74/229

Section

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INSPECTION OF FLOWING EXPLORATION HOLES,

PEAKE AND DENISON RANGES, SOUTH AUSTRALIA

NOVEMBER, 1974

A.F. WILLIAMS

Department of Mines
South Australia

D E P A R T M E N T O F M I N E S

S O U T H A U S T R A L I A

GEOLOGICAL SURVEY
ENGINEERING DIVISION

INSPECTION OF FLOWING EXPLORATION HOLES, PEAKE AND DENISON RANGES, SOUTH AUSTRALIA NOVEMBER, 1974

by

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HYDROGEOLOGY SECTION

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CONTENTS PAGE

PLATES

FIGURES

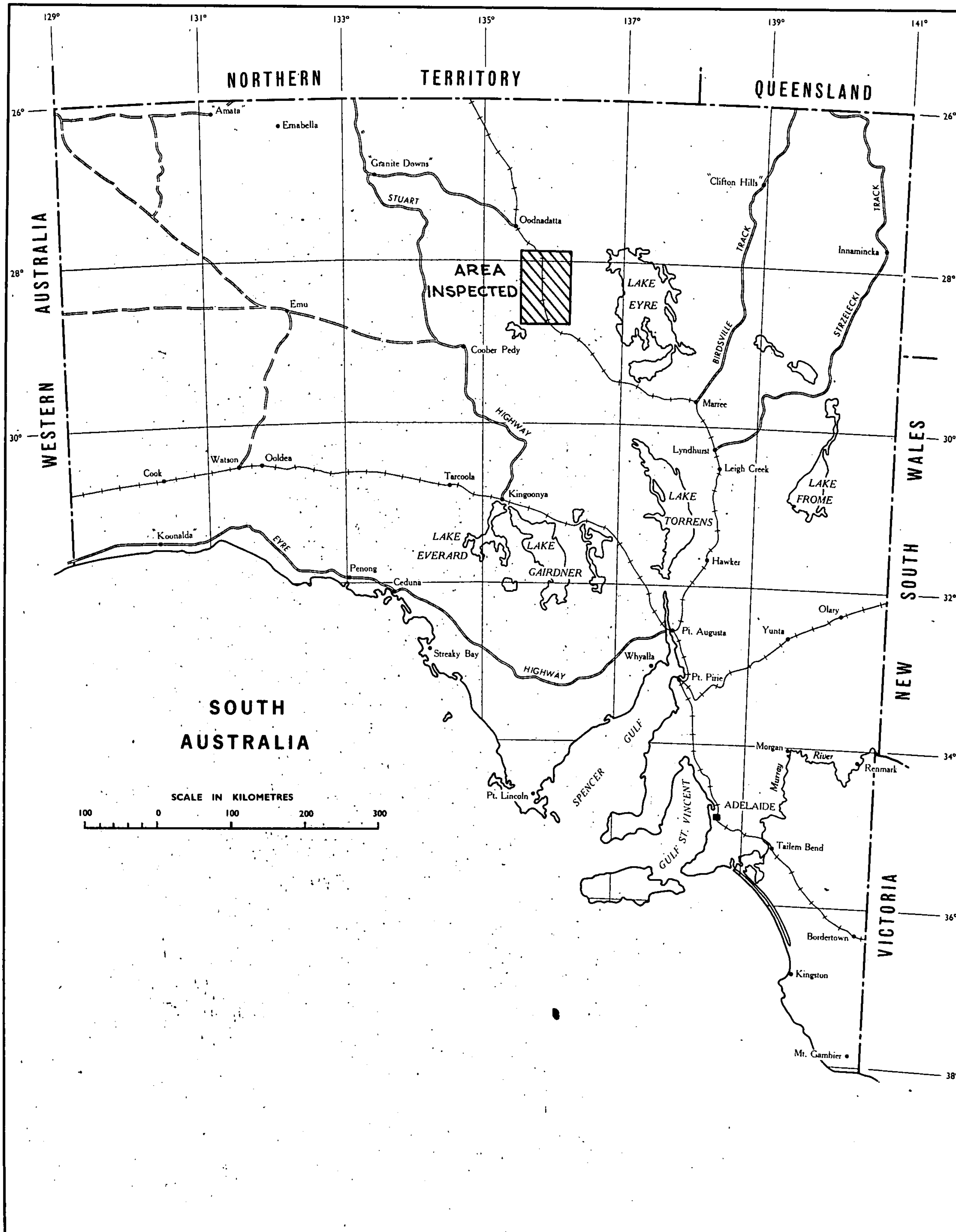

FIG.1

DEPARTMENT OF MINES —— SOUTH AUSTRALIA

Compiled. A.F.W.	GREAT ARTESIAN BASIN — BOREHOLE INSPECTION	Date: Dec. 1974
Drn. A.F. Ckd. A.F.	AREA LOCATION PLAN	Drg. No. S11152

P.F. No. 55850 994.2

DEPARTMENT OF MINES
SOUTH AUSTRALIA

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ABSTRACT

Flowing exploration boreholes in the area surrounding the Peake and Denison Ranges were uncontrolled and in various states of disrepair when inspected in November, 1974. Some bores were easily accessible, others could not be approached within 10 to 40 m using a heavy vehicle. About half had open casing. The majority might be plugged by pumping cement down the hole at a faster rate than the water flow although platforms will have to be constructed to work over some bores. Major problems exist with Chevron holes LHDH6, 7 and 15 and Shell SDA15. A rig will probably be required for their repair. All repair work is rechargeable except for that on 2 small seismic holes west of Old Nilpinna. It is stressed that this work be carried out as soon as possible as conditions of many bores are rapidly deteriorating.

Stricter exploration licence conditions and liaison between the Hydrogeology and Mineral Exploration Sections of the Mines Department are proposed to eliminate the problem of poor drilling and completion techniques in areas where water at a potentiometric level above ground surface is likely to be encountered. Borehole specifications and inspection during drilling will be required. This will become a matter of course when the state is defined under the Underground Waters Preservation Act.

INTRODUCTION

During recent

Over the last few years, a number of exploration boreholes drilled by both Government and private industry in the Peake and Denison Range area (see Fig. 1), have encountered artesian water flows which have not been adequately controlled. They are as follows (see Fig. 2 for locations):

(a) three drilled by the South Australian Department of Mines during a seismic survey in 1968 (TX line)

(b) fourteen drilled by Austral United Geophysical Pty. Ltd. for Pexa Oil in 1970 (PYC and PYH seismic lines)

(c) seven drilled by W.L. Sides and Son for Chevron Exploration in 1973 (LHDH 3, 3A, 5, 6, 7, 15 and 16)

(d) three drilled for Shell Development (Australia) in 1974 (SDA 13, 14 and 15).

Unfortunately techniques used to drill and complete these bores were inadequate to cope with the situation. The shallow seismic holes, drilled unsuspectingly into an artesian aquifer were left open. The weight of mud in the hole may have prevented initial flow but as this settled, many began to flow at rates of 1-2 l/sec (see later) with the occasional one flowing at a much larger rate (9-11 l/sec). Deeper exploration holes for coal and uranium ((c) and (d) above) intersected either most or the full depth of aquifer and often flowed at higher rates. These were poorly completed and often left to flow. This malpractice has resulted in not only a waste of a valuable resource but also access problems to vehicles and death of stock in the quagmires often created around the boreheads.

Various complaints and enquiries concerning these bores have been received both officially by the Department of Mines (see E.L. 108) and privately on several occasions by the author - see later. A field trip was therefore planned to investigate as many of these bores as possible in conjunction with a mound spring sampling and gauging programme in the same area. Each bore was examined in the light of access both to and down the hole and flow rates were measured (or estimated) to determine the most efficient method of control. It was hoped to be able to pump cement down these holes and thus kill the flow - provided access was good and the flow rate less than about 4 l/sec. The author was accompanied by W.R.P. Boucaut, South Australian Department of Mines, Professor J.W. Holmes of Flinders University, and P.J. Manoel, Engineering and Water Supply Department who assisted with all aspects of the inspection and sampling programmes.

Lack of time prevented inspection of any seismic holes and SDA13 and 14. There is some information available, however (see later). An aerial inspection of the seismic holes was carried out by R. Hancock, Chief Drilling and Mechanical Engineer, South Australian Department of Mines in November, 1973. Aerial photography flown by the S.A. Department of Lands in February, 1973 at a scale of 1:88 000 clearly shows the seismic lines and the flowing shotholes. Estimates of their output were calculated from the area of vegetation and free water surface surrounding each shothole (see later). Their accessibility can be judged from the aerial photographs. Logs for all holes appear in the Appendices.

CONTROL PROBLEMS

Flowing bores in the Great Artesian Basin have always been difficult to control - due either to the high temperature or high corrosive effects of the water or both. On the western margin (e.g. Peake and Denison Ranges region) it is not uncommon for head works and casing to corrode through in less than 3 years. Only recently have Great Artesian Basin bores been satisfactorily completed, using techniques such as pressure cementing and materials such as PVC or stainless steel for casing and headworks.

DETAILS OF FLOWING EXPLORATION BORES

1. SOUTH AUSTRALIAN DEPARTMENT OF MINES SEISMIC SHOTHOLES

(a) Introduction

In 1968, the S.A.D.M. carried out seismic work near old Nilpinna Ruins (see Fig. 2) as part of a survey of the Arckaringa Basin. Although no artesian flows were reported, three holes have subsequently overflowed (These are probably TX86, 94 and 97). All three were drilled either into (TX86) or within a metre or two (TX94, 97) of the Cretaceous Cadna-owie Formation which, although only an aquifer of secondary importance in this region, is hydraulically connected to the main aquifer - the Algebuckina Sandstone - which lies immediately beneath it. As far as is known, there were no reports of these three shot holes flowing before 1970.

(b) Access and estimated flows

Access to these three holes is difficult because of the boggy nature of creeks along the seismic line. These are permanently wet due to the flowing shotholes on the Pexa PYH line. From the aerial photograph, each hole appears surrounded by reeds and open water so it is unlikely that a heavy vehicle could approach to within more than 5-10 metres of the shothole. TX94 and 97 (18 and 17 on Fig. 2 and plate 1) appear more accessible than TX86 (19 on Fig. 2 and plate 1). An aerial view of TX 97 is presented on Plate 3.

Estimates of flow were derived by measuring the area of reeds and water around the borehole (distinguished by the black areas on aerial photos - see plates 1 and 2) and multiplying this by a figure for the mean evaporation for the area concerned. This figure was selected as 7 mm/day (see Appendix I). This gives flows of 0.3, 0.13 and 0.9 l/sec (or 250, 100, 700 gph) for shotholes 17, 18 and 19 respectively (see Table I). It will be seen later that this method at least gives an order of flow and can be accepted as a working value.

(c) Suggested method of control

Driller's logs show these holes to be all about 20 m deep (see Appendix II) and to have just penetrated or else just finished above the aquifer. Provided the shothole is still open to say 6-8 m and access is not too restricted, there should be no problem in killing the flows by pumping in cement.

2. PEXA SEISMIC SHOTHOLES

(a) Introduction

In 1970 Austral United Geophysical Pty. Ltd. whilst carrying out seismic work for Pexa Oil under P.E.L. 5 and 6, ran several lines in the same area as the

S.A.D.M. TX line. Along their PYH and PYC lines artesian flows were encountered in a similar manner to that mentioned above. The holes were again left open when drilled (mid February to March) but were flowing at least by mid June. This was reported to the author on the 7th July, 1970 by the manager of Nilpinna Station. The matter was then brought to the attention of the Petroleum Engineer, S.A.D.M. In all, there are some fourteen flowing Pexa shotholes, four on the PYC line occurring between PYC 95-105 (1 to 4 on Plate 2) and ten on the PYH line (occurring between PYH 90-106 (7-16 on Plate 1).

Reports of the Pexa work can be found in S.A.D.M. Env. 1236 and S.R. File 27/4/30. All holes are prefixed by WARRINA RUN 2/144/ except for No. 19 which is prefixed by WARRINA RUN 2/146/.

(b) Access and estimated flows

These holes were not visited and access can only be gauged from aerial photographs and local knowledge. On the PYC line, holes 1, 2 and 3 appear to present no problem although some cross country travelling will be required (see Plate 2). Hole 4 on the same line can be reached by detouring round the ruins and heading north from there (see Plate 2). Access to the PYH line is via the S.A.D.M. TX line. According to the station manager of Nilpinna, this track is rather boggy in part and detours are required where the track has been cut by water from flowing shot holes. Holes 7 to 11 can be reached from the west and holes 12-16 from the east (see Plate 1). On the basis of the aerial photographs access down the hole appears similar to the S.A.D.M. shotholes described above. Nearly all are surrounded by reeds and open water but most all should be approachable to within 10-15 m. Shothole 15 may be less accessible. An aerial view of hole 12 is presented on Plate 3.

Flows were estimated in the same manner as for the TX shotholes. Apart from one hole (14) flows were less than or about 2 l/sec (1 600 gph - see Table I). Hole No. 14 flows at about 12 l/sec.

(c) Suggested method of control

Driller's logs show these holes to be between 18 and 28 m deep (see Appendix II). All appear to have intersected the aquifer or penetrated to within a few metres of it. As with the TX shotholes, these could be killed by pumping in cement provided they are open to about 6-8 m. No. 14 however, with such a large flow, may prove difficult to control.

3. CHEVRON EXPLORATION DRILLHOLES

(a) Introduction

In mid 1973, Chevron Exploration Company, exploring for uranium on E.L. 22 (east of the Peake and Denison Ranges) drilled some sixteen bores, seven of which encountered artesian water. These were LHDH3, 3A, 5, 6, 7, 15 and 16 (see Fig. 2). Of these seven bores, four were left open by agreement with Peake Pastoral Company who require them for stock use (see letter in E.L. 22 docket). Those left open were LHDH5, 7, 15 and 16 (LHDH5, 7 and 16 are on Anna Creek Station, LHDH15 is on Peake Station).

According to a letter from Chevron on 9/7/73, the following drilling precautions were taken for the majority of holes.

"(i) a 6.1 m length of 127 or 152 mm casing was cemented into each hole prior to drilling.

(ii) if a flowing bore was not required by the station manager the drillhole was plugged with cement above the aquifer and filled in.

(iii) if a flowing bore was requested by the station, the hole was left open."

Additional information on some of these bores was also furnished in the same letter.

Borehole	Water Intersected	Flow(estimated)	Status
3	21 m	2.5 - 3.8 l/sec	Open
5	81 m	5 - 6.3 l/sec	Open
6	90 m	?	Plugged
7	105 m	38 -50 l/sec	Open
15	?	50 -63 l/sec	Open

As far as is known, apart from verbal inquiries by the Peake Pastoral Company as to whether the Department would undertake the rehabilitation of the flowing bores, nothing further was done between July, 1973 and November, 1974.

A report on E.L. 22 may be found in S.A.D.M. Env. 2182, Vols. I, II & III.

(b) Access and estimated flows

(i) LHDH2 (no photo)

This bore is fitted with a head works but is closed. No sign of leakage is evident. Access is not a problem.

(ii) LHDH3 (Plate 3, photo (i))

This bore was drilled in an area of mound springs. Ground is therefore treacherous and heavy vehicles may have trouble approaching the hole. At the time of inspection, the bore was shut off by means of a welded steel cap (not open as reported by Chevron on 9/7/73). A small leak has developed near the top of this casing with a very small flow. The back pressure is estimated as about 6-9 m. Further corrosion will increase the flow from the bore and impede access. In a further twelve to eighteen months, it may be almost impossible to approach the bore - so fast is the corrosion rate.

Flow was estimated as 2.5-3.8 l/sec by the driller.

(iii) LHDH3A (no photo)

This hole is about 5 m south of LHDH3 and capped similarly but there is no apparent leakage.

(iv) LHDH5 (Plate 4, photo (ii))

This bore occurs on flat ground which is poorly drained. Access is very bad - a plant or heavy truck could not approach closer than 20-30 m to the hole. The hole is open and water is flowing from the top of 152 mm casing which is sitting in the centre of a pool about 3 m in diameter and over 2 m deep. Flow from the casing was estimated at 0.7 l/sec. However, a strong flow of 5-6 l/sec was recorded by Chevron during drilling of the hole. Thus considerable leakage through the confining beds may be occurring or else the bore has partially collapsed thus reducing flow.

Anna Creek station is responsible forthe bore's maintenance.

(v) LHDH6 (Plate 4, photo (iii), (iv) and (vi))

This bore has been drilled at the top of a small rise, adjacent to a large creek. The bore is cased and cemented to a depth probably of the order of 5-10 m. No water issues from the bore but a significant amount is leaking via the confining beds into a small gully adjacent to the bore. Also minor seeps occur all round the edge of the rise (see Plate 4, photo (v). Access is bad - heavy vehicles might approach to within 5-10 m of the bore. The bore water has cut the main track necessitating a detour which involves a probable difficult crossing of a creek channel.

Flow was estimated as about 1/3 - 1/2 that in LHDH7 (a gauged flow) i.e. about 9-14 l/sec. This bore, together with LHDH2, 3 and 3A is the responsibility of Chevron Exploration and none were requested to be left for use as stock bores by Peake Pastoral Company.

(vi) LHDH7 (Plate 4, photo (vi))

Access to this bore is good - a plant or heavy truck could approach to within 2-3 m of the bore head. All water flow is via the casing. This flow was gauged with a current meter at about 29 l/sec (23 000 gph). Anna Creek Station is responsible for the maintenance of this bore.

(vii) LHDH15 (Plate 5, photo (i))

Access to this bore is also good. All water is flowing from the casing (152 mm). Peake Pastoral Company have accepted responsibility for the maintenance of this bore.

Flow was gauged by current meter as about 31 l/sec (24 600 gph).

(viii) LHDH16 (Plate 5, photo (ii))

This bore was drilled on flat ground and is consequently poorly drained. A plant or heavy vehicle might approach within 10 m of the borehole. All water is discharging through open casing (152 mm) which is surrounded by a thick growth of reeds. The bore has flooded the track so detouring is necessary. Anna Creek Station is responsible for the maintenance of this bore.

(c) <u>Suggested method of control</u> - (Logs are appended)

(i) LHDH2

May not require any work. Why a headworks was left on remains a mystery. It is suggested that headworks be removed to check whether it has intersected artesian water or not.

(ii) LHDH3

Backfilling by pumping cement down the hole to completely shut off the flow.

(iii) LHDH3A

As for LHDH3.

(iv) LHDH5

This bore may be "killed" by pumping cement down the casing provided a platform can be erected to enable more direct access.

(v) LHDH6

This might be effectively plugged by either drilling out the cement plug in the bore hole and re-cementing down the whole length or by grouting. A platform would be required here.

(vi) LHDH7

Pressure cementing P.V.C. casing might be possible with this hole if it is open to total depth. The casing collar should be able to be unscrewed and additional equipment attached (e.g. a shut-off valve if necessary).

(vii) LHDH15

Although this bore is easily accessible, its large flow would make it virtually impossible to use pumped cement for control. A similar technique used for LHDH7 might be used here.

(viii) LHDH16

Treatment as for LHDH5.

4. SHELL EXPLORATION HOLES

(a) Introduction

In early to mid 1974, Shell Development (Australia) drilled six bores on the western side of the Peake and Denison ranges while searching for coal. At least two (SDA15 and SDA13 and possibly a third, SDA14) intersected significant flows of artesian water. The contractor was Austral United Geophysical Pty. Ltd. SDA13 and 14 were drilled near old Nilpinna - not more than 300 m apart. For reference see E.L. 108, 108/1 dockets or S.A.D.M. Env. 2388.

(b) Access and estimates of flow

(i) SDA13

This hole was not inspected. Access to the bore is apparently very good - a vehicle may approach within a metre of the site (pers. comm. J. Nunn - Nilpinna Station manager).

The hole was abandoned at 84 m due to an excessive flow. According to Mr. Nunn, an attempt at plugging the flow was made by jamming a log down the hole. This was naturally unsuccessful and the bore is flowing at a rate of 2-6 l/sec (estimated by Mr. Nunn). This flow is consistent with older stock bores in the vicinity.

(ii) SDA14

This hole was not inspected. It is only 300 m east of SDA13 and apparently not flowing. Access therefore is presumably good.

(iii) SDA15 (Plate 5, photo iii and iv).

This bore is about 25 km (15.7 m) west of the Marree - Oodnadatta road along the Mount Toondina seismic track and was drilled on flat, poorly drained gibber plain. Access over the bore is very bad - no vehicle could approach closer than 30-40 m.

Flow was gauged at 8 l/sec (6 300 gph).

(c) Suggested method of control (logs appended)

(i) SDA13

An inspection is warranted to determine a suitable control method for this hole. According to the company report (Envelope 2388) the hole is uncased. Hopefully the piece of wood supposedly jammed in the hole is easily removed. The flow might be stopped by pumping cement down the hole.

(ii) SDA15

Although no casing is visible, a 127 or 152 mm diameter length is sitting at a slight angle in the hole about 0.1 - 0.2 m below the surface. This casing is full of sand (from aquifer) and gibbers. It is doubtful that this bore can be cemented off; most water appears to be coming up around the casing which is probably blocked along its whole length (6 m?). Here grouting may be again necessary. It should be noted that action was taken concerning this bore by the manager and owner of Allandale Station on which it is situated. Shell (see letter 29/7/74, E.L. 108 docket) requested the Drilling and Mechanical Branch of this Department to seal this hole and forward bills for all incurred costs on completion.

RECOMMENDATIONS FOR FUTURE DRILLING

Problems outlined in the proceeding section could be avoided if boreholes specifications were included in E.L. licence conditions. When impending legislation is implemented hopefully permits will be required before any drilling is undertaken. Completion specifications will be issued and must be adhered to. Where bores are to be used later for stock water supplies, they must be completed using pressure cementing techniques and corrosion resistant materials such as PVC and stainless steel.

It is therefore suggested in areas where problems can occur with groundwater whilst drilling exploration bores, that before granting E.L.'s, the Hydrogeology Section be contacted to obtain a set of specifications and that continued liaison be maintained with that section while the E.L. is current. A borehole inspector would be required to ensure adherence to specifications.

AFWilliams

19th December, 1974
AFW:IA

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Pexa Oil N.L., 1970. Lake Conway Seismic and Gravity Survey. S. Aust. Dept. Mines open file Env. 1236 (unpublished).

S. Aust. Dept. Mines - Drillers logs, 1968. S.A.D.M. TX Seismic lines.

Shell Development (Australia), 1974. Oodnadatta Reports E.L. 108.
S. Aust. Dept. Mines open file Env. 2388 (unpublished). See also
E.L. 108, 108/1 dockets.

A P P E N D I X I

NOTES ON THE METHOD OF ESTIMATING FLOW-RATES FROM THE AREA OF WATER AND VEGETATION SUPPORTED BY A DISCHARGE

PROFESSOR J.W. HOLMES - FLINDERS UNIVERISTY

NOTES ON THE METHOD OF ESTIMATING FLOW-RATES FROM

THE AREA OF WATER AND VEGETATION SUPPORTED BY A DISCHARGE

If it is not possible to obtain a direct measurement of discharge rate of flowing bores or mound springs, by stream gauging methods or metering, the rate may be estimated by a consideration of area of water and green vegetation. The appropriate evaporation rate is suggested from the correlation between net radiation and evapotranspiration, according to the following table.

Net radiation (R) and evapotranspiration (E)

(after Holmes & Watson (1967), and Hounam (1963)

	R (cal $cm^{-2}day^{-1}$)		E (mm day^{-1})	
	Jan	Jul	Jan	Jul
Adelaide	315	51	5.5	0.85
Alice Springs	304	85	?	?

The evapotranspiration of Oodnadatta and district is very similar to that at Alice Springs, as suggested by the maps of radiation over the continent, but this "inland" evaporation should be increased by 25% over that for Adelaide, to allow for additional advected heat during the summer months (Millar, 1964). Therefore, our best estimate of water loss from the vegetation and free water surface associated with a flowing bore (or mound spring) would be 7.0 mm day $^{-1}$ during January, in the Oodnadatta district.

During winter the discharge could support evaporation from an area perhaps 3½ times larger than the summer area, if we assume again the same enhancing effect of advection on evapotranspiration rates. Some enlargement of the area of "wet" vegetation, reeds and rushes etc. may occur during this season. However, water lack during summer should soon ensure suppression of the marginal plant growth if it occurs, and the error in the estimate of area, derived from aerial photographs should be only a small over estimate. The aerial photographs used were taken in February, 1973 (by the South Australian Lands Department) a most favourable time to minimise the errors in area.

The discharge may then be estimated from the correspondence that the evaporative loss from 1 ha at 7 mm day $^{-1}$ is equivalent to a discharge of 0.81 l s $^{-1}$.

Holmes, J.W. and Watson, C.L., 1967 - The water budget of irrigated pasture land near Murray Bridge, S.A. Agric. Meteorology, 4: 177-188.

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Millar, B.D., 1964 - Effect of local advection on evaporation rate and plant water status. Aust. J. Agric. Res. 15, 85-90.

APPENDIX II

SUMMARY OF DRILLERS LOGS

S.A.D.M. AND PEXA SHOTHOLES

SUMMARY OF DRILLERS LOGS - SEISMIC HOLES

Dept. of Mines (1968)

	Metres	
TX 86	0 - 6.1	Clay
	6.1 - 10.7	Blue shale
	10.7 - 19.8	Sand
TX 93	0 - 2.1	Sand
	2.1 - 19.8	Blue shale
TX 94	No record	
TX 95	0 - 6.1	Clay and sandstone bands
	6.1 - 19.8	Blue shale
TX 97	As above	
TX 98	0 - 6.1	Clay
	6.1 - 19.2	Blue shale
	19.2 - 19.8	Sandstone
TX 99	0 - 4.6	Red clay
	4.6 - 16.8	Blue shale
	16.8 - 19.8	Sandstone and blue shale

Pexa (1970)

PYC line

PYC 95	0 - 18.3	Sandstone and clay
	18.3 - 22.9	Clay
PYC 96	0 - 16.8	)as above
	16.8 - 22.9	)
PYC 97	0 - 3.0	Sand
	3.0 - 15.2	Clay and sandstone
	15.2 - 22.9	Clay
PYC 98	0 - 3.0	)as above
	3.0 - 18.3	)
	18.3 - 22.9	)
PYC 99	0 - 3.0	)as above
	3.0 - 18.3	)
	18.3 - 22.9	)
PYC 100	0 - 3.0	Sand
	3.0 - 18.3	Clay
	18.3 - 27.4	Sandstone and clay
PYC 101	0 - 4.6	Sand
	4.6 - 10.7	Sandstone
	10.7 - 18.3	Clay

PYC 102	0 - 3.0 Sand 3.0 - 15.2 Clay 15.2 - 2-.4 Sandstone and clay
PYC 103	as for PYC 102
PYC 104	0 - 3.0 Sand 3.0 - 15.2 Clay 15.2 - 22.9 Sandstone and clay
PYC 105	0 - 3.0 3.0 - 15.8 Clay 15.8 - 22.9 Sandstone and clay

No logs for PYH line

A P P E N D I X   I I I

SUMMARY OF LITHOLOGICAL LOGS - CHEVRON BORES

LHDH2, 3, 3A, 5, 6, 7, 15 and 16

LHDH 2

0	- 86.9	Claystone, siltstone
86.9	- 120.4	Cemented sands, siltstone, Aquifer?
120.4	- 137.2	Mainly sand, cemented, silty. Probably Algebuckina Sandstone.

LHDH 3

0	- 3.0	Alluvium
3	- 13.5	Claystone
13.5-	18.3	Siltstone, claystone
18.3-	22.9	Siltstone, becoming sandier with depth
22.9-	25.3	Sandstone, clayey. Aquifer.

Hole abandoned. Cased to 3.1 m. Flowing 2.5 - 3.8 l/sec.

LHDH 3A

Similar to LHDH 3

Depth 24.4 m. AQUIFER at 21.3 m.

LHDH 5

0.5-	2.0	Top soil and gravel, gypsiferous. Passing into claystone.
5.2-	93	Claystone, silty in part - becoming sandy
93	- 120.4	Sandstone, clayey at top. Aquifer. Strong flow of water 5 - 6.4 l/sec. Hole temporarily abandoned at 120.4 m.

LHDH 6

0	- 6.1	Alluvium gravel etc.
6.1	- 83.8	Claystone with about 20 - 30% siltstone increasing to 50% at 83.8 m
83.8	- 91.4	Siltstone with about 40% claystone at top - becoming silty and sandy at 91.4 m
91.4	- 117.3	Siltstone - up to 30% sandstone at about 103 m
117.3	- 122.2	Siltstone with sandstone and well sorted gravel Cadna-owie Formation (aquifer) after 103 m?
122.2	- 143.3	Sand, partly cemented, kaolinitic probably Algebuckina Sandstone

LHDH 7

0	- 0.6	Loose sand
0.6	-	Gravels
6.1	- 103.6	Grey claystone, siltstone with subrounded quartz gravel at about 103 m
103.6	- 120.4	Micaceous silts, some gravels and sand. Aquifer.
120.4	- 157.0	Sandstone, poorly to well cemented, kaolinitic

LHDH 15

0	- 3.0	Brown sandy clay
3.0	- 6.1	Fine to medium grained sand
6.1	- 9.1	Loose unconsolidated gravel
9.1	- 56.4	Sandstone, siltstone, claystone all fine grained
56.4	- 61.0	Sandstone, cemented to loose, some siltstone. Aquifer.
61.0	- 86.9	Sand, quartz, loose. Algebuckina Sandstone.

LHDH 16

0	- 77.7	Siltstone, claystone
77.7	- 94.5	Hard silicified sandstone with minor clay passing into loose sand at 85.3 m. Aquifer.

A P P E N D I X I V

LITHOLOGICAL LOGS - SHELL

SDA 13, 14 and 15

Borehole No. SDA13

Interval (ft.) EL 108

0	5	Mudstone, dark grey, massive, quartz sand 20%, medium grained, well sorted, rounded, clay 10%, limestone 10%, pink.
5	20	Sand, quartz 40%, lithics 20%, very fine grained, Mudstone 40%, dark green, moderately calcareous.
20	25	Muddy silt, weakly calcareous and sericitic.
25	40	Silty mudstone, dark grey, silt 40%.
40	65	Mudstone, grey, weakly silty.
65	70	Mudstone, grey, moderately silty.
70	75	Mudstone, grey, moderately silty, feldspathic quartz and 40%, medium grained, well sorted, moderately rounded, feldspar 15%, brown, minor pyrite.
75	80	Feldspathic sand,coarse grained, Mudstone 30%, grey, moderately silty.
80	85	Sand, medium grained, well sorted, sub angular, feldspar 20% brown.
85	90	Mudstone, pale yellow-brown, massive, very weakly sericitic.
90	95	Mudstone, pale yellow-brown, pyrite 15%, ¼" diam spheroidal nodules.
95	130	Sand, medium grained, moderately sorted, rounded.
130	135	Mudstone, grey, massive, weakly sericitic, Sand 20%, medium grained.
135	140	Sand, medium grained, mudstone 20%, grey.
140	150	Sand, coarse grained, moderately rounded, sorted.
150	155	Quartz sand, fine grained 80%, grit 20%.
155	165	Sand, medium grained, moderately sorted, rounded.
165	170	Quartz gravel, very coarse grained.
170	175	Sand, medium grained, moderately sorted, sub angular.
175	180	Mudstone, grey brown, massive, very weakly sericitic.
180	185	Mudstone, pale grey, very weakly silty and sericitic.
185	190	Sand, fine grained, moderately sorted, sub angular, Mudstone 20%, pale grey.
190	195	Sand, medium grained.
195	203	Sand, coarse grained, poorly sorted, sub angular.
203	205	Carbonaceous shale, very dark brown.
205	207	Coal, mainly dull, minor bright, dark brown to black, soft.
207	210	Mudstone, pale reddish brown.
210	215	Mudstone, very pale blue grey, very weakly silty.
215	220	Sand, medium grained, moderately sorted, sub angular.
220	225	Sand, fine grained, well sorted, moderately rounded, minor clay, yellow.
225	245	Sand, medium grained, well sorted, rounded.
245	275	Sand, fine grained, moderately sorted, rounded.
	TD	Hole abandoned due to excessive water.

Borehole No. SDA14

Internal	(ft.)	EL 108
0	5	Quartz sand, ferruginised, pale yellow brown, poorly sorted, angular, gypsum, limestone.
5	15	Sand, yellow brown, silicified and ferruginised, fine grained, strongly calcareous.
15	20	Silty mudstone, pale grey, moderately calcareous, siltstone, hard bands.
20	35	Silty mudstone, grey, moderately sericitic, minor siltstone, hard bands.
35	40	Mudstone, grey, strongly silty, weakly sericitic.
40	45	Mudstone, pale grey, moderately silty.
45	55	Muddy siltstone, pale grey, very weakly sericitic.
55	60	Mudstone 40%, pale grey, sand, pale yellow brown, fine grained 30%, coarse grained 30%, minor pyrite.
60	65	Mudstone, pale grey, sand 20%, medium grained.
65	70	Silty mudstone, strongly sericitic, quartz sand 30% medium grained, moderately sorted, rounded, minor biotite, Coal 10%, dull, brown-black, fiable, 6" band.
70	85	Quartz sand, coarse grained, moderately rounded sorted.
85	105	Sand, medium grained, moderately rounded, sorted.
105	110	Muddy quartz sand, very fine grained, moderately sorted, well rounded.
110	115	Sand, fine grained 60%, medium grained 40%.
115	125	Sand, medium grained well sorted, rounded.
125	130	Sand, medium grained, muddy silt 30%.
130	135	Sand, medium grained, moderately sorted and rounded.
135	165	Sand, coarse grained, moderately sorted, rounded.
165	170	Sand, medium grained, mudstone 40%, white, weakly silty, sericitic.
170	175	Sand, medium grained 70%, coarse grained 30%
175	180	Sand, medium grained, mudstone 10%, pale grey, weakly silty, sericitic.
180	190	Mudstone, pale grey, strongly silty, sericitic.
190	195	Sand, very coarse grained, moderately sorted, rounded.
195	200	Sand, medium grained.
200	205	Sand, medium grained 60%, grit 40%, well rounded.
205	220	Sand, medium grained, moderately sorted, rounded.
220	230	Sand, 50%, fine grained, Mudstone 40%, pale grey, weakly silty, siltstone 10%, silicified.
230	240	Sand, medium grained, well sorted, rounded, Mudstone 10%, grey.
240	250	Mudstone, pale grey, moderately sericitic, silty.
250	255	Mudstone, dark grey brown weakly sericitic.
255	275	Mudstone, pale grey, moderately silty, sericitic.
275	280	Sand, very fine grained, Mudstone 40%, pale grey, strongly sericitic.
280	290	Mudstone, pale grey, strongly silty, sericitic.
290	295	Mudstone, grey, moderately silty, sericitic.
295	300	Sandy mudstone.
300	305	Mudstone, dark grey, weakly sericitic.

Borehole No. SDA14

Internal (ft.) EL 108

305	310	Sandy mudstone, strongly sericitic.
310	315	Mudstone, dark grey, very strongly silty, sericitic.
315	335	Mudstone, dark grey, weakly sericitic.
335	395	Mudstone, dark green, weakly sericitic.
395	400	Sand, fine grained, moderately sorted, rounded.
400	440	Mudstone, dark green grey, massive.
440	450	Mudstone, dark green, sand 20%, fine grained.
450	475	Mudstone, dark green, massive.
475	480	Mudstone, dark green, quartz 10%, fine grained.
480	495	Mudstone, dark green.
495	500	Sand, fine grained, lithics 10%, minor muscovite.
500	515	Mudstone, dark green.
515	520	Mudstone, dark green, sand 10%, fine grained.
520	540	Mudstone, dark green.
540	545	Sand 50%, medium-fine grained, well rounded, sorted, mudstone 50%, dark green, minor pyrite.
545	550	Sand, medium grained.
550	555	Quartz sand, medium-fine grained, mudstone 20%, green.
555	565	Mudstone, dark green.
565	580	Sand, medium-fine grained, well sorted, rounded, claym yellow, white, minor pyrite.
580	590	Sand, medium-coarse grained, well sorted, rounded, minor pyrite.
590	610	Sand, very fine grained, minor feldspar, white.
610	630	Sand, medium grained, well sorted, moderately rounded, minor pyrite, white clay, feldspar.
630	635 TD	Sand, medium - coarse grained.

Borehole No. SDA15

Internal (ft.)		EL 108
0	10	Mudstone, pale yellowish grey, weakly sericitic, gypsum 5%.
10	20	Mudstone, pale grey, weakly sericitic, gypsum 5%.
20	25	Mudstone, pale blue grey, moderately sericitic, gypsum 5%.
25	30	Mudstone, pale blue grey, minor gypsum.
30	45	Mudstone, pale grey, weakly silty, moderately sericitic.
45	100	Mudstone, pale grey, massive.
100	110	Mudstone, pale grey, finely laminated.
110	120	Mudstone, pale grey, massive.
120	200	Mudstone, pale grey, weakly silty.
200	225	Mudstone, pale grey, massive.
225	230	Mudstone, pale green grey.
230	255	Mudstone, grey green.
255	265	Mudstone, grey green, sand 20%, fine grained, well sorted, rounded.
265	270	Mudstone 60%, grey, Sandy mudstone 40%.
270	280	Mudstone, dark green, massive.
280	285	Quartz sand, medium grained, well sorted, rounded, Mudstone 20%, dark green grey, minor pyrite.
285	295	Mudstone, dark green, minor sand.
295	300	Sand, coarse grained, well sorted, sub angular Mudstone 10%, dark grey, minor feldspar.
300	320	Mudstone, pale grey green, massive, moderately sericitic.
320	330	Quartz sand, coarse grained, well sorted, moderately rounded, Mudstone 20%, dark green, weakly sericitic.
330	335	Sand, very fine grained, well sorted, rounded, clay 20%, grey.
335	340	Sand, medium grained, poorly sorted, rounded, sand 10%, pink, very fine grained.
340	355	Sand, coarse grained, poorly sorted, rounded.
355	390	Sand, medium grained, moderately sorted, rounded.
390	395	Sand, medium grained, well sorted, rounded clay 10%, white.
395	400	Sand, medium grained, well sorted, rounded.
400	415	Sand, medium-fine grained, clay 10%, white, very weakly calcareous.
415	420	Sand, medium grained, moderately sorted, rounded, clay 5%, white, mudstone 15%, dark grey.
420	425	Sand, medium grained, clay 15%, white.
425	430	Sand, clean, medium grained,
430	435	Sand, medium grained, mudstone 10%, dark green, clay 10%, white, weakly calcareous.
435	485	Sand, clean, medium grained, well sorted, rounded, clay 10%, white.
485	490	Sand, medium grained, Mudstone 20%, pale grey.
490	495	Mudstone, pale grey, Sand 40%, fine-medium grained, well rounded, sorted.
495	500	Sand, medium grained, mudstone 10%, dark green, minor pyrite.
500	505	Sand, medium grained, pyrite 5%.

Borehole No. SDA15

Internal (ft.)		EL 108
505	510	Sand, very fine grained, mudstone 20%, dark green, minor pyrite.
510	515	Mudstone, pale grey, strongly silty, sand 20%, very fine grained.
515	520	Sand, fine grained, well sorted, rounded, mudstone 5%, dark green.
520	530	Sand, very fine grained, Mudstone 40%, dark green, very weakly sericitic.
530	535	Mudstone, pale grey-green, moderately silty, sericitic, Sand 40%, very fine grained, minor biotite.
535	545	Mudstone, dark green grey, very weakly sericitic, sand 20%, very fine grained.
545	550	Sand, fine grained, well sorted, rounded, minor pyrite, mudstone.
550	575	Mudstone, dark green grey, massive, very weakly sericitic, sand 10%, very fine grained.
575	590	Quartz sand, fine grained, well rounded, sorted minor pyrite, feldspar.
590	595	Mudstone, dark green, massive, sand, fine grained.
595	605	Sand, fine grained, well sorted, rounded, minor pyrite.
605	620	Mudstone, dark green, massive.
620	625	Sand, clean, fine grained, well sorted, rounded, minor pyrite.
625	630	Mudstone, dark green.
630	635	Mudstone, dark green, moderately silty, sericitic.
635	670	Sand, fine grained, well sorted, rounded.
670	675	Sand, 50%, fine grained, mudstone 50%, dark green.
675	680	Mudstone, dark green, sand 30%, fine grained.
680	685	Sand, very fine grained, well sorted, rounded.
685	690	Sand, medium grained, silty sand 30%. Mudstone 10%, dark green, strongly calcareous.
690	700	Silty sand, clay 15%, white, strongly calcareous.
700	705	Quartz sand, medium grained, moderately sorted, poorly rounded, silty sand 10% fine grained, mudstone 10%, dark green, minor feldspar.
705	710	Silty sand, fine grained, clay 30%, sand 10%. medium grained, strongly calcareous.
710	725	Sand, fine grained, well sorted, rounded, silty sand 10%, minor feldspar.
725	740	Sand, medium grained, well sorted, rounded, minor feldspar.
740	745	Silty sand 50%, pale grey, sand 50%, medium grained, strongly calcareous.
745	750	Quartz sand, fine grained.
750	760	Mudstone, dark grey green.
760	765	Sand, very fine grained, well sorted, rounded, minor feldspar.
765	770	Sand, medium grained.
770	775 TD	Sand, medium grained, Mudstone 20%, dark green.

TABLE 1

TEMPORARY NUMBERS, WARRINA RUN 2/144/1, 2, 3 etc.

A. Seismic holes - S.A.D.M. TX line (drilled 1968)

Number	Area of Discharge (m^2)	Flow(area evaporation - l/sec)	Flow (gph)	Remarks
17	3600	0.3	250	TX 97
18	1800	0.13	100	TX 94
*19	10900	0.9	700	TX 84 - area estimated

* Note - WARRINA RUN 2/146/19

B. Seismic holes - Pexa PYH and PYC lines (drilled 1970)

Number	Area of Discharge (m^2)	Flow(area evaporation - l/sec)	Flow (gph)	Remarks
1	24200	2	1600	These holes were drilled along PYC line and occur between PYC 95 to PYC 105
2	12100	1	800	
3	3600	0.3	250	
4	12100	1	800	
7	9700	0.8	650	These holes were drilled along the PYH line and occur between PYM 90 to PYH 106.
8	20600	1.7	1350	
9	20600	1.7	1350	
10	25400	2.1	1650	
11	23000	1.9	1500	
12	19400	1.6	1250	
13	16900	1.4	1100	
14	145200	11.8	9350	
15	6000	0.5	400	
16	10900	0.9	700	

C. Bores and springs near old Nilpinna (for comparison)

Number	Area of Discharge (m^2)	Flow(area evaporation - l/sec)	Flow (gph)	Remarks
4A	86700	6.8	5400	One Mile Bore-no flow on record
5	66500	5.4	4300	Small springs, old homestead bore (blocked) and Garden bore (State No. 6041/21) all contribute to this flow. Garden bore has been estimated at 6.41/sec previously.
6	50820	4.1	3250	Birribirriana Springs. Flows-good supply. No estimate (State No. 6041/20)

TABLE II - BORE DETAILS - CHEVRON BORES

HOLE	REFERENCE	BORE TEMP. (°C)	DEPTH (m)	FIELD CONDUCTIVITY	FIELD SAL. mg/l	LAB. SAL. mg/l	pH	SUPPLY(l/sec) E - Estimated G - Gauged
LHDH2	ANNA CREEK RUN 5/051/2	-	137.2	No leakage - bore fitted with headworks. Probably no artesian flow.				
LHDH3	UMBUM RUN 4 032/1.State No. 6141/38	26	25.3	8×10^3 @ 25°	4800	3900	7.6 (Merck Paper pH = 6.8)	2.5-3.8 (estimated by Chevron) but capped & slight leak.
LHDH3A	UMBUM RUN 4 032/1A State No. 6141/39	-	24.4	-	-			Capped - no flow
LHDH 5	UMBUM RUN 4 034/3 State No. 6141/40	29 (in pool)	120.4	7.8×10^3 @ 29	4330	3580	7.3 (Merck Paper pH = 6.8)	0.7(E).Some leakage occurs via the confining beds.Chevron estimated 5.0-6.3.
LHDH 6	UMBUM RUN 4 033/2	-	143.3	1.3×10^4 @ 29	7220	3830	7.4	9-14(E).Bore sealed. Flow outside casing.
LHDH 7	ANNA CREEK RUN5/051/1	31	157	8.5×10^3 @ 28	4810	3925	7.1	28.6(G).Chevron estimated 38-50.
LHDH15	WARRINA RUN RUN 1/026/6	31	86.9	4.3×10^3 @ 28	2430	2030	8.1 (Merck Paper pH = 6.5)	31.1(G).Chevron estimated 50-63.
LHDH16	UMBUM RUN 2 134/2 State No. 6141/41	31	94.5	4.6×10^3 @ 31	2460	1980	7.6 (Merck Paper pH - 6.9)	2(E)

TABLE III

<u>Bore Details - Shell SDA 13, 14 and 15</u>

HOLE NO.	DEPTH (m)	TEMPERATURE (°C)	FIELD CONDUCT. us/cm @ °C	FIELD SAL. mg/l	LAB. SAL. mg/l	FLOW l/sec	CASING & REMARKS
SDA 13	83.8					2-6	No casing Flow estimated
SDA 14	193.6	Apparently not flowing					No casing
SDA 15	236.2	31°C	3.6×10^3 @ 29	2000	1650	7.4	5-10 m of 150 mm casing offset and blocked.

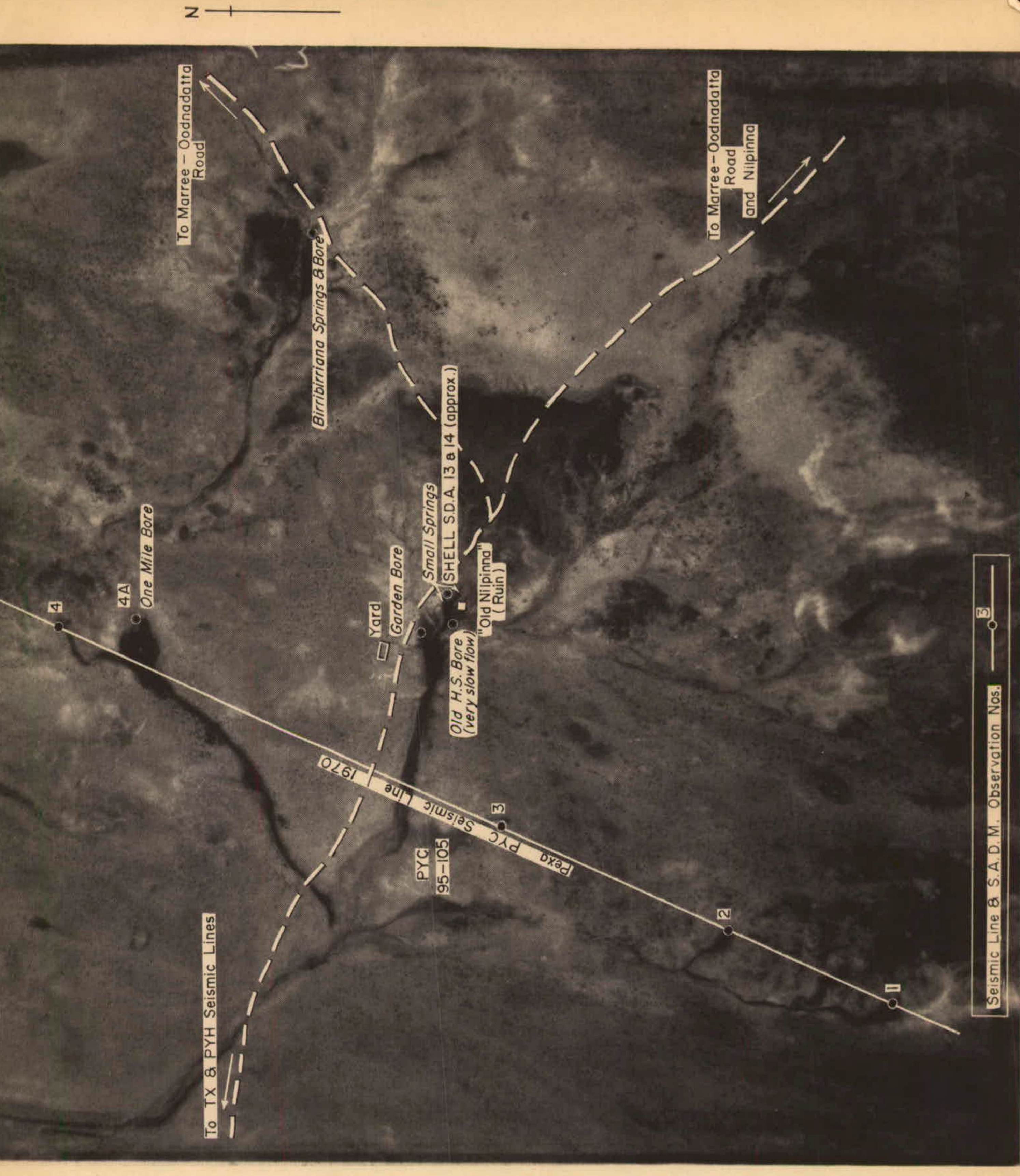


PLATE 1

PEXA SEISMIC SHOTHOLE LOCATIONS — PYC LINE

SCALE 1: 29 300

Aerial photo..... Svy 1503, No. 144.

Del. P.G.Y. Compiled A.F. Williams

S 11153

PLATE 2

S.A.D.M. & PEXA SEISMIC SHOTHOLE LOCATIONS — TX & PYH LINES

SCALE 1:29 300

Aerial photo.... Svy 1503., No. 146.

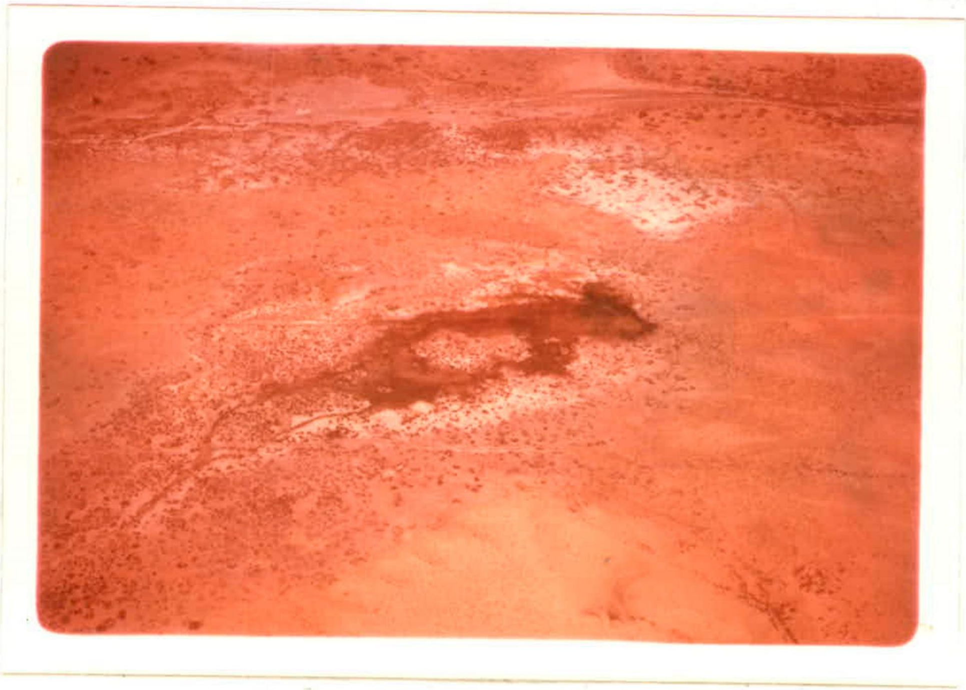
Del. P.G.Y. Compiled A.F. Williams

S 11154

PLATE 3

1. Looking west at shothole 17 (S.A.D.M.). Neg. No. 10636 (Slide).

Photo R. Hancock, Nov., 1973.



2. Looking westnorthwest at shothole 12. Neg. No. 10635 (Slide).

Photo R. Hancock, Nov., 1973.

PLATE 4

(i) LHDH 3. Neg. No. 25988

(ii) LHDH 5. Casing in pool in Centre of photo. Neg. No. 25993

(iii) LHDH 6. Note casing behind black board. Neg. No. 25989

(iv) Downstream from (iii) Neg. No. 25990.

(v) LHDH 6. Seeps around edge of rise. Neg. No. 25991.

(vi) LHDH 7. Neg. No. 25987

PLATE 5

(i) LHDH16. Neg. No. 26001
(Blackboard incorrect)

(ii) LHDH15. Correct reference
WARRINA RUN1/026/6. Neg.
No. 26002 Slide 10622

(iii) Left. SDA15
Casing buried
about 0.1 m below
centre of pool.
Neg. No. 26003
Slide 10623.

(iv) Left. SDA15
Bore near top
centre position
(dark patch).
Surrounded by
water and sa-
turated clay
soil overlain
by gibbers.
Neg. No. 10624
(Slide).

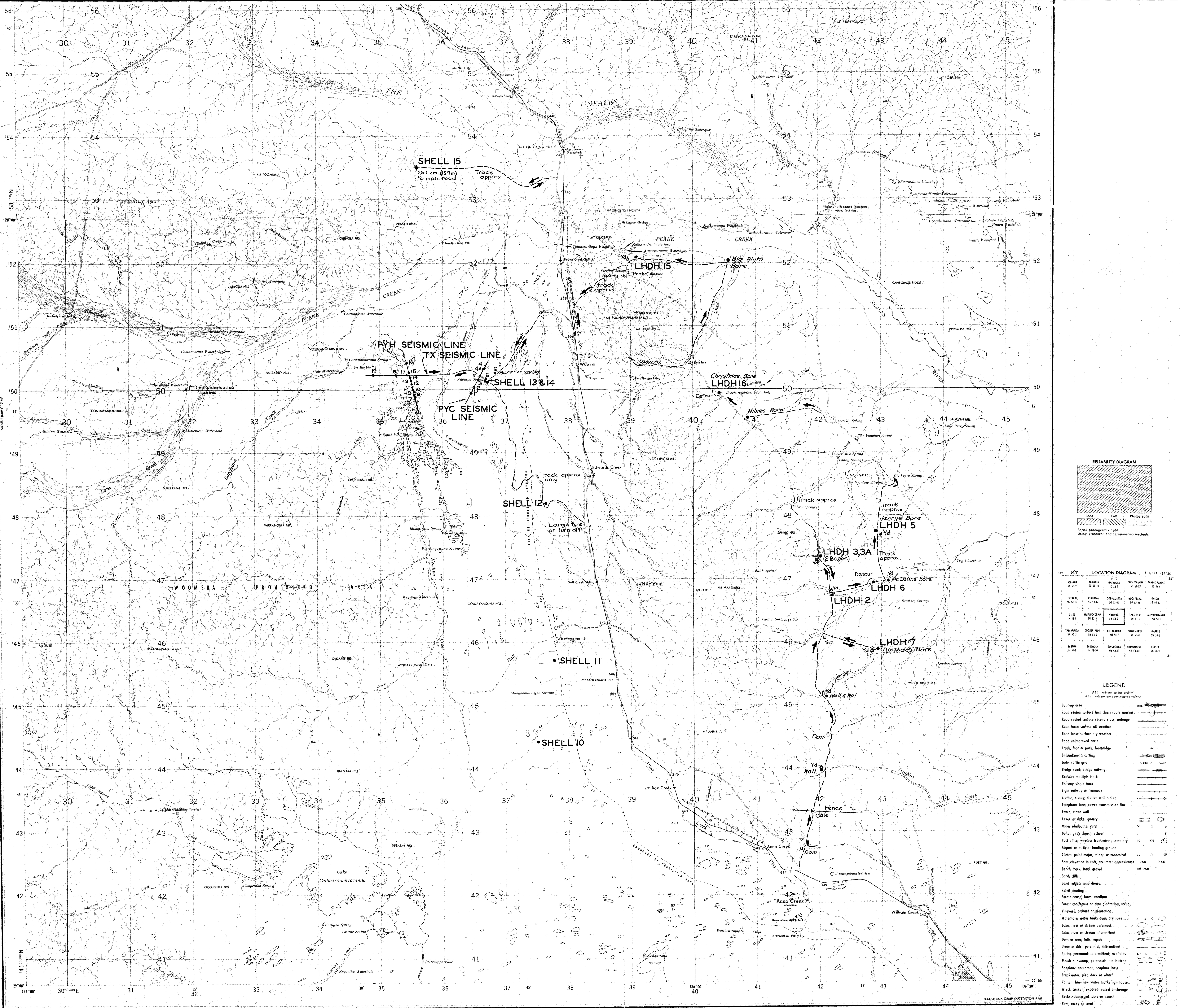


FIG. 2

- LHDH 3 Chevron Bores (1973)
- SHELL 13 Shell Bores (1974) [≡ S.D.A. 13 in text]

1–4
7–16 Seismic shot holes - Pexa (1970)
Note : 17, 18 & 19 are probably D.M. holes (1968)

Suggested route for inspection or rehabilitation work.

DEPARTMENT OF MINES — SOUTH AUSTRALIA			
GREAT ARTESIAN BASIN — BOREHOLE INSPECTION LOCALITY AND ACCESS PLAN FOR FLOWING EXPLORATION BORES			
HYDROGEOLOGY SECTION A.F.Williams	A.F. Williams GEOLOGIST	Drn. A.F.W.	SCALE: 1:250 000
		Tcd. A.F.	74 – 1076
		Ckd. A.F.	
Director of Mines		Exd.	DATE: December 1974

6042, 6041, 6141, 6040, 6140