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BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD No. 1964/111

GIRU UNDERGROUND WATER SURVEY, QUEENSLAND 1963

by

J.T.G. ANDREW and M. WAINWRIGHT

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CONTENTS

ILLUSTRATIONS

SUMMARY

Seismic refraction, resistivity, and gravity methods were used in the search for suitable underground water supplies for canegrowing at Giru in North Queensland during 1963. The quality of underground water and the locations of good aquifers were determined.

Of the three main areas of fresh water indicated by the survey, two are controlled by deltaic deposits. Additional fresh water also occurs in the form of a thin veneer on top of more-saline water.

This Record supersedes Geophysical Progress Report No. 1964/8.

1. INTRODUCTION

Sugar cane is grown in the vicinity of the Haughton River, centred on the town of Giru, about 30 miles E.S.E. of Townsville in North Queensland. The main cane-growing area lies between the railway to the north, and Major Creek Mountain to the south. To the west the cane-growing area is limited by a mountain range, and it extends for about a mile east of the Haughton River. The locations are shown in Plate 1. The sugar cane is watered partially by irrigation, and partially by natural rainfall. In view of the projected expansion of sugar production in the area, the Mill Suppliers Committee of Invicta Mill and the Australian Sugar Producers Association asked for a survey of the underground water resources of the area. The Irrigation and Water Supply Commission of Queensland (IWSC) requested the Bureau of Mineral Resources, Geology and Geophysics (BMR) to carry out a geophysical survey in the area in conjunction with the Burdekin Delta groundwater survey.

The work in the area was done in three stages. A preliminary resistivity survey was made in June 1963 by M. Wainwright (party leader). A seismic refraction survey and further resistivity work were done in September and October by J.T.G. Andrew (party leader) and M. Wainwright (geophysicist). A gravity survey was also made in October by L. Kevi (party leader) and J. Pigott (geophysical assistant). W.A. Wiebenga (Senior Geophysicist) visited the area during October. Two field hands were provided by the BMR and four by the IWSC.

2. GEOLOGY

No detailed geological report of the area is available, though some information is given in a survey of the Townsville-Bowen Region (CSIRO, 1953) and a map prepared by the IWSC in 1963. The basement rock in the area consists of granite, granodiorite, diorite, and tuff of Devonian and Permian age, mixed with agglomerate, limestone, and sandstone. The superficial deposits on the flat plain, where most of the sugar is grown, consist of deltaic deposits of the Ayr Group, and Flood Plain deposits of the Northcote system. A geological map of the area is given in Plate 2. In the rest of this report the term bedrock is used to refer to the highest-velocity refractor recorded, or to the high-resistivity material recorded at depth in the resistivity work.

3. METHODS AND EQUIPMENT

Three geophysical methods were used in the area in the course of the survey, viz. seismic refraction, resistivity, and gravity. For the seismic refraction work a 12-channel SIE amplifier unit with a 24-channel oscillograph and a Seismod was used, together with TIC 20-c/s geophones. In the seismic refraction method, the energy of an explosion is recorded at eleven geophones placed on the ground at intervals of 50 ft in a straight line. From the records obtained it is possible to calculate the depth to different layers beneath the surface of the ground, and the seismic velocity in the different layers. The method is described in detail by Parasnis (1962, pp. 122-127).

Three different instruments were used for the resistivity work; a Geophysical Megger using alternating current, and two direct-current instruments designed by the BMR (D.C. meter No. 1, and R.M. 1). No distinction has been made in this Record between the results obtained with the different instruments. The resistivity of water was measured using a mud cell.

The resistivity technique used was that of depth-probing. In this method a system of four electrodes is expanded in a straight line about a constant centre position, and the apparent resistance of the ground is measured at different spacings. Each depth-probe can be interpreted to give the depth to layers of different resistivity, and the resistivity of the different layers. A description of the method is given by Parasnis (1962, pp. 67-77). Both the Wenner and Schlumberger configurations described by Parasnis were used.

The gravity survey was done with Worden gravity meter No. W61; the results of the gravity survey were tied in with those of the gravity survey of the Burdekin Delta, with a common base. A report on the Burdekin Delta survey is in preparation. The elevations were determined with a vehicle-borne elevation meter and tied to benchmark AF No. 38 in Giru.

The results obtained from a gravity-meter survey show variations in density of material below the surface. The method is described by Parasnis (1962, pp. 31-41).

4. RESULTS

Seismic

The locations of the seismic spreads are shown in Plate 3. This plate also gives a contour plan of the bedrock in the area and shows the distribution of velocities in the bedrock. A figure is also given for the depth to weathered bedrock or consolidated sandstone, siltstone, or conglomerate, where they are indicated by the results. Table 1 gives an interpretation of seismic velocities in terms of rock types, based on results in localities with known material in Giru and in the Burdekin Delta.

TABLE 1

Seismic velocity (ft/sec)	Material
1000 to 2000	Soil, dry sand and clay
2000 to 5700	Water saturated sand, clay *etc*.
5700 to 6500	Semi-consolidated sandstone, conglomerate, siltstone, *etc*.
6500 to 10,000	Consolidated sandstone, siltstone, and conglomerate, and weathered bedrock
10,000 to 14,000	Partially-weathered bedrock
14,000 to 20,000	Fresh bedrock

Previous surveys (Wiebenga & Mann, 1962; Wiebenga, Polak, & Andrew, in preparation), have shown that in the range 2000 to 5700 ft/sec, the velocity is related to the clay content, the higher velocities being associated with a low clay content, and the lower velocities with a high clay content. Good aquifers have tended to show velocities in the range 4500 to 5700 ft/sec.

The results of the seismic work are shown in conjunction with the resistivity results in the form of cross-sections in Plate 4 and are discussed later.

Resistivity

The results of the resistivity depth-probes are shown with the seismic results in Plate 4. The cross-sections are discussed in detail later. The resistivity of material between the surface and the bedrock can be used to estimate the salinity of the groundwater. Table 2 compares the resistivity of the materials with the salinity of the pore solution.

TABLE 2

Resistivity of material (ohm-metres)	Total dissolved salts in pore solution (p.p.m.)	Classification
< 6	> 3000	Salt
6 to 20	3000 to 1000	Brackish
> 20	< 1000	Fresh

The figures in this table are based on an assumed porosity of between 30 and 35 percent. A more-detailed description of the calculation of salinity from resistivity is given in Appendix 1.

A number of determinations of the resistivity of water were obtained by measuring the resistance of a sample of water in a mud cell. These are shown in Plate 5. In some cases the values obtained are higher than would be expected from resistivity depth-probe results. This is because of the presence of a thin veneer of fresh water, which does not show up on the resistivity depth-probes, on top of more-saline water.

Resistivity and seismic cross-sections

The cross-sections, with interpretations and locations, are shown in Plates 4 and 5.

Cross-section E1 indicates thin layers of fresh water at G33(GB) and G14. The fresh water is associated with a velocity of 5000 ft/sec at both localities, which could represent a good aquifer.

Cross-section E2 indicates fresh water at GJ, and brackish to fresh water at G21. The velocity of 5000 ft/sec at GJ could represent a good aquifer.

Cross-section N1 indicates fresh water at HX and HW, but only at HX is the velocity of 5200 ft/sec suitable for a good aquifer. There is also a thin layer of fresh water at G3 (HF) where the velocity of 6100 ft/sec is too high for a good aquifer.

Cross-section N2 indicates fresh water at G22 and G23. It is possible that the velocity would be too high for a good aquifer.

Cross-section N3 indicates fresh water at GJ, GF, and GB; the velocity of 5000 ft/sec could represent a good aquifer.

In Plate 5 the areas where fresh water is indicated have been shaded. The biggest fresh-water area starts near the river at G22 and follows the line of an old course of the river, which is shown as a series of interrupted lagoons in Plate 2. It can be seen from the cross-section that the thickness of fresh water decreases towards the north, and is very thin at G33, where it overlies brackish water.

A second area is alongside the present course of the river between G3 and G14; this is not so well developed as the first area.

The third area is at HW and HX. Its exact extent is unknown; it is possible that the fresh water in this locality could come either from the river or from local rainfall.

Both the first and second fresh-water areas are within the Ayr Delta Group of deposits as shown in Plate 2, whereas the third area is in the Flood Plain Group. The fresh water disappears before it reaches the saline lands of the Bowling Green Littoral Group.

There are existing supplies of fresh water being used in the first two areas.

Gravity

The results of the gravity survey are shown in Plate 6 in the form of a Bouguer-anomaly contour map.

The local features shown in this map are overshadowed by a strong upward regional gravity trend in a northerly or north-easterly direction. They may be recognized by bulges in the contour lines, or by widening and narrowing of the space between contour lines. The features may be correlated with undulations in the unweathered bedrock, e.g. features near Stations A, B, and C coincide with locations where the seismic work (see Plate 3) shows the unweathered bedrock to be relatively deep.

Alternatively some of the local features could be explained by density variations within the unweathered bedrock assuming that variations above the unweathered bedrock are small.

5. CONCLUSIONS

Over a large part of the area the groundwater has a high salinity, making it unsuitable for the irrigation of sugar cane. The localities where the best supplies should be available are indicated in Plate 5. Both of the main potential fresh-water areas as indicated by the geophysical survey areas are located in the deltaic deposits of the Ayr Group and are at present partially used for supplies of fresh water.

The obvious reason for the presence of salt water at depth throughout the area is a consequence of the fact that the area was covered by the sea in recent geological time. Above present-day sea level the salt water has been largely replaced by fresh water, but below sea level little of the salt water has been replaced by fresh. Most of the pumps now operating in the area are taking their supplies from the thin veneer of fresh water that is floating on top of the salt water. This means that increasing the size and capacity of existing supplies will tend to cause an increase in salinity of the water pumped. To increase supplies it would be preferable to put in new pumping systems.

In the fresh-water areas indicated, care should be taken in the sinking of pumping bores, as the thickness of fresh water is not large, and a deep hole might draw salt water instead of fresh.

6. REFERENCES

CSIRO	1953	Survey of Townsville-Bowen region 1950. CSIRO Land Research Series No. 2.
PARASNIS, D.S.	1962	APPLIED GEOPHYSICS. Methuen. Monograph, London.
WIEBENGA, W.A. and MANN, P.E.	1962	Bundaberg geophysical survey for underground water, Queensland 1960. Bur. Min. Resour. Aust. Rec. 1962/74 (unpubl.).
WIEBENGA, W.A., POLAK, E.J., and ANDREW, J.T.G.	-	Burdekin Delta geophysical survey, Queensland 1962. Bur. Min. Resour. Aust. Rec. (in preparation).

APPENDIX 1

Derivation of salinity from resistivity results

If the resistivity of an aggregate of water and solid material is ρa, and the resistivity of the water is ρ_w, then:

$$\log (\rho a/\rho_w) = 1.25 \log V \qquad \text{(Wiebenga, 1955)}$$

where V is the porosity

The factor of 1.25 is dependent on the porosity, but for unconsolidated material this value is acceptable.

Plate 7 gives a plot of this relation.

If the total dissolved salt content is S and the water resistivity at 20°C is ρ_1, then a relation exists of the form:

$$\log S = 3.68 - 0.92 \log \rho_1 \qquad \text{(Dyson and Wiebenga, 1957)}$$

This is plotted in Plate 8.

To calculate the resistivity of water samples at 20°C (ρ_{20}) from their resistivity (ρ_t) at a temperature t the following relation is used:

$$\log \rho_{20} = \log \rho_t - 0.9 \ (20-t)/100 \qquad \text{(Dyson and Wiebenga, 1957)}$$

This relation holds in the range 10° to 40°C and is also plotted in Plate 8.

The criteria for water quality established by the Water Resources Council in June 1963 are :

$<$ 1000 p.p.m. dissolved salts	good-quality irrigation water
1000 to 3000 p.p.m. dissolved salts	salt water, tolerant crops only
$>$ 3000 p.p.m. dissolved salts	unsuitable for irrigation

References

DYSON, D.F. and WIEBENGA, W.A. 1957 Final report on geophysical investigations of underground water, Alice Springs, NT 1956. Bur. Min. Resour. Aust. Rec. 1957/89 (unpubl.)

WIEBENGA, W.A. 1955 Geophysical investigations of water deposits, Western Australia. Bur. Min. Resour. Aust. Bull. 30

APPENDIX 2

Data of some gravity stations in the Giru district

Station number	Latitude (south)	Longitude (east)	Elevation above MSL (ft)	Observed gravity (mgal)	Latitude correction (mgal)	Elevation correction (mgal)	Bouguer anomaly (mgal)
0	19°31'25"	147°06'15"	25.3	+9.64	+3.08	+1.72	+14.44
21	19°33'45"	147°06'50"	33.3	+9.10	+0.90	+2.27	+12.27
41	19°31'45"	147°05'00"	22.0	+8.24	+2.73	+1.50	+12.47
61	19°30'55"	147°08'00"	24.8	+11.08	+3.49	+1.74	+16.31
76	19°34'40"	147°06'40"	47.3	+8.85	+0.02	+3.22	+12.09
156	19°33'00"	147°03'25"	32.5	+4.16	+1.55	+2.22	+7.93

Elevation correction constant = 0.069816 mgal/ft

Observed gravity values relative to Ayr base station

Absolute value of observed gravity at Ayr base station : 978,644.4 mgal

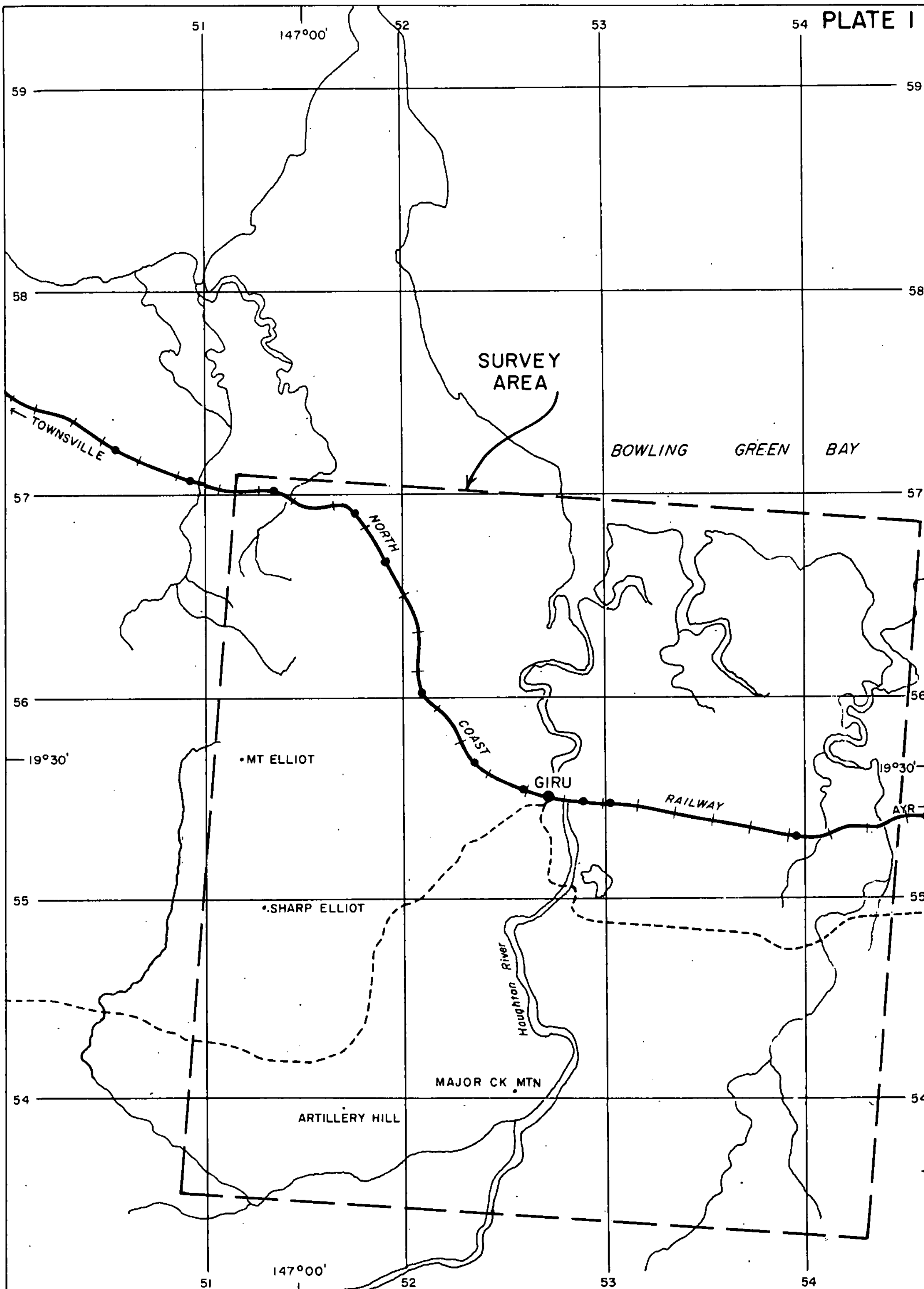
Latitude corrections relative to Ayr base station (latitude : 19°34'40"S)

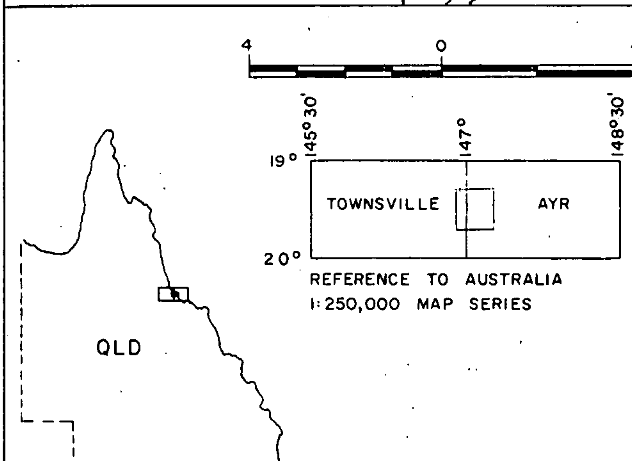
Location descriptions

Station No.	Description
0	On Ayr - Giru highway, 2000 ft south from Invicta sugarmill, at telephone pole L2.
21	Junction of Ayr - Giru highway and Upper Houghton road, at signpost Ayr 21 miles.
41	Junction of Giru - Townsville highway and Giru - Woodstock road, at signpost 'Townsville 31 miles'.
61	Hodel railway station, north-east corner of station building.
76	On Upper Houghton road, two miles south of junction with Ayr - Giru highway, at sign 'Ace and Sons.'
156	On Giru - Woodstock road, 2.2 miles south-west of junction to Giru - Townsville highway, marked by metal plate AF37 on metal peg between two high metal stakes.

Note: Locations of stations along highways refer to position of highways in 1963.

PLATE I





GIRU QLD

UNDERGROUND WATER SURVEY

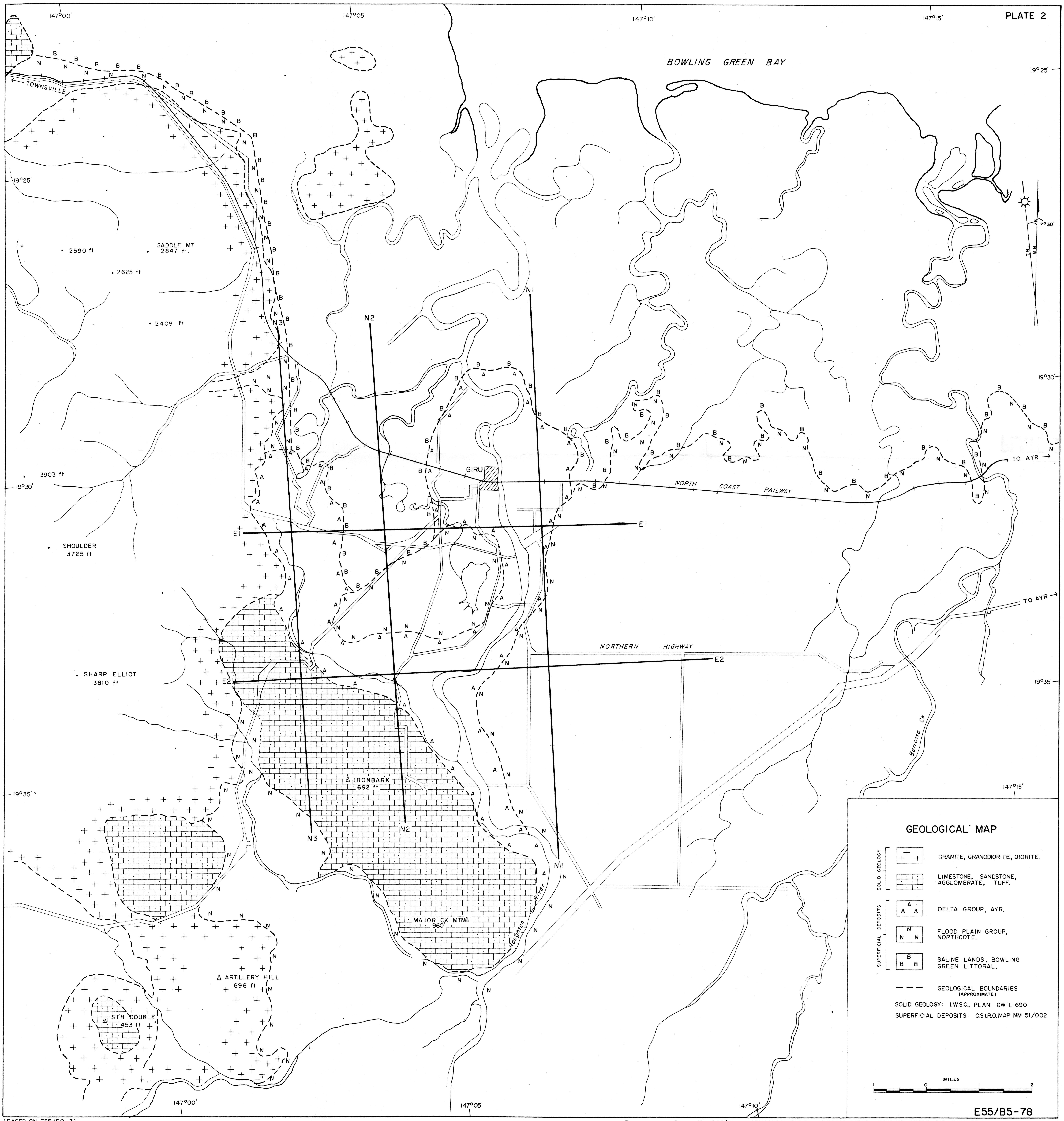
1963

LOCALITY MAP

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS **E55/B5-77**

To accompany Record No. 1964/111

PLATE 2



GIRU UNDERGROUND WATER SURVEY, 1963

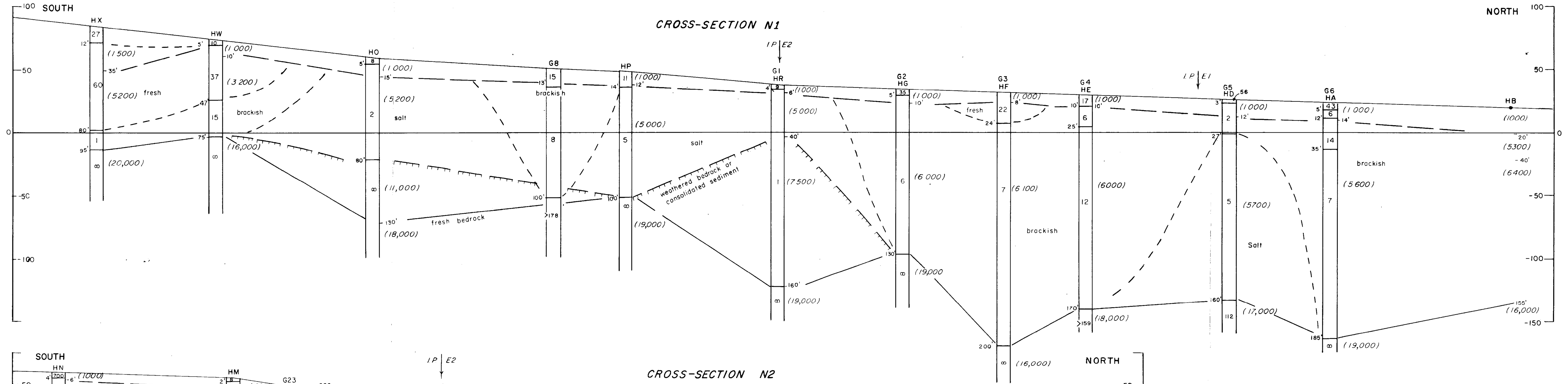
(BASED ON E55/B0-3)

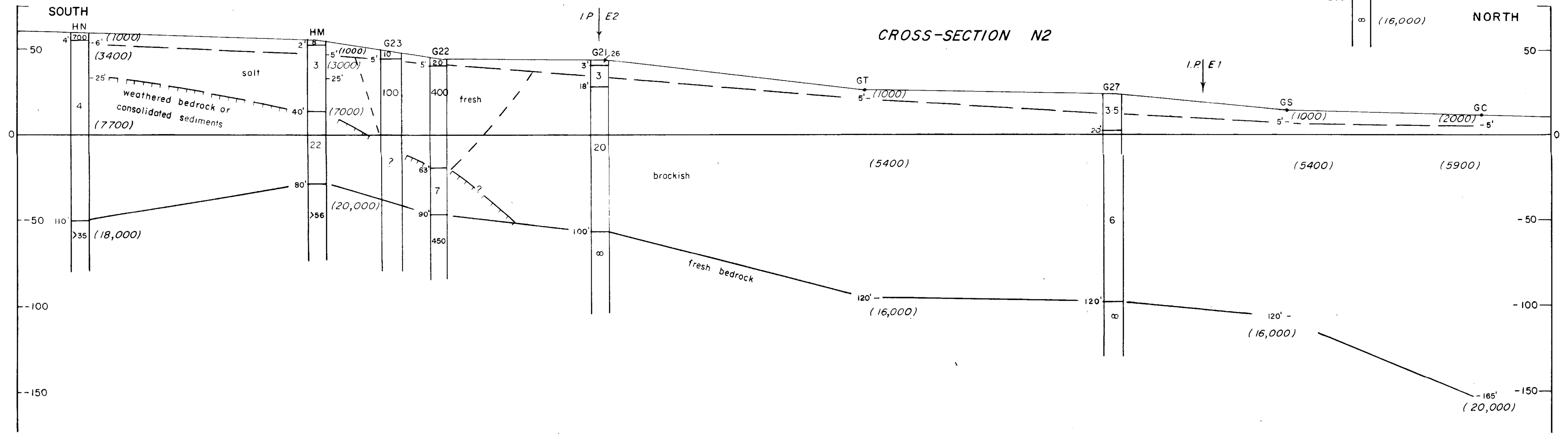
To accompany Record No. 1964/111

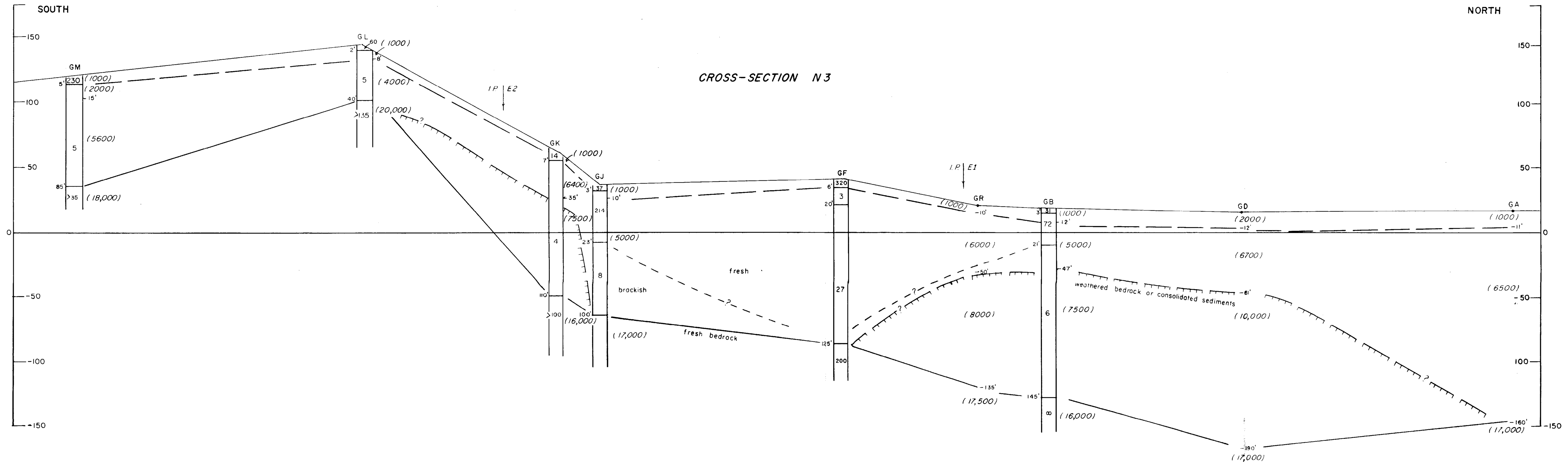
GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

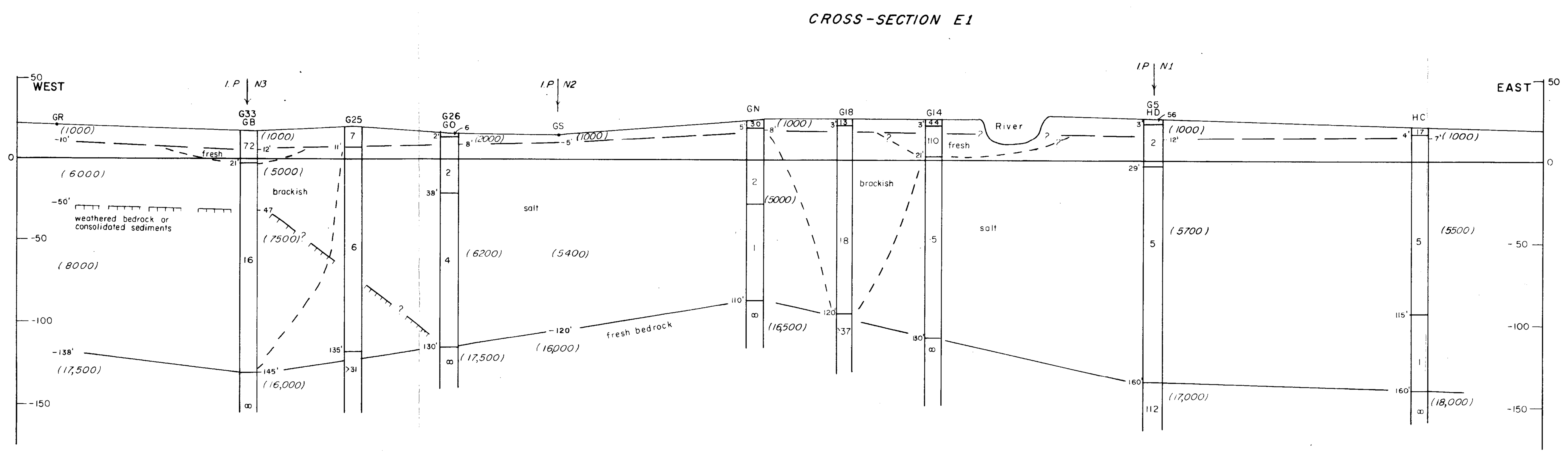
GIRU, QLD, 1963 UNDERGROUND WATER

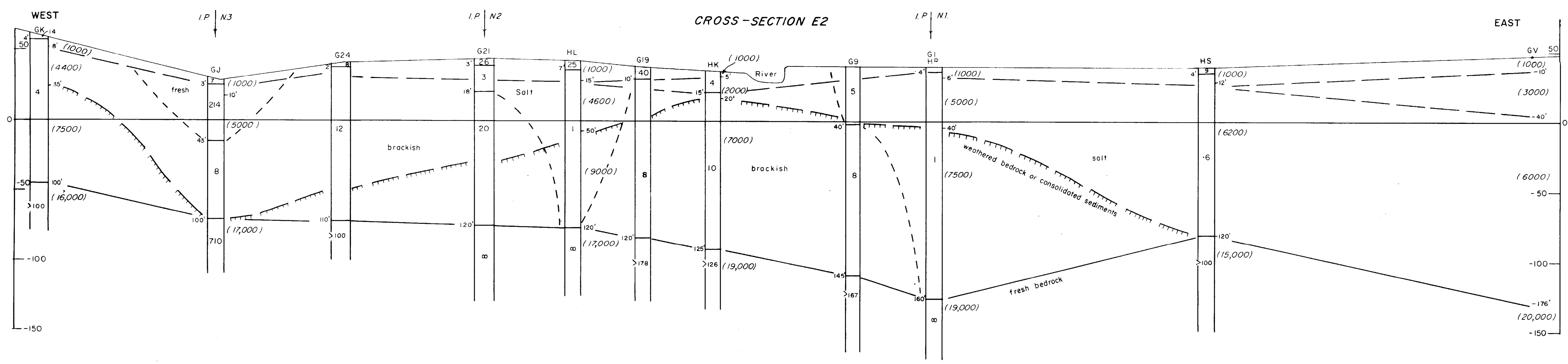
To accompany Record No. 1964/111 GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS









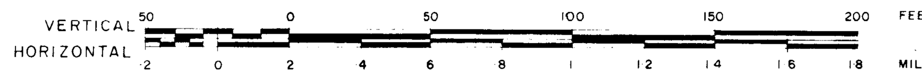


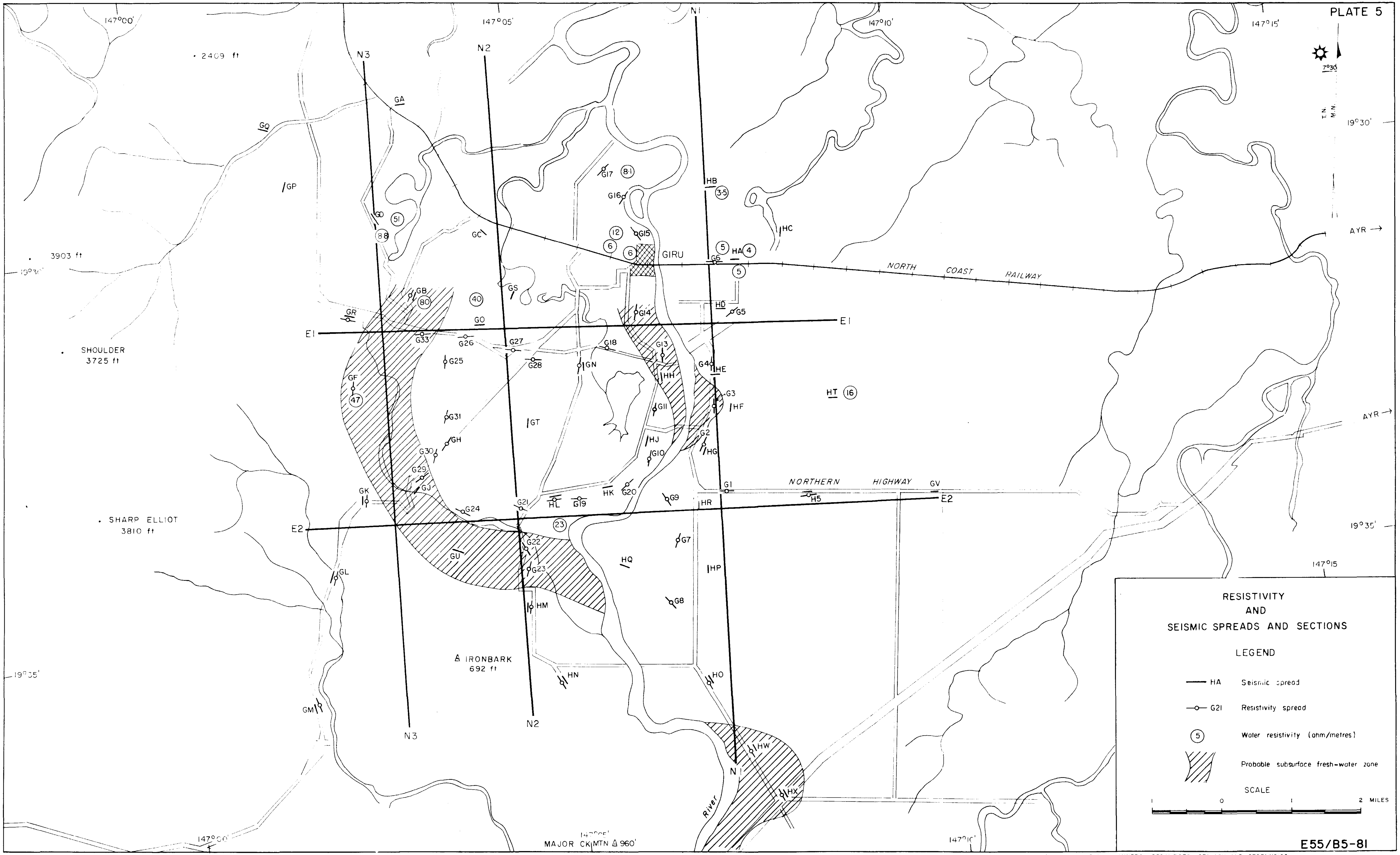
LEGEND

6	Resistivity (ohm/metres)
HX,GB	Seismic station or seismic station and resistivity depth probe
G3	Depth-probe only
(17,000)	Seismic velocity (ft/sec)
fresh brackish salt	Salinity of water in sediments
— — — —	Salinity boundaries from resistivity
	Boundaries from seismic velocities
I.P.	Intersection Point

GIRU QLD

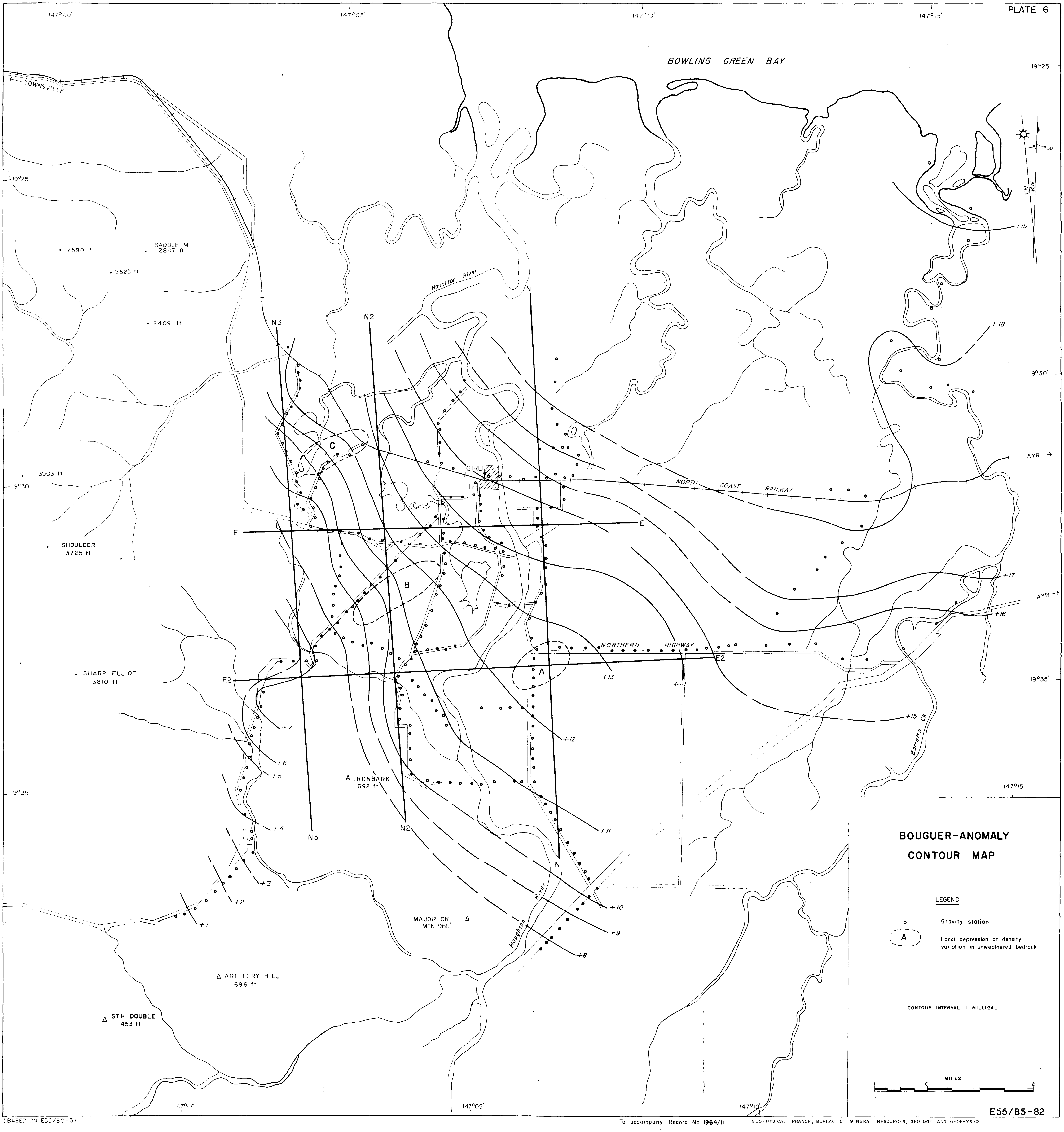
CROSS-SECTIONS SHOWING SEISMIC AND RESISTIVITY RESULTS





GIRU QLD 1963 UNDERGROUND WATER.

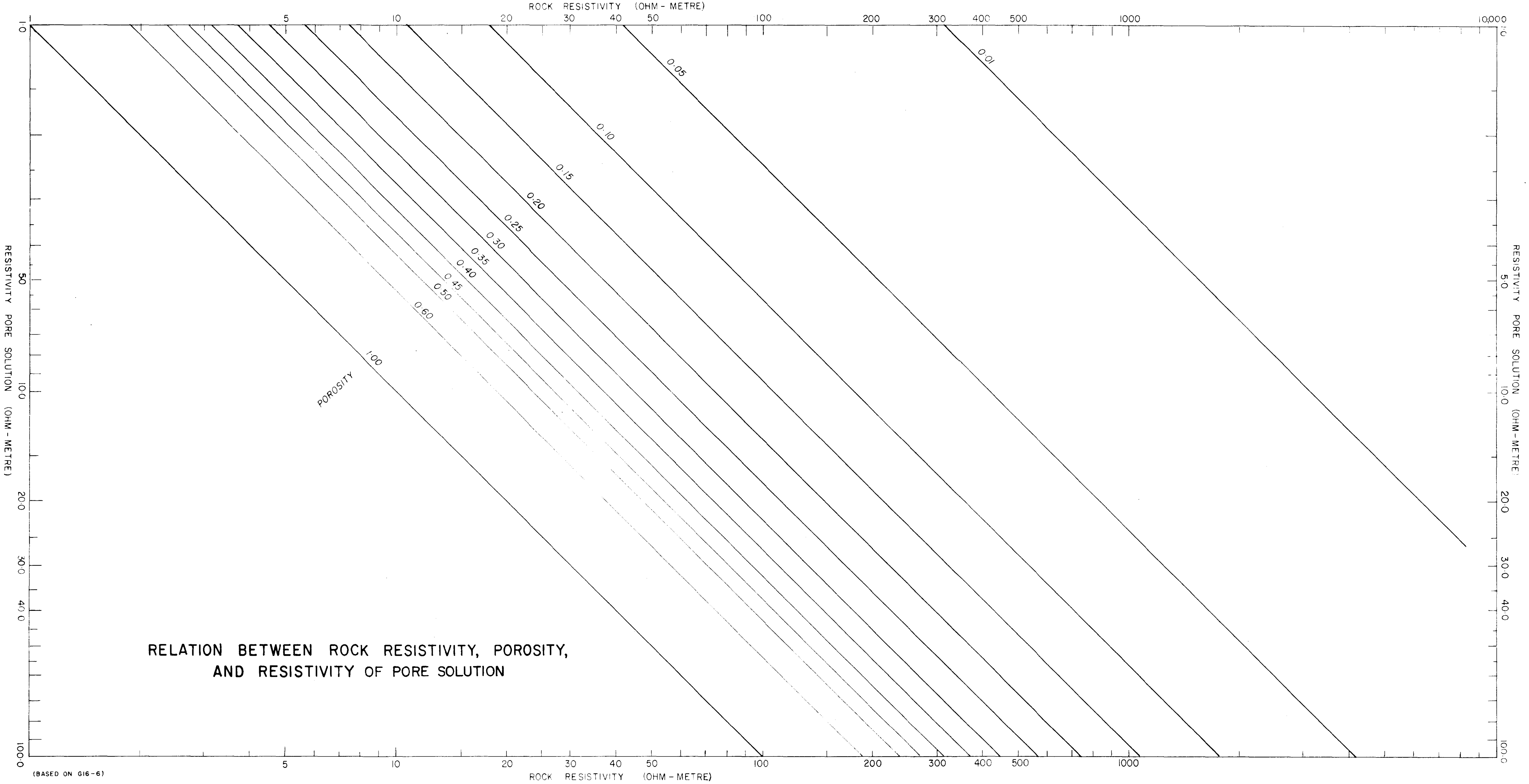
To accompany Record No. 1964/111 GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS



(BASED ON E55/B0-3)

To accompany Record No. 1964/111

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS



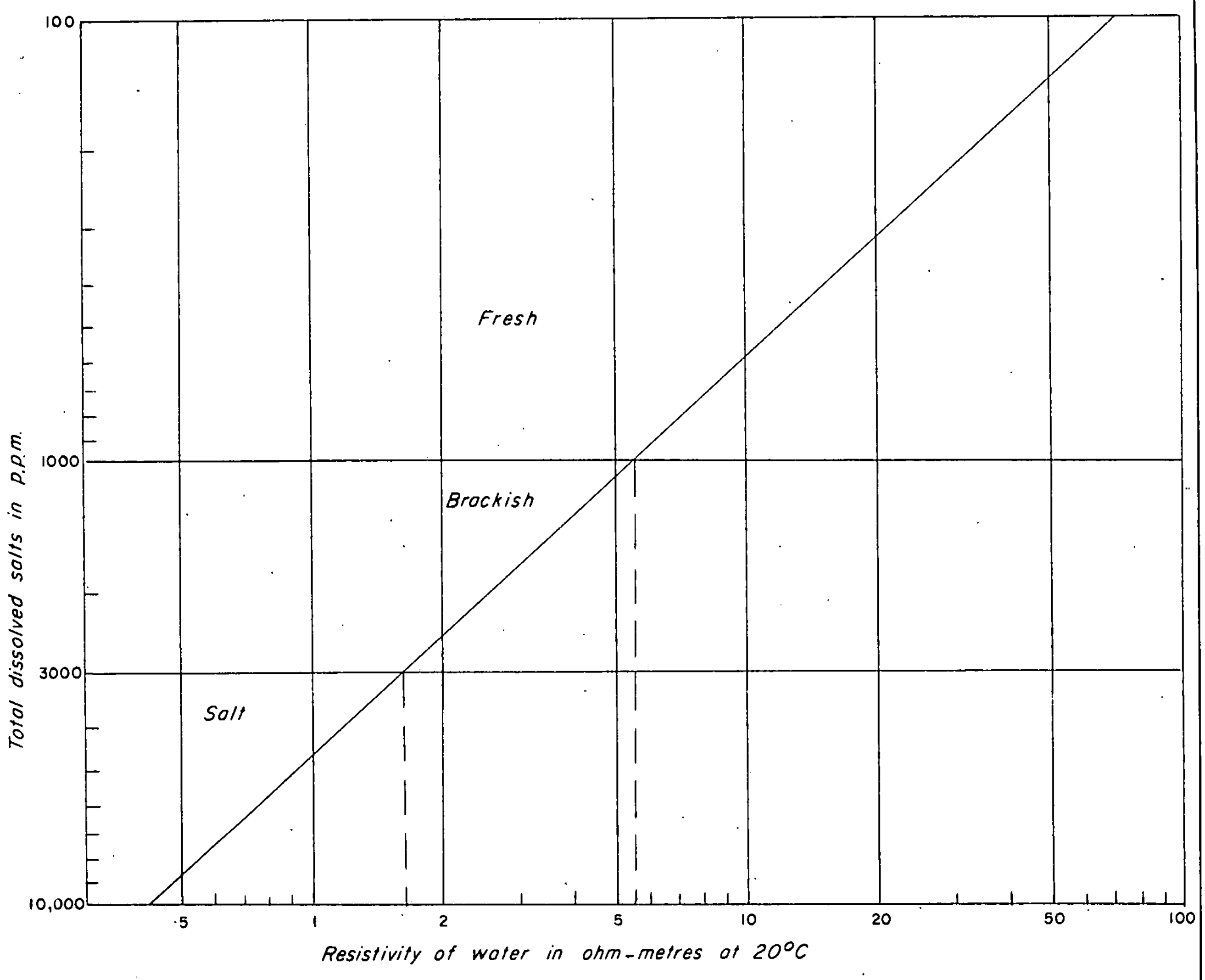
RELATION BETWEEN ROCK RESISTIVITY, POROSITY, AND RESISTIVITY OF PORE SOLUTION

GIRU, QLD, 1963 UNDERGROUND WATER

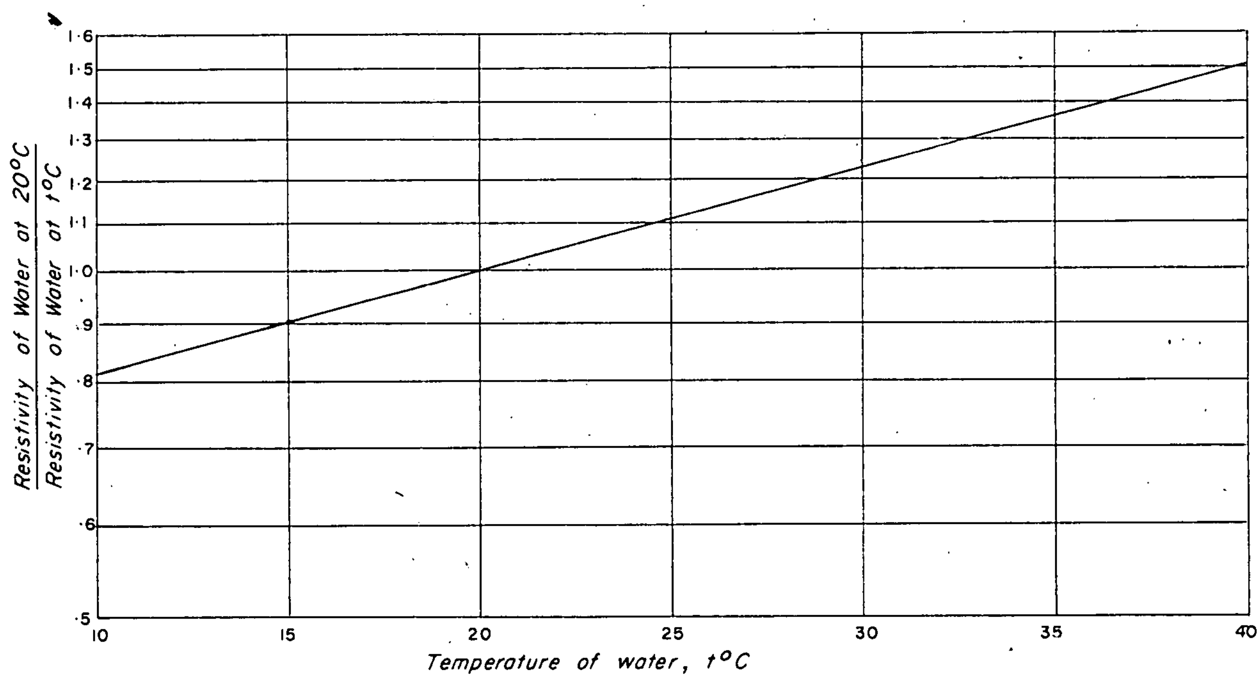
To Accompany Record No 1964/111

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics. E55/B5-83

PLATE 8



1. WATER RESISTIVITY TO SALINITY CONVERSION DIAGRAM



2. TEMPERATURE CORRECTION DIAGRAM FOR RESISTIVITY