DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

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INVESTIGATION OF A POSSIBLE SITE FOR UNDERGROUND GAS STORAGE IN THE NORTHERN ADELAIDE PLAINS

GEOLOGICAL SURVEY

by

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SUMMARY AND RECOMMENDATIONS

Geophysical and geological surveys and drilling in the Port Gawler area of the Northern Adelaide Plains have located evidence of a Tertiary palaeochannel incised within Proterozoic bedrock. This channel is presumed to be filled with sands and gravels (North Maslin Sands) and is known to be capped by clays and lignites (Clinton Formation). Subsequent Cainozoic deposition has buried this channel to a depth of approximately 350 m below present-day ground surface.

Based on seismic evidence, the channel is approximately 1800 m wide and extends northeast from Port Gawler for at least 5 km, and possibly up to 10 km, and has a gentle southwest gradient, estimated to be 1 in 700. The infilling sands and gravels appear to have an average thickness of about 20 m and should have sufficiently high porosity and permeability to constitute a good reservoir.

The overlying caprock of clays and lignites is approximately 20 m thick and forms a sheet-like body which infills the uppermost part of the channel and directly overlies bedrock on either side. The underlying bedrock, tight limestone and dolomite near Port Gawler and weathered clayey siltstone to the east, probably has low permeability, similar to that of the clays and lignites.

Present data therefore indicate favourable reservoir and seal conditions for the storage of natural gas in the channel

although the headward extent and configuration is not yet fully defined.

Assuming a realistic effective reservoir porosity of 15%, a gas storage pressure of 2800 kPa (400 psi), and an onshore channel length of 7.5 km, estimated gas storage capacity is 280 million cu.m (10 BCF).

It is recommended that exploration of the proposed storage sands be continued in three stages:

(1) A stratigraphic well to be drilled in the centre of the channel on an existing seismic line to confirm the presence of the potential reservoir sands and caprock. Estimated cost, $30,000.

(2) Provided that the reservoir sands and caprock are confirmed in Stage I, analysis and testing of core to be carried out. A second well to then be drilled near the first so that pump testing can be carried out to test caprock integrity and reservoir characteristics. Estimated cost, $20,000.

(3) Detailed gravity surveying to indicate suitable sites for approximately 20 line km of seismic reflection surveying using detailed high resolution techniques to define the geometry of the northeastern part of the channel. Estimated cost, $50,000.

The complete programme of three stages is estimated to cost a total of $100,000 and its duration to be about six months.

INTRODUCTION

Exploration for a suitable underground gas storage target in the Northern Adelaide Plains was initiated in 1964. Prior to the present investigation four other areas have been examined and rejected as target areas, mainly due to the shallow depth of potential reservoir sands and the lack of adequate confining beds. The history of exploration to 1978 is contained in a report by Cockshell, Nelson and Cooper (1978).

Drilling in the Korunye area north of Two Wells (Fig. 1) was undertaken in 1978 to test for the presence and areal extent of the deep Northern Adelaide Plains Aquifer C (which includes the North and South Maslin Sands and the Clinton Formation). Biostratigraphic examination of these wells showed that the sands intersected were younger than Aquifer C sands and an evaluation of the data led to a new conceptual model for the deposition of Eocene sediments in this portion of the St. Vincent Basin.

As a consequence exploration was concentrated in the Port Gawler area (Fig. 1) where Observation Bore F, drilled between 1961 and 1964 (Lindsay, 1965), had intersected a thick Cainozoic sequence including all known Tertiary units of the eastern St. Vincent Basin (Lindsay, 1969). A stratigraphic log of Bore F is shown in Fig. 2. In this bore the Clinton Formation comprises mainly clays and lignites which appear to provide good hydrological separation of the North and South Maslin Sands. This indicated that the underlying 19 m thick North Maslin Sands, at a depth of 330 m, would be a good target for further study. Although the porosity and permeability of these sands were not determined during the development of the bore, high values of these properties were indicated as groundwater flowed at the surface during development and sands were blown up the hole during casing operations. Groundwater salinities in the order of 60 000 mg/l were obtained from these sands.

EXPLORATION IN THE PORT GAWLER AREA

The first stage of exploration in the Port Gawler area was the drilling in 1978 of Buckland Park No. 1 (Fig. 1), a stepout well from the known occurrence of North Maslin Sands in Port Gawler Bore F. Drilling revealed 8.4 m of Clinton Formation sands, clays and lignites directly overlying clayey weathered siltstone bedrock at a depth of 280 m. This indicated a suitable northerly confinement for the target North Maslin Sands.

Following this, high resolution seismic reflection surveys were carried out between Buckland Park No. 1 and Port Gawler Bore F (lines SV-78-G to K, Fig. 1). These successfully defined the geometry of the target sands north of Bore F (line SV-78-G1, Fig. 2). Definition of the target sands was less successful on lines SV-78-I to K because of poor shooting conditions and the effects of a marked bedrock-high structure immediately north of SV-78-J. Also, as shown by later data, the orientation of these lines was unfavourable for the clear definition of the channel bank.

In December 1978, Legoe No. 1 was drilled to test the easterly extent of the North Maslin Sands and their continuity with North and South Maslin Sands (Lindsay, 1969) encountered in Virginia "A2" bore (Fig. 1). Legoe No. 1 intersected 20.5 m of Clinton Formation clays and lignites directly overlying clayey weathered siltstone bedrock at a depth of 313 m. This suggested that unlike the Clinton Formation and younger units, the underlying North Maslin Sands had a much more restricted, channel-like distribution, and that they extended either north or south of Legoe No. 1 or terminated west of it.

During the drilling of Legoe No. 1 a gravity survey carried out over the area indicated three features of interest:

(1) A prominent linear gravity high trending north-south east of Port Gawler and west of Buckland Park No. 1, probably

associated with the bedrock ridge shown by previous seismic work.

(2) Approximately 2 km northeast of Port Gawler the gravity high is cut by a relative gravity low, which may be interpreted as caused by a channel in the bedrock. To the east of this gravity low, interpretation is uncertain because there are fewer data points, but a northeasterly orientation of the channel is indicated.

(3) A gravity high is associated with the Redbanks Fault, indicating a significant rise in bedrock elevation to the east.

To more accurately define the bedrock channel, presumed to contain the North Maslin Sands, a detailed high resolution seismic reflection survey was carried out along Line SV-79-A (Fig. 1) . The seismic section (Fig. 3) clearly shows a channel 1800 m wide at a depth of 350 m, which has been interpreted on the basis of seismic velocity analysis and stratigraphic correlation as being filled with about 19 m of North Maslin Sands. The overlying Clinton Formation fills the uppermost part of the channel and extends to the north and south where it directly overlies the weathered bedrock. The northern bank of the channel is difficult to interpret precisely due to possible off-section effects of the nearby bedrock high.

Detailed gravity profiles along seismic lines SV-78-G1 (Fig. 2) and SV-79-A (Fig. 3) show good correlation between gravity lows and channel development, and suggest that further detailed gravity surveys could outline the general channel configuration.

CONCLUSIONS

The North Maslin Sands intersected at a depth of 330 m in

Port Gawler Bore F appear to be a suitable target for underground storage of natural gas because of their high porosity and permeability and channel-like distribution. Clays and lignites of the overlying sheet-like Clinton Formation appear to have suitable caprock potential.

A model of the proposed storage target is shown in Fig. 4. There is little evidence to indicate the extent and gradient of the channel northeastwards from seismic line SV-79-A, but it is thought that the Redbanks Fault may provide the eastern limit to the North Maslin Sand, as indicated by the displacment of upper aquifers across it (Shepherd, 1975).

ENGINEERING CONSIDERATIONS

To estimate gas storage capacity, a storage pressure of 2800 kPa (400 psi) and an effective reservoir porosity of 15% (porosity 20% and water saturation 25%) have been used. The pressure was calculated as normal hydrostatic pressure at the expected storage depth, based on the behaviour of Port Gawler Observation Bore "F" during development (described on page 3). For a channel head 7.5 km northeast of Port Gawler and a gas bubble extending to Port Gawler, a storage capacity of 280 million cu.m (10 BCF) is expected.

Overseas experience has shown that perhaps one third to one half of the storage can be used for peak shaving storage, the remainder being "cushion" gas to assist production by expansion; never-the-less, such a proportion would meet peak shaving requirements arising from the present gas sales contracts.

Not all of the injected gas will be recoverable at the end of the life of the storage. There is not reliable means of estimating this amount at this time, but an amount remaining of one half of the initial injection would not be unrealistic.

RECOMMENDATIONS

The North Maslin Sands in the Port Gawler area offer potential for underground storage of natural gas. In order to confirm that this storage is adequate, it is recommended that exploration proceed in three stages:

Stage I

A stratigraphic well should be drilled in the centre of the channel to confirm by coring the presence of the expected reservoir and the suitability of overlying sediments as a caprock. This well should be sited on station 87, line SV-79-A (Fig. 1), where the thickest reservoir section should be intersected and minimum disruption will occur to land-use. A complete suite of geophysical logs, including a detailed seismic velocity well shoot should be run. On-site supervision of cementing and casing techniques is essential. The well should be designed to take a suitably sized pump at depth, in anticipation of Stage II testing.

The estimated cost of this stage is $30,000.

Stage II

Providing suitable reservoir sands and caprock are confirmed in Stage I, detailed analysis and testing of core should follow.

A second well should then be drilled nearby into the South Maslin Sands, terminating above the Clinton Formation. Pump testing of the first well and observation of static water level of the South Maslin Sands aquifer should indicate both caprock integrity and reservoir characteristics.

The estimated cost of this stage is $20,000.

Stage III

Providing suitable results are obtained from Stage II, detailed seismic reflection and gravity surveys should be carried out to define channel configuration. Detailed gravity surveying should precede seismic work and thus help locate seismic lines: a grid covering 15 km^2, with station spacing of 250 m, seems necessary for suitable coverage. Approximately 20 km of detailed high resolution seismic reflection surveying should define the channel northeast of line SV-79-A. An initial seismic line extending 8 km northeast from the proposed stratigraphic hole is expected to show the linear extent of the channel. A follow-up survey of four 3 km lines perpendicular to the channel should then indicate the channel width. The minimum detail necessary for this surveying is 12-fold CDP stacking (1200% coverage).

The estimated cost of Stage III is $50,000.

The complete programme of three stages is estimated to cost a total of $100,000 and its duration should be about six months.

This phase of investigation should complete the delineation of the areal extent of the channel and allow a much better estimate to be made of the total quantity of gas that could be stored and recovered.

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GEOPHYSICIST

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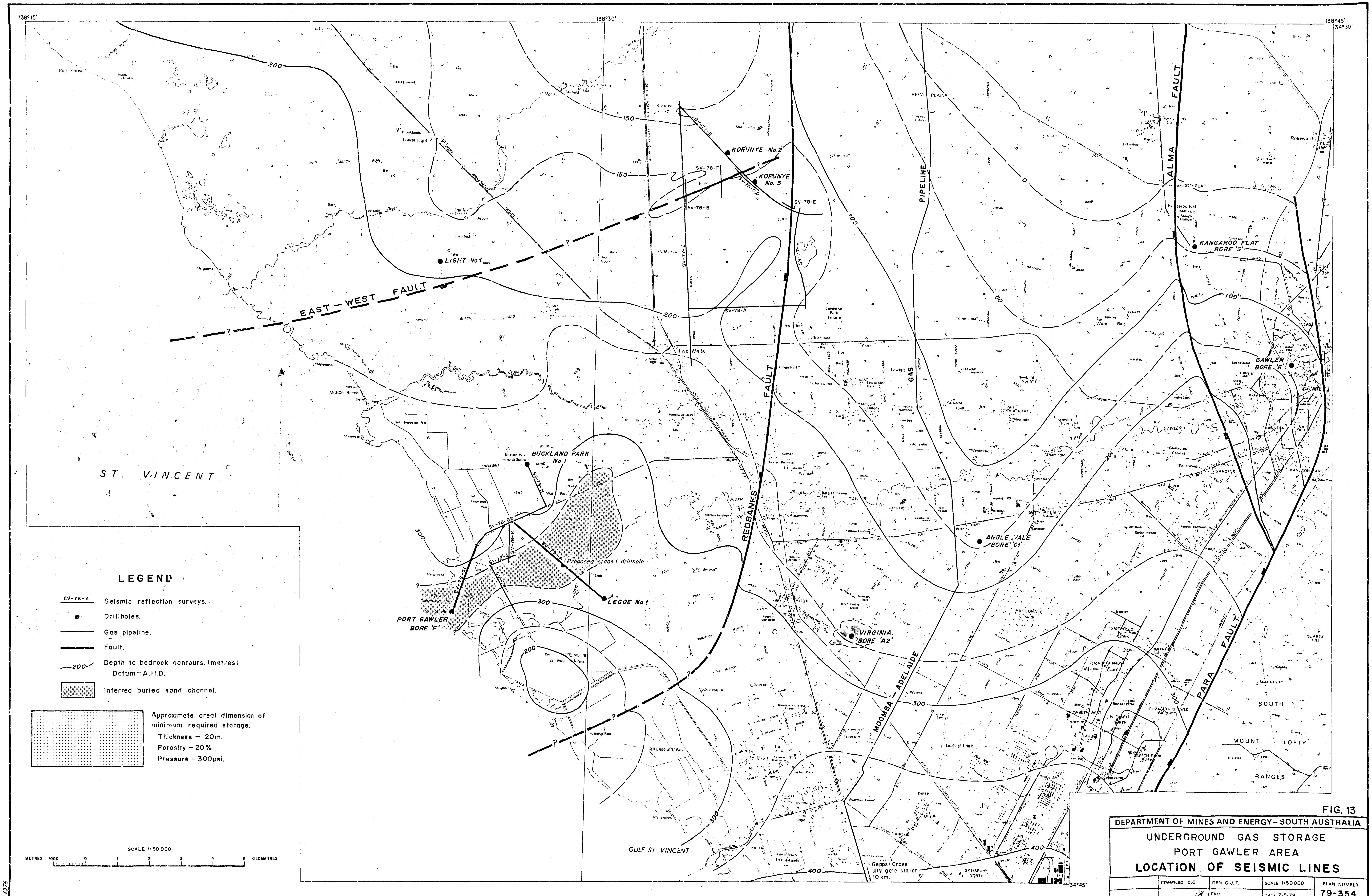
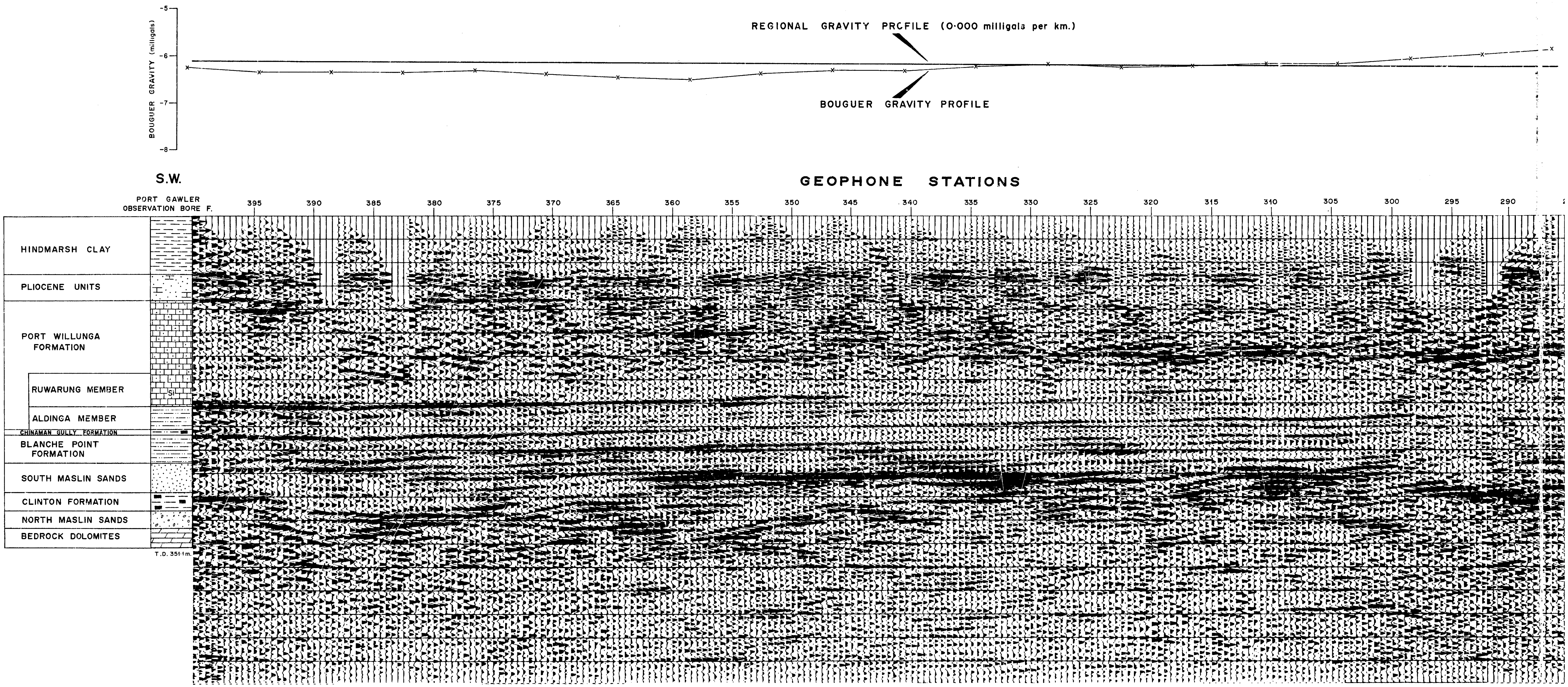

138°15'
138°30'
138°45'
34°30'
34°45'
Port Prime
Brooklands
Lower Light
Light
Korunye
KORUNYE No.2
KORUNYE No. 3
LIGHT No 1
EAST – WEST FAULT
ALMA FAULT
REDBANKS FAULT
PARA FAULT
PIPELINE
GAS
MOOMBA – ADELAIDE
REEVES PLAINS
Roseworthy
KANGAROO FLAT BORE 'S'
Two Wells
Lewiston
GAWLER BORE 'R'
Gawler
GAWLER RIVER
BUCKLAND PARK No.1
ANGLE VALE BORE 'C1'
VIRGINIA BORE 'A2'
LEGOE No.1
PORT GAWLER BORE 'F'
Proposed stage 1 drillhole.
SV-78-F
SV-78-B
SV-78-C,D
SV-78-E
SV-78-A
SV-77-E
SV-77-D
SV-78-G2
SV-78-K
SV-78-J
SV-78-I
SV-78-G1
SV-78-H
SV-79-A
ST. VINCENT
GULF ST. VINCENT
SOUTH MOUNT LOFTY RANGES
ELIZABETH
Gepps Cross city gate station 10 km.
SALISBURY NORTH
200
150
100
50
0
300
400
LEGEND
SV-78-K Seismic reflection surveys.
Drillholes.
Gas pipeline.
Fault.
200 Depth to bedrock contours. (metres) Datum – A.H.D.
Inferred buried sand channel.
Approximate areal dimension of minimum required storage.
Thickness – 20m.
Porosity – 20%
Pressure – 300psi.
SCALE 1:50 000
METRES 1000 0 1 2 3 4 5 KILOMETRES
FIG. 13
DEPARTMENT OF MINES AND ENERGY – SOUTH AUSTRALIA
UNDERGROUND GAS STORAGE
PORT GAWLER AREA
LOCATION OF SEISMIC LINES
COMPILED D.C.
DRN G.J.T.
CKD
SCALE 1:50 000
DATE 7-5-79
PLAN NUMBER 79-354
DIRECTOR GENERAL
1376


REGIONAL GRAVITY PROFILE (0·000 milligals per km.)
BOUGUER GRAVITY PROFILE
BOUGUER GRAVITY (milligals)
-5
-6
-7
-8
S.W.
GEOPHONE STATIONS
PORT GAWLER OBSERVATION BORE F.
395
390
385
380
375
370
365
360
355
350
345
340
335
330
325
320
315
310
305
300
295
290
HINDMARSH CLAY
PLIOCENE UNITS
PORT WILLUNGA FORMATION
RUWARUNG MEMBER
ALDINGA MEMBER
CHINAMAN GULLY FORMATION
BLANCHE POINT FORMATION
SOUTH MASLIN SANDS
CLINTON FORMATION
NORTH MASLIN SANDS
BEDROCK DOLOMITES
T.D. 351·1m.

1376

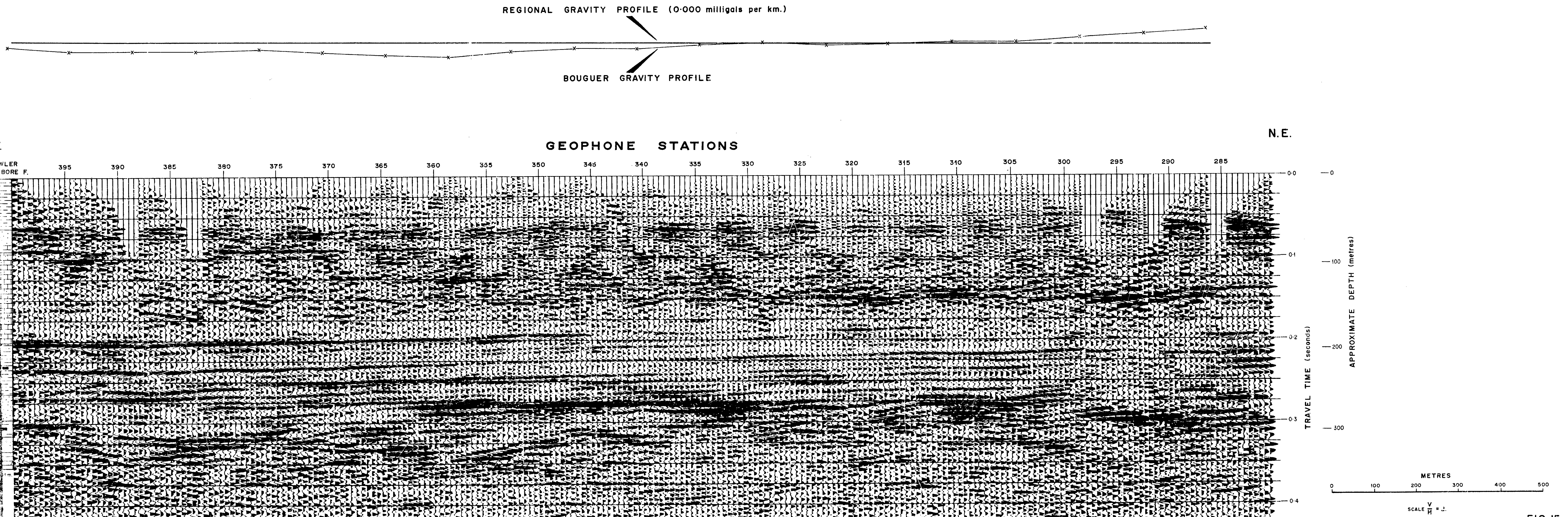


FIG. 15

DEPARTMENT OF MINES AND ENERGY – SOUTH AUSTRALIA			
UNDERGROUND GAS STORAGE PORT GAWLER AREA **SEISMIC SECTION OF LINE SV-78-G1**			
COMPILED D.C.	DRN G.J.T.	SCALE 1:3876	PLAN NUMBER 79-352
	CKD	DATE 7·5·79	

BOUGUER GRAVITY (milligals)
-8
-9
-10
-11
REGIONAL GRAVITY PROFILE (0·667 milligals per km.)
BOUGUER ANOMALY PROFILE
N.
GEOPHONE STATIONS
PORT GAWLER ROAD
PROPOSED STAGE 1 DRILLHOLE
GAWLER RIVER
9
14
19
24
29
34
39
44
49
54
59
64
69
74
79
84
89
94
99
104
109
114
119
124
129
APPROXIMATE DEPTH (metres)
0
100
200
300
400
TRAVEL TIME (seconds)
0·0
0·1
0·2
0·3
0·4
0·5
0·6
0·7
0·8
0·9
1·0

1376

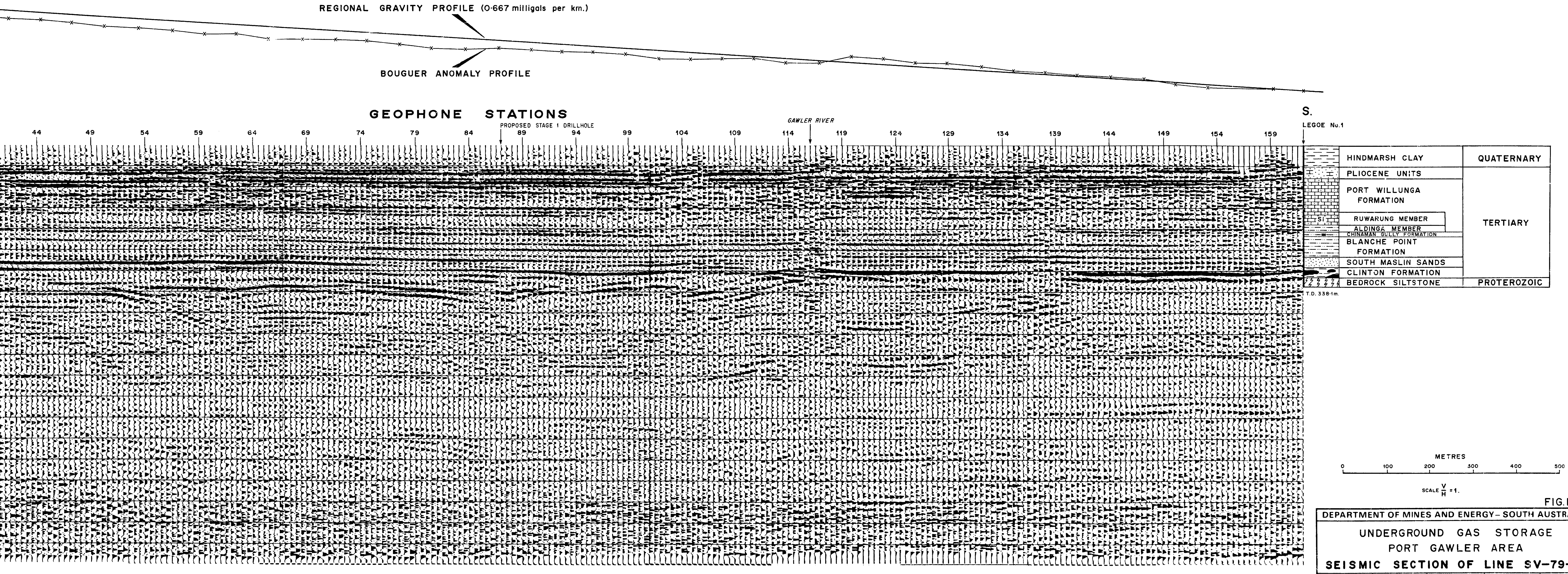


FIG. 16

DEPARTMENT OF MINES AND ENERGY – SOUTH AUSTRALIA

UNDERGROUND GAS STORAGE
PORT GAWLER AREA
SEISMIC SECTION OF LINE SV–79–A

D.C.	DRN. G.J.T.	SCALE 1:3876	PLAN NUMBER
	CKD.	DATE 3-5-79	79-351

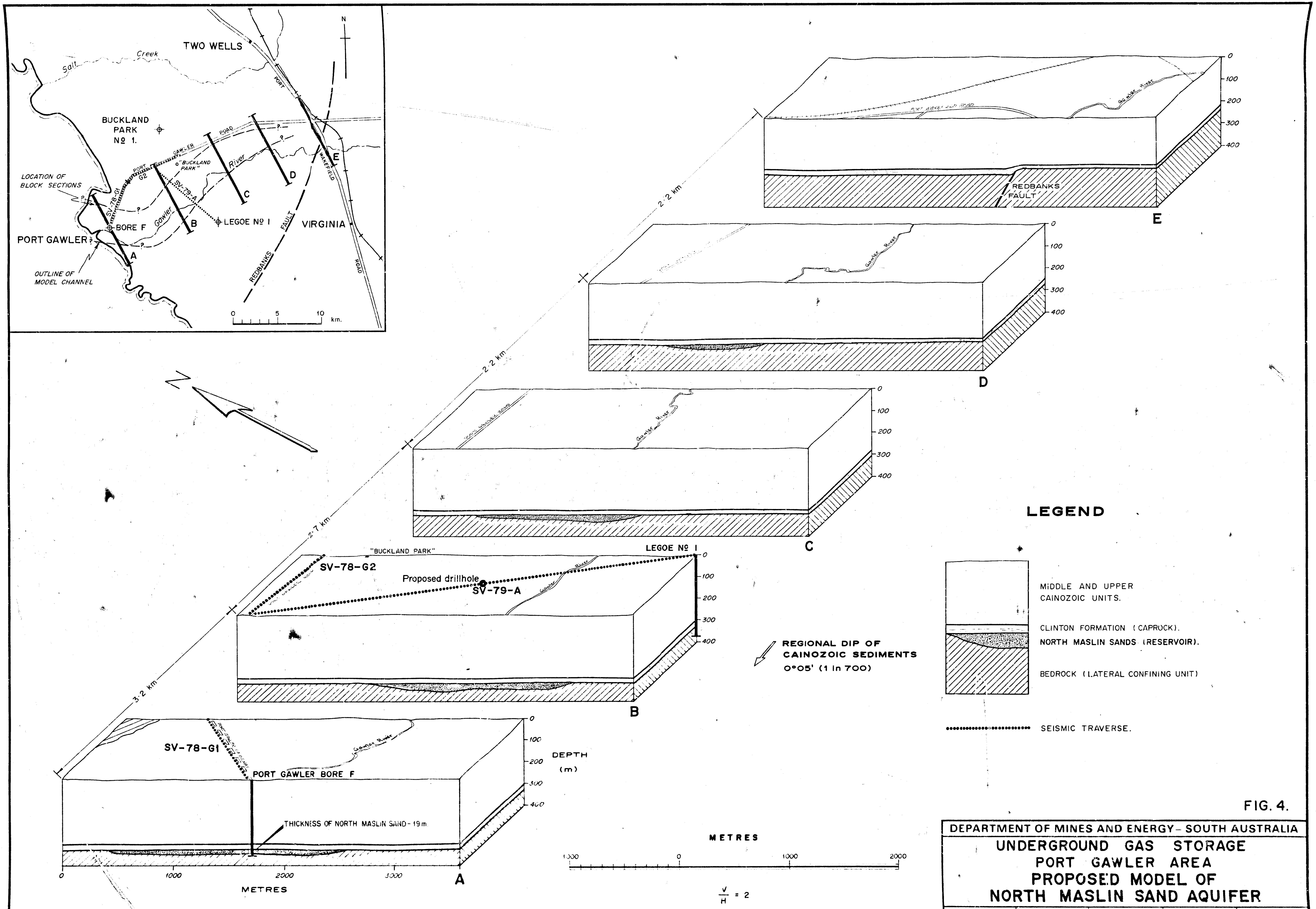


FIG. 4.

DEPARTMENT OF MINES AND ENERGY – SOUTH AUSTRALIA

UNDERGROUND GAS STORAGE
PORT GAWLER AREA
PROPOSED MODEL OF
NORTH MASLIN SAND AQUIFER

COMPILED C.D.C. N.R.S. Hor 1:20 000 Ver 1:10 000

DIRECTOR GENERAL

79-353