DEPARTMENT OF MINES

SOUTH AUSTRALIA

GEOLOGICAL SURVEY

ENGINEERING GEOLOGY DIVISION

HONEYMOON DEPOSIT URANIUM LEACHING PROJECT PROPOSED PROGRAMME FOR AQUIFER TESTING AND GROUNDWATER POLLUTION CONTROL

by

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DEPARTMENT OF MINES
SOUTH AUSTRALIA

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SUMMARY AND CONCLUSIONS

1. Basic hydrogeological information, without which detailed pollution control and monitoring operations cannot be planned, is not available for the Honeymoon uranium deposit. In particular:-

   (i) A fully penetrating exploration well is needed to obtain representative water samples and potentiometric levels for all aquifers in the orebody itself and in the sequence overlying it. If water quality is shown to vary substantially within the channel sands two more similar wells will be required. Cable tool drilling is appropriate and the cost is estimated at $20,000 per hole.

   (ii) The basal sand aquifer should be tested by constant dischage pumping for 72 hours, using the cable tool hole as the production well, with 4 observation wells to be provided by Minad.

   (iii) The upper sand aquifer should be tested similarly if an aquifer is shown to occur above the channel sands using a production well and two observation wells drilled by Minad.

2. Groundwater quality monitoring prior to and during leaching can be achieved with two sets of observation wells.

   (i) A set of 20-25 wells should be constructed 12 months prior to the commencement of leaching operations, to monitor the basal sand aquifer peripheral to the orebody.

   (ii) If an aquifer is shown to occur above the channel sands a grid of 20-25 wells should be completed in it across the area above the orebody; these should be drilled 12 months prior to the commencement of leaching operations.

3. There is no likelihood of contamination of the aquifers of the Great Artesian Basin by the leaching operations.

4. Basic hydrogeological information (water quality and hydraulic information for each potential aquifer) should be obtained at a much earlier stage in any other similar exploration programme, so that well completion methods can be determined and pollution monitoring operations can be planned at an earlier stage, with adequate data.

5. Future drill-holes in the area must be abandoned with cement plugs set between aquifers.

6. A consulting group as AMDEL should be employed for on-site water sampling and analyses.

INTRODUCTION

Currently Mines Administration Pty. Ltd. are conducting exploratory drilling programmes for sedimentary uranium deposits in the southern Frome Embayment. A visit was made to Curnamona by the authors from 23.11.76 to 25.11.76, to inspect drill sites, drilling operations and sampling techniques and to hold discussions with geologist Grant Ellis of Mines Administration. Discussion of equipment and method for constructing wells for hydrogeological information was held with Bill Anderson, overseer for Sides Drilling Contractors.

This report proposes an investigation of the groundwater to establish baseline values prior to in situ leaching trial tests and commencement of production, and outlines monitoring operations aimed at early detection of pollution which could be caused by the leaching operations.

REGIONAL GEOLOGY

The Frome Embayment contains shallow marine deposits of upper Jurassic and Cretaceous age, overlain by Tertiary and

Quaternary terrestrial sediments. Near the Honeymoon ore deposit, the Cretaceous-Recent sediments are slightly more than 120 metres thick, and they rest on pre-Cambrian metamorphic rocks.

The Tertiary sediments in the southern portion of the embayment are of particular interest. The early Tertiary deposits (Palaeocene-Eocene Eyre Formation sands and clays) are found within distinct palaeochannels incised into the older sediments and sometimes the basement rocks, and are mineralised in places. They are blanketed by lacustrine silts and clays, of the Miocene Namba Formation and then by Quaternary sands and clays (Figure 1).

The Yarramba Channel (Brunt, 1976), which includes the Honeymoon and East Kalkaroo Deposits, contains a thickness of up to 55 metres of channel fill deposits, incised into Cretaceous clays and silts, and overlain by Tertiary and Quaternary clays, silts and minor sands 60-70 metres thick. The main uranium mineralisation in the Honeymoon Deposit coats coarse quartz sand grains in the lowest of three sand beds within the channel.

HYDROGEOLOGICAL DRILLING PROGRAMME

One cable-tool hole should be drilled by the Department of Mines to the base of the orebody (125 metres) to obtain water samples from each separate sand bed, and several samples from thick sands, to be analysed for all the constituents appropriate for basic information, some of which will later be used during monitoring (see Appendix 2). Casing will be driven to obtain water levels from each sand, to allow an assessment of the hydraulic separation between the aquifers.

Specifications are in Appendix 1 and the estimated cost is $20,000, excluding the cost of the numerous water analyses,

which might be carried out by AMDEL, on site.

The hole will be completed with a sand-screen fully penetrating the basal sand to allow it to be used as a production well for subsequent aquifer test.

The aim is to obtain the basic hydrogeological information necessary to design pollution monitoring programmes, and it cannot be achieved except with cable-tool drilling. It is expensive because of the proportion of rig time used for basal sampling and water level measurement, and comparison with rapid, open-hole rotary drilling is irrelevant, as this method cannot meet the sampling requirements.

PROPOSED AQUIFER TESTING PROGRAMME

Aquifer testing is required for two reasons.

1. Determination of aquifer parameters of the Basal Sand aquifer and its confining bed is needed to predict the effects of leaching operations and the rate of movement of any inadvertant pollution.

   This test could utilise the Department of Mines cable-tool hole for production, with four rotary drilled (Mines Administration) observation wells, three in the basal sand and one in the middle sand (as shown on Figure 1).

   Measurement of the potentiometric level in the middle sand with the separate observation well would enable the amount of leakage between the sand beds to be calculated.

2. If an aquifer is shown to occur overlying the channel sands a test in the upper sand is required to test for leakage through the clay that overlies the channel

sands. This test could also supply information for flow rate calculations within the channel sands. This test would require a production well fully penetrating the upper sand, and two observations wells, one in the upper sand and one in the aquifer above the clay. They could be rotary drilled by Mines Administration, with careful aquifer sand sampling for well screen selection.

GROUNDWATER CONTAMINATION AND MONITORING

The main pre-requisite for any assessment of groundwater pollution is sufficient background data so that deviations greater than natural fluctuations can be recognised. As there are no hydrochemical data available, the monitoring proposals made here can only be in general terms.

The list of constituents to be analysed from water samples taken during monitoring are summarised in Appendix 2 and have been chosen with reference to the criteria used by the Texas Water Quality Board.

The list should be strictly adhered to during the phase of compilation of background information. Subsequent relaxation may be possible depending upon the results - in particular an indicator such as ammonia, or Total Nitrogen, could be used for most routine monitoring, with the complete suite of anlayses performed at less frequent intervals or whenever the indicator suggests that pollution has taken place.

Three leakage paths are available from the orebody.

1. <u>Along the sand beds of the palaeochannel</u>

   This is the most direct and most likely path for the migration of fluids, and there are three possible approaches to the problem.

1.1 Ignore it as a pollution problem, as the available (limited) data suggests that any better quality (<5,000 mg/l) groundwater is to be found above the clays which consistently blanket the channel (Grant Ellis, Mines Administration, pers. comm.). Any leaching operation would of necessity involve monitoring wells to ensure that pregnant solutions were not leaving the area, and a serious loss would be detected and remedied for purely economic reasons. After the completion of mining, hydraulic gradients would be similar to those at the start (a requirement, not an assumption), groundwater movement would be slow (quantitative data is not yet available) and the uranium in solution would probably precipitate in the different Eh/pH environment out of the ore-body. The ammonium carbonate leachate would not be a serious problem in an aquifer with water salinity of the order of 10,000 mg/l.

These arguments make assumptions about the water quality in the channel sands, their implied lack of future development, and cannot be supported, particularly when the expected public interest is considered.

1.2 Monitor the operation with a row of perimeter holes (closely spaced observation wells) to allow sampling at varying depths by setting expandable packers, or by the construction of separate holes to each channel sand at each monitoring point. This is considered essential, and details depend upon the results of cable tool drilling. The wells should be constructed

a minimum of 12 months before leaching starts and it may be necessary to sample them at 5 metre intervals, or within each sand bed it more appropriate, to establish baseline water quality data. Several of these wells should be sampled monthly until leaching operations begin, to determine the natural variations in water quality. The number of wells sampled, and number of intervals within each well, will depend upon the data obtained from the initial sampling.

During leaching operations the basal sand should be sampled at least weekly, and tested for a simple indication of pollution (such as ammonia). If pollution is indicated, then analysis for all components must follow, and remedial action must be taken.

1.3 Prevent outward migration, by the construction of peripheral injection wells across the palaeochannel on each side of the orebody. Injections of aquifer water to raise potentiometric levels along each row would prevent migration of pollutants out of the area. The spacing of these wells, and the number of potentiometric level monitoring holes necessary, cannot be calculated until aquifer parameters are known. Monitoring would also be necessary, but with a smaller number of wells than in 1.2.

2. Into any aquifer above the palaeochannel

Leakage through the clays separating the channel sands from each other and from any upper aquifer may occur under the influence of injection pressures but will be very slow. The leakage rate could be calculated from an

aquifer test of the upper channel sands. Leakage is more likely to occur because of faulty well construction, and it could be argued that there should be a monitoring hole in the upper aquifer adjacent to each injection well if it can be shown that the head difference under the influence of injection would cause upward leakage. The head difference under the influence of injection must first be established, and if upward leakage could occur a grid of monitoring wells should be constructed over the area of the orebody. Approximately 25 wells in 3 rows along the long axis of the orebody would be appropriate, with identical monitoring to those in the basal sand. The wells should be completed in a way that will allow sampling of the basal section of the aquifer.

3. Into the Cretaceous sediments flanking the palaeochannel

The Cretaceous sediments have been described as 'mud-stones' and on that basis are unlikely to be a problem. Grant Ellis has reported minor sand within the sequence and cable-tool drilling would have to be carried out before an assessment of the need to (or possibility of) construction of monitoring wells can be assessed. Monitoring of the Cretaceous aquifers (if they are shown to exist) will not be necessary unless:-

(1) Pollution is proved in the adjacent Tertiary sediments, and/or

(2) The orebody is too close to the edge of the channel (i.e. closer than the spacing between the basal sand monitoring wells) to allow effective monitoring of the basal sand aquifer between the orebody and the edge of the channel. This is not likely to apply for the Honeymoon deposit.

(3) Detailed investigations of the Cretaceous sediments are not considered warranted unless serious pollution is proved in the adjacent channel sands.

POSSIBLE CONTAMINATION OF GREAT ARTESIAN BASIN BY THE LEACHING OPERATION

One source of public concern may be the fear that the good quality groundwater of the Great Artesian Basin could inadvertantly be contaminated by solutions from the leaching operation.

Although the movement of groundwater in the southern Frome Embayment is likely to be to the north, preferentially along the channel sands, it is unlikely that water in the Tertiary channels could affect the Jurassic aquifers of the G.A.B. All the work carried out to determine the direction of groundwater flow in the G.A.B. (e.g. in Ward (1946), p. 60) suggests that the main aquifers do not extend south of Lake Frome, and that flow is to the south, i.e. that the area is one of groundwater discharge from the G.A.B. aquifers. Even if the Tertiary channels were eroded into the Jurassic aquifers of the G.A.B. (and that would be very difficult to prove or disprove) available data suggests that the groundwater flow direction would be from the Jurassic sand into the Tertiary sand.

COMPLETION OF EXPLORATION AND PRODUCTION/INJECTION WELLS

All exploration wells that have been drilled in the area have been abandoned open-hole, without any cement plugs to ensure protection of separate aquifers. In the Honeymoon deposit area there is very little hydrogeological data available, the best reported information being that of Chugg and Pontifex (1959) for the similar Curnamona area, 100 km to the west. Discussion with Mr. Grant Ellis and David Brunt, the Mines Administration

geologists working in the area, helped in the general assessment of the hydrogeology as it affects well completion.

It is likely that the palaeochannel sands can be regarded as one aquifer system, with a consistent clay layer acting as an upper confining bed, with an unconfined aquifer system overlying it in places. Mr. Brunt considers that it is absent near the Honeymoon Deposit. The water quality in the upper aquifer is probably better than the lower, and the hydraulic relationship between them is not known.

The minimum requirement for abandonment of every exploration well in areas where an upper aquifer occurs is for an adequate cement plug to be set in the clay interval which overlies the chnnel sands, for groundwater resource protection.

The leaching operations will be confined to the basal sand within the channel deposits, and any hole left open which penetrates that sand will allow leakage of leaching solution out of the orebody into the overlying middle member sand. Mining operations therefore may dictate that exploration wells have a cement plug set in the clay immediately above the basal sand, and that production/injection wells must be pressure cemented from the top of the basal sand to the surface.

Until water quality data are available for the separate sands within the palaeochannel, it is not possible to set conditions for abandonment in that part of the section. Future exploration programmes should obtain basic hydrogeological information at the commencement of the drilling programme, as the best time to ensure that hydraulic seals are provided where necessary is at the completion of drilling of each hole.

SAMPLING AND ANALYSIS TECHNIQUES

It is proposed to complete observation wells with 75 mm PVC (Class 12 costs $4 per metre) rather than with standard 150 mm water well casing $16.50 per metre). The proposed grid of observation wells amount to about 4,000 metres of casing, not allowing for several wells to different aquifers at each location. The PVC casing would therefore cost $50,000 less than the steel.

There are no portable (e.g. electric submersible) pumps available commercially that fit inside 75 mm casing, and it is recommended that work be commenced to develop a sampling tool capable of withdrawing 0.1-0.05 l/sec from a 75 mm hole against a maximum head of 100 metres (potentiometric levels for basal sand are unknown).

The multiplicity of components to be analysed may represent a serious problem in rapid transport of samples to Adelaide, and it is considered that a portable laboratory, on site, will probably be the most sensible approach. This would be needed intermittently during development (e.g. during the cable-tool drilling programme) and almost continuously during production stages. An organisation such as AMDEL could give advice about the most sensible approach, and could presumably provide such a service, and be totally responsible for sample collection, analysis, and reporting on results.

J.D. WATERHOUSE,
GEOLOGIST.

J.C. BEAL,
GEOLOGIST.

12th January, 1977
JDW:JCB:ST

REFERENCES

Brunt, D., 1976. Preliminary evaluation of *in situ* leaching on M.T.A. Uranium deposits in the Lake Frome area, South Australia. Confidential report - Mines Administration Pty. Ltd., stored in Envelope 2511 - IV, S. Aust. Dept. Mines.

Chugg, R.I. and Pontifex, I.R., 1959. Report on groundwater conditions and prospects, Curnamona Pastoral Co., Pastoral Leases 1899, 1826 and 1846, pastoral plan 5 north. S. Aust. Dept. Mines unpub. rept. 48/162.

Hunkin, G.G. The Environmental Impact of Solution Mining for Uranium. Mining Congress Journal Oct. 1975.

Ker, D.S., 1966. The Hydrology of the Frome Embayment in South Australia. Rep. Invest. S. Aust. Dept. Mines, 27.

Lackey, J., 1974. Solution Mining (In Situ Leaching). A Literature Survey. AMDEL Rept. No. 988, Australian Mineral Development Laboratories, Adelaide.

Texas Water Quality Board. Permit to Dispose of Wastes to Atlantic Richfield Co. (Clay West Mine) 30th July, 1976.

Ward, L.K., 1946. The occurrence, composition, testing and utilisation of underground water in South Australia, and the search for further supplies. Bull. Geol. Surv. S. Aust. 23 : 281 pp.

Waterhouse, J.D., 1976. Hydrogeology of the Honeymoon deposit uranium leaching project, Lake Frome - Stage 1 - Summary of Regional Hydrogeology and Proposals for further Investigations. S. Aust. Dept. Mines unpub. rept. 798.

APPENDIX I

Cable Tool Hole Specifications

DOCKET NO. E.L. 259 ..... PROPOSED HOLE NO. .....

FILE NO. .....

SOUTH AUSTRALIAN DEPARTMENT OF MINES

PROPOSAL FOR CABLE TOOL/~~ROTARY/HAMMER~~ DRILL HOLE

CLIENT : Mines Administration Pty. Ltd.

AUTHORIZATION OR INITIATION : JDW

CLIENT'S REPRESENTATIVE : Mr. D. Brunt

TELEPHONE : Brisbane 221-2366

PROJECT : Honeymoon Deposit Groundwater testing

WATER/~~DRAINAGE~~ XXXXXXXXX

LOCATION : (SEC. HD. 10 km SE of
(DESCRIPTIVE : Yarramba H.S
(Southern Frome Embayment)

MILITARY SHEET
PHOTO RUN.
NO.
SURVEY

OBJECTIVE OF DRILLING : Production bore fully penetrating "Basal Sand" in Yaramba Channel.
Collection of hydrogeological data during drilling

REQUIRED FINAL SIZE OF HOLE : 200 mm ANTICIPATED DEPTH : 125 m

METHOD OF COMPLETION : screw cap 0.5 m above G.L

REQUIRED DEPTH (IN TERMS OF OBJECTIVES) : Full penetration of Tertiary sequence

CASING PROGRAMME : 200 mm casing run or driven within 2 m of bit throughout to allow water sampling. Pressure cemented to "Lower clay" at 100-105 m. 150 mm stainless steel wirewound screen from approx, 105-115m, with sump resting on basement at 120-125 m

SAMPLING :

Open Tube : As Casing Programme

Sealed Tube : As Casing Programme

Cores : Continuous 105-115 if possible

Others : Sludge samples every 2m Bulk samples for sieve analysis every 0.5 m in sand sections.

WATER SAMPLING :

All waters cut - as directed by site geologist.

ANTICIPATED DRILLING CONDITIONS

FROM (m)	To (m)	LITHOLOGY	Quality (mg/l)	Water Level (m)
0	75	Sandy clay	10 000	50 approx.
75	115	Clay with sand beds	?	?
115	125	Hard clay		
125	-	Basement rock		

STORAGE OF SAMPLES : Core boxes, linen bags for sand samples

SEALED TUBES : To be despatched to Thebarton

GEOLOGIST : J.D. Waterhouse
J.C. Beal

DRILL SITE INDICATION : Geologist on site

NOTE :

This proposal has been prepared solely for use by officers of the Department of Mines; it is not an agreement between the client and the Department.

Date 25 June, 1976.....

DRILLING ENGINEER :

Date .....

APPENDIX II

List of Sample Constituents to be analysed

LIST OF SAMPLE CONSTITUENTS TO BE ANALYSED

Calcium	Ca	Vanadium	Va
Magnesium	Mg	Zinc	Zn
Sodium	Na	Ammonia	NH_3
Potassium	K	Carbonate	Co_3^{--}
Arsenic	As	Bicarbonate	HCO_3^-
Barium	Ba	Sulphate	SO_4^{--}
Boron	B	Chloride	Cl^-
Cadmium	Cd	Fluoride	F^-
Copper	Cu	Nitrate	NO_3^-
Chromium	Cr	pH	
Iron	Fe	Total Dissolved Solids	
Manganese	Mn	Conductivity	
Mercury	Hg		
Molybdenum	Mo		
Nickel	Ni		
*Radon	Ra		
Selenium	Se		
Silver	Ag		
Uranium	U		

*In pci/l

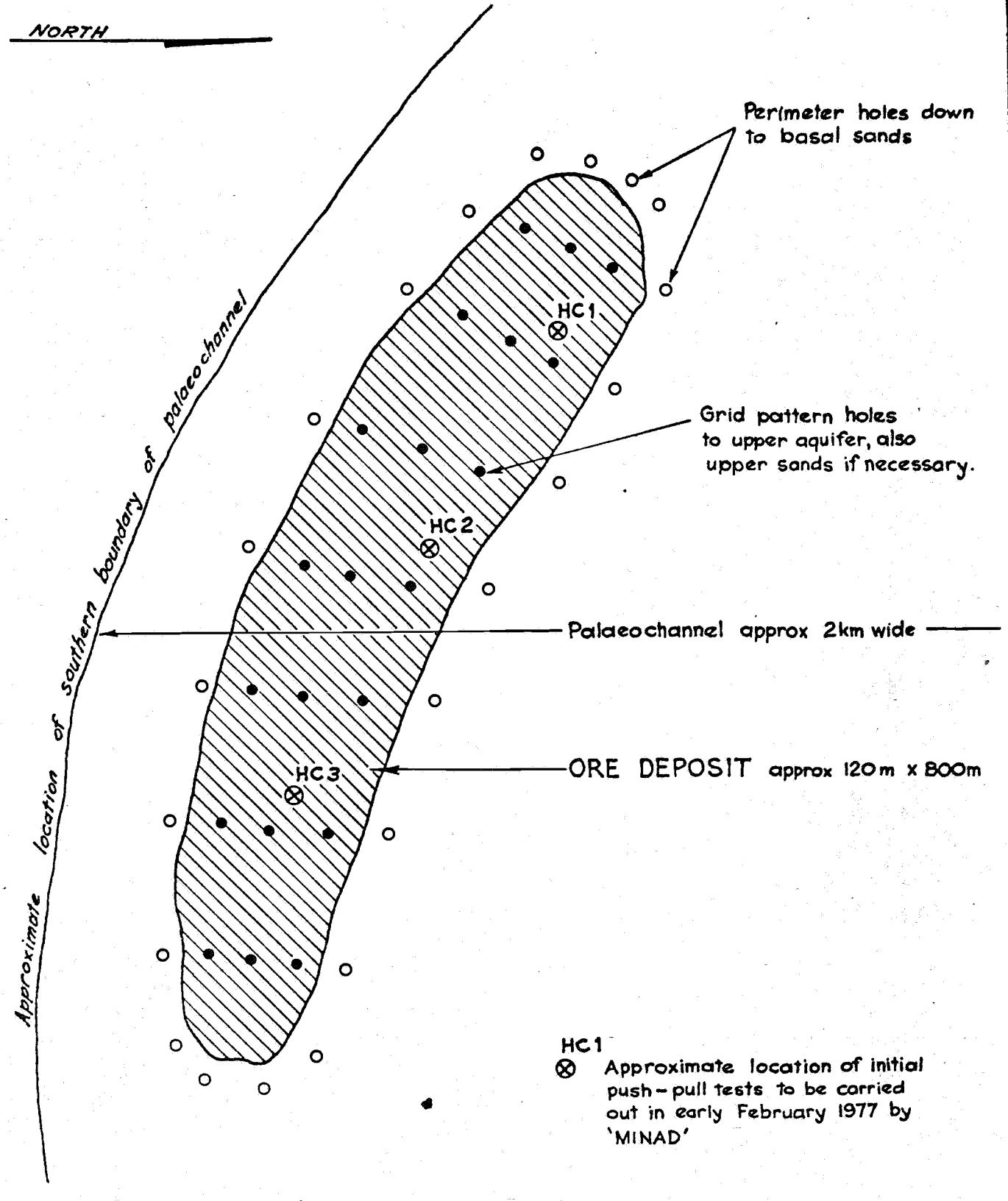

FIG.2

	DEPARTMENT OF MINES—SOUTH AUSTRALIA	Scale: DIAG.
Compiled: J.C.Beal	LAKE FROME URANIUM LEACHING PROJECT HONEYMOON DEPOSIT	Date: 6·1·77
Drn. A.F. | Ckd.	DIAGRAMMATIC LOCATION OF MONITORING WELLS	Drg. No. S12531

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