCITY IN FT./SEC.
RESISTIVITY PROFILE
UNWEATHERED BEDROCK BOUNDARY
TOPOGRAPHY

GEOPHYSICIST

GEOPHYSICAL INVESTIGATION OF UNDERGROUND WATER
AT MOUNT MORGAN, QUEENSLAND, 1959

FLETCHER-McBRIDE CREEKS AREA
(PART 2)

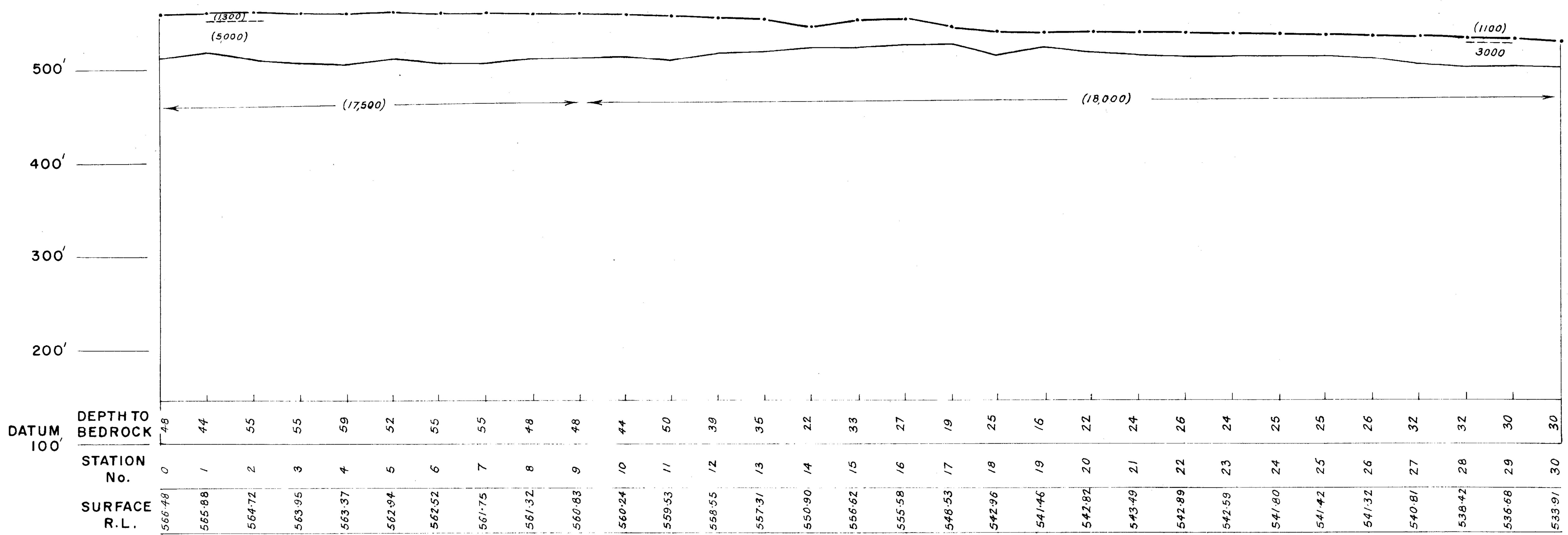
SECTIONS SHOWING DEPTH TO UNWEATHERED BEDROCK AND APPARENT RESISTIVITY PROFILES

(AFTER MOUNT MORGAN LIMITED, PLAN No 25-50)
LEVELS DATUM: STATE

HORIZONTAL SCALE IN FEET
200 0 200 400 600 800
VERTICAL SCALES AS SHOWN

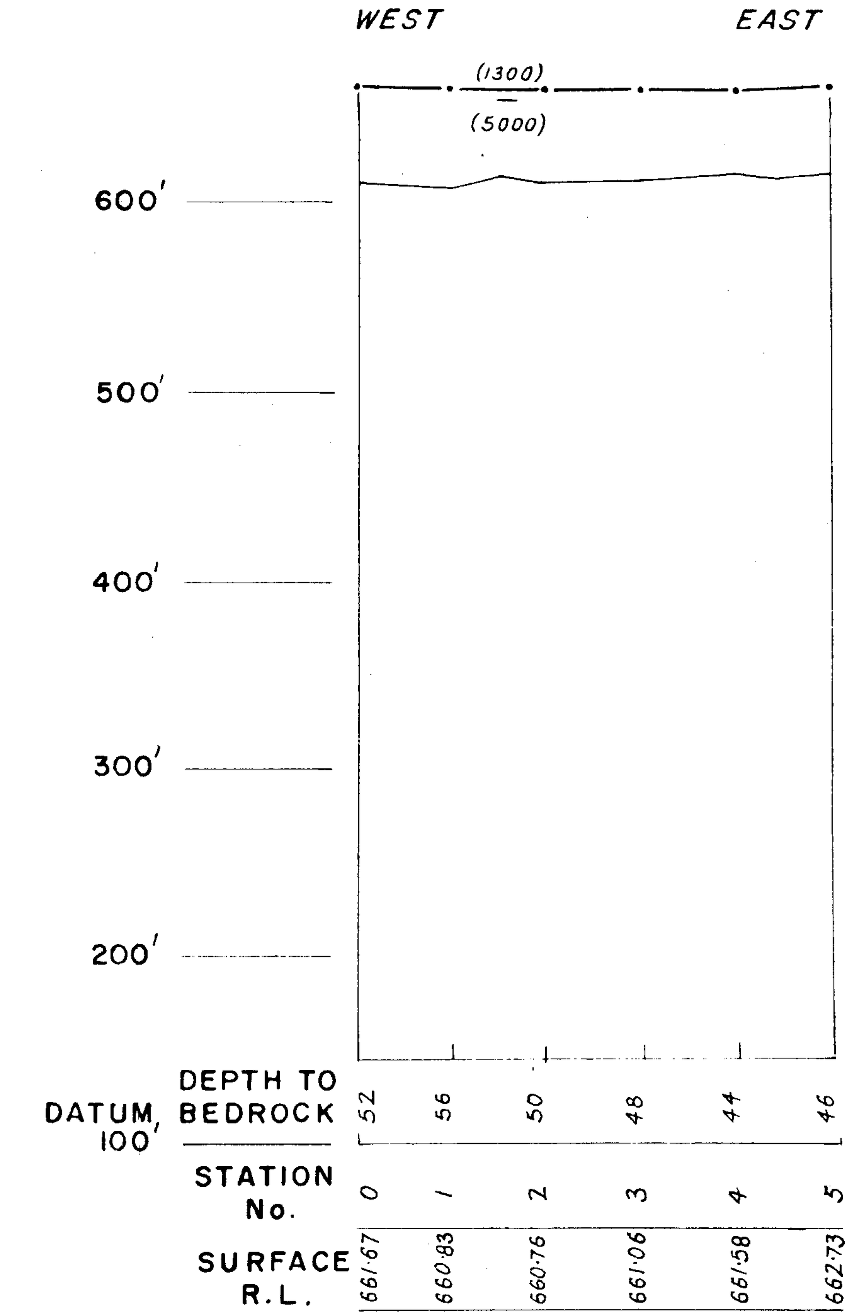
AREA-A

TRAVERSE T

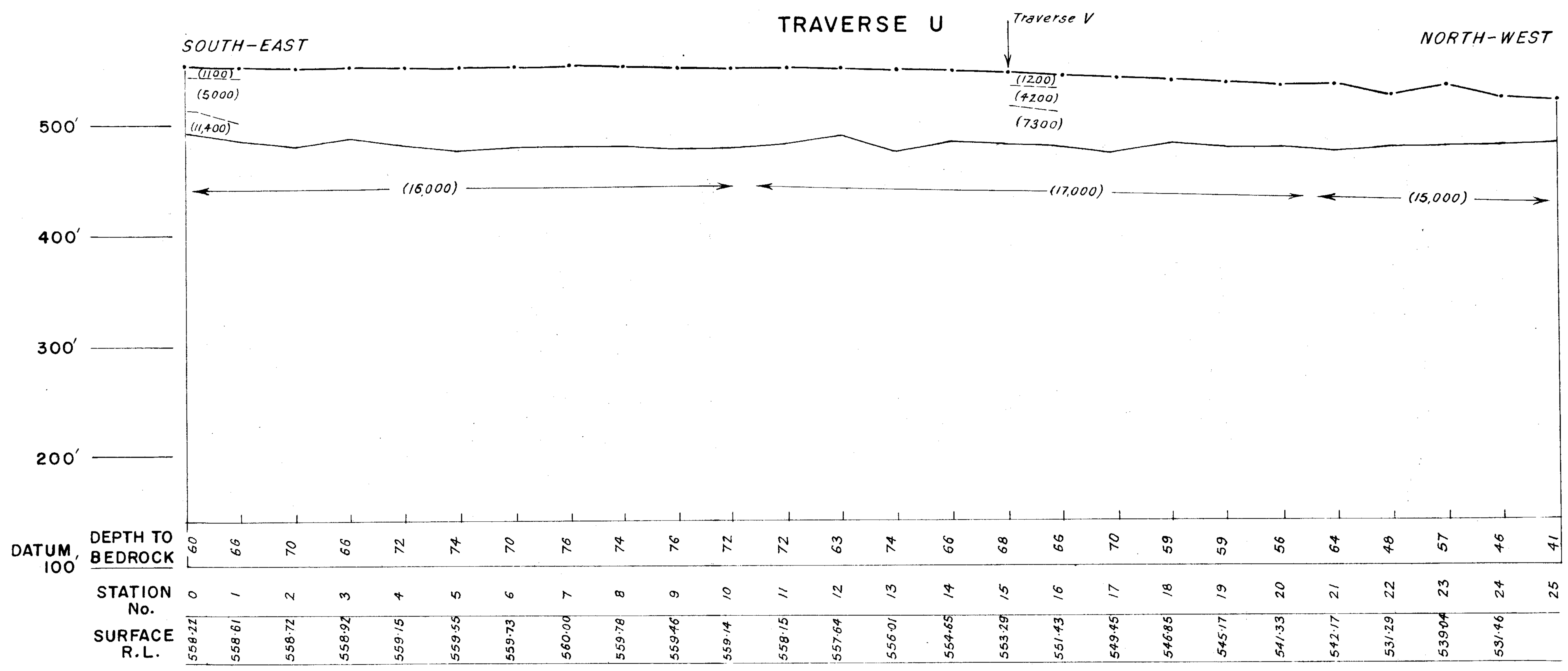


AREA-B

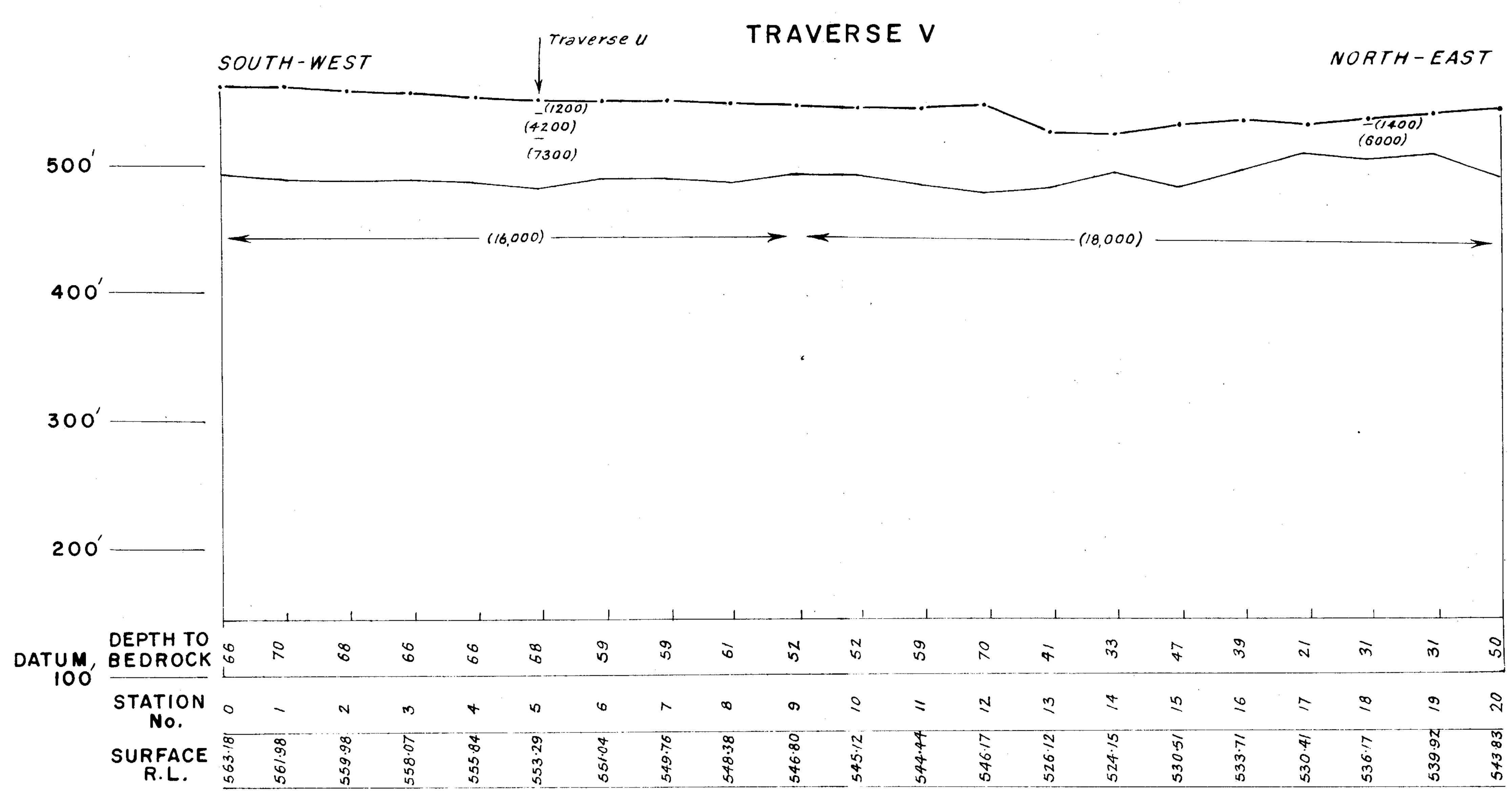
TRAVERSE W



TRAVERSE U



TRAVERSE V



LEGEND

(12,000) SEISMIC VELOCITY IN FT./SEC.

TOPOGRAPHY

UNWEATHERED BEDROCK BOUNDARY

HORIZONTAL SCALE IN FEET

200 0 200 400 600 800

VERTICAL SCALE AS SHOWN

LEVELS DATUM: STATE

GEOPHYSICAL INVESTIGATIONS OF UNDERGROUND WATER AT MOUNT MORGAN, QUEENSLAND, 1959

SECTIONS SHOWING DEPTH TO UNWEATHERED BEDROCK NINE MILE CREEK AREA

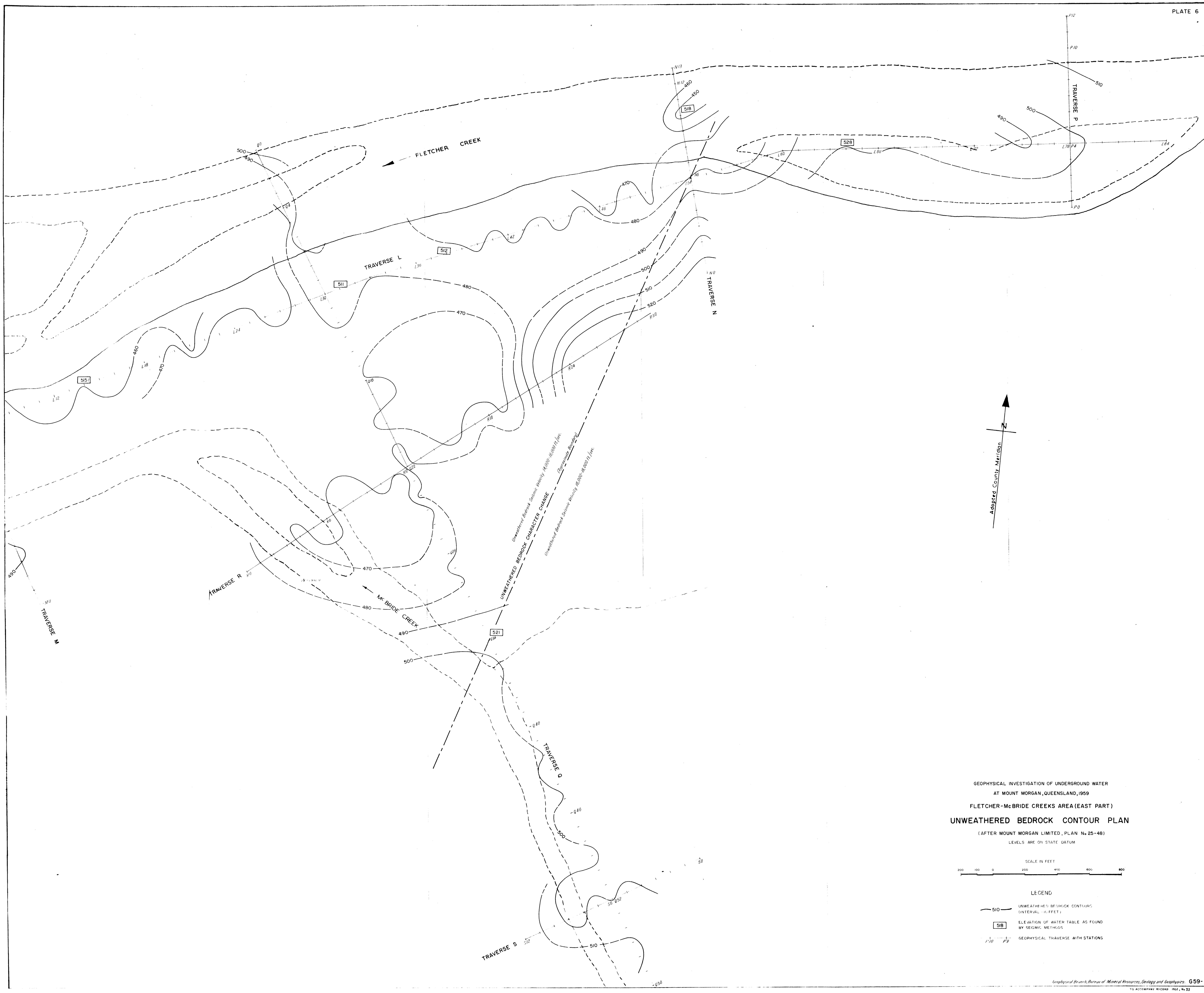
(AFTER MT. MORGAN LTD. PLAN 25-53)

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics G 59-3-1

TO ACCOMPANY RECORD 1961, No.53

TO ACCOMPANY RECORD 1961, No 53

PLATE 6



TO ACCOMPANY RECORD 1961, No 53

GEOPHYSICAL INVESTIGATION OF UNDERGROUND WATER
AT MOUNT MORGAN, QUEENSLAND, 1959

NINE MILE CREEK, AREA "A"

UNWEATHERED BEDROCK CONTOUR PLAN

(AFTER MOUNT MORGAN LIMITED, PLAN No 25-52)
LEVELS ARE ON STATE DATUM

SCALE IN FEET
200 100 0 200 400 600 800

LEGEND

—510— UNWEATHERED BEDROCK CONTOURS (INTERVAL - 10 FEET)

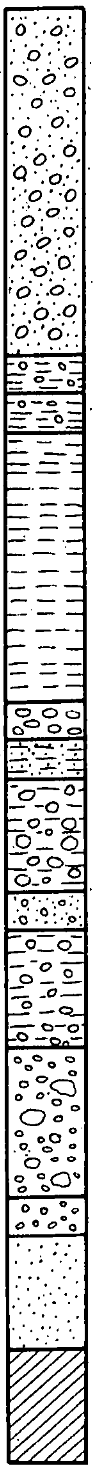
558 ELEVATION OF WATER TABLE AS FOUND BY SEISMIC METHODS.

V10 V9 GEOPHYSICAL TRAVERSE WITH STATIONS

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics. G59-3-3

TO ACCOMPANY RECORD 1961, No 53

PLATE 8



R.L.	DEPTH	LOG
487·14	0	
		SAND GRAVEL AND LITTLE CLAY
469·14	18	YELLOW CLAY WITH SOME GRAVEL
467·14	20	" " " LESS "
465·14	22	
		RED CLAY
451·14	36	COARSE GRAVEL
449·14	38	SAND WITH CLAY
447·14	40	
		FINE TO MEDIUM SIZED GRAVEL AND CLAY
441·14	46	CLEAN SAND AND FINE GRAVEL
439·14	48	
		FINE TO MEDIUM SIZED GRAVEL AND CLAY
433·14	54	
		FINE GRAVEL AND FRAGMENTS FROM LARGE BOULDERS
425·14	62	FINE GRAVEL
421·14	64	
		COARSE SAND AND GRIT
417·14	70	
		BEDROCK - DECOMPOSED
411·14	76	

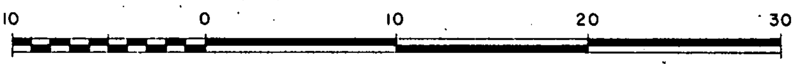
BORE COMMENCED: 30-9-'59 COMPLETED: 13-10-'59
WATER LEVEL AT 14 FT. R.L. 473 ON 2-10-'59
DRILL USED: PERCUSSION

GEOPHYSICAL INVESTIGATION OF UNDERGROUND WATER
AT MOUNT MORGAN, QUEENSLAND, 1959

KONARA BORE LOG No 11

(AFTER MOUNT MORGAN LIMITED,
PLAN No 6-95)

SCALE IN FEET



Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics. G59-5-2