DEPARTMENT OF MINES
SOUTH AUSTRALIA

GEOLOGICAL SURVEY
GEOPHYSICS DIVISION

SHALLOW SEISMIC REFRACTION SURVEY OVER PROPOSED STREAM GAUGING SITES NEAR HAWKER S.A.

1) Mernmerna Creek
2) Boolcunda Creek

by

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Rept.Bk.No. 77/126
G.S. No. 5945
DM. No. 553/77

28th October, 1977

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PLANS

DEPARTMENT OF MINES
SOUTH AUSTRALIA

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ABSTRACT

Shallow seismic refraction traverses were carried out over six proposed sites for stream gauging near Hawker in South Australia. The results have determined bedrock topography and the depth to the water table at each site. The sub-surface was clearly defined at each site by three velocity zones: 380 m/s for dry creek gravel; 1400 m/s for saturated gravel; and basement velocities greater than 2 400 m/s.

INTRODUCTION

The Engineering and Water Supply Department Water Resources Branch is involved in measuring the quantity of flow in several creeks in the Flinders Ranges of South Australia. (See Plan No. S 13103.) For this purpose stream gauging stations have been established which record the level of water in each creek. Since some water flows below the creek gravel it was important to know the shape of the impervious creek bed. In some cases it may be desirable to construct a weir in order to measure low flow rates and suitable weir sites require shallow bedrock topography. For these reasons shallow seismic refraction profiles were requested over six sites in two creeks near Hawker S.A. (see Plan No. S 13104). The purpose of the seismic work was to define the shape and depth of the bedrock-alluvium contact at each site. The fieldwork was carried out over three days from the 30th August, 1977.

METHOD

In seismic refraction investigations a pulse of energy is transmitted into the ground and the arrival of this energy at a series of geophones is recorded. For this survey arrays of 12 geophones with 5 m spacing between each were used. Small charges of AN60 blasting gelignite were used as the energy source and for each spread shots were fired in the middle, at each end and from 20 m to 40 m off each end. Three spreads were used on line 1 at Mernmerna Creek and one spread at each of the other sites. Each geophone location and shot point was levelled in order to determine a topographic profile at each site.

A 12 channel S.I.E. P.19 seismograph coupled to an S.I.E. recording oscillograph was used to record the shot time and the arrival of energy at each geophone. Additional near surface information was obtained at several places using a smaller geophone spacing of 1.5 m in "weathering" spreads. For each shot a chart record was produced which recorded the response of each geophone with time.

INTERPRETATION

For each record, travel times to each geophone were determined and these were plotted against distances to produce time distance graphs (see Plan No. S11496). The times corresponding to arrivals from the bedrock were irregular indicating significant topography on the fresh bedrock. The method of reciprocal analysis (Hawkins, 1961) was used to obtain time depths to bedrock at each geophone location. (Time depth and other terms are illustrated in plan no. S11495.) The velocities in the overlying material were calculated from the weathering spreads using conventional refraction analysis at shot points (see Plan No. S11496).

Using this velocity information and assuming that the water table was horizontal, the time depths were converted to depths to bedrock. These interpreted depths were then used to prepare cross sections for each site. The reciprocal method also allowed corrected basement velocities to be calculated by removing the effects of basement topography.

RESULTS

Seismic refraction profiles were measured at three sites on Mernmerna Creek (MC) and at 3 sites on Boolcunda Creek (BC). The results at all sites were remarkably consistent with three velocity zones being recorded on all lines. The table below summarizes the velocity information.

TABLE 1

	Velocity	Material
V1	360 - 420 m/s	Poorly sorted dry creek gravel.
V2	1 300 - 1 500 m/s (used 1 400 m/s)	Saturated creek gravel.
V3	2 500 - 5 400 m/s	Bedrock (usually unweathered).

Cross sections showing the distribution of the different velocity layers above bedrock are presented in Plans No. 77-947 and 77-948. The locations of the seismic spreads are shown on Plan No. S13104. To enable precise relocation of each spread, photographs of each site were taken and are available if required.

Surface gravel (velocity V1) was present in the creeks over all lines except at some locations where there were small pools of surface water. In these cases depths to the horizontal water table was established from the known levels. These depths coincided with those revealed in backhoe pits and also with the depth to the 1 400 m/s horizon established by weathering spreads. Where there was no surface water the depth to the water table was obtained from weathering spreads.

The variations in bedrock velocity (V3) may be due to different geological units and to differing depth of weathering. Most velocities over 3 000 m/s indicate fairly fresh bedrock, and all the measured bedrock velocities indicate that they would be impermeable to water. The PARACHILNA geological sheet (Dalgarno and Johnson, 1966) shows that the Mernmerna Creek sites are underlain by the Bunyeroo Formation dolomitic shales. The ORROROO geological sheet (Binks, 1968) shows that the Boolcunda Creek sites are underlain by the Uroonda Siltstone member of the Umberatana Group.

Specific details at each site are discussed in turn.

Mernmerna Creek

MC Line 1

A long line using three spreads was necessary to provide information from beneath a broad flood plain as well as under the present creek location. The line was located about 6 m downstream from the weir and gauging station. Elevations were tied to an E. & W.S. benchmark at the site. Reciprocal coverage at geophones 1 and 2 was hindered due to a steep cliff north of geophone 1. (Plan No. 77-947).

The north end of this line was atypical due to the presence of outcropping cemented gravel which had an apparent velocity of 1 520 m/s under geophones 1 and 2. This velocity is similar to that in the water saturated gravel but it was considered that if the cemented gravel extended to bedrock it would exclude water flow as it appeared impermeable. Under the creek section (geophones 1 to 12) the corrected bedrock velocity was 3 800 m/s and its interpreted depth varied from less than 1 m to 3 m. The water table was at the surface between geophones 3 and 4.

Under the flood plain a two layer situation was evident with alluvium (velocity 360 m/s) overlying bedrock (velocity 3 300 m/s) at a depth ranging from 2 m to 4 m. A weathering spread centred 27.5 m south of geophone 34 indicated a bottom layer with velocity 1 700 m/s which may be highly weathered bedrock.

MC Line 2 (Site A)

This site was about 2 km downstream from line 1 at a point where the creek narrowed slightly after Slaty Ck. joined Mernmerna Ck. The north bank was massive outcropping bedrock and to the south there was a bank of alluvium and possible residual weathered bedrock (Plan No. 77-947). The depth to the water table was about 1.5 m and the interpreted basement profile shows two troughs, the deeper being 5 m deep. A change in the bedrock velocity from 4 500 m/s to 3 500 m/s between geophones 5 and 6 may be due to a change in basement formation and/or to increased depth of weathering.

MC Line 3 (Site B)

This line is a further 500 m downstream and bedrock outcrops 5 m from each end of the spread. Several backhoe pits were sunk here and the approximate location and results of these are plotted on the section (Plan No. 77-947). The results agree well with the seismic interpretation and there is less than .5 m difference in depths to bedrock. The bedrock is deepest (5 m) at the northern end near geophone 1.

Boolcunda Creek

BC Line 1

This site was about 150 m downstream from the Boolcunda Ck. gauging station and 2 m down from the site of a washed out water control weir. A pool of water at the surface between geophones 3 and 4 enabled the water table to be established. Three backhoe pits were sunk 2 m upstream from this line and the results and approximate locations are shown on the cross section for this line (Plan No. 77-948). To the south of this line a steep cliff of massive bedrock prevented the usual off-end shot.

The interpreted water table depths tied in with the level observed in the pits, but the interpreted basement depths differed by up to a metre at holes A and B. The reason for this was probably due to the displacement between the holes and the line. The depth to the bedrock along this line varied from 1 m to 2 m and a change in basement velocity was observed near geophone 5.

BC Line 2

This line was situated about 5 m upstream from the Boolcunda Ck. gauging station recorder well and extended from the north side of a large water pool and up the northern bank. The bedrock appeared to be outcropping under the pool and a large outcrop occurred at the edge near geophone 12 (Plan No. 77-948). The interpreted thickness of alluvium was quite constant along the spread only varying between 1.5 m and 2 m. A change in basement velocity from 3 510 m/s to 2 600 m/s occurred at geophone 7, the lower velocity indicating either deeper weathering or perhaps a different basement formation.

BC Line 3

This line was about 400 m downstream from the gauging station. Bedrock outcrops in cliffs to the north and in a shallow gully to the south. The maximum interpreted depth to bedrock is 6 m in a large channel near the north bank. Depth to the water table is 1.5 m at geophone 3 (Plan No. 77-948).

CONCLUSIONS

The seismic refraction method in these cases proved to be successful in defining the shape of the bedrock-alluvium interface and was useful in determining the depth to the water table. The three clearly defined velocity zones provided good contrast and the method was able to distinguish between dry gravel (380 m/s), saturated gravel (1 400 m/s) and bedrock (greater than 2 500 m/s). The cross sections (in Plans No. 77-947 & 77-948) summarise the results. This method could be usefully applied again in cases where the configuration of the bedrock across streams is required. However lines across large surface pools would be impractical unless under-water geophones and cables were used.

DC Roberts

DCR:DJJ
28th October, 1977

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GEOPHYSICAL SERVICES SECTION

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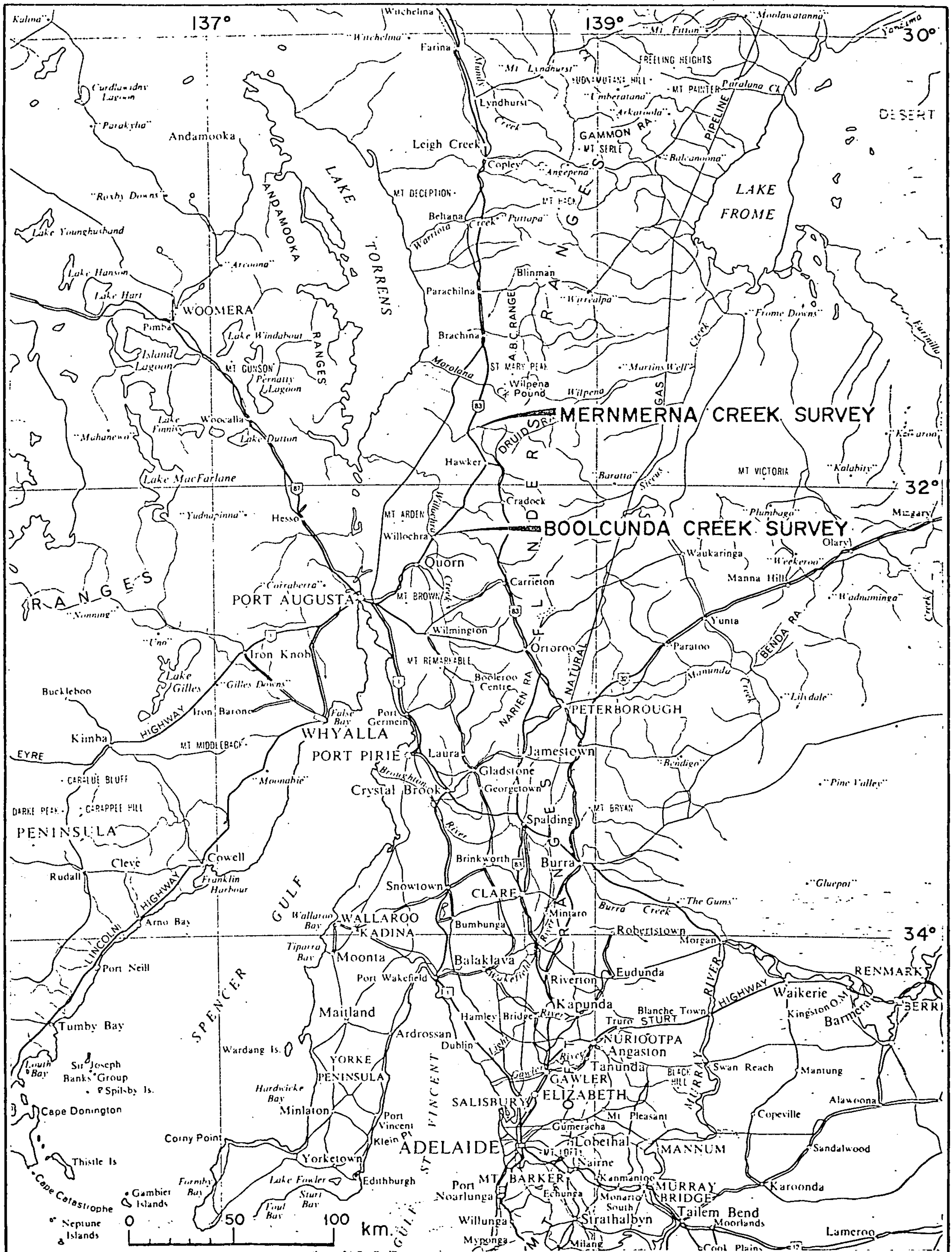
BINKS, P.J., 1968: ORROROO map sheet, Geological Atlas of South Australia, 1:250 000 series. Geol. Surv. S. Aust.

DALGARNO, C.R., and JOHNSON, J.E., 1966: PARACHILNA map sheet, Geological Atlas of South Australia, 1:250 000 series. Geol. Surv. S. Aust.

HAWKINS, L.V., 1961: The reciprocal method of routine shallow seismic refraction investigations. Geophysics, 16 (6) : 806-819.



GEOPHYSICAL SERVICES SECTION	DEPARTMENT OF MINES—SOUTH AUSTRALIA	Scale: 1:2 500 000
Compiled: D.C.Roberts	MERNMERNA AND BOOLCUNDA CREEKS SEISMIC SURVEY LOCALITY MAP	Date: 21-10-77
Drn. N.S. / Ckd. A.F.		Drg. No. S 13103

500—6.76 G6584 O

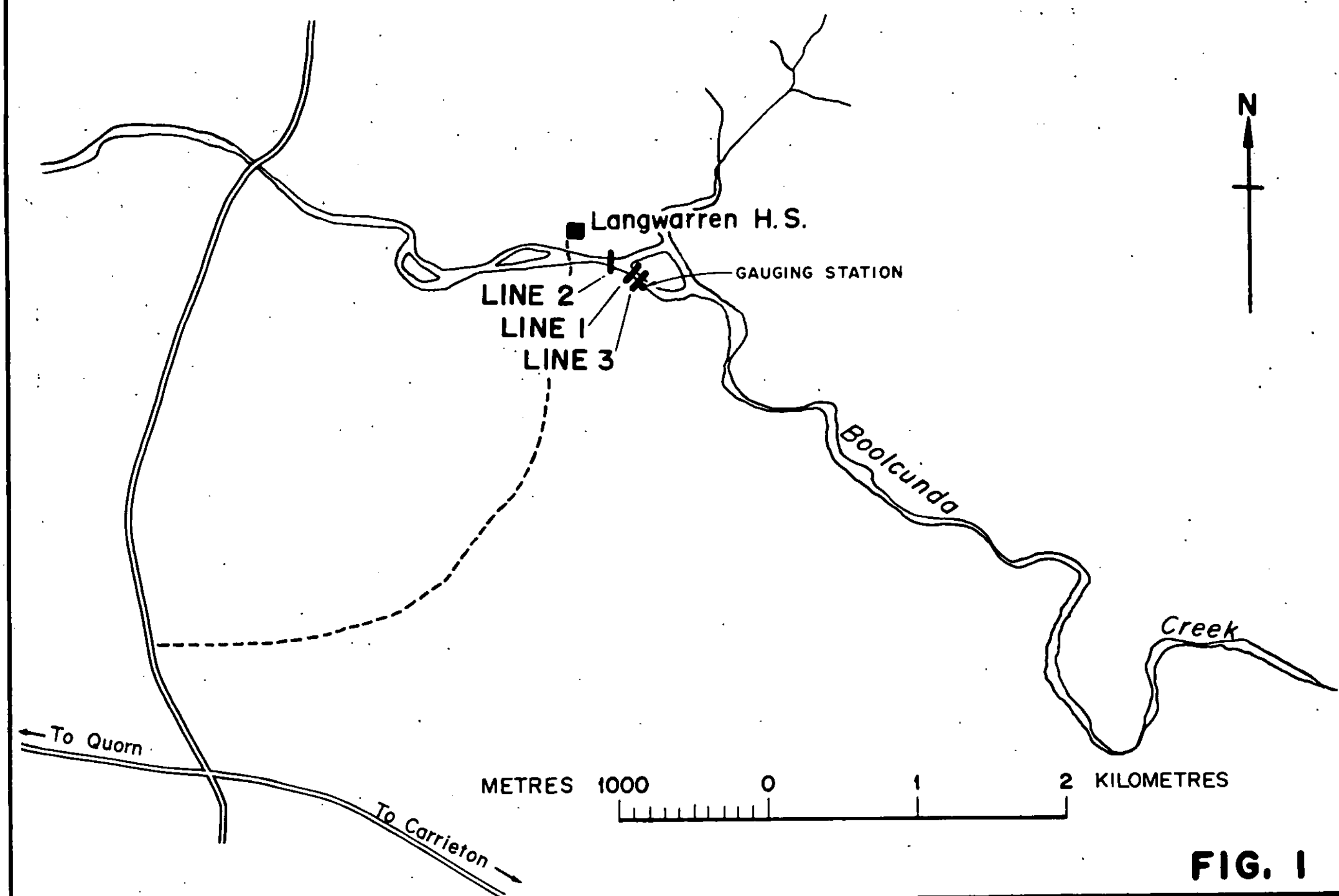


FIG. 1

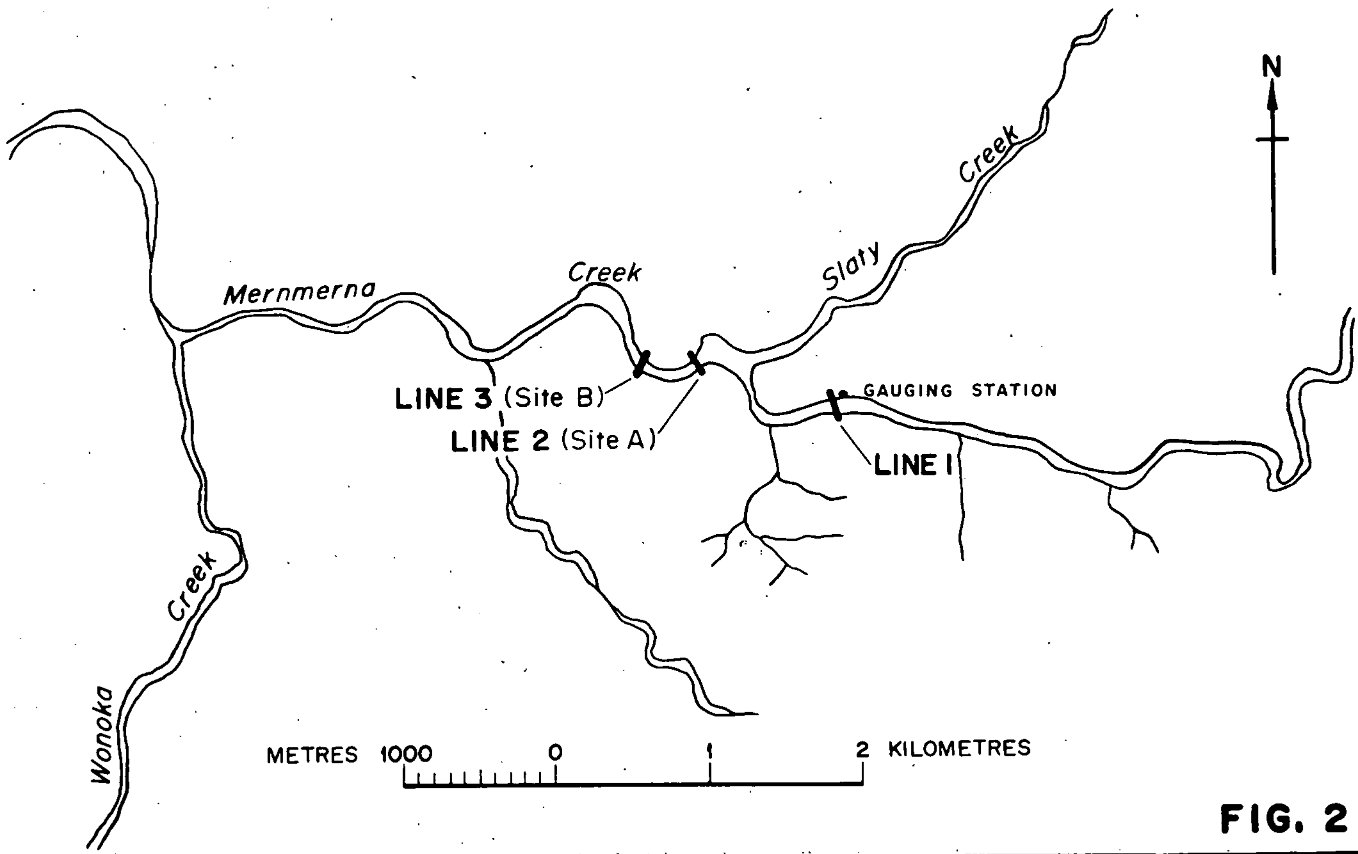
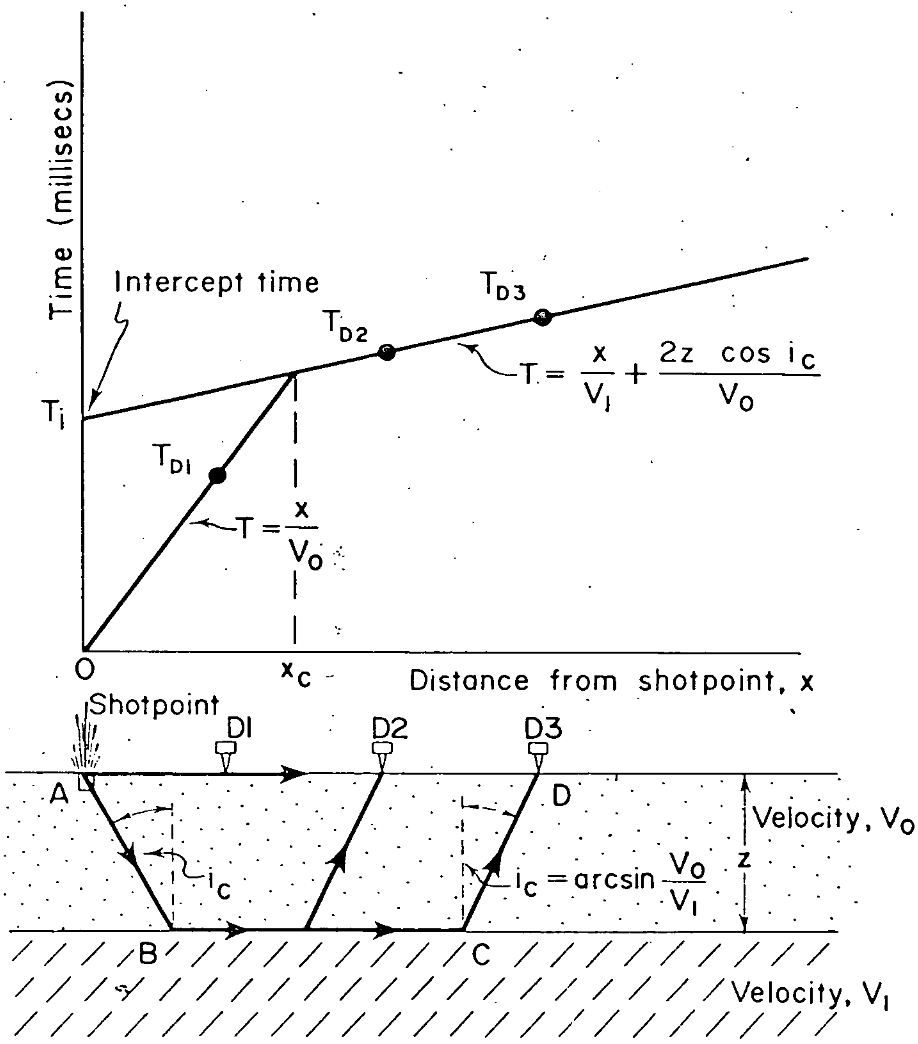


FIG. 2

GEOPHYSICAL SERVICES SECTION	DEPARTMENT OF MINES – SOUTH AUSTRALIA	SCALE. 1:50 000
COMPILED : D.C. Roberts	MERNMERNA AND BOOLCUNDA CREEKS SEISMIC SURVEY	DATE: 21-10-77
DRN : N.S. / CKD. A.F.	LINE LOCATIONS	PLAN NUMBER: S 13104



Travel times

(a) Direct wave : $T = \dfrac{x}{V_0}$

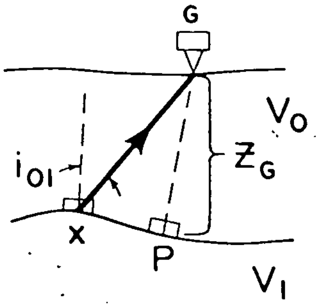
(b) Refracted wave : $T = T_{AB} + T_{BC} + T_{CD}$

$$T_{AB} = T_{CD} = \frac{z}{V_0 \cos i_c}$$

$$T_{BC} = \frac{x - 2z \tan i_c}{V_1}$$

DEPARTMENT OF MINES — SOUTH AUSTRALIA

GEOPHYSICAL SERVICES SECTION	Drn. R.N	SEISMIC REFRACTION TWO LAYER CASE	SCALE:
	Tcd. A.F.		S11496
	Ckd.		
	Exd.		DATE: April 1975

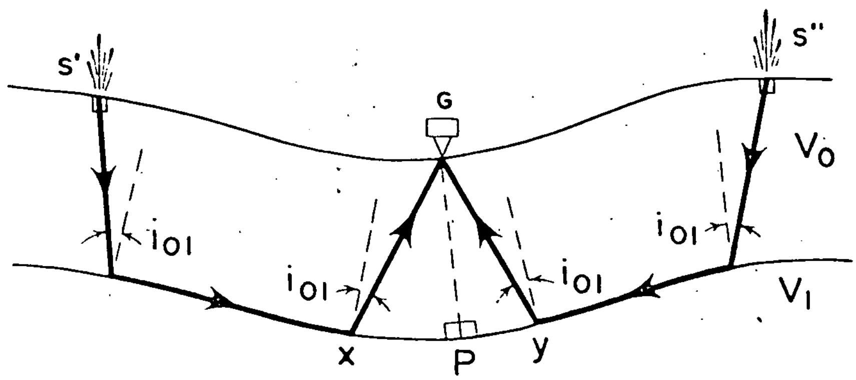


TIME DEPTH

T_G = time delay in travelling between refractor and surface

$$= \frac{Gx}{V_0} - \frac{Px}{V_1}$$

$$= \frac{Z_G \cos i_{01}}{V_0}$$



$$T_G = \tfrac{1}{2}(T_{s'G} + T_{s''G} - T_{s's''})$$

(1) Determine reciprocal time $T_{s's''}$

(2) Add recorded travel times from shooting each way

(3) Subtract $T_{s's''}$ and divide by 2

(4) Calculate depth Z_G

DEPARTMENT OF MINES — SOUTH AUSTRALIA			
GEOPHYSICAL SERVICES SECTION	**Drn.** RN	SEISMIC REFRACTION	**SCALE:**
	Tcd. AF	METHOD OF RECIPROCAL ANALYSIS	S11495
	Ckd.		
	Exd.		**DATE:** April 1975

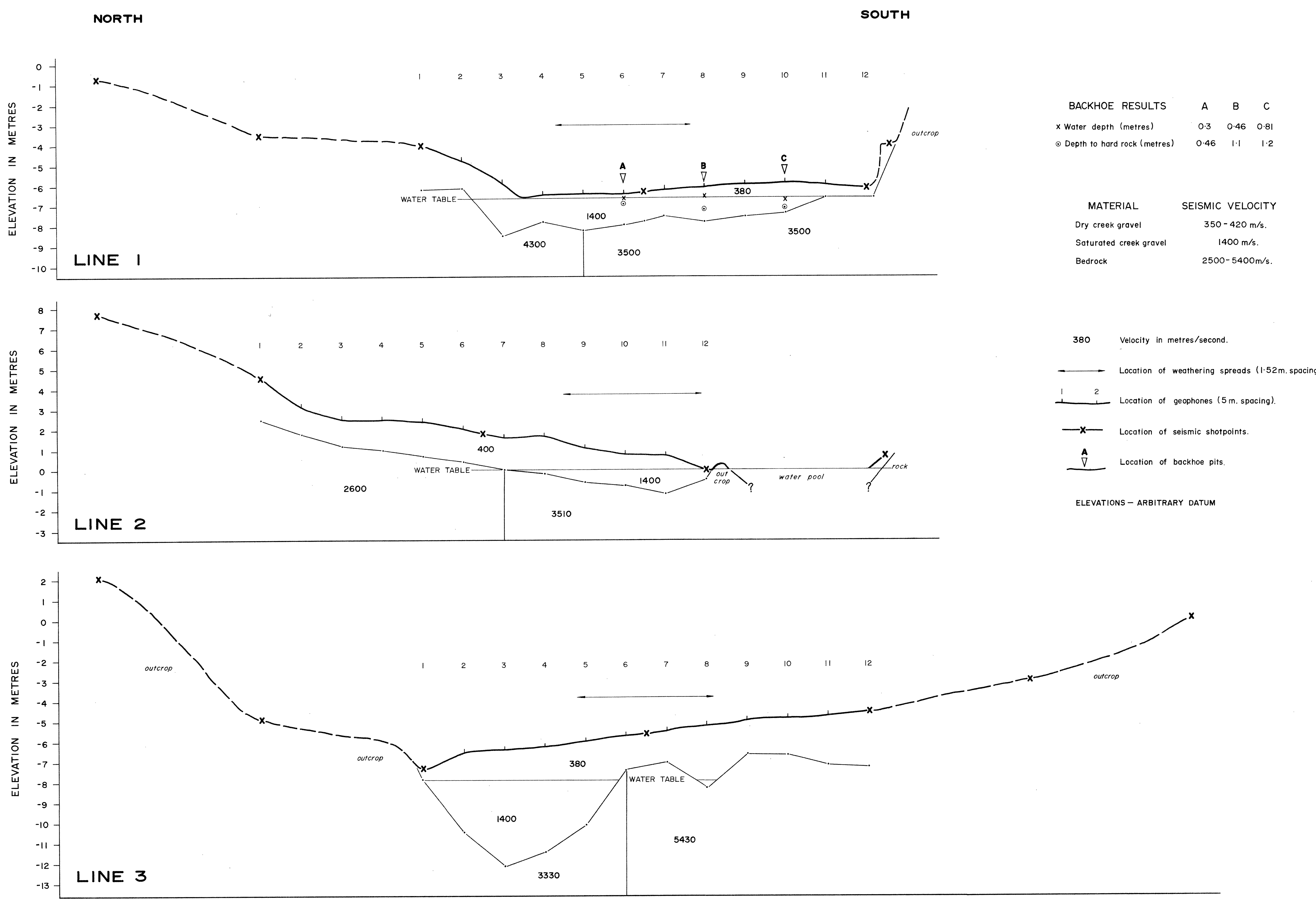
500—2.59 665

DEPARTMENT OF MINES—SOUTH AUSTRALIA

MERNMERNA CREEK SEISMIC SURVEY
INTERPRETED CROSS SECTIONS

LINE 1, LINE 2 (Site A), LINE 3 (Site B).

GEOPHYSICAL SERVICES SECTION	COMPILED: D.C.R.	DRN: N.S.	SCALE: 1:250	PLAN NUMBER
DIRECTOR OF MINES		CKD: A.F.	DATE: 26-10-77	77-947



METRES

10 0 10 20

$\frac{V}{H} = 0{\cdot}4$

DEPARTMENT OF MINES—SOUTH AUSTRALIA				
BOOLCUNDA CREEK SEISMIC SURVEY INTERPRETED CROSS SECTIONS LINE 1, LINE 2, LINE 3.				
GEOPHYSICAL SERVICES SECTION	COMPILED: D.C.R.	DRN: N.S.	SCALE: 1:250	PLAN NUMBER
DIRECTOR OF MINES		CKD: A.F.	DATE: 26-10-77	77-948