Northern Territory Government
Department of Infrastructure, Planning and Environment

Report No.: 05/2000A

ROCKY HILL - OORAMINNA
GROUNDWATER INVESTIGATION
2000

R.E. Read & R.J. Paul

Natural Resources Division
Alice Springs

March 2002

EXECUTIVE SUMMARY

The Rocky Hill – Ooraminna area, located 25 km south east of Alice Springs contains freehold blocks, NT Portions 1476 and 4704, ‘the Undoolya Rocky Hill Agricultural Block and the future ‘Rocky Hill borefield’ respectively. It is in the Amadeus Basin, and contains the Ooraminna anticline and a gentle west-plunging syncline, ‘Rocky Hill Syncline’. The Rocky Hill Syncline has a large resource of groundwater in aquifers of the Pacoota, Mereenie and Ooraminna Sandstones and the Pertnjara Group. Because of the shallow dips there is a large area of the Mereenie Sandstone, Ooraminna Sandstone Member and Pertnjara aquifers at economic drilling depth, and an extensive phreatic surface that provides a large volume of available storage. The aquifers are important both as a future water supply for Alice Springs and as a possible source of water for horticulture.

The study was designed to better define the water quality in the area and hence improve the estimate of the volume in storage. This will provide a basis for rational decisions concerning future water allocations of groundwater with less than 1000 mg/L total dissolved solids. Groundwater with less than 500 mg/L should be reserved for Alice Springs water supply.

Seventeen bores were drilled in 2000, including limited core recovery. Ten bores were drilled for EM calibration and did not penetrate below the water table. Two pump tests on one bore were carried out. Ten core samples were petrographically described, and the permeability and porosity tested. Data from earlier investigations for town and horticultural supplies and from oil drilling has been incorporated.

The geology as interpreted from bores does not match the published map. It is believed that some of what has been mapped as Mereenie Sandstone is in fact Ooraminna Sandstone Member. The Mereenie Sandstone, Ooraminna Sandstone Member, and units of the Hermannsburg Sandstone are all lithologically similar and difficult to distinguish in outcrop and in chip samples from air drilling. Bores have been correlated largely on the basis of the gamma logs.

The thickness of the Mereenie Sandstone in the Rocky Hill – Ooraminna area, perhaps as little as 100 m or less in places, is substantially less than the 365 m at Roe Creek borefield. However in part it is overlain by ?Ooraminna Sandstone Member. The transmissivity of the Mereenie Sandstone ranges from about 3000 m^2/day to 20 m^2/day. Transmissivity is generally highest near outcrop and decreases down dip. An average specific yield value of 9.6% was obtained from petrophysical analysis.

A key finding of this investigation is there are substantial aquifers within the Hermannsburg Sandstone, which has previously been disregarded as having no significant aquifers.

A review of water level hydrographs, starting 1963 showed the following points:

- Up to about 400 000 m East the hydraulic gradient in the Mereenie Sandstone has been reversed westward because of pumping at Roe Creek.
- Similarly pumping from the Pacoota Sandstone at Roe Creek has effected the Pacoota Sandstone at Rocky Hill.
- East of 400 000 m East water levels are falling at about 0.1 m per year. This is believed to be the decay of a recharge mound pre-dating the period of record.

- Hydrographs show responses to flows in Roe Creek and the Todd River, but the overall effect is small. An average recharge rate of 2,000 ML/year was derived by volume change calculations.

Most of the area contains water of less than 1000 mg/L TDS. Low HCO_3/Cl near Roe Creek and to a lesser extent near the Todd River indicates that some recharge occurs. At the eastern end of the syncline salinities rise up to 6 000 mg/L, indicating a present or former discharge zone.

Stored volume in the Mereenie Sandstone and Ooraminna Sandstone Member was calculated by drawing simple sections across the syncline, calculating the area of aquifer in the cross-section, hence the volume of aquifer and, by assuming an effective porosity, the volume of water in storage.
Effective porosity of the Mereenie Sandstone was assumed to be approximately 0.10 and that of the Ooraminna Sandstone Member approximately 0.08.. The estimated stored volumes of water between 391 000 E and 422 000 E, the approximate extent of water under 1000 mg/L are;

1 002 000 ML to 100 m depth from the surface.
2 692 000 ML to 200 m depth from the surface.

These estimates are conservative. Because of the sparse information about the geometry of the Mereenie Sandstone at depth, the volume has been calculated with the conservative assumption that the dip remains constant. If there is substantial flattening out the stored volume will be greater. The considerable volume stored in aquifers in the Hermannsburg Sandstone, which is mostly under 1 000 mg/L has been ignored.

Water of under 500 mg/L occurs in the southern part of the Rocky Hill Borefield Reserve and extends to the south of it. The boundaries of the reserve should be reviewed by the Controller of Water Resources.

Keywords

Subject	Groundwater Resource Assessment
Geology	Amadeus Basin Pertnjara Group Hermannsburg Sandstone Ooraminna Sandstone Member Mereenie Sandstone Pacoota Sandstone
Location	Rocky Hill - Ooraminna Area Undoolya Station Proposed Rocky Hill Borefield Undoolya Rocky Hill Agricultural Block

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LIST OF ABBREVIATIONS

CRT	constant rate test
EC	electrical conductivity
EM	Electro Magnetic
ID	inside diameter
km	kilometres
L/s	litres per sec
m	metres
mbgl	metres below ground level
mg/L	milligrams per litre
mm	millimetre
RN	registered number
s	drawdown
SWL	standing water level
SS	sandstone
T	transmissivity
TDS	total dissolved solids
µS/cm	microSiemens per centimetre

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1 INTRODUCTION

The Rocky Hill – Ooraminna area is located approximately 25 km south east of Alice Springs (Figure 1.1) and the main investigation area reported upon is defined from Easting (MGA) 385000 to 435000 and Northing (MGA) 7340000 to 7370000. The 2000 investigation drilling also looked at an area near Mount Ooraminna were water levels are approximately 50 metres lower than in the Rocky Hill – Ooraminna area. The areas drilled in 2000 are shown in Figure 1.2.

1.1 History of Groundwater Investigations

Several hydrogeological investigations have included the drilling of investigation bores in the Rocky Hill - Ooraminna area (Figure 1.3). Much of the early drilling was part of the Mereenie Sandstone investigation. This was centred on the source of Alice Springs' water supply, the Roe Creek Borefield area, approximately 15 km south west of Alice Springs. The Mereenie Sandstone is the main groundwater source for the Roe Creek Borefield. The 1970s' investigation was aimed at defining a new borefield at Rocky Hill to supplement production from the Roe Creek Borefield.

The 1998 – 1999 investigation drilling programs looked at the regional setting of the Mereenie Sandstone and Pertnjara Group. The investigation produced improved knowledge on the extent of the resource and allowed decisions to be made on water allocations of groundwater for town water supply and horticultural use. The 1998 – 1999 investigation drilling included drilling of core and drilling of bores specifically designed for isotope sampling. The investigation has been able to better define the geological sequence and to produce maps of water quality and groundwater level contours.

1.2 Other Studies

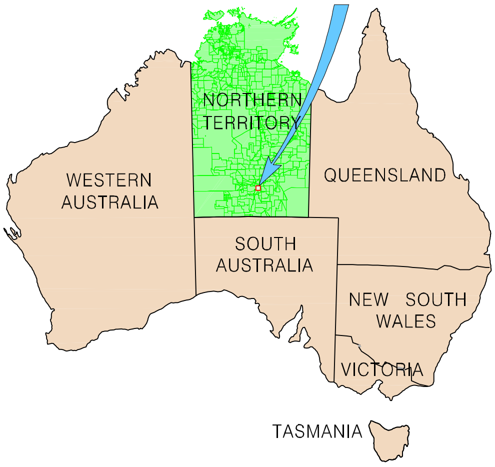
Several other studies were carried out in 1999 – 2000 in the Rocky Hill – Ooraminna area by various agencies.

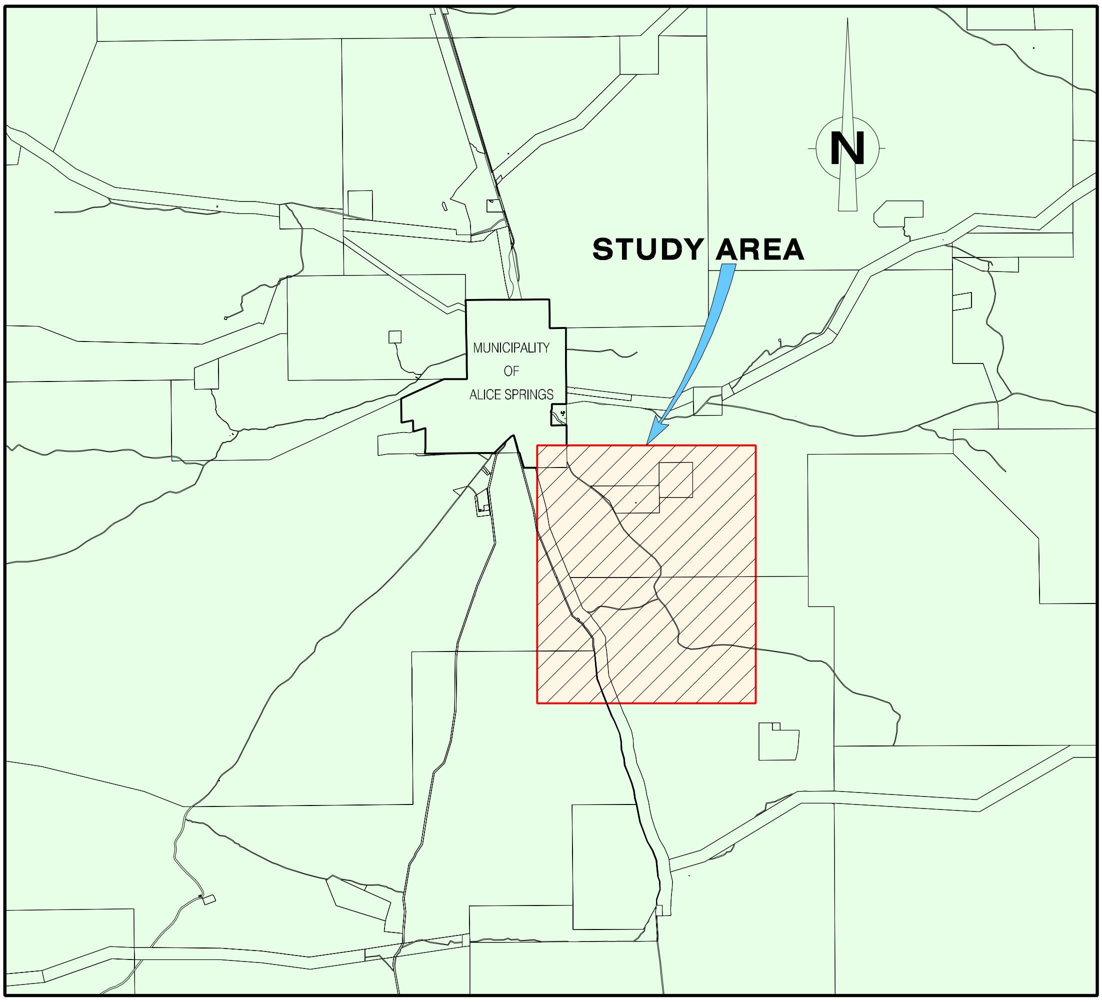
International Atomic Energy Agency (IAEA) are making an assessment on the potential utilisation of long-term isotope responses of hydrological systems, particularly groundwater aquifers, in the quantitative understanding of hydrodynamic changes induced by exploitation. Isotope data were collected from the Mereenie Sandstone at Roe Creek Borefield and surrounding ares in 1977 (Calf, 1978). BRS conducted isotope sampling of the Roe Creek Borefield and Rocky Hill – Ooraminna area in 1999 and 2000, which included re-sampling bores from the 1977 sampling program. The main objective is to see if there has been any long term isotope response from the pumping at Roe Creek Borefield.

Matthew Hales, an Honour's student from the University of Wollongong, completed his thesis on the stratigraphy of the Rocky Hill – Ooraminna area. The primary aim of Hales' thesis was to determine the subsurface stratigraphy of the Rocky Hill _ Ooraminna area from drillhole and local outcrop data.

Gary Humphreys conducted an EM survey along several lines in the Rocky Hill – Ooraminna area in 1999 to get baseline EM readings. There was heavy rain in the first half of 2000 and

MAP LOCALITY





SCALE 1 : 1 000 000 @ A4

kilometres 0 10 20 30 40 50 100 kilometres

Projection: UTM Zone 53 - Central Meridian 135 deg. E

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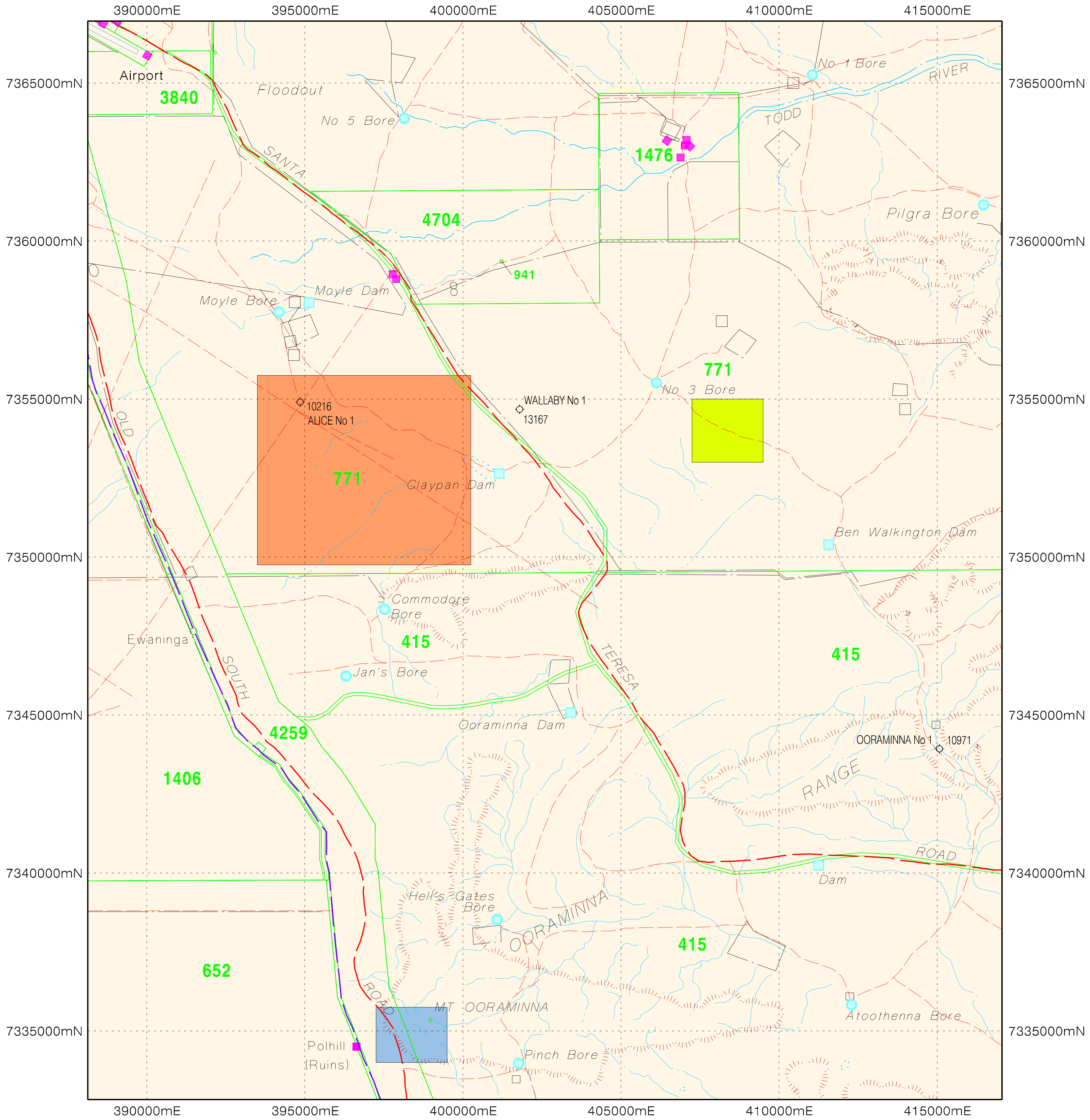
FIGURE 1.1
LOCALITY PLAN



LEGEND

	Cadastral Boundary
415	NT Portion Number
	Fence / Yard
	Unsealed Road
	Vehicle Track
	Abandoned Railway
	Major Drainage
	Minor Drainage
	Range Line / Relief
•	Range Peak
■	Building / Structure
○	Stock Bore
□	Dam
◇	Petroleum Exploration Bore
🟨	2000 Drilling Program Area 1
🟧	2000 Drilling Program Area 2
🟦	2000 Drilling Program Area 3

SCALE 1 : 150 000 @ A3

kilometres 0 1 2 3 4 5 10 15 kilometres

Horizontal Datum: GDA 94   Vertical Datum: AHD   Map Grid: MGA 94 - Zone 53

Projection: UTM - Central Meridian 135 deg. E   Grid Interval: 5000 m

GDA

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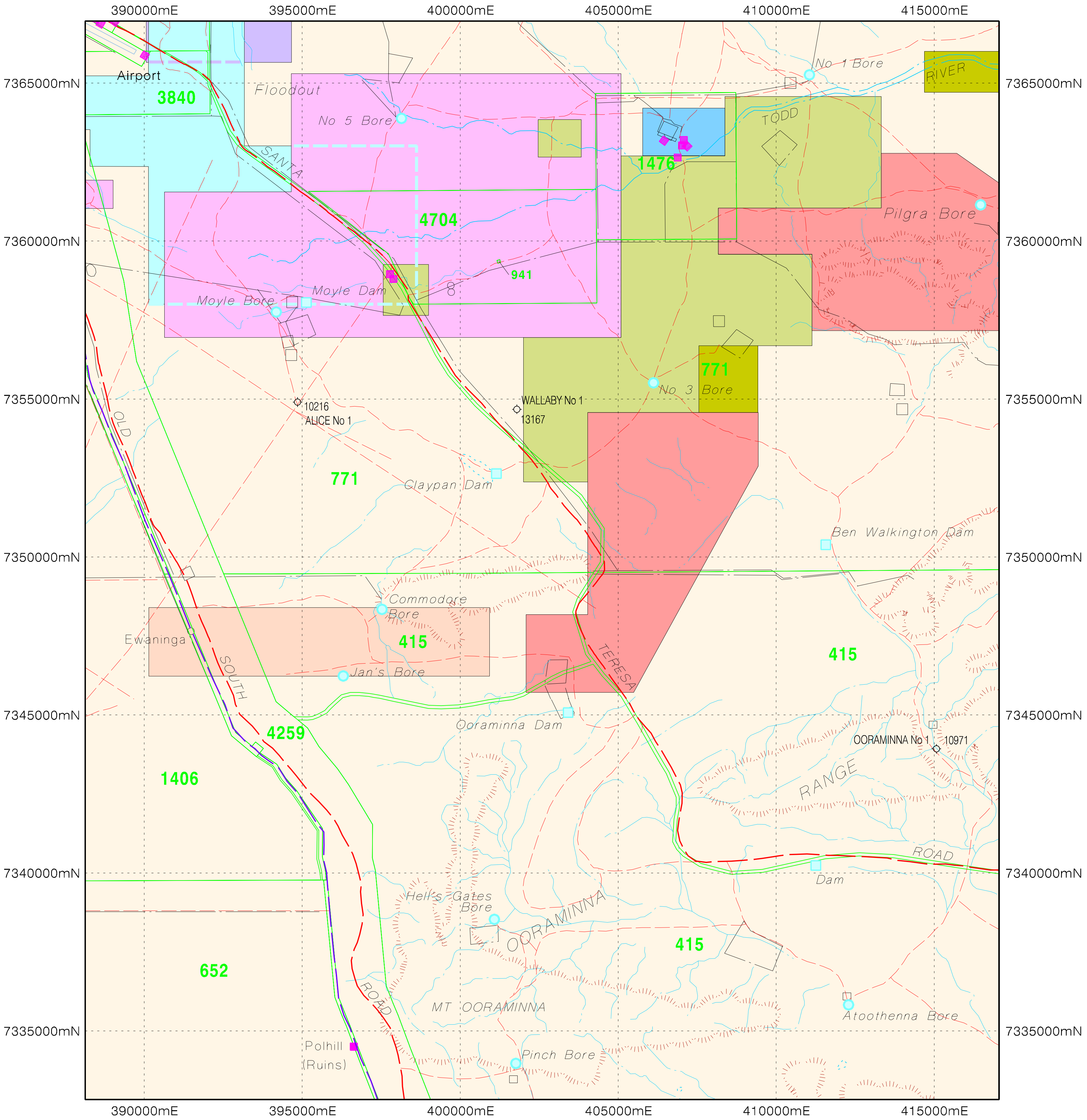
FIGURE 1.2

2000 DRILLING PROGRAM AREAS



SCALE 1 : 150 000 @ A3

kilometres 0 1 2 3 4 5 10 15 kilometres

Horizontal Datum: GDA 94 Vertical Datum: AHD Map Grid: MGA 94 - Zone 53

Projection: UTM - Central Meridian 135 deg. E Grid Interval: 5000 m

GDA

LEGEND

—	Cadastral Boundary
415	NT Portion Number
— · —	Fence / Yard
— —	Unsealed Road
- - -	Vehicle Track
— —	Abandoned Railway
— · —	Major Drainage
—	Minor Drainage
˄˄˄	Range Line / Relief
•	Range Peak
■	Building / Structure
○	Stock Bore
□	Dam
◇	Petroleum Exploration Bore
🟪	Amoonguna Investigation
▭	Mereenie Sandstone Investigation Stage 2
▆	East Emily Investigation Stage 2
🟦	Undoolya - Rocky Hill Agricultural Block Bores
🟪	Rocky Hill Investigations 1974 to 1977
▭	Alice Springs Landcare 1997
🟥	Rocky Hill - Ooraminna Investigation 1998
🟩	Rocky Hill - Ooraminna Investigation 1999

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FIGURE 1.3

PREVIOUS DRILLING PROGRAM AREAS

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several lines were resurveyed in September 2000 to see if any changes in EM values had occurred from the rainfall events. Ten boreholes were drilled to a maximum depth of 50 m and one to a depth of 79 m. These bores were drilled to calibrate the vertical profiles of the lines. The boreholes were terminated above the water table except for the last one, RN17553. This bore penetrated the water table and PVC casing was inserted to construct it as a monitoring bore. The EM bores were geophysically logged with an induction sonde and gamma sonde. Humphreys is analysing the data and will be reporting on the results later.

2 PROJECT AIMS

2.1 Rocky Hill - Ooraminna Stage 3 Drilling - 2000

The Rocky Hill – Ooraminna area has been shown to contain a large resource of water in the Mereenie Sandstone and possibly, from the 1998 and 1999 investigation results, in weathered sandstone of the Pertnjara Group. A hypothesis has been made that the aquifers are not necessarily stratigraphic, but are largely controlled by weathering.

The object of the investigation is to better define the aquifer system including the hypothesised Pertnjara aquifer(s). It is believed that these aquifers may have different hydraulic parameters than the Mereenie Sandstone and this may impact upon extractable volumetric estimates of the groundwater resource. This will have repercussions for a water allocation management plan.

Six investigation sites were initially selected to be drilled, including two deep holes to penetrate the full thickness of the Pertnjara group and terminate in the Mereenie Sandstone. The investigation sites are summarised in Table 2.1 with approximate position, proposed depth, rig time, materials needed and purpose tabulated. Sites 4 and 5 were not drilled due to time constraints. A seventh site was selected east of Alice No. 1 (RN 10216), after drilling RN17536. This site was selected because no bores had been drilled in the area so there was a lack of water quality data in the area.

Site 1 was intended to conclusively show the stratigraphic position of aquifer, Hermannsburg Unit 1 (Dr1), identified in 1999 (Read & Paul, 2000), and to construct a bore that can be used for pump-testing the Dr1 aquifer with RN 17234 as an observation bore. Core samples were taken every 50 metres during drilling.

Site 3, adjacent to Alice No. 1 (RN10216), will test the salinity and yield of aquifers in the Pertnjara Group. The drilling log for Alice No. 1 records a lost circulation zone at 209 metres, which is a possible aquifer zone. The stratigraphy from Alice No. 1 Well Completion report (Pemberton *et al*, 1964) is:

0 – 351 m	Pertnjara Group
351 – 641 m	Mereenie Sandstone
641 – 912 m	Pacoota Sandstone

Site 6 will investigate an anomaly in water levels in the Mereenie Sandstone in the Deep Well and Rocky Hill – Ooraminna areas. The water level in RN11852, in the Rocky Hill – Ooraminna area is approximately 452.8 mAHD (28/08/2001) while the water level in RN17540, in the Deep Well area is approximately 408.4 mAHD (28/08/2001). This is a difference of 44 metres over seven kilometres whereas the gradients in the two areas are approximately 5 metres or less over seven kilometres.

Cores from selected intervals taken during drilling were sent to a laboratory for porosity and permeability analysis and to Matthew Hales for thin section description.

Table 2.1 Rocky Hill – Ooraminna 2000 Groundwater Investigation Sites

Site No	Location	East (MGA)	North (MGA)	Proposed Depth (m)	Rig Time	Materials	Purpose
1.	Near RN17234	408250	7353850	500	3 weeks	Mud drill Core every 50 m 200 mm casing to 220 m Cement plug at about 220 m Test pump	1 To confirm the stratigraphic position of the aquifer Dr1. 2 To pump test the Dr1 aquifer.
2.	Near Ewaninga	397000	7351000	300	3 days	Air drill Core Dr 100 mm PVC 300 m	To test the salinity and yield of aquifers in the Mereenie Sandstone and Pertnjara Group in the southern limb of the syncline.
3.	Near Alice No. 1 (RN10216)	394700	7355000	350 m	3 days	Air drill 350 m 100 mm PVC casing	To test the salinity and yield of aquifers in the Pertnjara Group indicated by a zone of last circulation in Alice No. 1.
4. *	Between RN17394 and RN6504	425500	7365650	250 m	1 week	Mud drill 250 m of 100 mm PVC casing Drill to base of Pacoota Sandstone	1 To better define the extent of the saline water (collect water sample after bore cased). 2 To establish a monitoring point at the east end of the syncline. 3 to locate the base of the Mereenie Sandstone.
5. *	Near RN17392	402840	7356450	500	3 weeks	Mud drill Core Dr and Pzm. 200 mm casing to 260 m Cement plug at about 260 m Test pump	1 To confirm the stratigraphic position of the aquifer Dr3. 2 To pump test the Dr3 aquifer.
6.	Nose of Ooraminna Anticline	398000	7335000	200 m	3 days	Air drill 200 m 100 mm PVC	Investigate compartment boundary between Rocky Hill – Ooraminna and Deep Well areas.
7.	East of RN10216	397800	7354200	200 m	2 days	Air drill 200 m 100 mm PVC	Investigate the water quality were no bore Have previously been drilled.

* Sites 4 and 5 not drilled due to time constraints.

Geophysical logging of all sites was undertaken after drilling with gamma, caliper, electric and fluid resistivity tools. Gamma logs can be a useful tool for helping select lithology boundaries of different units.

Sites 1 was constructed with 200 mm steel casing as a test pumping bore. The bore was open, initially, to the aquifer(s) in the Mereenie Sandstone. Test-pumping was undertaken for 48 hours with an existing investigation bore used as an observation bore. The bore was reconstructed with the Hermannsburg Sandstone aquifer(s) open. Test-pumping was undertaken for 48 hours with an existing investigation bore used as an observation bore.

Out puts from the investigation program are:

- Better definition of the geomorphology and stratigraphy of the Rocky Hill – Ooraminna area through basin / facies analysis and characterisation. This enables better estimates of groundwater storage.
- Further permeability and porosity data to give better estimates of groundwater storage in the different stratigraphic formations including values for the Hermannsburg Sandstone aquifer.

3 REVISION OF STRATIGRAPHY IN THE ROCKY HILL – OORAMINNA AREA WITHIN THE AMADEUS BASIN

Matthew Hales, an Honours student from the University of Wollongong, carried out a geological study of the Rocky Hill – Ooraminna area. His thesis, titled "A Stratigraphic Revision of Cambrian to Devonian Sediments in the Rocky Hill – Ooraminna Area, Amadeus Basin, N.T." has given a different interpretation of the stratigraphy of the Cambrian to Devonian sediments for the area. To determine the subsurface stratigraphy in the Rocky Hill – Ooraminna area he looked at the subsurface stratigraphy of Roe Creek borefield, the stratigraphy at nearby outcrops and samples from the investigation area.

3.1 Techniques Utilised

The techniques used to analyse the stratigraphy at Rocky Hill – Ooraminna were field examination of adjacent outcrops, drill cuttings examination, petrographic analysis, grain size analysis, XRD (X-ray diffraction) analysis and gamma logging. Hales reported varying degrees of effectiveness for the different techniques. The examination of outcrop was effective, in that it provided samples for further analysis, and it provided a section close to the investigation area that could be used for comparison with the underground geology in the borefields. The examination of drill cutting returns showed little to no correlation between holes. The examination of core returns proved much more valuable than the drill cuttings. The core returns allowed examination of the geology in situ and provided samples for petrographic grain size and XRD analysis. Petrographic examination of the core samples and outcrop samples provided the best way to discriminate between stratigraphic units in the Roe Creek and Rocky Hill borefield areas. Distinct differences were found between the stratigraphic units. Grain size analysis and XRD analysis proved only moderately successful. Gamma logging, when used in conjunction with other techniques, proved useful.

3.2 Cored Holes investigated

In and around the Rocky Hill – Ooraminna area a number of holes have been drilled for oil and groundwater investigations. Most holes were drilled by percussion so only cuttings returns are available. Selected holes were drilled during the 1998, 1999 and 2000 investigations using a coring bit. This involved removing the drill string at the desired depth, attaching a three metre core barrel, running the drill string, coring and then retrieving the core barrel by removing the drill string again.

Oil exploration hole Alice # 1 (RN10216), was drilled to investigate a "seismically anomalous area that portrayed both structural closure and events characteristic of reef-type development in the lower Jay Creek Limestone Formation of the Peraoorrta Group" (Pemberton et al. 1964). The hole was drilled through the units of interest in this study and was cored at selected intervals.

Rocky Hill DDH was drilled in 1977 to investigate a gamma spike in borehole RN10919 at 120 metres depth. No stratigraphic log was given by the investigators in the report by Moore (1978).

3.3 Results

Hales (2000) classified all samples into stratigraphic units, compared the results of his study with the results of previous studies (Lau, 1989) (Jolly *et al*, 1994), and revised the stratigraphy of the Rocky Hill borefield. Table 3.1 compares Hales' interpretation with previous interpretations. Figure 3.1 shows the previous generalised stratigraphy and Hales revised stratigraphy.

Table 3.1 Comparison of Geological Interpretations

Lau (1989)	Jolly *et al* (1994)	Hales (2000)
Mereenie Sandstone I, II and III	Mereenie Sandstone Unit A	Pacoota Sandstone Sequence 4
Mereenie Sandstone IV	Mereenie Sandstone Unit B	Mereenie Sandstone
Mereenie Sandstone V	Mereenie Sandstone Unit C	Ooraminna Sandstone Member

The stratigraphy at Rocky Hill – Ooraminna has been difficult to interpret, as the main geological units are all sandstones. A well sited cored hole would give a clearer understanding of the stratigraphy, and hence, a better conceptual hydrogeological model of the Rocky Hill – Ooraminna area.

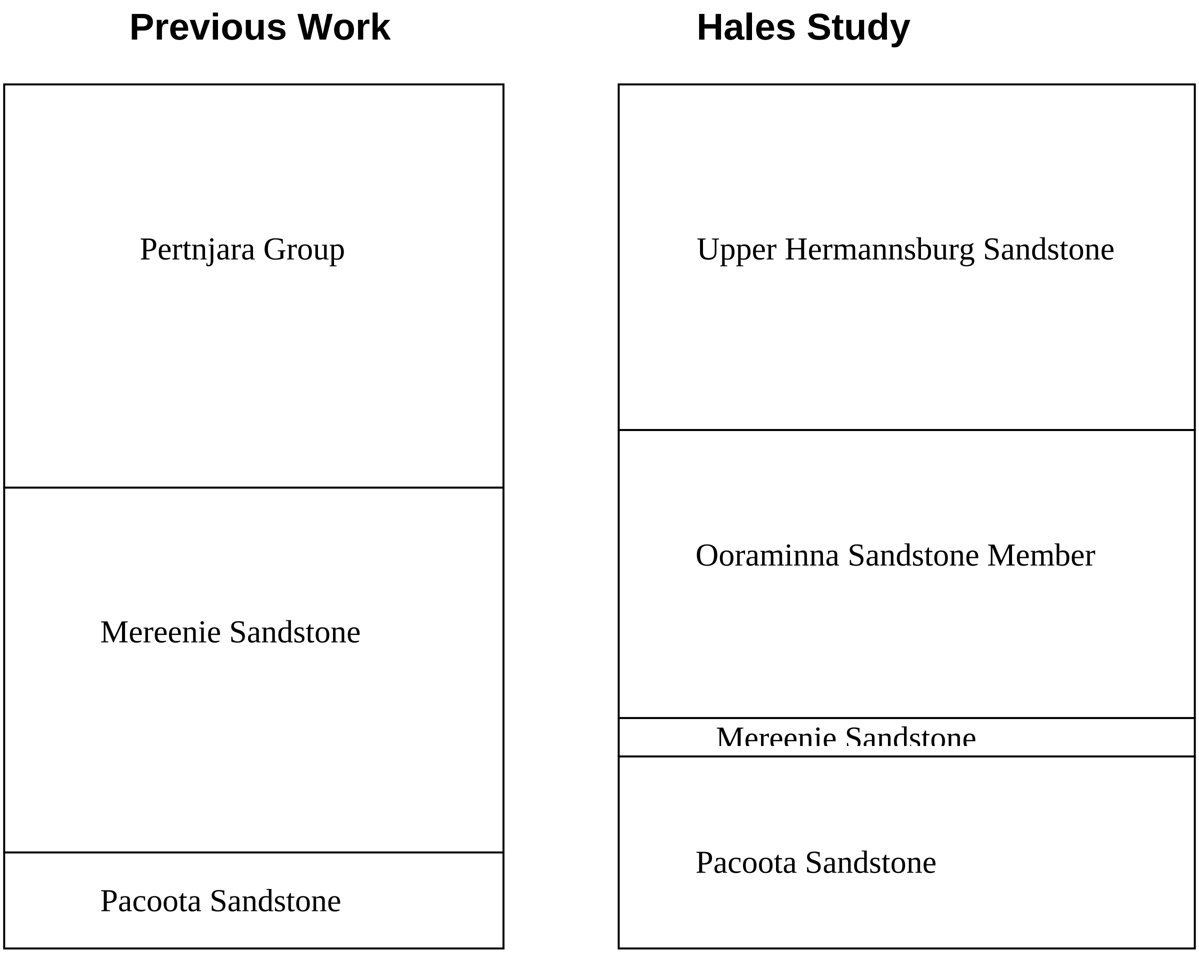


Figure 3.1 Generalised Comparison of Previous Work and Hales Stratigraphic Logs for Rocky Hill – Ooraminna Area

4 DRILLING INVESTIGATIONS

4.1 Pre 2000 Investigation Drilling

Several drilling programs have been carried out to investigate the Mereenie Sandstone near Alice Springs. These programs have included the drilling of investigation bores in the Rocky Hill - Ooraminna region. The bores drilled prior to 2000 by the Government, oil companies, mineral companies, rural block owners and pastoralists are presented in Figure 4.1. Figure 1.2 shows the drilling investigations by project area.

4.2 2000 Investigation Drilling

The 2000 investigation sites were selected to give more information on water quality and geology in the Rocky Hill - Ooraminna area. Four bores were drilled in the Rocky Hill – Ooraminna area and two bores were drilled in the Ooraminna anticline area, south of the main project area. Figure 4.2 shows the locations of the bores and Figure 4.3shows the bores in relation to outcrop / sub-crop geology. The summary of the 2000 investigation drilling is tabulated in Table 4.1. In Figure 4.3 the interpreted tracelines of sub-crop geology do not match the outcrop geology taken from the published geology map (Shaw and Wells, 1983).

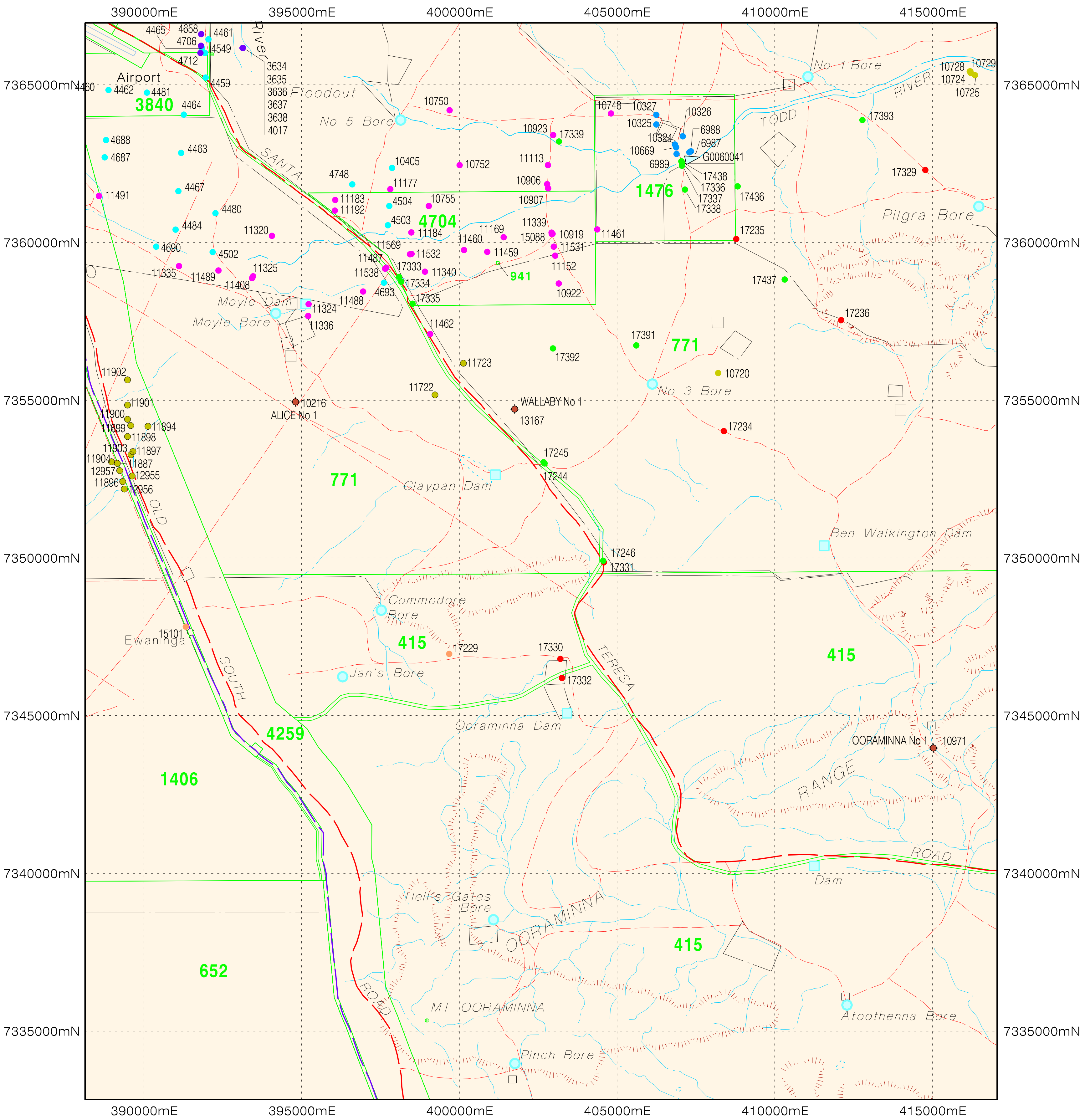
All holes, except RN17354, were cased with 100 mm ID class 12 PVC casing. Bore RN17534 was originally cased with 152 mm ID steel to 264.1 m and open hole to 503.0 m. This bore was pump tested and then reconstructed with 202 mm ID steel casing to 111.3 metres. The bore was open hole to 200 metres with the rest of the hole backfilled and plugged. The geological interpretation and bore completion diagrams of the bores are in Appendix B.

4.3 Drilling for EM Calibration

Ten bores were drilled to a maximum depth of 50 metres and RN17553 was drilled to a depth of 79 metres. The bores were drilled to help calibrate the vertical EM profiles.. The bores were geophysically logged with the gamma and induction conductivity tools. All holes, except RN17553, were backfilled at the completion of geophysical logging. Bore RN17553 was cased with 50 mm PVC casing to give an additional groundwater monitoring point. The EM bore locations are in Table 4.2 and shown on Figure 4.4.

4.4 Geological Logging

Samples were collected every three metres during drilling. These were geologically logged in the field and / or in the soils laboratory. Drill samples, which have been broken up by a tri-cone or hammer bit, are usually crushed to sand fragments. This makes for difficulty in distinguishing between the different sandstones so it is often difficult to assign drill samples to a geological formation.



LEGEND

—	Cadastral Boundary
415	NT Portion Number
— · —	Fence / Yard
— —	Unsealed Road
- - -	Vehicle Track
— —	Abandoned Railway
— · —	Major Drainage
—	Minor Drainage
‴‴	Range Line / Relief
•	Range Peak
○	Stock Bore
□	Dam
◁	Stream Gauging Station
◆	Petroleum Exploration Bore
●	Amoonguna Investigation Bores
●	Mereenie Sandstone Investigation Stage 2
●	East Emily Investigation Stage 2
●	Rocky Hill Agricultural Block Bores
●	Rocky Hill Investigations 1974 to 1977
●	Alice Springs Landcare bores 1997
●	Bores drilled 1998 programme
●	Bores drilled 1999 programme
●	Mineral Exploration Bores

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SCALE 1 : 150 000 @ A3

kilometres 0 1 2 3 4 5 10 15 kilometres

Horizontal Datum: GDA 94 Vertical Datum: AHD Map Grid: MGA 94 - Zone 53
Projection: UTM - Central Meridian 135 deg. E Grid Interval: 5000 m

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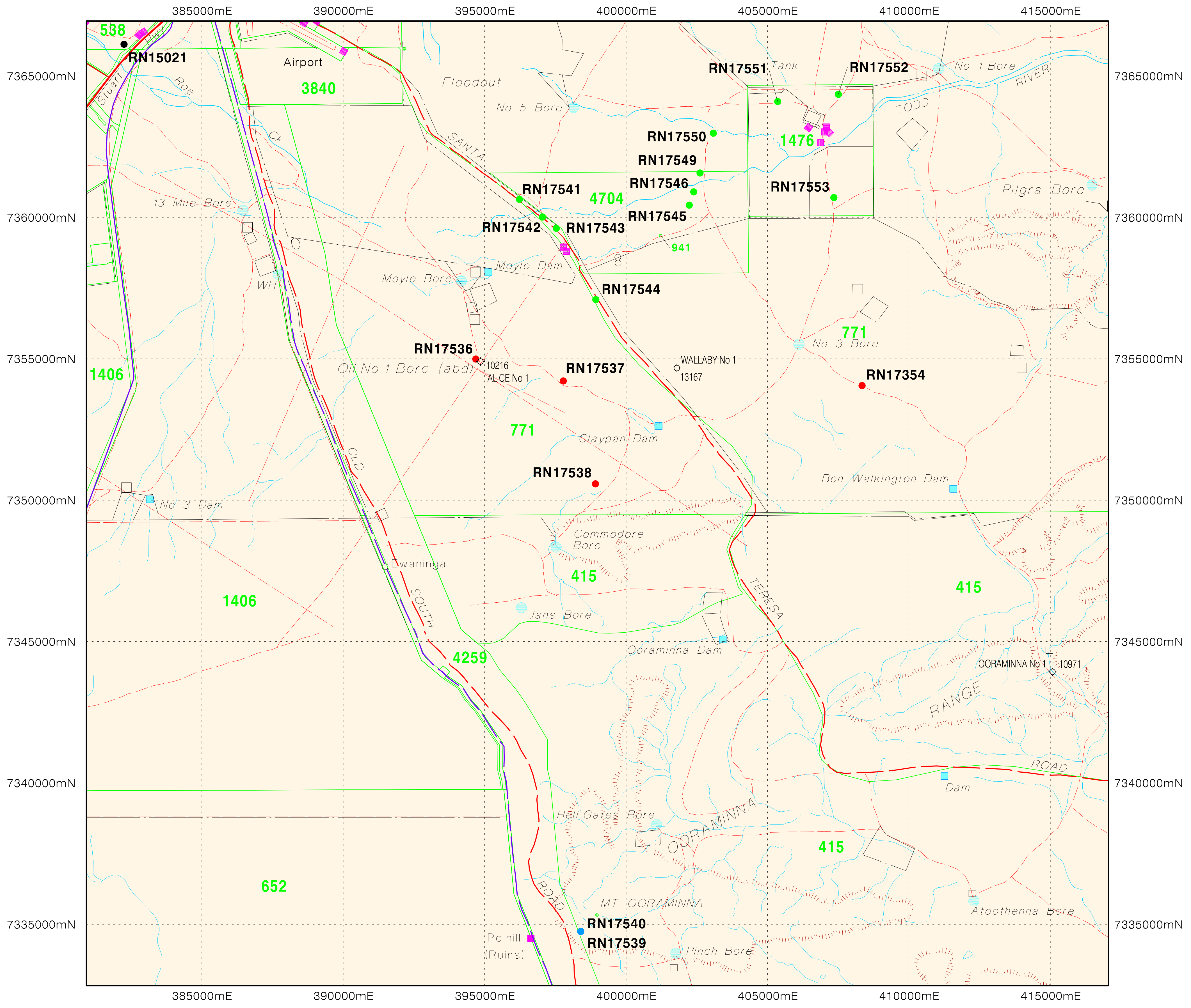
FIGURE 4.1

PREVIOUS PROGRAM BORE LOCATIONS



LEGEND

- Cadastral Boundary
- 415 NT Portion Number
- Fence / Yard
- Highway
- Sealed Road
- Unsealed Road
- Vehicle Track
- Railway
- Abandoned Railway
- Major Drainage
- Minor Drainage
- Range Line / Relief
- Range Peak
- ■ Building / Structure
- ○ Stock Bore
- □ Dam
- ◇ Petroleum Exploration Bore
- ● Rocky Hill 2000 Investigation Bores
- ● Ooraminna 2000 Investigation Bores
- ● Rocky Hill 2000 EM Geophysical Bores
- ● Roe Creek 1987 Investigation Bore

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GDA

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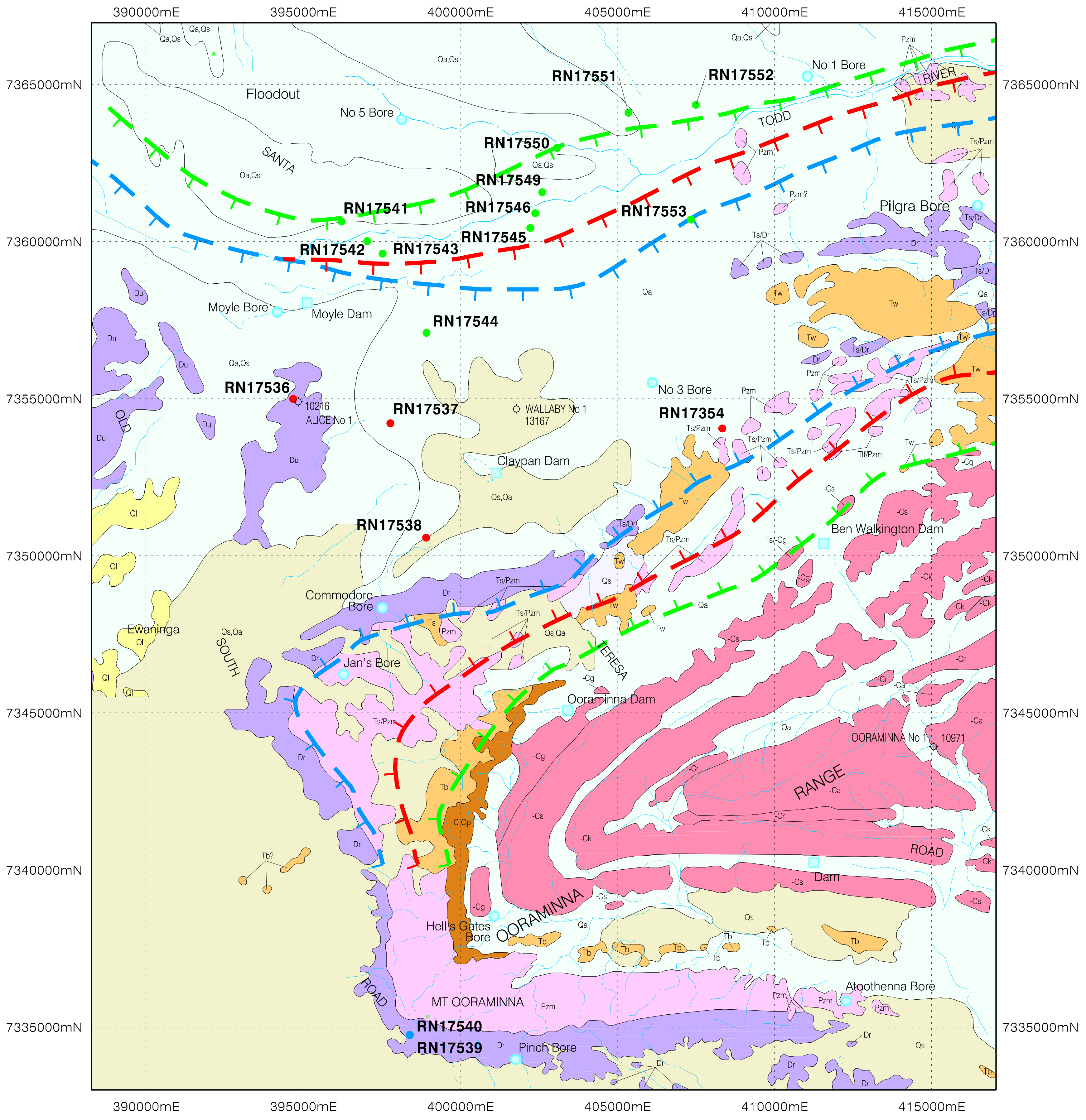
ROCKY HILL - OORAMINNA GROUNDWATER INVESTIGATION 2000

FIGURE 4.2

BORE LOCATION MAP



LEGEND

SCALE 1 : 150 000 @ A3

kilometres 0 1 2 3 4 5 10 15 kilometres

Horizontal Datum: GDA 94 Vertical Datum: AHD Map Grid: MGA 94 - Zone 53

Projection: UTM - Central Meridian 135 deg. E Grid Interval: 5000 m

GDA

Drg. nrasp59

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NOTE:
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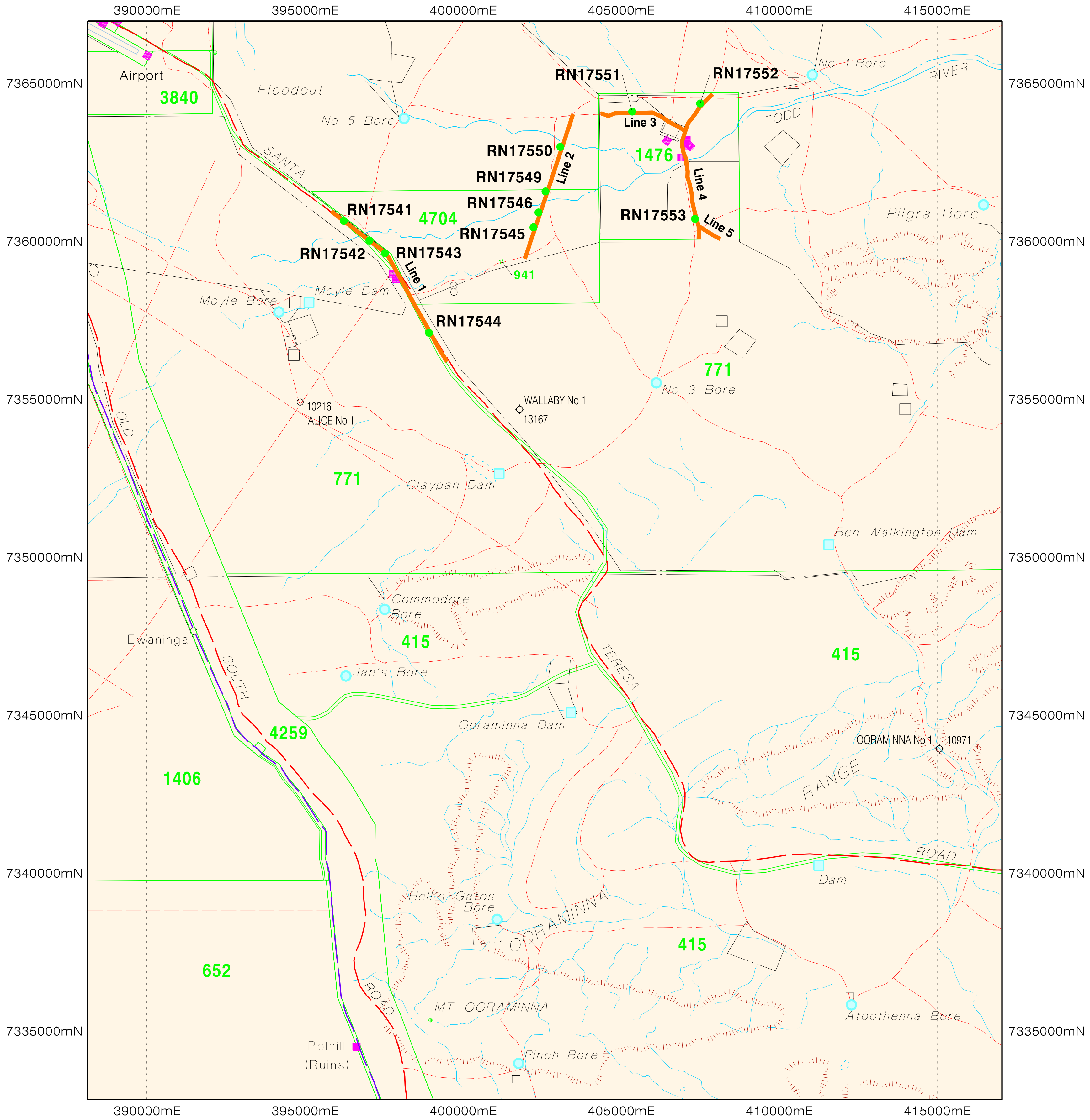
ROCKY HILL - OORAMINNA GROUNDWATER INVESTIGATION 2000

FIGURE 4.3

AREA GEOLOGY

After Shaw et al, 1983. (Alice Springs SF53-14) and Ranford & Cook, 1964. (Rodinga SG53-2) Trace lines amended by Read and Paul, 1999.



SYMBOL LEGEND

- Cadastral Boundary
- 415 NT Portion Number
- Fence / Yard
- Unsealed Road
- Vehicle Track
- Abandoned Railway
- Major Drainage
- Minor Drainage
- Range Line / Relief
- Range Peak
- ■ Building / Structure
- ○ Stock Bore
- □ Dam
- ◇ Petroleum Exploration Bore
- ● Rocky Hill 2000 EM Geophysical Bores
- 1998 Geophysical Survey Line

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ROCKY HILL - OORAMINNA GROUNDWATER INVESTIGATION 2000

FIGURE 4.4

EM GEOPHYSICAL SURVEY

Table 4.1 Investigation Bores Drilled in 2000

RN	Dates Drilled	Easting (AMG)	Northing (AMG)	TD (m)	Casing Details	Slotted intervals (m from - to) Slot size	Airlift Yield (L/s)	SWL (mbgl) Date	Interpreted Geological Formation (m)	Comments
RN17354	07/04/2000 to 05/06/2000	408256	7353851	503	263.1 m of 152 mm ID steel casing	Open Hole from 263.1 metres	Mud Drilled	55.62 02/06/2000	Qa 0 - 6 Dr65Do 50 - 300 Pzm 300 - 310 Ꞓop 310 - 503	Bore Construction during first test pumping.
RN17354, reconstructed	27/06/2000 to 28/06/2000 Bore reconstructed	As above			111.3 m of 202 mm ID steel casing	Open Hole from 111.3 metres to 200.0 metres Backfilled to 205 m 200 – 205 metres Cement plug.	Mud Drilled	52.57 01/07/2000		Bore reconstructed before second test pumping
RN17536	07/06/2000 to 12/06/2000	394559	7354820	351.0	197.5 m of 100 mm PVC	Open Hole	Est 20+		Qa 0 - 3 Db 3 - 120? Dr 120 - 297 Do 297 - 351	
RN17537	13/06/2000 to 19/06/2000	397648	7354047	163.5	142.6 m of 100 mm PVC	130.6 – 142.6 3 mm	Est 20		Qa 0 - 6 Du 6 - 135 Dr 135 - 163.5	
RN17538	19/06/2000 to 21/06/2000	398785	7350408	103.7	103.7 m of 100 mm PVC	91.7 – 103.7 3 mm	3.5		Qa 0 - 6 Dr 6 - 103.7	
RN17539	22/06/2000	398264	7334580	30.2	Bit Shanked. Abandoned hole and Backfilled	-	-	-	Qa 0 - 12 Dr 12 - 30.2	
RN17540	22/06/2000 to 26/06/2000	398264	7334583	211.0	211 m of 100 mm PVC	199 – 211 3 mm	1.5		Qa 0 - 12 Dr 12 - 198 Do 198 - 211	
RN17553	15/07/2000	407218	7360531	79.0	79.0 m of 50 mm PVC	73.0 – 79.0 1 mm	<0.1	-	Qa 0 - 6 Dr 6 - 79	

Lost Circ. = Lost Circulation
Dr = Hermannsburg Sandstone, units 1, 2 & 3
Pzm B = Mereenie Sandstone Unit B

Qa = Quaternary Alluvium
Do = Ooraminna Sandstone Member
Pzm = Mereenie Sandstone undifferentiated
ꞒOp = Pacoota Sandstone

Table 4.2 EM Hole Locations

RN	EM Number	Line Number	Easting (MGA)	Northing (MGA)
17541	EM1/00	Line 1/500	396230.09	7360640.75
17542	EM2/00	Line 1/1500	397040.99	7360013.61
17543	EM3/00	Line 1/2300	397534.37	7359615.87
17544	EM4/00	Line 1/5000	398930.63	7357094.01
17545	EM5/00	Line 2/3800	402234.59	7360437.01
17546	EM6/00	Line 2/3300	402391.11	7360907.13
17549	EM7/00	Line 2/2300	402613.69	7361569.90
17550	EM8/00	Line 2/500	403080.31	7362980.56
17551	EM9/00	Line 3/1000	405356.62	7364101.47
17552	EM10/00	Line 4/500	407500.22	7364354.47
17553	EM11/00	Line 4/4300	407346.36	7360701.98

4.5 Coring

Several bores were cored by adding a 3.6 metre core barrel to the end of the drill string, coring the interval required, removing the drill string and core barrel from the bore and retrieving the core. RN17354 was cored every 50 metres to 500 metres, giving ten cored sections for this hole. Three other holes were also cored. Cored intervals are shown in Table 4.3.

Selected sections of core were sent to Geotechnical Services Pty Ltd for petrophysical analyses (porosity / permeability testing and specific retention tests, see Table 7.1). The Geotechnical Services Pty Ltd test results are in Appendix C. Samples were also selected for petrographic analysis by Matthew Hale.

Table 4.3 Investigation Bores Cored in 2000 Drilling Program

RN	**Cored Interval**	**Stratigraphic Unit** (according to Hales)
RN17354	50 – 53	Ooraminna Sandstone Member
RN17354	100 –103	Ooraminna Sandstone Member
RN17354	150 – 153	Ooraminna Sandstone Member
RN17354	200 – 203	Ooraminna Sandstone Member
RN17354	250 – 253	Ooraminna Sandstone Member
RN17354	300 – 303	Mereenie Sandstone
RN17354	350 – 353	Pacoota Sandstone
RN17354	400 – 403	Pacoota Sandstone
RN17354	450 – 453	Pacoota Sandstone Sequence 3
RN17354	500 – 503	Pacoota Sandstone Sequence 1?
RN17536	348 – 351	Ooraminna Sandstone Member
RN17537	91.5 – 94.5	Undandita Member
RN17540	211 – 214	Ooraminna Sandstone Member

4.6 Geophysical Logging

All the 2000 investigation holes were geophysically logged. Three sondes, gamma, caliper and SP/SPR were run if the bore was still uncased. In cased bores only the gamma sonde was used. Gamma logs for the 2000 drilling are shown in the bore completion diagrams in Appendix B.

Gamma logs prior to 1992 are in analogue (chart) form and some strategic bores need to be re-logged to get the data in digital format.

Braybrook (1976) used gamma logs from RN11324 and RN11336 to calculate a dip of 10° for the northern limb of the Rocky Hill syncline.

The gamma logs have been an aid in determining the geological sequence. At this stage the correlation between Rocky Hill and the Roe Creek Borefield is still unclear.

5 TEST PUMPING

5.1 Pre 2000 Test-Pumping

Pumping tests were conducted at Rocky Hill as part of investigations between 1974 and 1977 (Verhoeven *et al*, 1977) and 1998 and 1999 (Read & Paul, 2000). Table 5.1 summarises testing, and Table 5.2 summarises the results.

Table 5.1 Schedule of Test Pumping before 2000

Pumped Bore	Test Type	Start		Duration minutes	Discharge *l*/s	Observation Bores	Field Book No
		Time	Date				
10755	Step 1	09:00	19/12/74	100	3.4		318
	Step 2	10:40	19/12/74	100	5.7		
	Step 3	12:20	19/12/74	100	8.0		
	Step 4	14:00	19/12/74	100	10.0		
	Step 5	15:40	19/12/74	100	20.0		
	Constant Rate	07:40	20/12/74	1400	13.3		
	Recovery	07:00	21/12/74	700			
10919	Step 1	08:30	25/08/75	100	15.7	11339	382
	Step 2	10:10	25/08/75	100	25.6		
	Step 3	11:50	25/08/75	100	35.1		
	Step 4	13:30	25/08/75	100	45.1		
	Step 5	15:10	25/08/75	100	56.3		
	Step 6	16:50	25/08/75	10	60.9		
	Recovery	17:00	25/08/75				
	Constant Rate	08:10	26/08/75	4400	50.2		
	Recovery	09:30	29/08/75	3090			
10922	Step 1	10:30	1/9/75	140	7.07		383
	Step 2	12:50	1/9/75	100	8.01		
	Step 3	14:30	1/9/75	160	10.0		
	Step 4	17:10	1/9/75	100	11.0		
	Constant Rate	09:30	2/9/75	4340	11.0		
	Recovery	09:51	5/9/75	50			
11152	Step 1	08:15	1/9/76	100	3.5		522
	Step 2	09:55	1/9/76	100	6.0		
	Step 3	11:35	1/9/76	100	9.0		
	Step 4	13:15	1/9/76	100	11.9		
	Step 5	14:55	1/9/76	100	13.8		
	Constant Rate	08:10	2/9/76	5840	12.4		
	Recovery	09:30	6/9/76	1440			
11169	Step 1		20/09/76	100	3.6		520 book missing
	Step 2		20/09/76	100	6.05		
	Step 3		20/09/76	100	8.45		
	Step 4		20/09/76	100	15.23		
	Step 5		20/09/76	100	18.74		
	Constant Rate		27/09/76	1440	40.0		
	Recovery		10/02/77	2880	32.1		
11177	Constant Rate	12:10	14/09/76	1400	2.66		521
	Recovery	11:31	15/09/76	1312			
11324	Prelim 1	12:30		100	5.0		510
	Prelim 2	14:10		50	8.0		
		15:00		10			
	Step 1	08:45	20/07/76	100	3.4		
	Step 2	10:25	20/07/76	100	4.6		
	Step 3	12:05	20/07/76	100	5.5		
	Step 4	13:45	20/07/76	100	7.1		
	Step 5	15:25	20/07/76	20	9.1		
	Constant Rate	11:00	21/07/76	1500	6.1		
	Recovery	12:00	22/07/76	1800			
11325	Step 1	08:00	10/03/77	100	15.1	11408	568
	Step 2	09:40	10/03/77	100	21.0		
	Step 3	11:20	10/03/77	100	25.0		
	Step 4	13:00	10/03/77	100	29.9		
	Step 5	14:40	10/03/77	100	36.1		
	Constant Rate	09:10	14/03/77	4280	32.1		
	Recovery	08:30	17/03/77	1380			
11336	Step 1	11:20	25/08/76	100	3.0		513
	Step 2	13:00	25/08/76	100	6.0		
	Step 3	14:40	25/08/76	100	9.0		
	Step 4	16:20	25/08/76	100	11.0		
	Step 5	18:00	25/08/76	100	12.5		
	Constant Rate	09:10	26/08/76	1465	10.5		
	Recovery	09:30	27/08/76	1285			

Table 5.1 continued

Pumped Bore	Test Type	Start Time Date	Duration minutes	Discharge *l*/s	Observation Bores	Field Book No
11340	Preliminary	15/10/76	50			567
	Step 1	08:00 27/04/77	100	4.03		
	Step 2	09:40 27/04/77	100	5.48		
	Step 3	11:20 27/04/77	100	6.98		
	Step 4	13:00 27/04/77	100	8.96		
	Step 5	14:40 27/04/77	100	11.02		
	Constant Rate	08:40 28/04/77	1440	10.00		
	Recovery	08:00 29/04/77				
11460	Step 1	08:10 16/02/77	100	13.0		571
	Step 2	09:50 16/02/77	100	20.0		
	Step 3	11:30 16/02/77	100	25.0		
	Step 4	13:10 16/02/77	100	29.9		
	Step 5	14:50 16/02/77	100	36.8		
	Constant Rate	09:40 22/02/77	2900	32.1		
	Recovery	10:00 24/02/77	1320			
11461	Step 1	06:40 05/02/77	100	13.0		549
	Step 2	08:20 05/02/77	100	19.4		
	Step 3	10:00 05/02/77	100	23.9		
	Step 4	11:40 05/02/77	100	28.0		
	Step 5	13:20 05/02/77	100	36.8		
	Constant Rate	12:10 07/02/77	1430	32.1		
	Recovery	12:00 08/02/77	600			
11487	Step 1	08:00 01/03/77	100	15.1	11538	562
	Step 2	09:40 01/03/77	100	20.0		
	Step 3	11:20 01/03/77	100	25.0		
	Step 4	13:00 01/03/77	100	29.9		
	Step 5	14:40 01/03/77	100	36.8		
	Constant Rate	08:10 02/03/77	710	32.1		
	Recovery	20:00 02/03/77	700			
	Constant Rate	09:40 22/03/77	2900	32.1		
	Recovery	10:00 24/03/77	1320			
11488	Prelim Development	09:30 07/03/77	200	10.2-12.0		564
	Step 1	08:40 04/05/77	100	4.3		
	Step 2	10:20 04/05/77	100	5.48		
	Step 3	12:00 04/05/77	100	6.94		
	Step 4	13:40 04/05/77	100	8.54		
	Step 5	15:20 04/05/77	100	11.02		
	Constant Rate	08:10 05/05/77	2900	10.0		
	Recovery	08:30 07/05/77	2220			
11489	Step 1	08:45 28/03/77	100	15.1		570
	Step 2	10:25 28/03/77	100	21.8		
	Step 3	12:05 28/03/77	100	26.1		
	Step 4	13:45 28/03/77	100	29.9		
	Step 5	15:25 28/03/77	100	35.7		
	Constant Rate	08:45 29/03/77	2990	32.1		
	Recovery	10:30 31/03/77	1230			
11491	Constant Rate	08:40 16/05/77	1400	3.12		561
	Recovery	08:00 17/05/77	1440			
11531	Constant Rate	4/04/77	3050	7.2		565
11532	Step 1	07:40 21/04/77	100	15.1	11487	559
	Step 2	09:20 21/04/77	100	21.0	11569	
	Step 3	11:00 21/04/77	100	26.1		
	Step 4	12:40 21/04/77	100	29.9		
	Step 5	14:20 21/04/77	100	35.7		
	Constant Rate	09:10 10/05/77	2690	32.1		
	Recovery	06:25 15/05/77	1500			
17244	Step 1	24/4/99	60	11.7	17245	1451
	Step 2	24/4/99	60	20.3		1452
	Step 3	24/4/99	60	35		
	Constant Rate	09:05 27/4/99	975	30		
	Recovery	01:20 28/4/99	100			
	Constant Rate	08:00 18/5/99	1765	25		
	Recovery	13:25 19/05/99	480			
17246	Step	11:41 29/4/99	60	10	17331	1449
	Step	12:41 29/4/99	60	20		1450
	Step	13:41 29/4/99	60	33		
	Recovery	14:41 29/4/99	60			
	Constant Rate	12:21 12/5/99	461	25		
	Recovery	20:02 12/5/99	1080			
	Constant Rate	14:15 12/5/99	2880	25		
	Recovery	14:15 15/5/99	2375			
	Constant Rate	11:10 11/10/99	2880	25		
	Recovery	11:10 13/10/99	2985			

Table 5.2 Pre-2000 Test Pumping Results

RN	Aquifer $^{(1)}$	Aquifer T $^{(2)}$	Apparent T $^{(3)}$	S	Revised T	Revised S	Response type
10755	ꞒOp	120	120				Jacob, shows some leakage
10919	ꞒOp	2200	2200	0.011 doubtful match	1500	.016	Leaky aquifer
10922	Do/Pz		130				
11152	Do/Pzm/ꞒOp	20	60				
11169	Pzm	1 500	4200	0.011	1 700		Jacob,
11177	ꞒOp	10	40				
11324	ꞒOp	40	200				leaky aquifer
11325	Pzm	1200	1 000	0.008	1000	0.01	leaky aquifer?
11336	Pzm		180				leaky aquifer
11340	Pzm		200				leaky aquifer
11460	Pzm	600	1600		600		leaky aquifer
11461	Pzm	500	500				?
11487	Do/Pzm	1700	1700	0.0005	1650	0.001	Theis, needs checking Straight line log-log early time
11488	Do/Pzm/ꞒOp		130				leaky aquifer
11489	Pzm	1200	1200				check
11491	PzmA	10	10				Theis
11531	Pzm/ꞒOp		50				
11532	Pzm	1 000	2100	0.0001	1 000	0.01	Leaky aquifer, using RN 11487
10728	Pzm/ꞒOp	370				0.0006	Theis
17244		400		0.001			Leaky aquifer
17246		3 000		0.005			Double bounded leaky aquifer

(1) Dr Hermannsburg Sandstone Do, Ooraminna Sandstone Member, Pzm Mereenie Sandstone, ꞒOp Pacoota Sandstone

(2) Verhoeven *et al* (1977) best estimate of transmissivity.

(3) Empirical estimate used for predicting long term drawdowns, which may include the effects of boundaries and leakage.

(4) The storage coefficients refer to pump-test time scales and should not be confused with the effective porosity that will determine long term aquifer yield.

5.2 RN17354

5.2.1 Introduction

This bore was tested twice as shown in Table 5.3. The first test started on 22/6/2000, with the bore at the drilled depth of 504 m. The second test was started on 3/7/2000 after the bore had been back-filled and plugged at 201.4 m

Table 5.3 Schedule of Test Pumping RN17354

Test	Start		Stop		Rate	Comments
	Date	Time	Date	Time	(L/s)	
Step 1	22/6/2000	1345	22/6/2000	1445	6	Test 1
Step 2	22/6/2000	1445	22/6/2000	1545	8	
Step 3	22/6/2000	1545	22/6/2000	1645	10	
Recovery	22/6/2000	1645	22/6/2000	1747		
Constant rate	23/6/2000	0810	24/6/2000	0810	12	
Recovery	24/6/2000	0810	24/6/2000	0850		
Step 1	03/07/2000	0900	03/07/2000	1040	10	Test 2
Step 2	03/07/2000	1040	03/07/2000	1220	12	
Step 3	03/07/2000	1220	03/07/2000	1700	14	Extended step
Recovery	03/07/2000	1700	03/07/2000	1710		Rapid recovery
Constant rate	04/07/2000	0810	05/07/2000	0037	15	Test stopped by mechanical failure
Recovery						Full recovery in < 2 minutes

5.2.2 Standing Water Levels

Table 5.4 lists a history of standing water level measurements in this bore. It can be seen that there have been sizeable variations in the apparent standing water level. This is due both to differences in head between the upper and lower aquifers and changes in the temperature of the water column in the bore. This will be discussed in more detail below.

5.2.3 Test 1

5.2.3.1 Step Test

The drawdowns for the step test are shown in Figure 5.1.

Values of s/Q, not corrected for the effects of the previous steps are shown in Table 5.5. It can be seen that values of s/Q are smaller at higher pumping rates. This is probably a result of the bore developing during the test, but possibly also a result of changes in the temperature of the water column.

Table 5.4 Standing Water Levels for RN17354

Date	Time	Standing Water Level, m below surface	Comments
21/6/2000		55.62	Prior to pumping
22/6/2000	1657	55.17	Immediately after the end of step testing
23/6/2000	0730	55.32	Before constant rate test
24/6/2000	0811	54.9	Immediately after the end of pumping
24/6/2000	0850	55.12	40 minutes after the end of pumping
1/7/2000		52.75	After bore reconstructed to 200 m and before Test 2
5/7/2000	0040	52.75	After second constant rate test

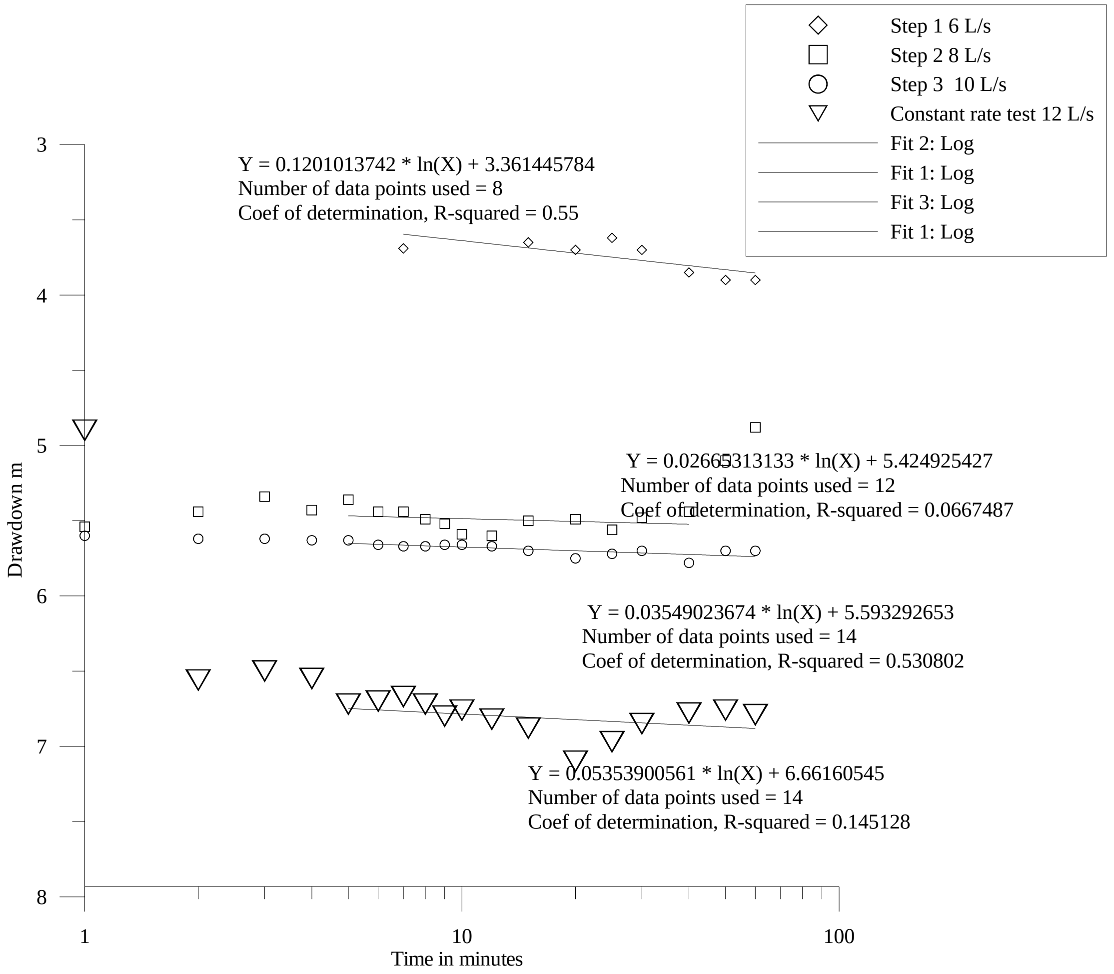


Figure 5.1 RN17354 Test 1, Step Test Drawdowns.

Table 5.5 RN17354, Values of s/Q

Q	s 60 uncorrected	s 60 uncorrected/Q
6	3.853182	0.64
8	5.534053	0.69
10	5.738602	0.57
12	6.880813	0.57

5.2.3.2 Constant Rate Test

A plot of pumped bore drawdown is shown in Figure 5.2. It is not clear why the plot is so erratic. Some development may have occurred during the test. An increase in turbidity was noted at 20 minutes, corresponding to a rise in water level. No drawdown was detected in the observation bore, which is to be expected as it is in a shallower aquifer. Recovery to 0.04 m above the starting water level occurred in the first minute. From a straight line fit to the drawdown after 20 minutes a transmissivity of about 200 m^2/day is estimated.

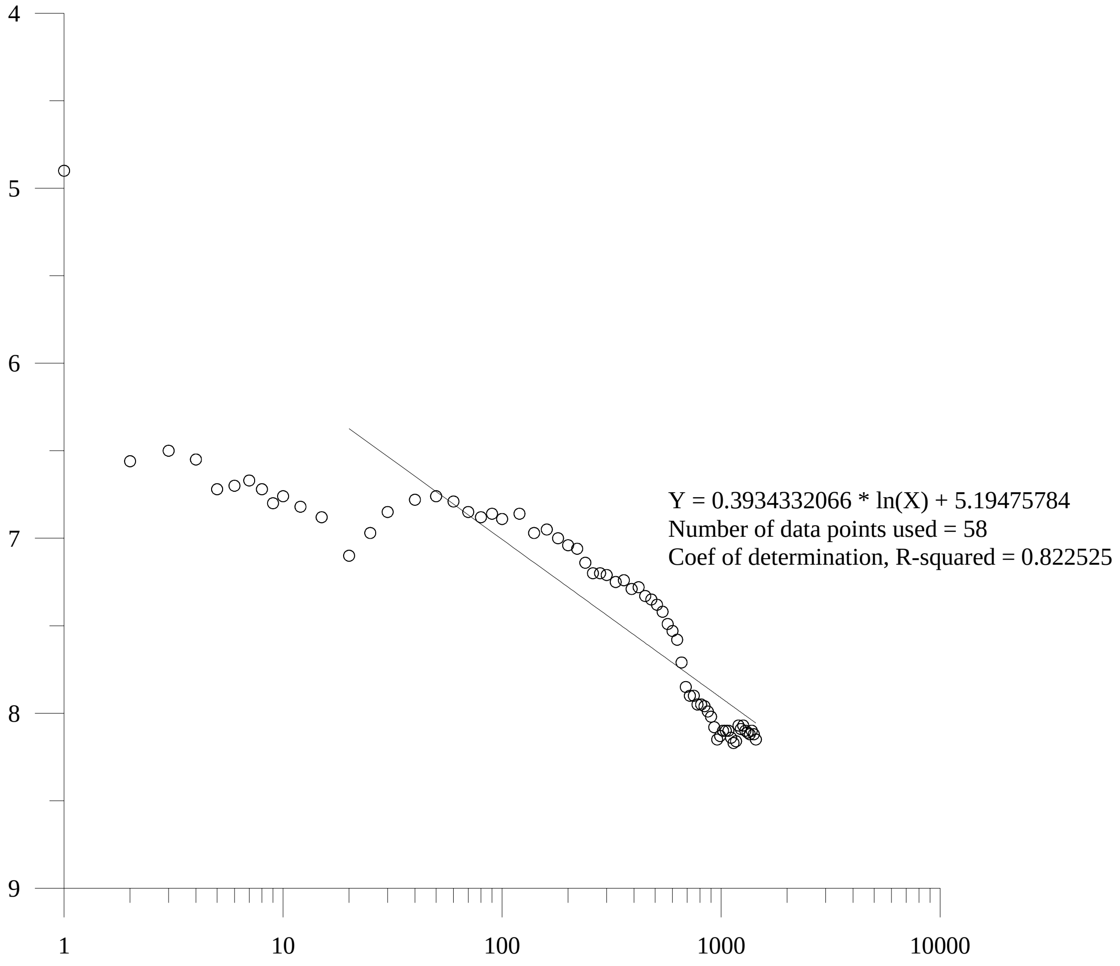


Figure 5.2 RN17354 Test 1, Constant Rate Test

5.2.3.3 Discharge Parameters

Graphs of the discharge parameters are shown in Figure 5.3. Recorded temperature varied widely during the test, but average about 29.5 ^{o}C. This is due to the method of measurement, as the temperature log indicates that the temperature of the aquifer is about 35 ^{o}C. The difference must be due to cooling of the water as it rises in the bore column, cooling between the pump discharge and the measurement point and calibration of the instrument. Electrical conductivity showed a definite decline from an initial 1900 µS/cm to about 1700 µS/cm during the test. The initial low conductivity would have been water left in the bore from the previous pumping. No significant change of pH is evident. The smell of hydrogen sulphide was noted through the test.

5.2.3.4 Standing Water Levels

Temperature at about 500 m was about 35.9 ^{o}C, compared with 29.9 ^{o}C at 200 m. Using the Schoeller equation and the temperature log the mean Specific Gravity of the water column was calculated as 1.0048, compared with 1.0063 for temperature at the hole bottom. Multiplied by the length of the column this represents a change in head of 0.65 m between the water column at equilibrium and the column filled with water from the aquifer near the bottom of the hole. This is enough to account for the fall in water level observed at the end of pumping (Table 5.4).

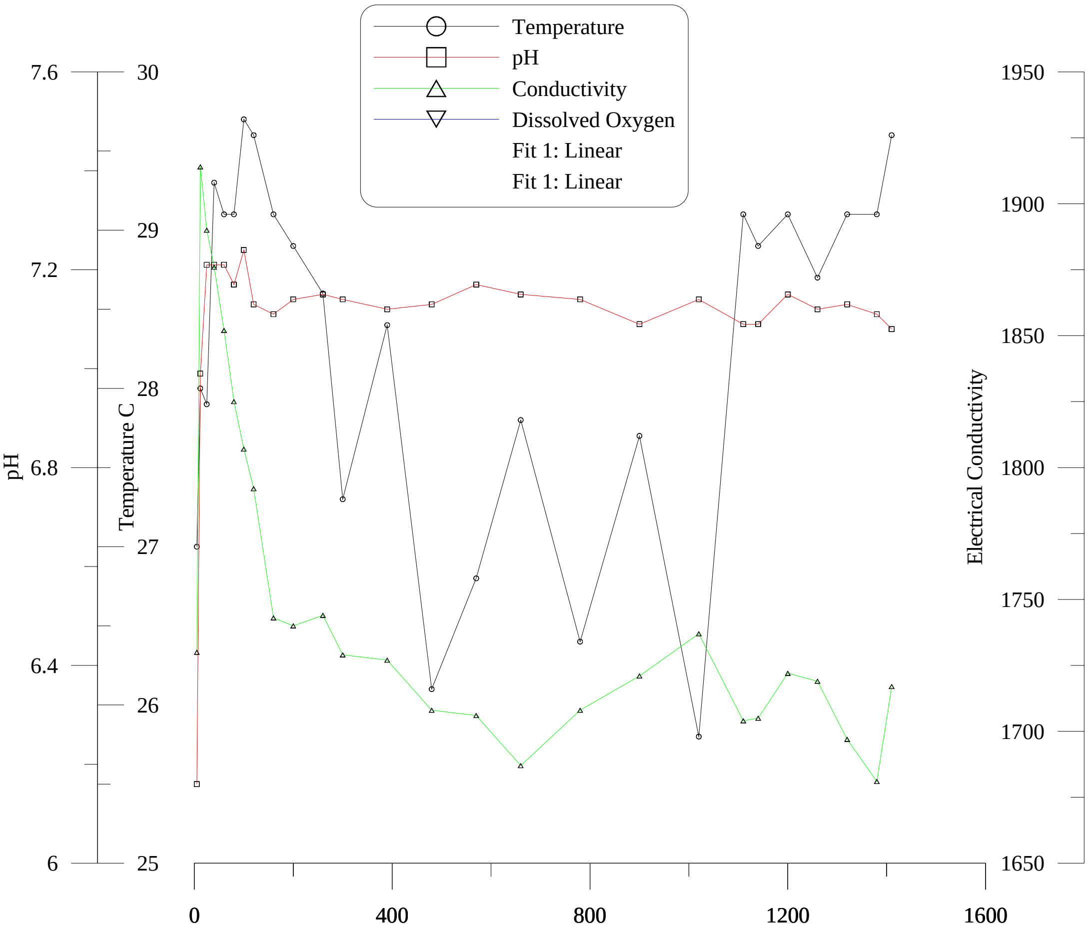


Figure 5.3 RN17354Test 1, Physical Parameters

5.2.4 Long Term Yield

The bore has been back-filled since the test. The results can be used as an indication of the yields that could be expected from this aquifer in this location. It is not possible to estimate the turbulent loss terms that might be present at higher pumping rates, and it is likely that the bore was not fully developed. With these qualifications it is probable that a properly constructed bore here could yield about 40 L/s with a pumping level of under 100 m in the medium term. In the longer term as development lowers the water table either deeper pumping levels or lower pumping rates would be needed.

5.3 Test 2

5.3.1 Step Test

The bore was step-tested as shown in Table 5.3. Drawdowns are shown in Figure 5.4. It can be seen that drawdowns are erratic and that there is generally an upward trend during the steps. This could be due to difficulties in controlling the rate and/or development of the bore during the test. Cloudy water and some sand was noted throughout step testing, suggesting that development was still taking place. Because there is no clear trend in the steps drawdown values from 10 to 100 minutes were averaged. s/Q values are shown in Table 5.6. These are more or less constant in the step test and decrease in the constant rate test indicating development.

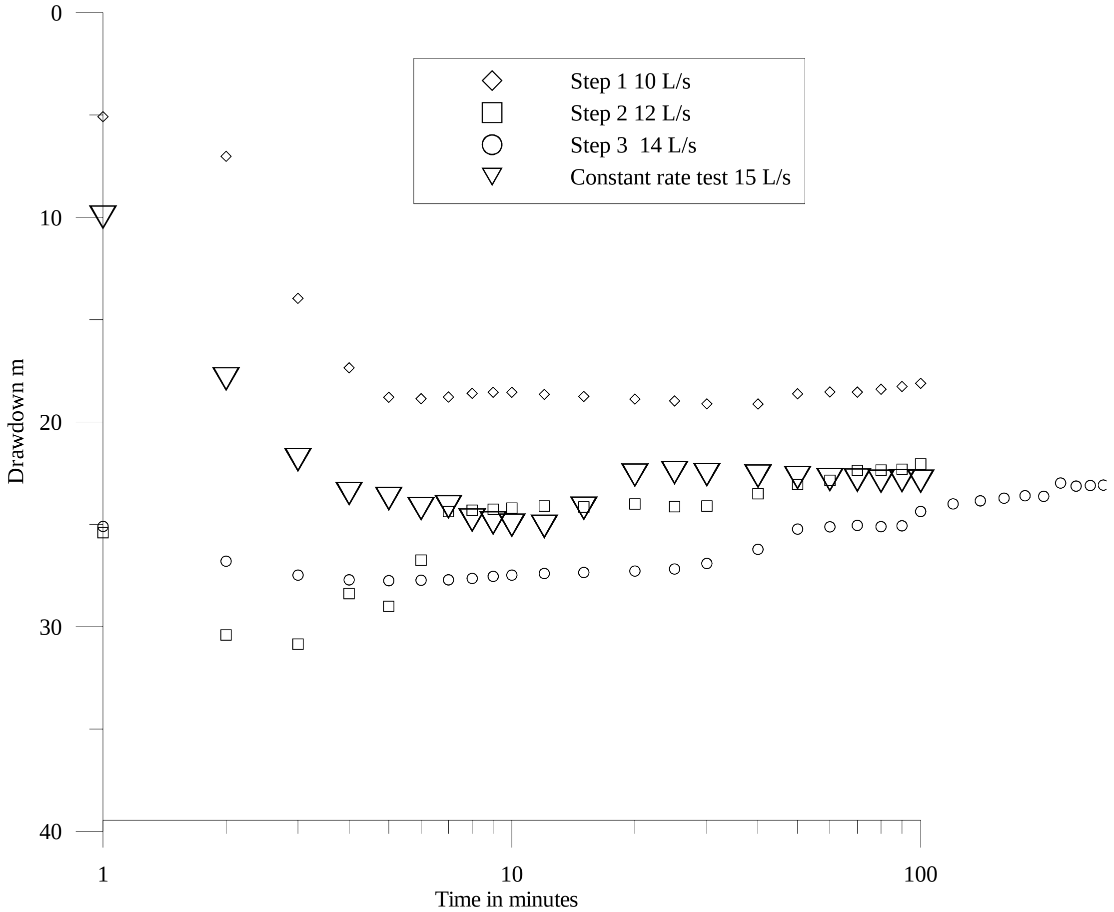


Figure 5.4 RN17354, Test 2 Step Test Drawdowns

Table 5.6 RN17354, Values of s/Q

	Step 1	Step 2	Step 3	Constant Rate
Q L/s	10	12	14	15
Average s	18.65	23.32	26.14	23.21
Average s/Q	1.87	1.94	1.87	1.55

5.3.2 Constant Rate Test

The pumped bore drawdown plot is shown in Figure 5.5. It can be seen that the plot is erratic because of the difficulty in maintaining the pump rate. A straight line fit from 25 to 150 minutes gives a transmissivity of 300 m^2/day. Drawdown in the observation bore was very small, and it is clear that little of the water pumped was coming from the aquifer in which it was completed. Physical parameters were not determined during this test.

5.3.3 Long Term Yield

The bore was mud-drilled and it is clear that the mud has invaded the aquifer and destroyed the permeability. To reliably test this aquifer a new production bore would need to be drilled. The best that could be said is that a properly constructed bore at this location would have a long term yield of at least 15 L/s and possibly up to about 60 L/s.

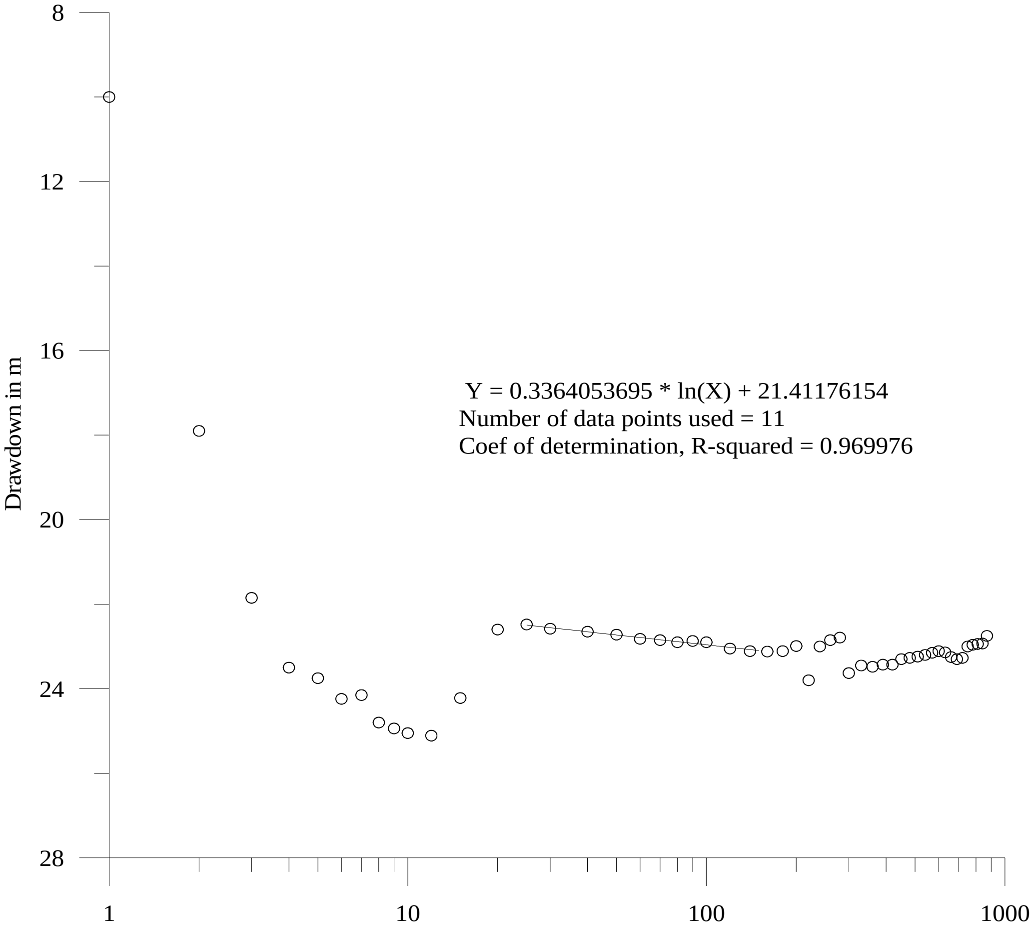


Figure 5.5 RN17354 Test 2, Constant Rate Drawdowns

6 CHEMISTRY

Water samples were collected at the first water strike and at significant increases in air-lift yields. The chemical analyses of water samples collected during drilling and test pumping are shown in Table 6.1 and Table 6.2.

6.1 Groundwater Salinity

The drilling in 2000 better defined the south western boundary of water less than 500 mg/L TDS (RN17537, 481 mg/L) and TDS greater than 1,000 mg/L (RN17536, 1010 mg/L). RN17536 is approximately 120 metres north of RN10612 (Alice No. 1 oil well). A contour map of TDS values is shown in Figure 6.1. The area of the contours is the approximate area of the Mereenie Sandstone aquifer. The deepest water sample analysed for each bore was used in the contour diagram as this usually had the highest TDS value. If there were drilling and test pumping samples analysed from the same bore then the test pumping TDS result was used.

Figure 6.1 shows low TDS water in an area along Roe Creek where recharge to the Mereenie Sandstone and Pertnjara Group could occur. There is also water below 500 mg/L around RN17537 and RN17392, which are further away from Roe Creek. The water quality deteriorates to the east of the Undoolya Rocky Hill Agricultural Block, with the 1,000 mg/L boundary occurring close to RN17329.

RN12045, Undoolya No. 3 Bore, has higher TDS values than the surrounding bores. Drilling records show 0.2 L/s of high salinity water (EC 31,200 µS/cm, approximately 20,000 mg/L TDS) was encountered between 58 and 62 metres in the Tertiary sediments overlying the Hermannsburg Sandstone. . A properly constructed bore, casing off the upper high TDS aquifer, should be drilled to replace RN12045. A representative water sample from the major underlying aquifer could then be obtained. RN12045 and RN10545 would need to be plugged below the upper high TDS aquifer to stop contamination of high TDS waters through these bores.

6.2 Durov Plots

Figure 6.2 shows a Durov plot of chemical analyses for the 2000 drilling). All the chemical analyses for the Rocky Hill – Ooraminna area have been grouped by TDS and plotted in Figure 6.3.

Figure 6.3 shows the low TDS water has high HCO_3^-, typical of recharge water. The low TDS water comes from bores RN17392, RN17334, RN17235 and the Roe Creek Borefield sample. These are close to Roe Creek, which should be a zone of preferential recharge during any flows. The anions show a movement from high HCO_3^- values and low TDS values (recharge area) to high Cl and high TDS values. The cations show a trend moving from the middle of the cation field to the Na+K end with increasing TDS.

Rocky Hill - Ooraminna 2000 Investigation
Total Dissolved Solids Contours

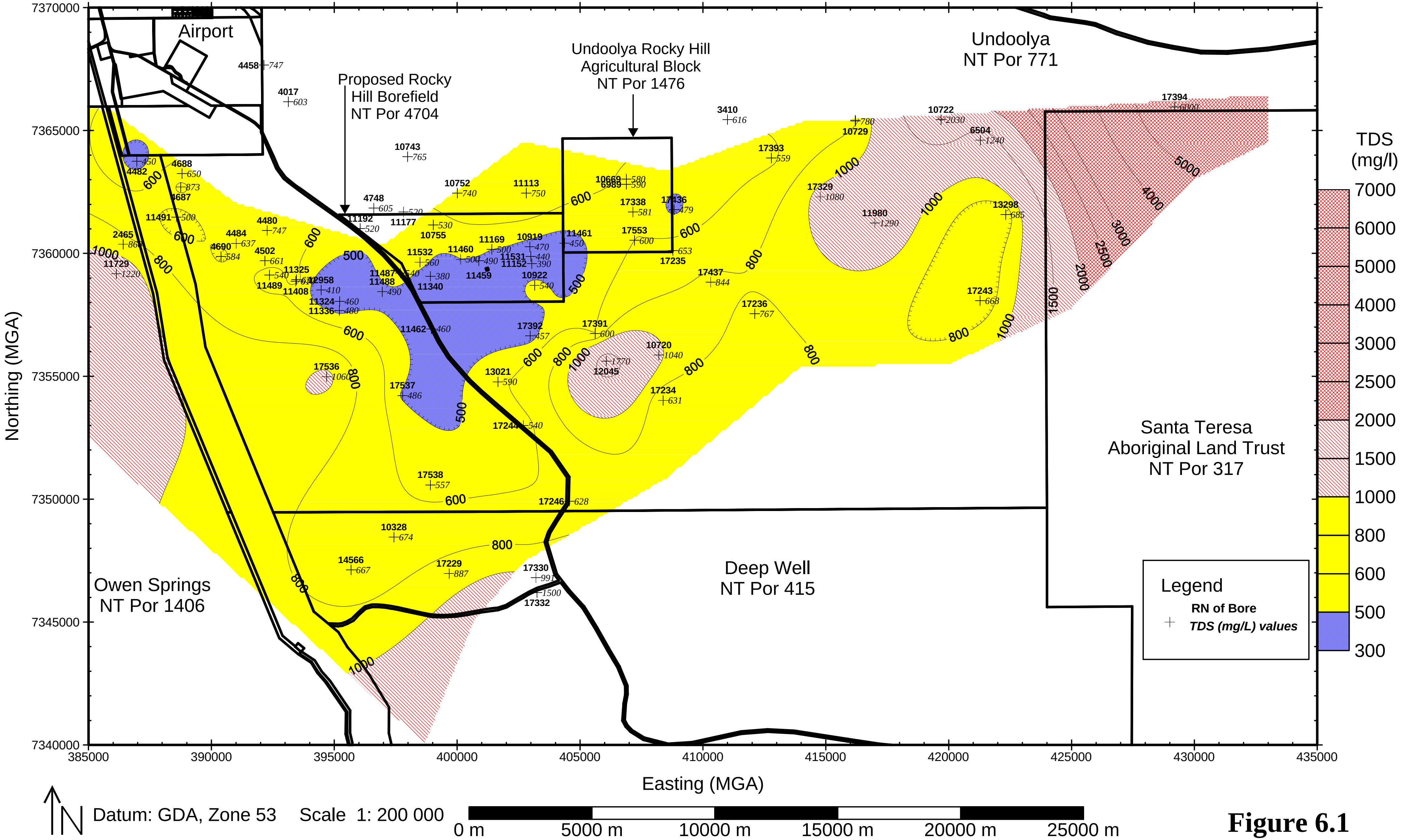


Figure 6.1

Rocky Hill - Ooraminna Groundwater Investigation - 2000

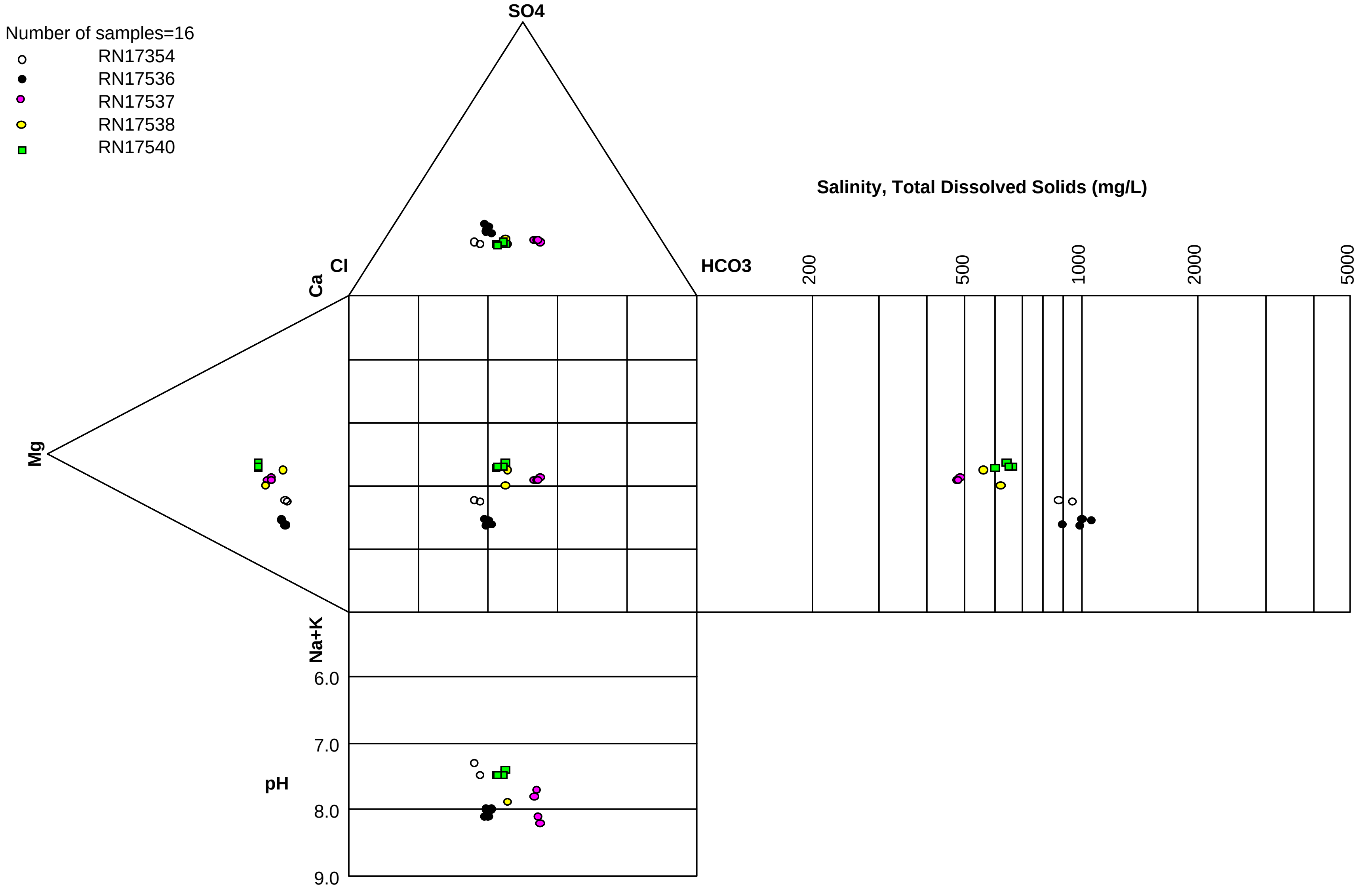


Figure 6.2

Rocky Hill - Ooraminna Groundwater - All Investigations

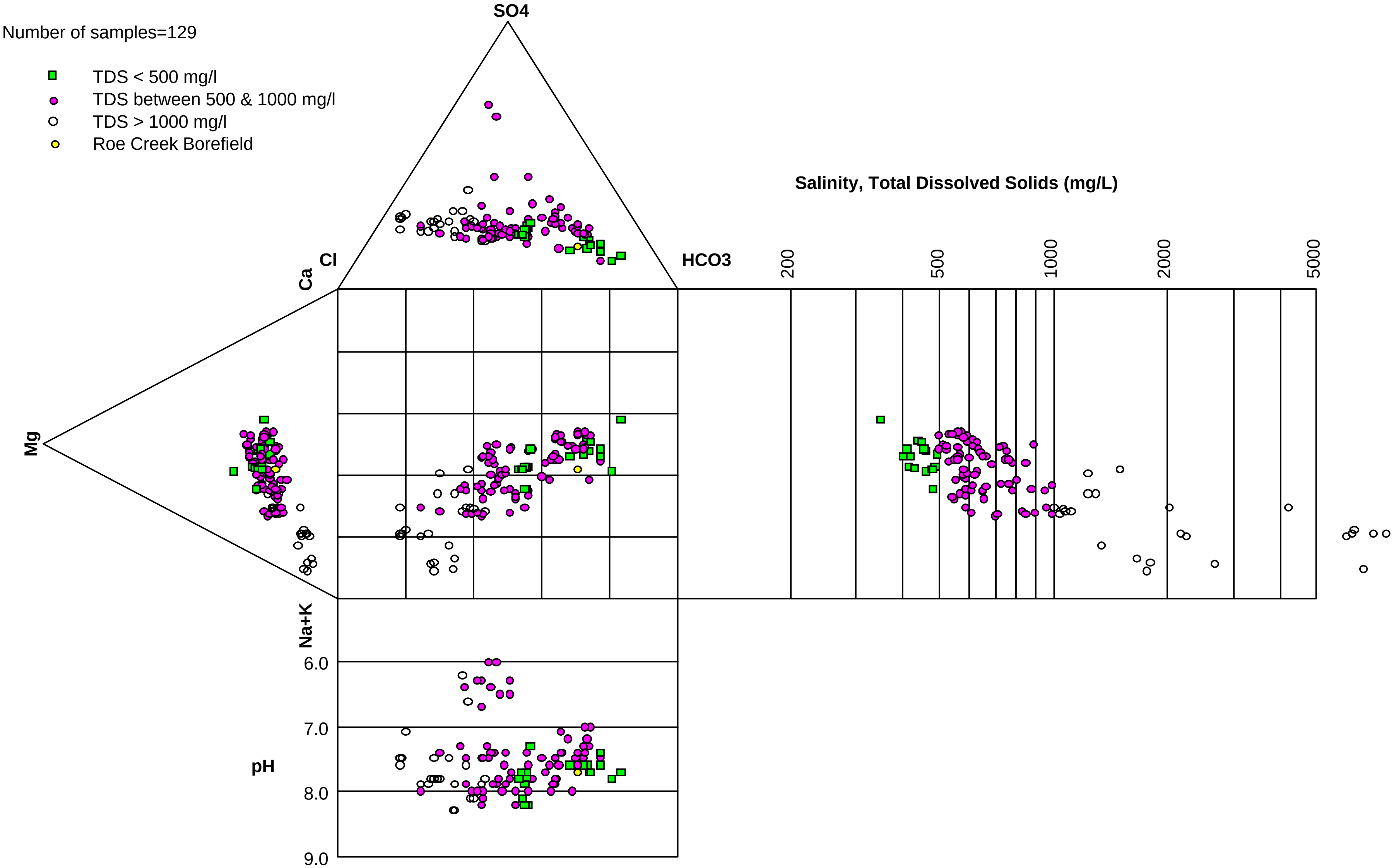


Figure 6.3

Table 6.1 Chemical Analyses (Major Ions) from 2000 Investigation Drilling Program.

RN	Date	Depth (metres)	Discharge (L/s)	pH	TDS (mg/L)	Na (mg/L)	Ca (mg/L)	Mg (mg/L)	K (mg/L)	Cl (mg/L)	SO_4 (mg/L)	HCO_3 (mg/L)
17354	22/06/00	Pumped	10	7.5	945	188	75	37	12	302	150	282
17354	24/06/00	Pumped	12	7.3	881	173	72	36	12	299	150	254
17536	09/06/00	235.5	20	8.0	990	224	53	41	11	292	190	288
17536	09/06/00	246.3	20+	8.0	895	206	50	38	10	262	170	284
17536	10/06/00	306.3	20+	8.1	1060	218	58	43	10	292	210	291
17536	10/06/00	348.0	20+	8.1	1010	216	59	44	10	297	220	280
17537	13/06/00	85.5	1.5	7.8	482	80	47	27	10	111	85	231
17537	13/06/00	91.5	10	7.7	474	81	47	25	7	107	83	225
17537	14/06/00	115.5	20	8.2	486	82	50	26	6	109	84	244
17437	14/06/00	139.5	20+	8.1	481	82	47	25	6	107	84	235
17538	20/06/00	85.7	0.5	7.4	617	100	54	34	16	173	110	235
17538	20/06/00	97.7	3.5	7.9	557	89	63	24	11	159	90	220
17540	24/06/00	191.8	0.3	7.5	598	84	60	36	10	173	91	203
17540	24/06/00	199.0	0.8	7.4	645	87	68	38	10	178	99	243
17540	24/06/00	205.0	1.3	7.5	662	94	69	40	10	188	110	250
17540	24/06/00	211.0	1.5	7.5	649	94	68	40	10	208	110	254
17553	05/10/00	70.5	<0.1	7.5	600*	90	52	23	6	116	u/s	219

Table 6.2 Chemical Analyses from 2000 Investigation Drilling Program.

RN	Date	Depth (metres)	Discharge (L/s)	pH	TDS (mg/L)	Fe (total) (mg/L)	SiO_2 (mg/L)	NO_3 (mg/L)	F (mg/L)	HCO_3 (mg/L)	HCO_3/Cl	Total Hardness (as CaCO3) Calculation (mg/L)	Total Alkalinity (as CaCO3) (mg/L)
17354	22/06/00	Pumped	10	7.5	945	u/s	18	7	0.5	282	0.54	339	231
17354	24/06/00	Pumped	12	7.3	881	0.8	17	<1	0.5	257	0.49	328	211
17536	09/06/00	235.5	20	8.0	990	0.3	21	7	1.4	288	0.57	301	236
17536	09/06/00	246.3	20+	8.0	895	u/s	21	7	1.4	284	0.63	281	233
17536	10/06/00	306.3	20+	8.1	1060	0.6	22	7	1.4	291	0.58	321	239
17536	10/06/00	348.0	20+	8.1	1010	0.8	21	7	1.3	280	0.55	328	230
17537	13/06/00	85.5	1.5	7.8	482	u/s	20	8	1.2	231	1.21	228	189
17537	13/06/00	91.5	10	7.7	474	u/s	20	8	0.7	225	1.22	220	185
17537	14/06/00	115.5	20	8.2	486	u/s	19	8	0.5	244	1.30	232	200
17537	14/06/00	139.5	20+	8.1	481	u/s	19	8	0.5	235	1.28	220	193
17538	20/06/00	85.7	0.5	7.4	617	u/s	22	<1	0.6	235	0.79	274	193
17538	20/06/00	97.7	3.5	7.9	557	u/s	16	8	0.5	220	0.80	256	180
17540	24/06/00	191.8	0.3	7.5	598	u/s	9	11	0.6	203	0.68	298	167
17540	24/06/00	199.0	0.8	7.4	645	u/s	15	7	0.6	243	0.79	326	199
17540	24/06/00	205.0	1.3	7.5	662	u/s	15	4	0.6	250	0.77	337	206
17540	24/06/00	211.0	1.5	7.5	649	u/s	12	3	0.6	254	0.71	334	208
17553	05/10/00	70.5	<0.1	7.5	600*	u/s	11	u/s	0.9	219	1.10	224	180

These trends are typical for groundwater system with the recharge water being high in HCO_3^- and having low TDS values. As the water moves along its flow paths in the saturated zone, increases of TDS and most of the major ions normally occur.

Several bores showed high SO_4^- values. These are possibly due to dissolution of gypsum or oxidation of pyrite

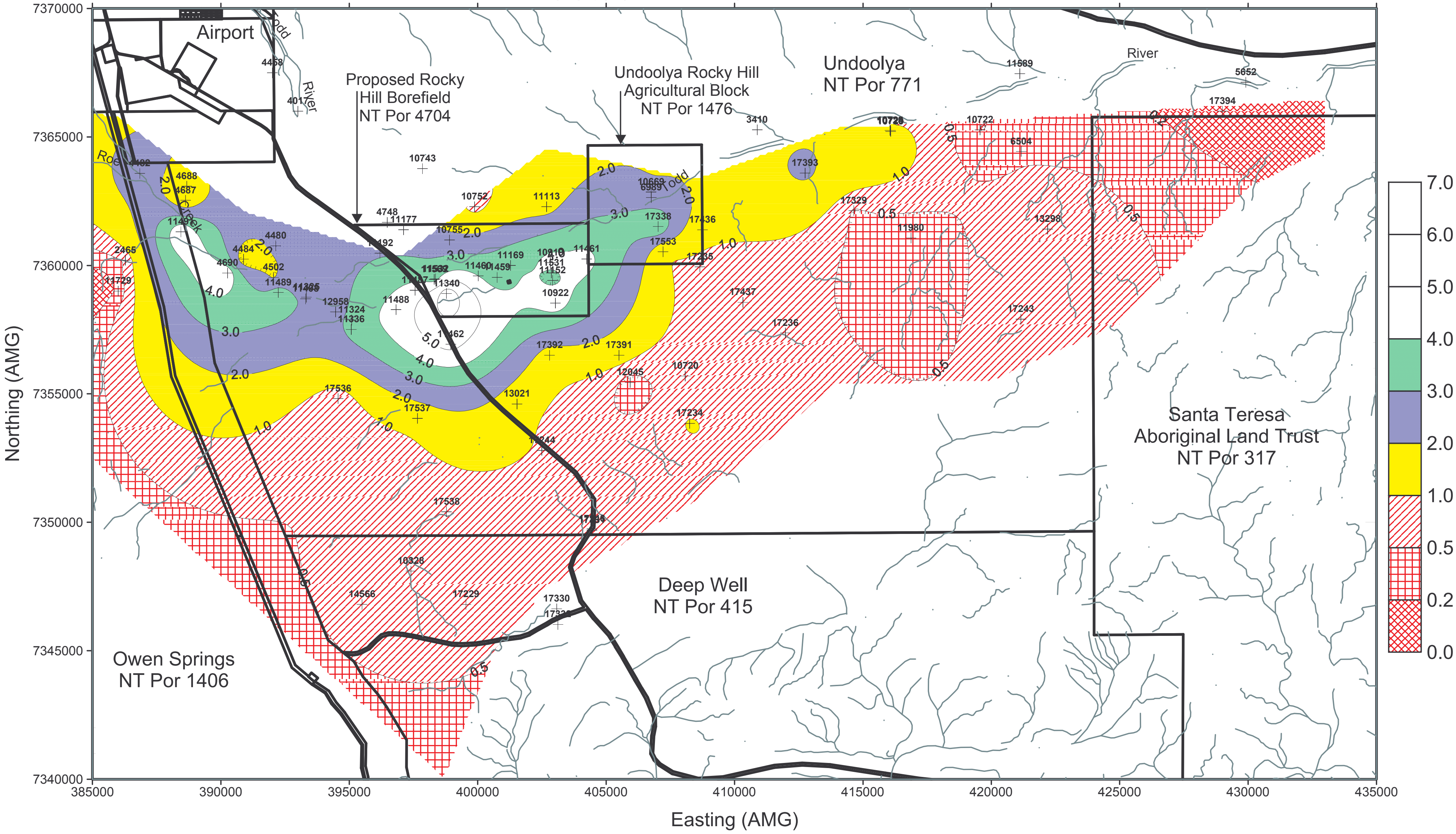
6.3 HCO_3/Cl Ratios

The HCO_3/Cl ratios have been calculated from the chemical analysis results using milli-equivalents/L units. This ratio gives an indication of recharge areas because recharged water is low in Cl and high in HCO_3. An HCO_3/Cl ratio contour diagram was calculated after the 1998 and 1999 drilling programs at Rocky Hill (Read & Paul, 2000). The 2000 drilling program has better defined the southern boundaries for the HCO_3/Cl ratio contours and the contour diagram has been updated (Figure 6.4). RN17537 has a TDS of less than 500 mg/L but the HCO_3/Cl ratio of 1.3 indicates the water is not a recent recharge event or there is mixing of waters. The contour diagram indicates that recharge is occurring along the site of the present day Roe Creek.

6.4 Interpretation

The interpretation from the 1998 and 1999 drilling programs for the Rocky Hill - Ooraminna area is that there is a major recharge zone along Roe Creek where the HCO_3/Cl ratios are higher and the TDS values lower. Recharge from the Todd River does not have as big an impact as Roe Creek recharge as HCO_3/Cl ratio values are not as high along the Todd River. The area near RN17394 has high TDS and very low HCO_3/Cl ratio values and is interpreted as a discharge or former discharge zone. The interpretation has remained the same after the 2000 drilling except that recharge from the Todd River could be greater than previously thought as a major recharge event was interpreted from water level data (see section 9).

Rocky Hill - Ooraminna 2000 Investigation
HCO3/Cl Ratio Contours



Datum: GDA 94 Scale 1: 200 000

0 m 5000 m 10000 m 15000 m 20000 m 25000 m

N

Figure 6.4

7 RESULTS OF CORE ANALYSIS

Several cores were taken during the drilling program. Selected samplers were sent off to Geotech in Western Australia for specific yield and water permeability analysis. Matthew Hales selected samples for petrographic description and X-ray diffraction analysis.

7.1 Hydraulics (Specific Yield, Sy and Porosity, Ø)

Nine samples from RN17354, one from RN17536 and several from RN17537 were sent off to Geotech for porosity, permeability and specific yield analysis. Unfortunately the core samples from RN17537 were too friable and a core plug could not be cut. The results from Geotech are in Tables 7.1 below. The permeability results were reported in millidarcys and have been converted to hydraulic conductivity in metres/day.

Table 7.1 Results of Porosity & Permeability Testing (Amdel)

RN	Depth (metres)	Helium Porosity (%) @ ambient	Grain Density gm/cc	Forward water permeability (mD) @ ambient	Reverse water permeability (mD) @ ambient	Hydraulic Conductivity (m/d) [1]	Specific Yield (%) @ 10 kPa	Specific Yield (%) @ 33 kPa
17354	101.10	21.3	2.65	70	67	0.058	3.5	10.0
17354	152.40	19.0	2.64	35	35	0.029	1.6	9.3
17354	200.00	23.2	2.66	214	204	0.18	2.7	14.7
17354	251.75	20.5	2.66	36	32	0.030	1.0	7.7
17354	302.30	24.9	2.65	1032	997	0.86	14.2	18.9
17354	351.30	22.4	2.66	153	153	0.13	1.1	13.7
17354	400.40	9.8	2.82	<0.01	<0.01	0.0	0.0	0.0
17354	450.80	8.2	2.72	28	28	0.023	1.6	5.8
17354	500.70	9.7	2.71	38	50	0.033	2.9	7.1
17536	349.40	26.0	2.65	778	786	0.65	13.5	20.3

[1] mD x 8.35×10^{-4} = m/d

The results from 1999 and 2000 have been graphed with permeability v specific yield and are shown in Figure 7.1. This shows a good correlation between the permeability and specific yield. The specific yield (@ 33 kPa) can be calculated from the equation below.

specific yield = 3.7709Ln(permeability) – 5.9175.

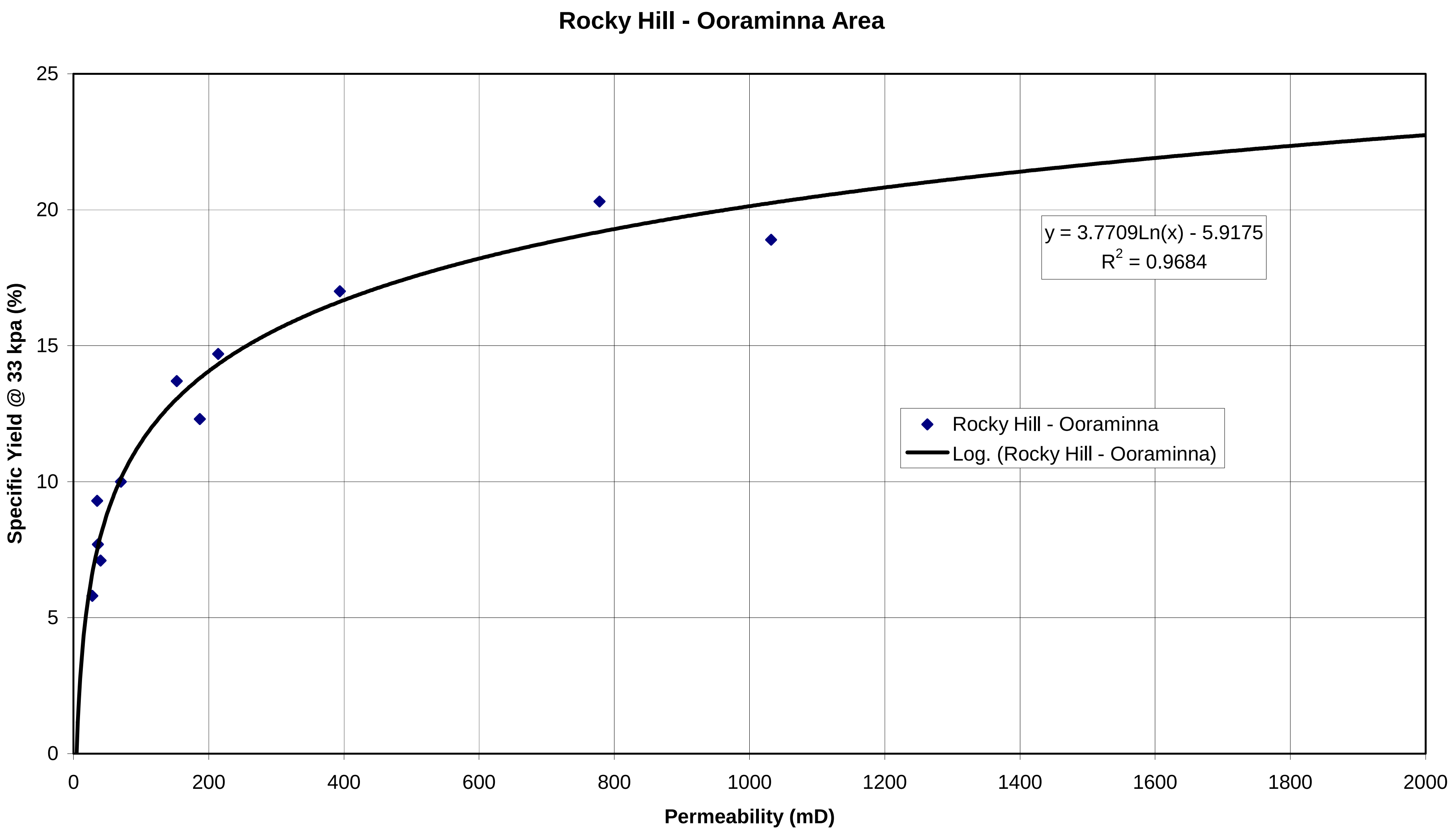


Figure 7.1 Permeability v Specific Yield for Rocky Hill – Ooraminna Core Samples

8 ESTIMATION OF STORED VOLUME

The estimate of stored volume has two components:

- The estimated specific yield of each aquifer.
- The estimated volume of each aquifer.

8.1 Specific Yield

Specific yield is defined as the volume of water that will drain under gravity from a unit volume of rock over a long period of time. The specific yield is best estimated from the response to long term pumping.
For the purposes of this study the specific yield must be estimated from petrophysical data.

8.1.1 Ooraminna Sandstone Member

Specific yield determinations have been done for 9 samples of Ooraminna Sandstone Member. These are shown in Table 8.1 below.

Table 8.1 Specific Yields of Cores from Ooraminna Sandstone Member

RN	Depth m	He Porosity (%)	Permeability mD	Specific Yield 10 kPa	Specific Yield 33 kPa	Specific Yield 240 kPa
17335	70.00	25.37	17.16	0.8	5.2	9.8
17335	71.83	26.35	3500	22.4	23.1	23.2
17336	51.42	25.64	508.76	6.3	17	18.7
17354	102	21.3	68.5	3.5	10	14.2
17354	150.5	19	35	1.6	9.3	13
17354	201.3	23.2	209	2.7	14.7	16.6
17354	250.15	20.5	34	1	7.7	11.4
17392	214.87	22.47	281.35	1.4	12.3	14.3
17536	349.45	26	782	13.5	20.3	22.1
Mean		23.1	624.6	5.5	12.4	15.3
Maximum		26.4	3500	22.4	23.1	23.2
Minimum		19.0	17.2	0.8	5.2	9.8
Median		23.2	68.5	2.7	10.0	14.2
Geometric mean		22.9	126.6	2.9	11.2	14.7
Standard Deviation		2.9	1279.9	7.7	6.2	4.6

General opinion is that 33 kPa yield is the best estimate of gravity drainage.

Because there are a large number of samples for which He porosity and permeability have been determined, the relation between specific yield and these parameters was investigated. Results are shown in Table 8-2 and Figure 8-1. It can be seen that at 10 kPa the log and linear fits have similar correlation coefficients. For 33 kPa and 240 kPa the log fit is clearly better. Note that the equation is only valid for a limited range of permeabilities, since Y in the equations below can never be <0 or >1.

Table 8.2 Relation between Specific Yield and Permeability, Ooraminna Sandstone Member

Capillary Tension	Fit	Equation*	Correlation coefficient
10 kPa	linear	Y = 0.000229 * X + 0.0975	0.86
	log	Y = 0.135 * ln(X) - 0.458	0.73
33 kPa	linear	Y = 0.000133 * X + 0.480	0.52
	log	Y = 0.113 * ln(X) - 0.0182	0.91
240 kPa	linear	Y = 8.57E-005 * X + 0.627	0.41
	log	Y = 0.0739 * ln(X) + 0.299	0.75

*Y is (Specific Yield)/(Helium Porosity)
X is permeability in milliDarcys

Table 8.3 below shows measured porosity and permeability and estimated 33 kPa specific yield for 11 samples. The first two samples from RN 10216 have much lower porosities than any others tested. Permeability was not determined for these, presumably because it was too low. These two samples are clearly different to the bulk of the Ooraminna Sandstone Member, and presumably represent silty units within it. They were assigned a specific yield of zero and included in the average. Table 8.4 shows a comparison between the two sets of samples.

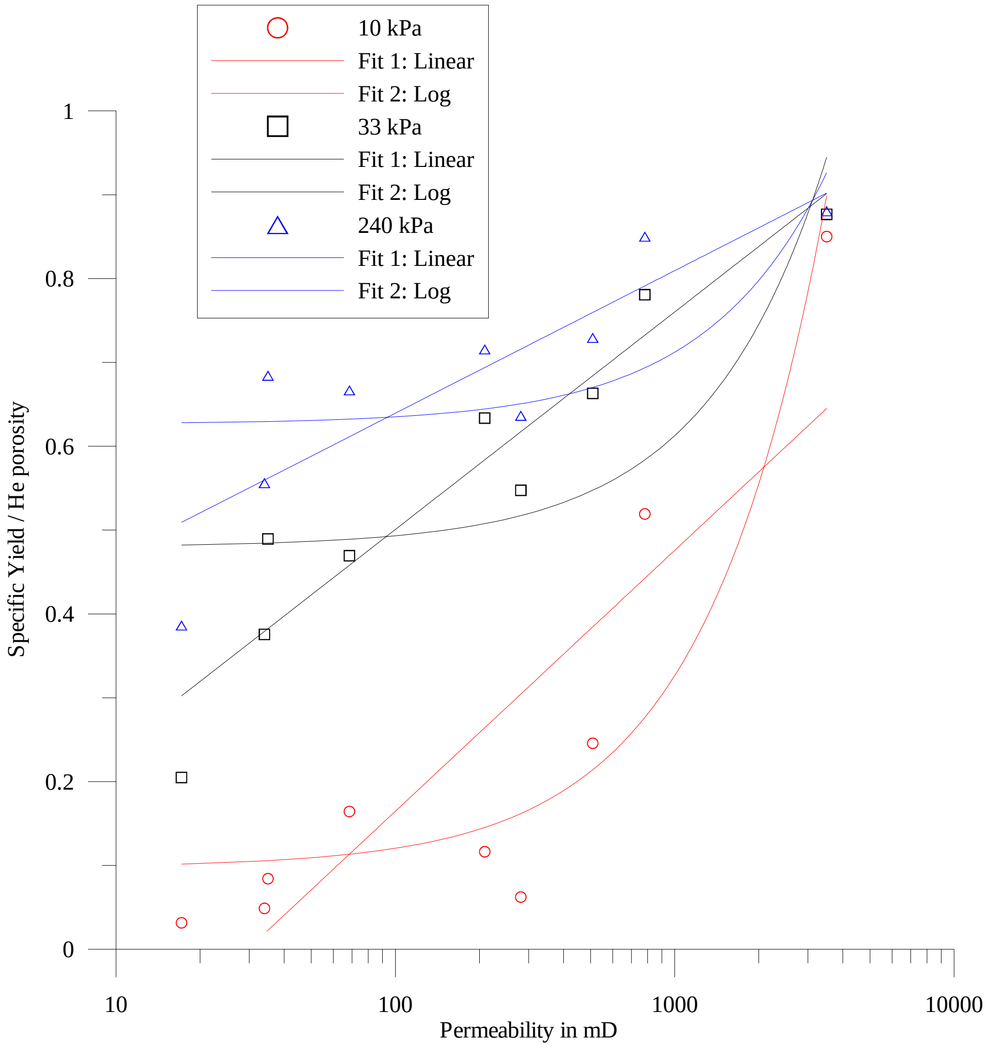


Figure 8.1 **Relation between Specific Yield and Permeability, Ooraminna Sandstone Member**

Table 8.3 Specific Yield Estimated from Permeability, Ooraminna Sandstone Member

RN	Plug Depth (mbgl)	Measured He Porosity (%)	Measured Permeability (mD)	Estimated Specific Yield at 33kPa/He porosity by formula	Estimated Specific Yield % 33 kPa
10216	436.0	10	*-(1)*	-	*0.0*
10216	537.8	11	*-(1)*	-	*0.0*
10216	342.7	22	197	0.58	*12.7*
10216	342.7	21	46	0.41	*8.7*
17334	70.93	28.53	175.69	0.56	*16.1*
17336	51.37	26.19	1001.67	0.76	*19.9*
17337	50.54	24.75	723.27	0.72	*17.9*
17337	52.89	25.37	715.84	0.72	*18.3*
17338	51.51	23.67	281.35	0.62	*14.6*
17392	214.92	22.47	277.45	0.62	*13.8*
17393	90.91	25.46	132.85	0.53	*13.6*
Mean		21.9	322.8	0.647	*12.3*
Median		23.7	197	0.62	*13.8*
Standard deviation		6.00	337.35	0.0877	*6.8*

(1) Not measured, presumably because the cores had very low permeability.

Table 8.4 Comparison of Samples with Measured and Estimated Specific Yield, Ooraminna Sandstone Member

Parameter	Statistic	Cores for which specific yield was measured	Cores for which specific yield was estimated from permeability
No of samples		9	11
Helium Porosity	Mean	23.1	21.7
	Maximum	26.4	28.5
	Minimum	19.0	10.0
	Median	23.2	23.6
	Geometric mean	22.9	
	Standard Deviation	2.9	6.0
Permeability mD	Mean	624.6	322.8
	Maximum	3500.0	723
	Minimum	17.2	0
	Median	68.5	197
	Geometric mean	126.6	
	Standard Deviation	1279.9	377
33 kPa specific yield	Mean	12.4	*12.3*
	Maximum	23.1	*19.9*
	Minimum	5.2	*0.0*
	Median	10.0	*13.8*
	Geometric mean	11.2	
	Standard Deviation	6.2	*6.8*
	Standard Deviation of estimate	2.1	*2.1*

* Values in italics are for the calculated data, not measured data

The two estimates of 33 kPa specific yield are similar.

There are two problems in relating these values to the available stored volume.

- The reliability of the estimate of specific yield.
- The uncertainty as to how well the 33 kPa specific yield really represents the specific yield under gravity drainage.

The estimate of the specific yield will be influenced by the following:

- Random error in the samples.
- Systematic error. The more competent sandstone is more likely to be cored and selected for testing.

Bearing the above uncertainties in mind a specific yield of 8% was selected to estimate the volume stored in the Ooraminna Sandstone Member.

8.1.2 Mereenie Sandstone

This unit is relatively thin at Rocky Hill and its contribution to the stored volume is around 4% of the total (see Table 8.6).

Only one core from the Mereenie Sandstone at Rocky Hill has had petrophysical work done on it. This had a specific yield at 33 kPa of 18.9%. Petrophysical work was done on core from RN 15020 and 15021 at Roe Creek. A specific yield of 10% has been arbitrarily selected to calculate the stored volume at Rocky Hill.

8.1.3 Pacoota Sandstone

What was formerly regarded as Unit A of the Mereenie Sandstone has been assigned by Hales (2000) to Parasequence 4 of the Pacoota Sandstone. Only one core from the Mereenie Sandstone at Rocky Hill has had petrophysical work done on it. This had a specific yield at 33 kPa of 13.7%.

A specific yield of 10% has been arbitrarily selected to calculate the stored volume at Rocky Hill.

8.2 Geological Cross-Sections

A series of cross-sections were drawn across the syncline. Correlations were largely based on gamma logs, and petrographic examination of cores when available.

8.2.1 Section 386 000E

Only the northern limb of the syncline appears on this section (Fig. 8.2). No bores have penetrated the full thickness of the Mereenie Sandstone, but it is at least 105 m thick.

8.2.2 Section 391 000 E

There is poor geological control on this section (Fig. 8.3). The Mereenie Sandstone has not been intersected.

8.2.3 Section 397 000 E

There is reasonably good control on the north side of this section (Fig. 8.4). The geometry of the Ooraminna Sandstone Member has been inferred by assuming that the Hermannsburg Sandstone above it is of constant thickness. It is not known if the Mereenie Sandstone or Parasequence 4 of the Pacoota Sandstone extend to the southern side of the syncline.

8.2.4 Section 402 700 E

There is good control on the north end of this section and fair control on the southern side (Fig. 8.5). The syncline is shallower than on the sections above. The Mereenie Sandstone wedges out down dip. Parasequence 4 of the Pacoota Sandstone is present on the southern side of the syncline, but the gamma logs indicate that it is missing on the north.

8.2.5 Section 408 500 E

The syncline is shallower in this section (Fig. 8.6). There is one thin intersection of Mereenie Sandstone on the southern flank, but it has not been recognised elsewhere

8.2.6 Section 414 000 E

The syncline is shallow and flat in this section (Fig. 8.7). RN 17236 has a complete gamma log. Two cores were cut in RN 17393 confirming that it bottomed in Ooraminna Sandstone Member.

8.2.7 Section 420 000 E

The interpretation of this section is based largely on two incomplete gamma logs in RN 6504 and RN 17243. Both these logs clearly have a distinctive downward increasing “ramp”. This suggests that the dip across the syncline is quite flat. The “ramp” has been interpreted as Parasequence 4 of the Pacoota Sandstone. It is possible that it is in fact Ooraminna Sandstone Member, but the former interpretation has been used as being the more conservative consistent with the available evidence. If this is correct then the Ooraminna Sandstone Member is above the water table in this section (Fig. 8.8). The only bores in the centre of the syncline have no geophysical logs and only one geological log that cannot be interpreted.

Table 8.5 shows summarised data for the sections.

Table 8.5 Summarised Data for Sections

Section	**Dip on N flank**	**Dip on S flank**	**Ooraminna Sandstone Member**		**Mereenie Sandstone**		**Pacoota Sandstone, Parasequence 4**	
			Thickness	Width	Thickness	Width	Thickness	Width
386 000	12	-	215	1000	105+	550+	Not intersected	
391 000	5 approx	?, no information	?	1900	? Not intersected	?	Not intersected	
397 000	6	? no information	185 to 155	2100 + 1200	30 to 0	300, thinning with depth	120	1900
402 700	1 to 3	5	290	3500 + 2900	50 to 0	2000, thinning with depth	95	1200
408 500	3 approx	6	250	2200 + 2100	10		80	800
414 000	9 ?	5	195	1200 + 2100			70	550 + 700
420 000	?	4 ?	Above water table		0		100	

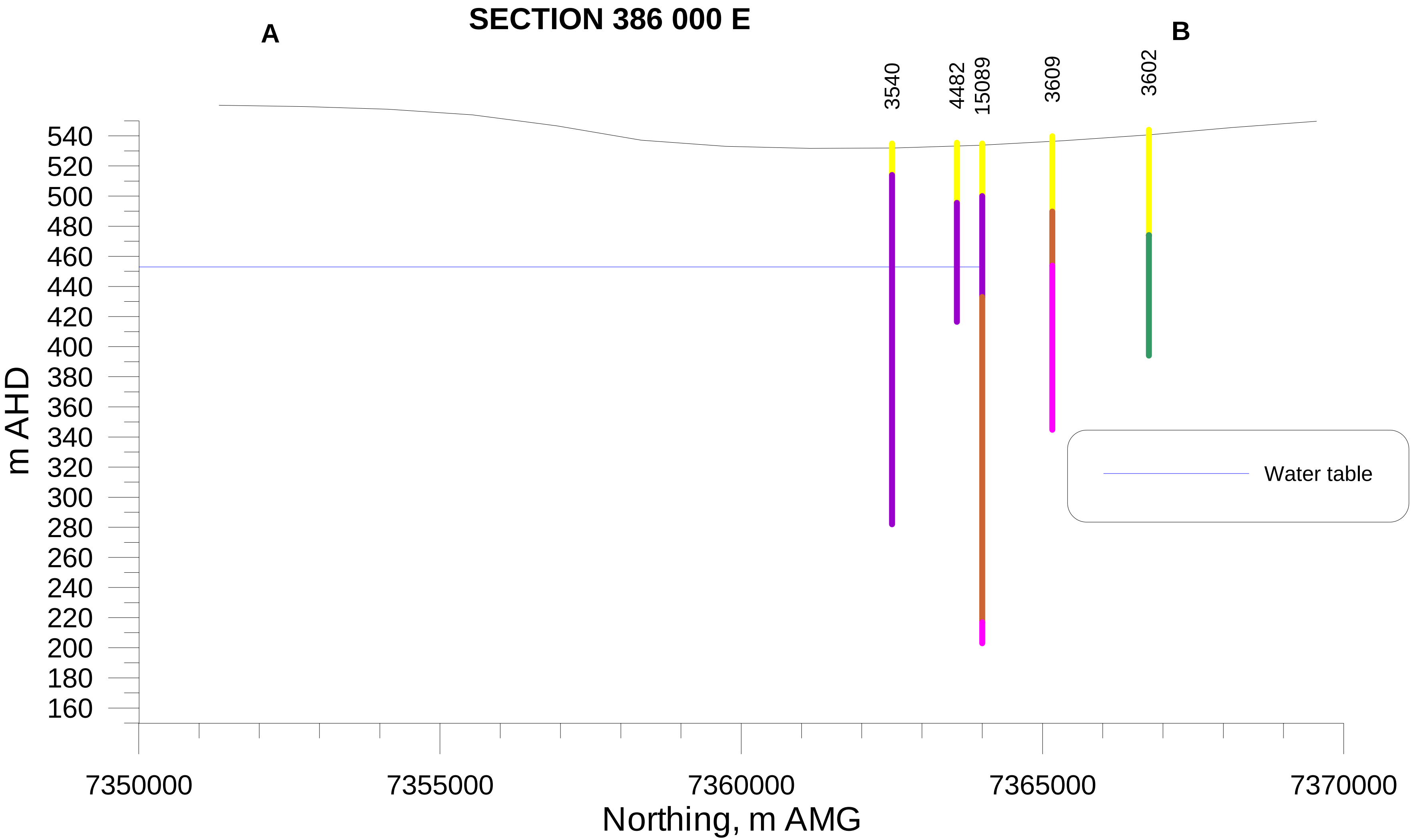


Figure 8.2 Section 386 000E

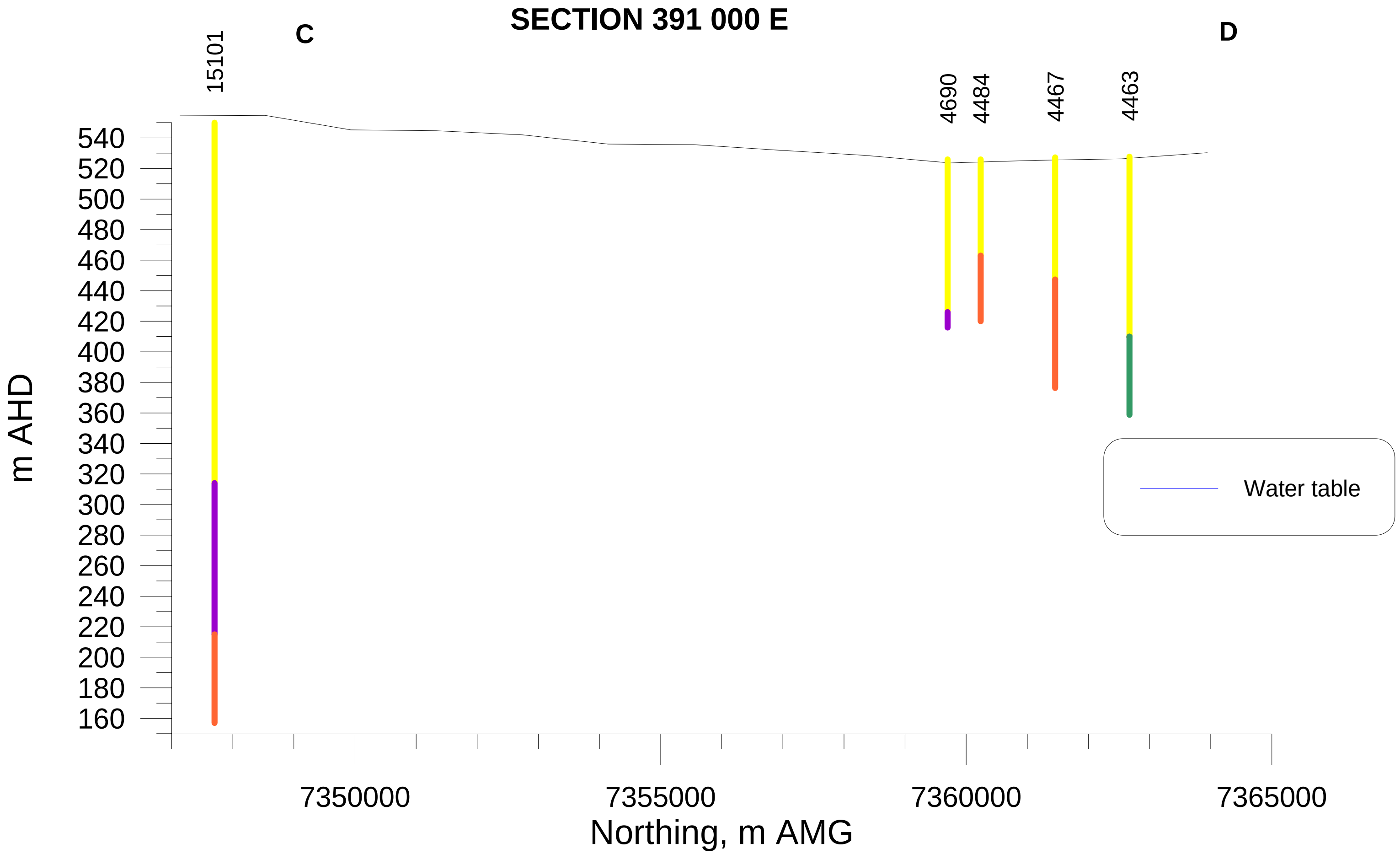


Figure 8.3 **Section 391 000E**

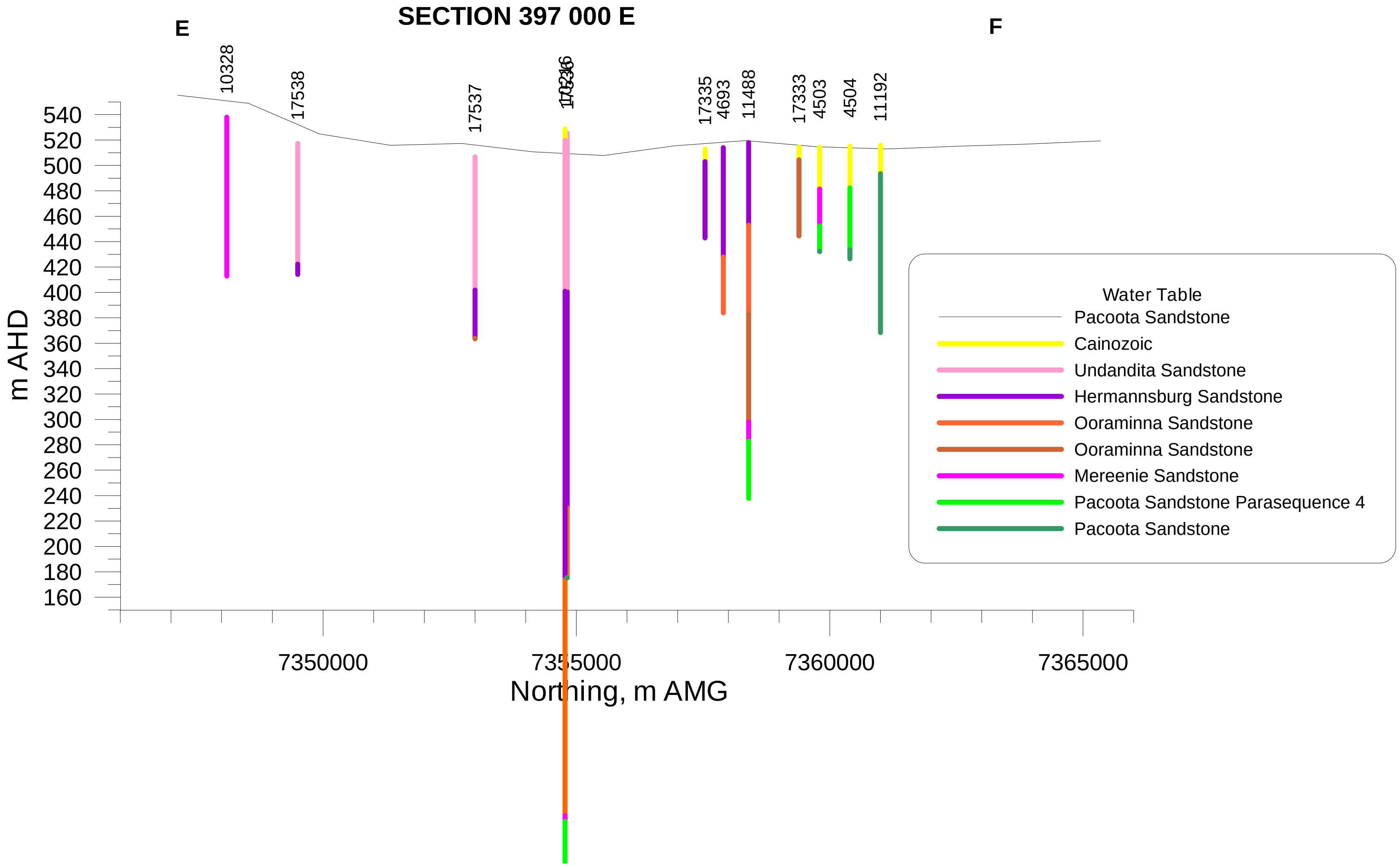


Figure 8.4 **Section 397 000E**

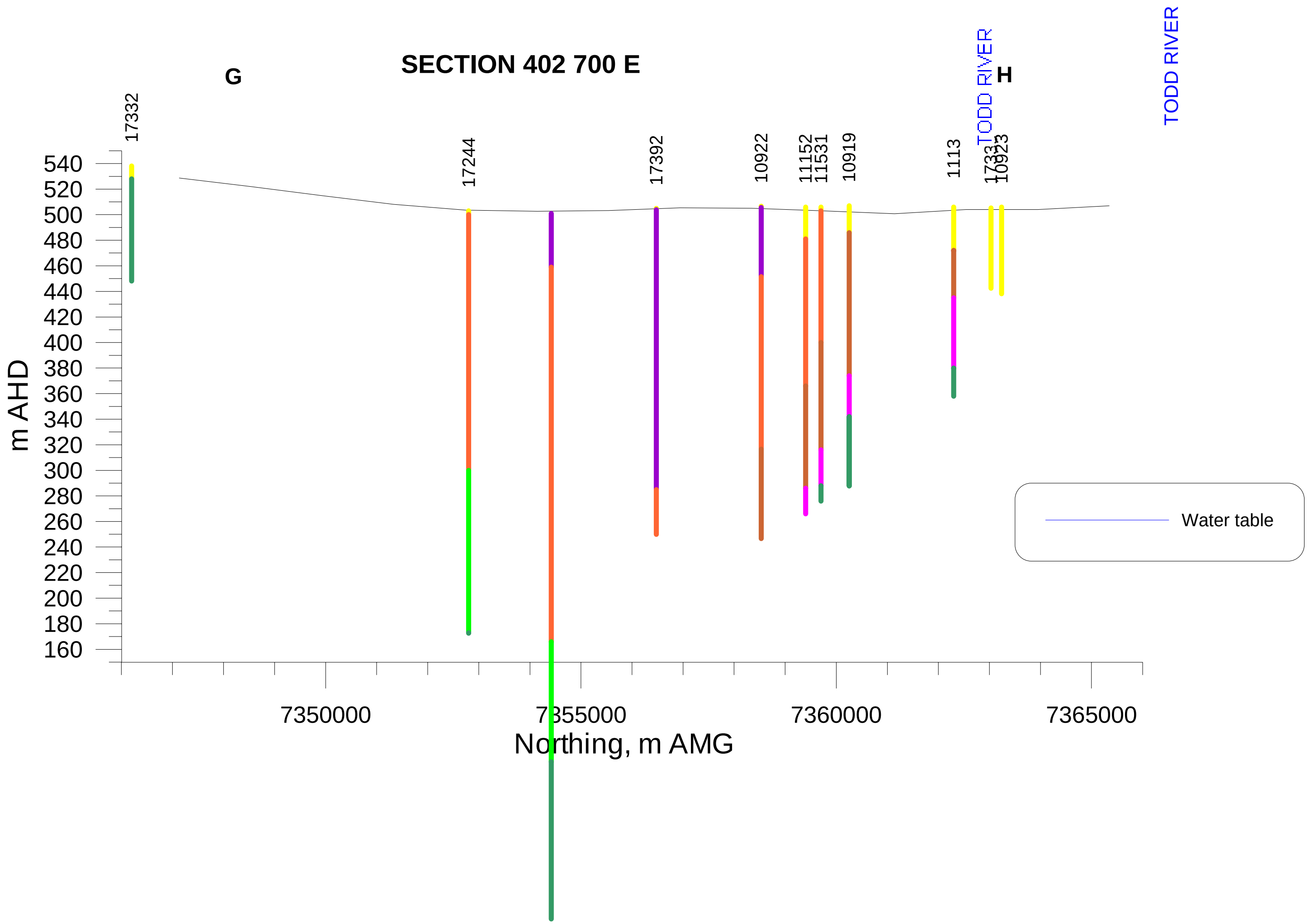


Figure 8.5 **Section 402 700E**

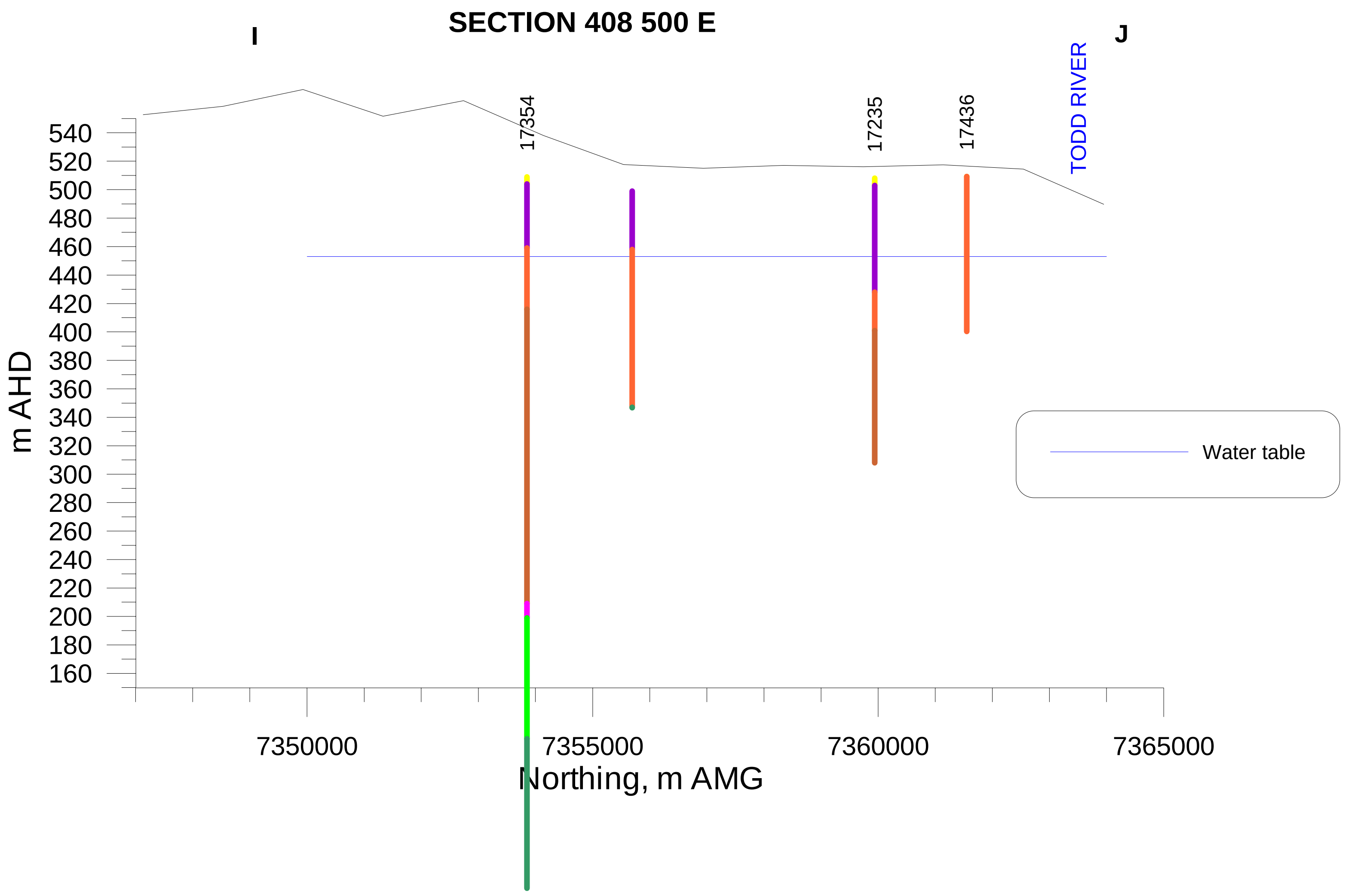


Figure 8.6 Section 408 000E

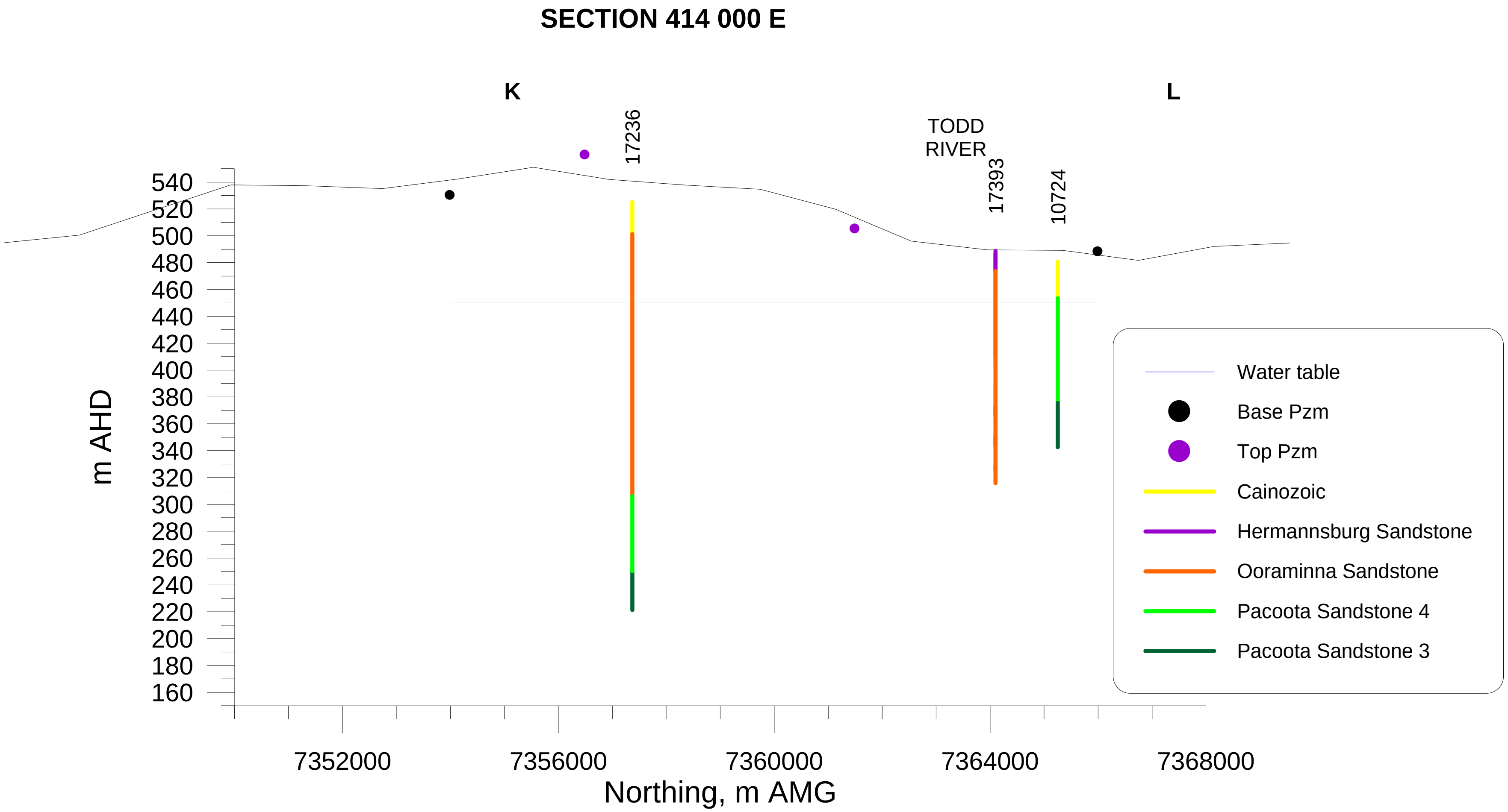


Figure 8.7 **Section 414 000E**

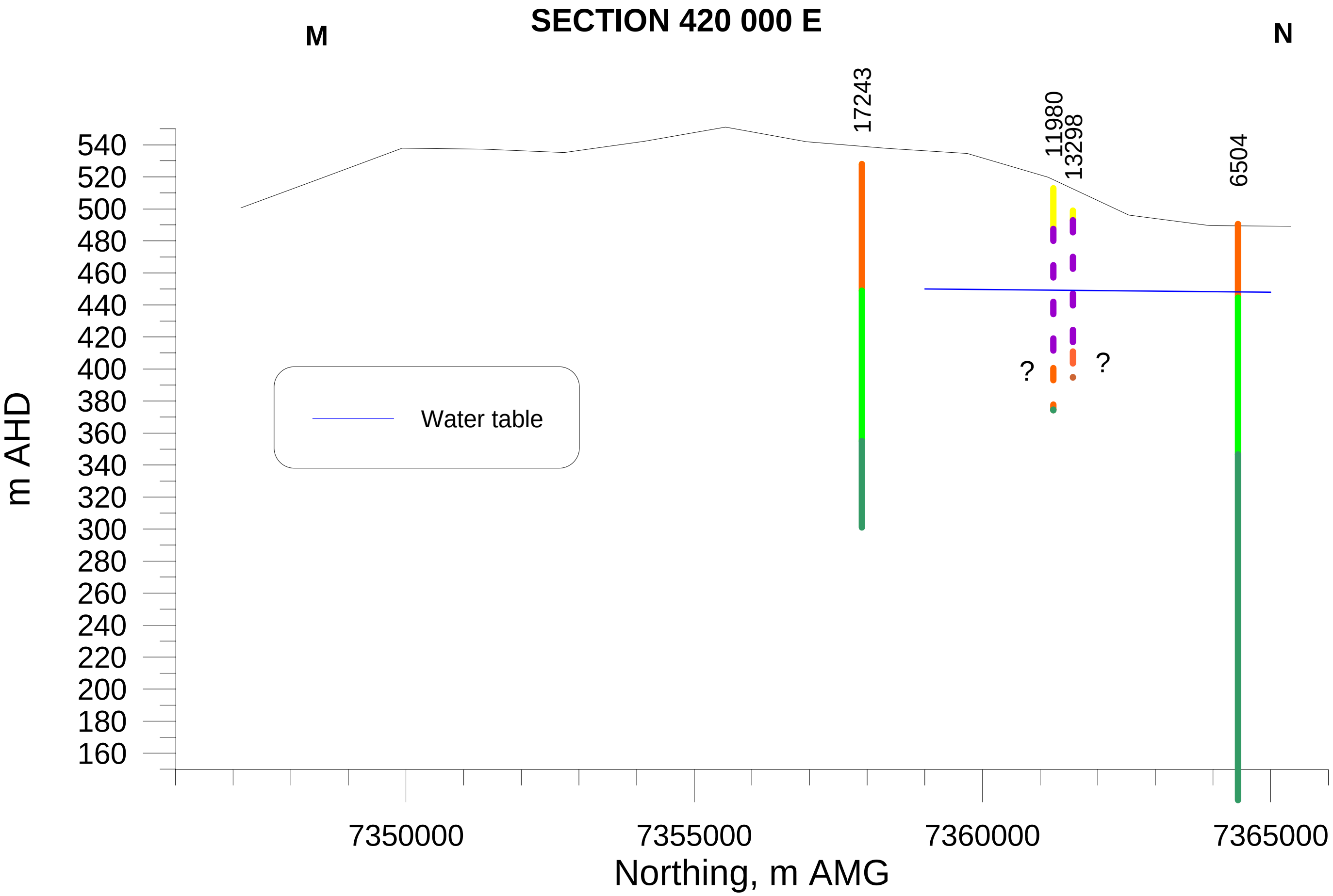


Figure 8.8 **Section 420 000E**

8.3 Calculation of Stored Volume

The eastern limit of the good quality water was assumed to be 422 000 E, as this is the eastern limit to which drilling has proved water of under 1000 mg/L. It is possible that the saline water is limited by the NNW trending fault that cuts across this part of the syncline.

For the purposes of the calculation the western limit was assumed to 391 000 E. This was selected as being approximately the western limit of the effects of pumping at Roe Creek borefield. Water levels here are falling at about 0.4 m per year, mostly as a result of pumping at Roe Creek. Stored volume of water between 391 000 E and 422 000 E was estimated as follows:

- The area of each aquifer unit on each cross-section was calculated by making conservative assumptions about the geometry.
- The volume of aquifer between each pair of cross-sections was estimated by multiplying their average area by the distance between them.
- The aquifer volumes above were summed.
- The stored volumes were estimated by multiply the aquifer volumes by the specific yield for each aquifer, as determined in Section 8.1

Calculated stored volumes are shown in Table 8.6 and Figure 8.9.

Table 8.6 Stored Volume Estimates

Depth of dewatering		**Volume in storage m^3**			**Total, all aquifers**	
m AHD	**Approx. depth from surface**	**Ooraminna Sandstone Member**	**Mereenie Sandstone**	**Pacoota Sandstone, Parasequence 4**	**Total m^3**	**Total GL (1)**
400	100	6.66E+08	4.45E+07	2.91E+08	1.00E+09	1002
350	150	1.30E+09	7.76E+07	5.75E+08	1.95E+09	1952
300	200	1.86E+09	1.02E+08	7.29E+08	2.69E+09	2692
250	250	2.23E+09	1.19E+08	9.66E+08	3.32E+09	3319
200	300	2.55E+09	1.27E+08	1.07E+09	3.75E+09	3747
150	350	2.83E+09	1.31E+08	1.17E+09	4.13E+09	4126

(1) gL is gigalitres, that is 1 000 ML.

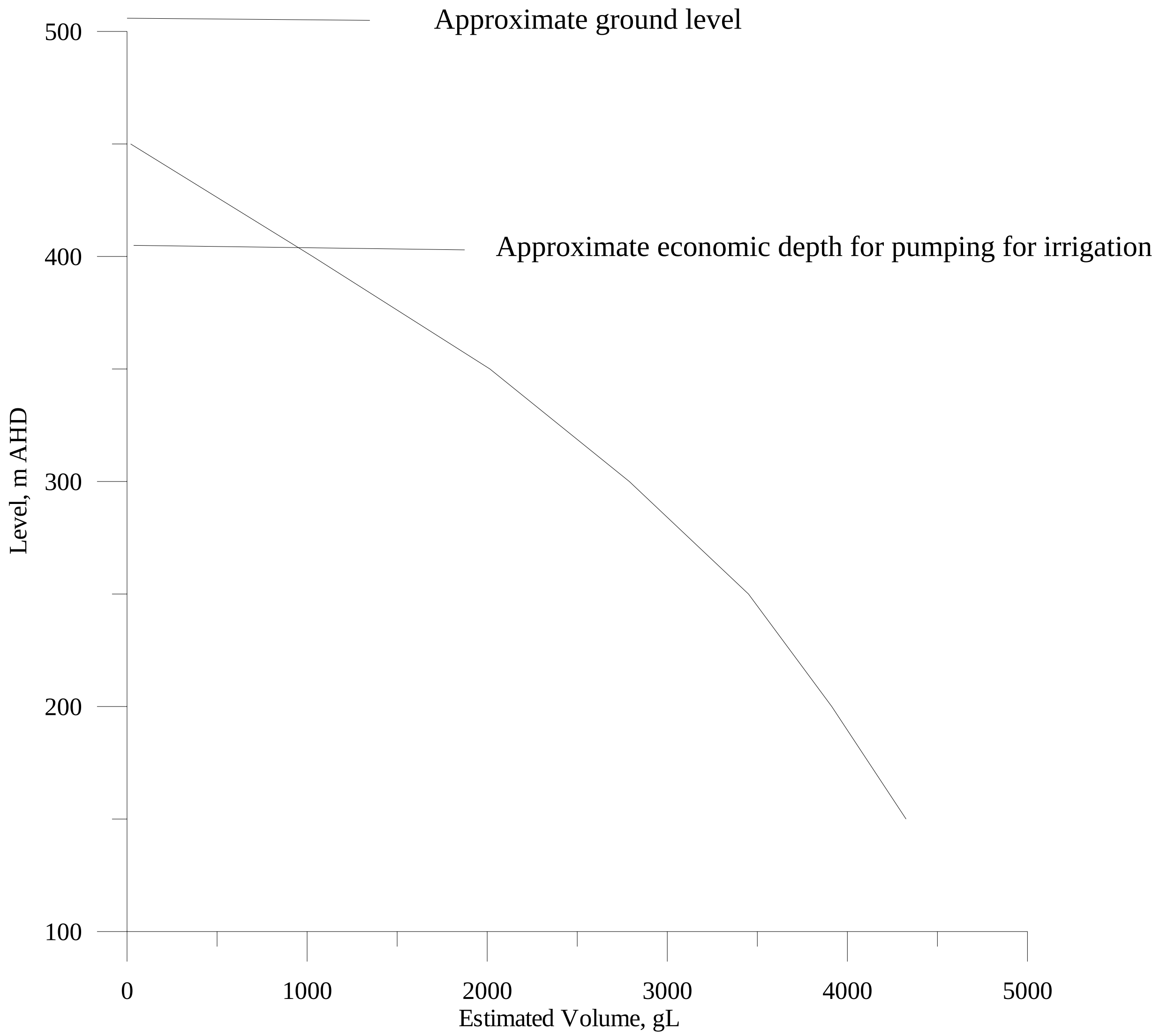


Figure 8.9 Depth and Estimated Volume in Storage

9 RECHARGE AND THROUGHFLOW

Groundwater levels have been monitored in the Rocky Hill – Ooraminna area regularly with some monitoring bores having records commencing in 1962. Bore RN3609, at the western end of the Rocky Hill area, has shown a 26 metre decline in water level since 1962 (Fig. 9.1). The graph shows a good straight line fit for the period August 1983 to the end of 1990. The slope of the line decreases from 1991 onwards, possibly due to decreased extraction from the Mereenie Sandstone. If the slope from 1983 to 1990 had continued after 1990 the water level would have been approximately 3 metres deeper in June 2001.

Some bores showed an increase in water level from the end of 1999 to June 2001. The bore with the biggest increase was RN10722 (Fig. 9.2) which showed a 1.25 metre increase in water level. This increase in water level followed good rainfall events in 1999 and 2000 and is attributed to recharge from the Todd River.

9.1 Recharge Estimates

In areas with deep water tables, virtually all water that passes the root zone could recharge the groundwater aquifer. Average regional recharge over a long period then equals average regional groundwater discharge (de Vries & Simmers, 2002). From Table 8.6 the amount of water in storage from the top 50 metres of the aquifer is 1,002GL or 1,002,000 ML. The water level has been calculated to be declining at 0.1 m/year in the Rocky Hill – Ooraminna area (Read & Paul, 2000). From these figures the average annual regional discharge, which equals the average annual regional recharge is calculated as:

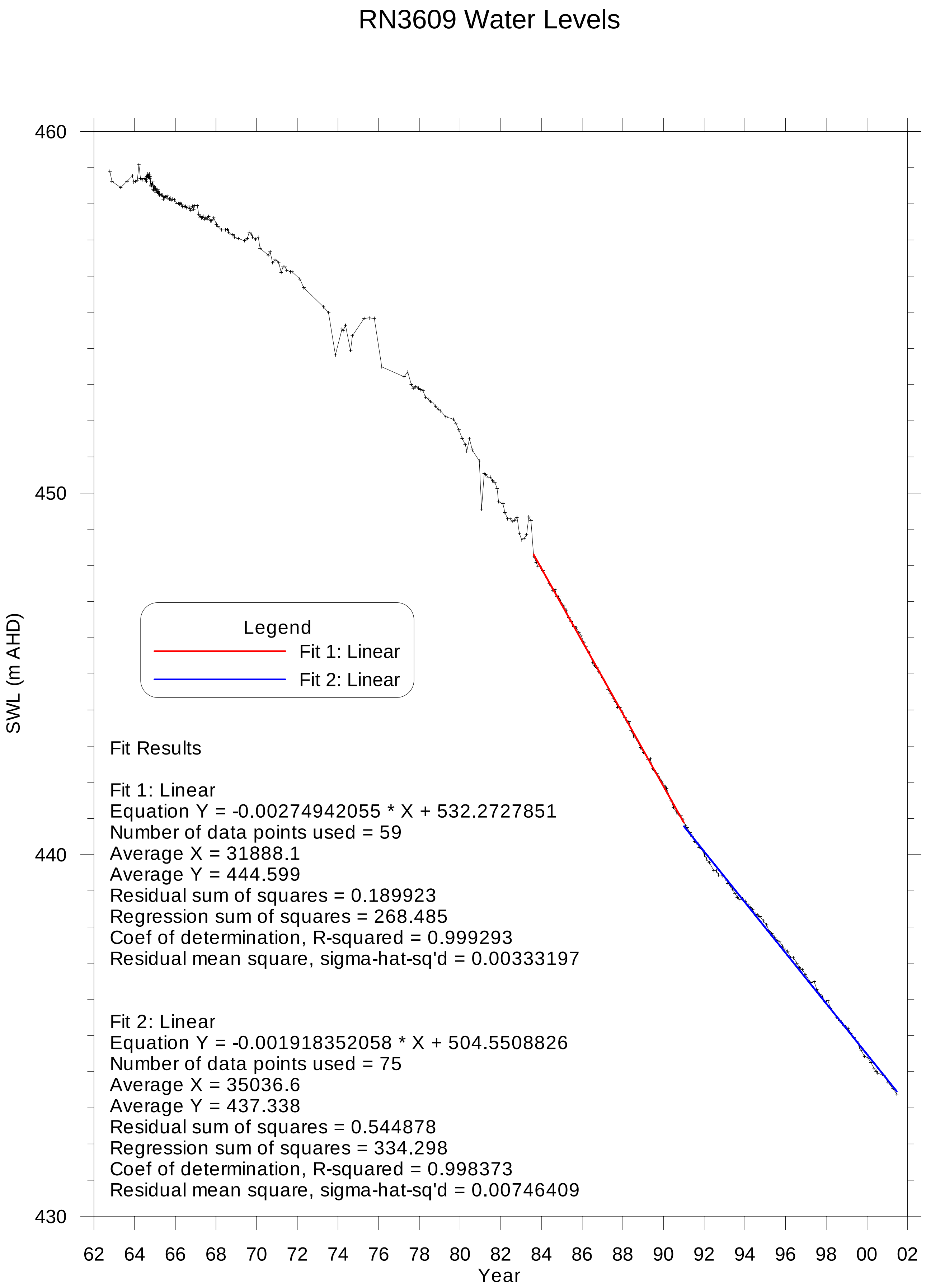
$\frac{1{,}002{,}000 \times 0.1}{50}$, approximately 2,000 ML/year.

Read (Read & Paul, 2000) calculated the natural outflow not affected by pumping from the eastern Rocky Hill – Ooraminna area, based on the decline in water levels from 1988 to 1998, as in the range of 1,000 to 3,000 ML/year.

9.2 Regional Throughflow

The annual average discharge has been estimated at 2,000 ML/year. Using Darcy's Law, Q = iTW, where Q = discharge, i is the hydraulic gradient and W the width of the aquifer, estimates of transmissivity, T, have been calculated for the eastern part of the Rocky Hill – Ooraminna area. From Figure 9.4 the hydraulic gradient is approximately 8m / 5,000m = 1.6×10^{-3}. The width of the aquifer is approximately 8,000 m and Q = 2,000,000 m^3/year or approximately 5,500 m^3/day. Putting these figures into Darcy's Law returns a T value of approximately 430 m2/day.

The potentiometric surface in Figure 9.3 shows that the discharge area for the eastern half of the Rocky Hill – Ooraminna area is in the eastern part of the Rocky Hill – Ooraminna area with the potentiometric surface in the Mereenie Sandstone sloping gently east. No specific area has been identified as a discharge zone, so it is possible that discharge is occurring over a wide area.



```
Fit Results

Fit 1: Linear
Equation Y = -0.00274942055 * X + 532.2727851
Number of data points used = 59
Average X = 31888.1
Average Y = 444.599
Residual sum of squares = 0.189923
Regression sum of squares = 268.485
Coef of determination, R-squared = 0.999293
Residual mean square, sigma-hat-sq'd = 0.00333197


Fit 2: Linear
Equation Y = -0.001918352058 * X + 504.5508826
Number of data points used = 75
Average X = 35036.6
Average Y = 437.338
Residual sum of squares = 0.544878
Regression sum of squares = 334.298
Coef of determination, R-squared = 0.998373
Residual mean square, sigma-hat-sq'd = 0.00746409
```

Figure 9.1

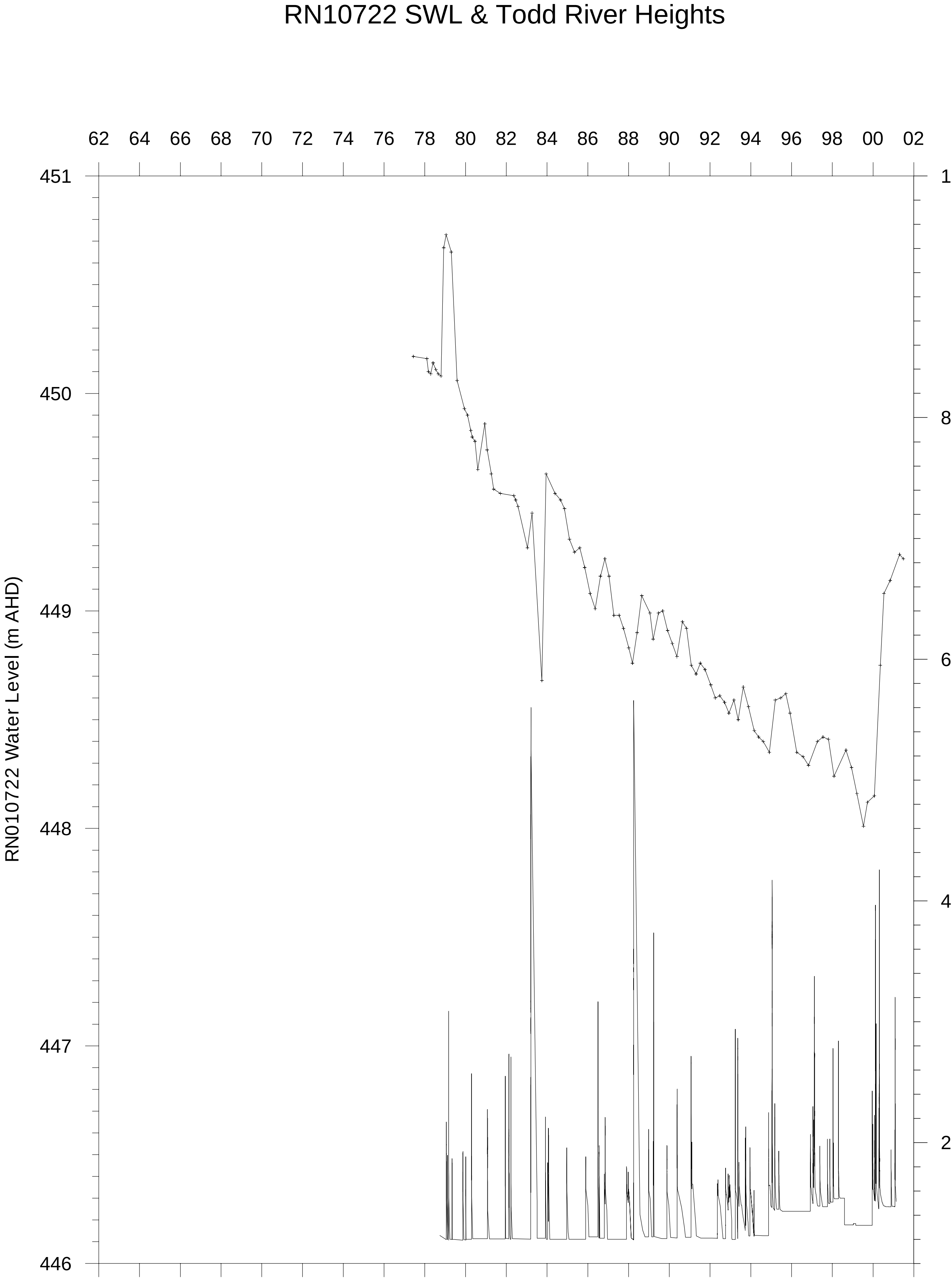

RN10722 SWL & Todd River Heights
62
64
66
68
70
72
74
76
78
80
82
84
86
88
90
92
94
96
98
00
02
451
450
449
448
447
446
RN010722 Water Level (m AHD)
10
8
6
4
2
Todd River Hieght (m)

Figure 9.2

There is an approximately 50 m water level difference between the Rocky Hill – Ooraminna area and the Deep Well area to the south, even though the Mereenie Sandstone occurs in both areas . The potentiometric surface in Figure 9.3 shows no movement of groundwater to the south. This is studied in more detail in chapter 12.

9.3 Water Volume Changes in the Mereenie / Ooraminna Sandstone

Groundwater contour maps have been produced using the software program Surfer for January 2000 (Fig. 9.3) and July 2001 (Fig. 9.4). These dates were chosen because most water level graphs showed a minimum in January 2000 and a maximum in July 2001. Figure 9.5 shows the change in water level for January 2000 to July 2001. Surfer calculated the volume change as 9.2×10^7 m^3. Using a specific yield of 10 % this is a recharge event of 9,200 ML, but since these events are rare the average annual recharge will be much less than this. The western part of the Rocky Hill – Ooraminna area was calculated to have lost 2,800 ML of water over the same period. There was an overall gain of 6,400 ML of water from January 2000 to June 2001 in the Rocky Hill – Ooraminna area.

9.3.1 Modelled Volume Changes at Roe Creek Borefield

Jolly *et al* (1994) modelled groundwater flow in the Mereenie Sandstone in a local Roe Creek model and a regional model. They concluded that the extraction from the Roe Creek borefield was not intercepting regional throughflow but that extraction was coming from "local" storage. Modelling indicated that with an annual extraction rate of 10 million m^3 (10,000 ML), annual inputs from recharge, up dip flow and across strike flow were only in the order of 0.5 million m^3 (500 ML). It was concluded that the hydraulic performance of the Roe Creek borefield could be conceptualised by a "tank model". This resulted in the development of a relationship between cumulative extraction and drawdown in the borefield. Borefield cumulative extraction was plotted against drawdowns from three representative monitoring bores (RN3609, RN5731/5798 [data sets combined] and RN3600) for the period 1964 to 1989, which resulted in a predictive error for water levels of less than 5%.

The relationship between cumulative extraction and drawdown in the borefield needs to be re-analysed to include the data collected after 1989 and see if the "tank model" is still valid for the Roe Creek borefield. If the relationship between cumulative extraction and drawdown in the Roe Creek borefield is still valid it can be used as a simple but effective means of predicting the future water levels within the Roe Creek borefield.

Rocky Hill - Ooraminna Investigation
Potentiometric Surface January 2000

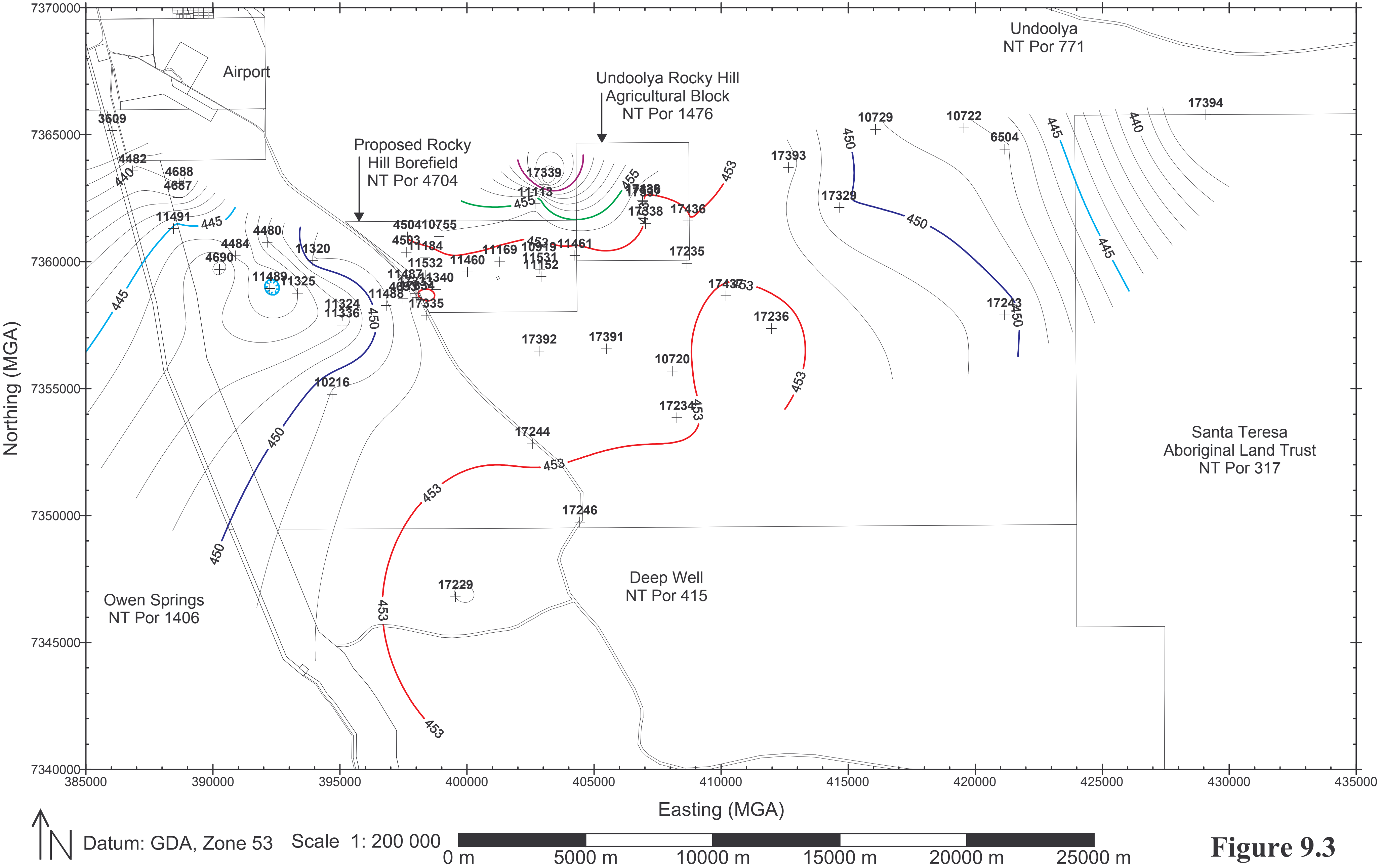


Figure 9.3

Rocky Hill - Ooraminna Investigation
Potentiometric Surface July 2001

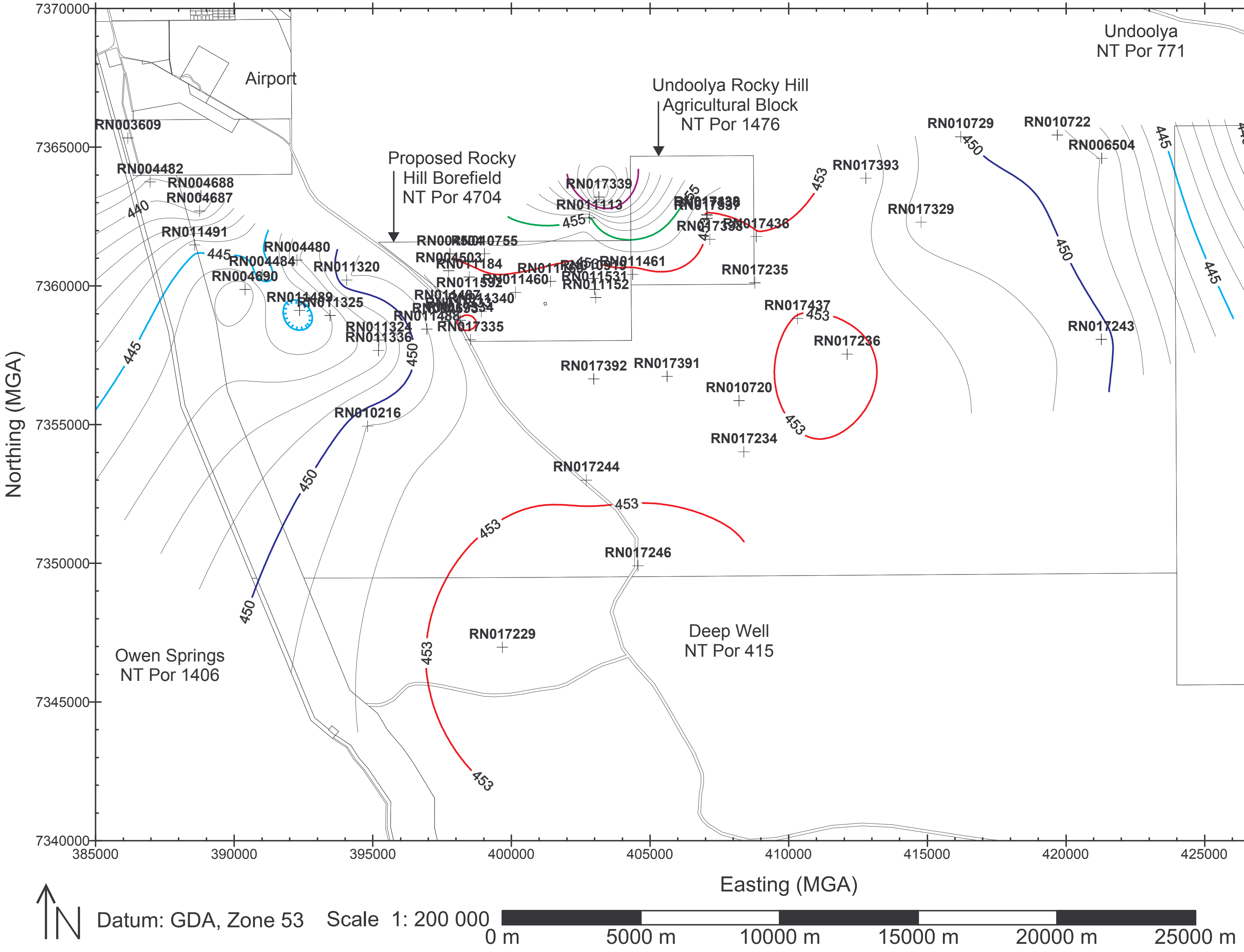
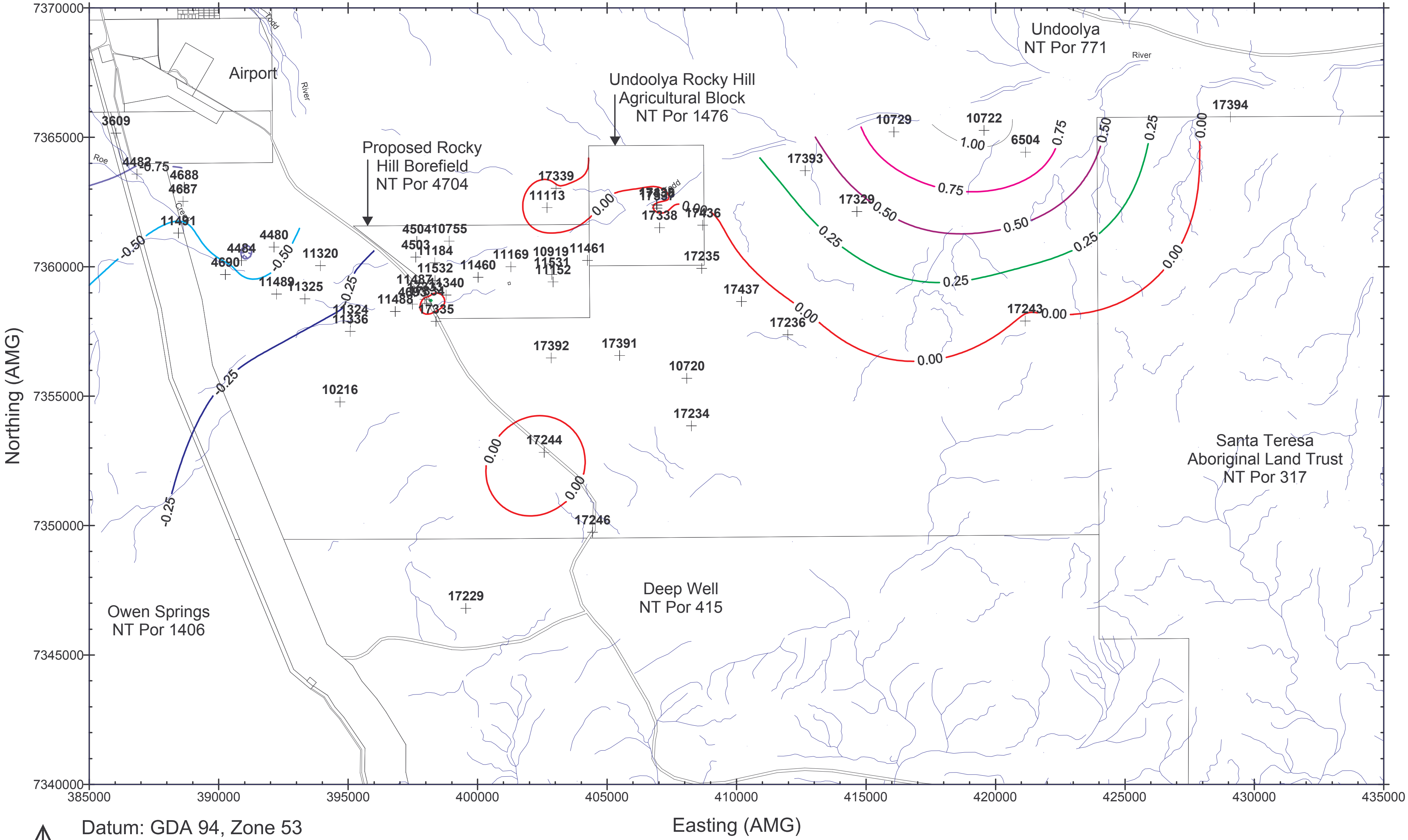


Figure 9.4

Rocky Hill - Ooraminna Investigation
Potentiometric Surface Change : January 2000 to July 2001



Datum: GDA 94, Zone 53

Scale 1: 200 000

0 m 5000 m 10000 m 15000 m 20000 m 25000 m

N

Figure 9.5

10 BRS ISOTOPE SURVEY RESULTS

International Atomic Energy Agency (IAEA) are making an assessment on the potential utilisation of long-term isotope responses of hydrological systems, particularly groundwater aquifers, in the quantitative understanding of hydrodynamic changes induced by exploitation. Isotope data were collected from the Mereenie Sandstone at Roe Creek Borefield and surrounding ares in 1977 (Calf, 1978). BRS conducted isotope sampling of the Roe Creek Borefield and Rocky Hill – Ooraminna area in 1999 and 2000, which included re-sampling bores from the 1977 sampling program. The main objective is to see if there has been any long term isotope response from the 25 years of pumping at Roe Creek Borefield.

Apart from bores historically sampled for isotopes additional bores were selected for the following reasons:

(i) to determine the extent of recharge from the Todd River / Roe Creek drainage system;
(ii) to examine changes in radioisotope values along flow paths in the Mereenie Sandstone;
(iii) to assess the contribution of inter-aquifer flow to recharge in the Mereenie Sandstone;
(iv) and to examine the sustainability of the pumping regime in the Alice Springs area.

Hostetler (2001) reported that bores within the Mereenie Sandstone approaching Roe Creek show an increase in 14C from the regional background level of 20-25 pmC to almost 50 pmC. In the Rocky Hill area recharge from the Todd River had raised the level of 14C to over 70 pmC. The bores close to Roe Creek are also distinctive in stable isotope chemistry being much more depleted in 2H and 18O compared with bores elsewhere in the Mereenie Sandstone. In bores away from Roe Creek , 13C becomes more enriched with increasing alkalinity. The bores along Roe Creek show no fractionation suggesting a short residence time.

Hostetler concluded that the primary source of recharge to the Roe Creek borefield / Rocky Hill – Ooraminna area is throughflow of groundwater from the regional Amadeus Basin, through the mechanism of distributed recharge. There is also a component of recharge due to the intermittent stream system associated with the Roe Creek / Todd River system, although it does not seem to influence the hydrochemistry or radioisotopic values more than a few kilometres from the creek.

He also concluded that inter-aquifer flow from the Pacoota Sandstone to the Mereenie Sandstone is probably low as the distinctive hydrochemistry / radioisotopic values have little effect on nearby Mereenie bores.

The large depth to the water table at Roe Creek Borefield acts to average out the different pulses of recharge. Hostetler states that the age given by the isotopes is related more to the travel time from the surface through the unsaturated zone. Because the recharge has taken so long to reach the water table there should be no change in the values in the various radioisotopes since sampling by Calf (1978).

11 FUTURE ALICE SPRINGS TOWN WATER SUPPLY FROM ROCKY HILL

The hydrogeological characteristics of the Mereenie Sandstone at the Roe Creek Borefield and Rocky Hill – Ooraminna area are significantly different. The Roe Creek Borefield has a thicker sequence than at Rocky Hill as Unit C is thought to be missing at Rocky Hill. The Mereenie Sandstone is dipping at approximately 30° at Roe Creek Borefield while at Rocky Hill the dip on the limbs of the 'Rocky Hill Syncline' is approximately 10°. Consequently greater storage is available for exploitation from a shallower depth

The specific yield in the Mereenie Sandstone, at the Roe Creek Borefield, has been calculated at 20% while at Rocky Hill an average specific yield of 9.6 % was obtained from petrophysical analysis. All calculations at Rocky Hill have used a specific yield of 10%for the Mereenie Sandstone and 8% for the Ooraminna Sandstone Member. The transmissivity of the Mereenie Sandstone at Rocky Hill ranges from about 3000 m^2/day to 20 m^2/day. The Roe Creek Borefield area was modelled by Jolly *et al* (1994) and the best fit was obtained by using an unconfined west - east transmissivity of 10,000m^2/day in the borefield area and west - east transmissivity of 3,000m^2/day in the remaining unconfined area.

The Mereenie Sandstone at Roe Creek Borefield has, in part, had a unique weathering imprint put on it (Jolly et al, 1994). This has resulted in zones with an anomalously high degree of fracturing, and associated high hydraulic conductivities, on either side of the Iwupataka Erosion Feature. The high yielding production bores of Roe Creek Borefield situated west of Roe Creek are sited in such a zone.

Whether or not Rocky Hill is used as a borefield will be most probably based on the economics of the cost of deepening the bores at Roe Creek and drilling deeper bores down dip of the present production bores against the cost of setting up the infrastructure for a new borefield ie. drilling and testing new production bores and associated pipelines to existing pumping stations.

12 MOUNT OORAMINNA GROUNDWATER LEVELS

The water levels in the Rocky Hill – Ooraminna area and Deep Well area show an approximately 50 metre difference with the Rocky Hill – Ooraminna area water level around 452 m AHD and the Deep Well Area around 402 m AHD. An investigation bore, RN17540, was drilled near Mount Ooraminna to investigate the significant change in water levels between the Rocky Hill – Ooraminna area and the Deep Well area. Monitoring bore RN11852, approximately 8 km north of RN17540, shows a 44.44 metre difference in water levels from RN17540. Figure 12.1 shows the groundwater contours for August 2001 in the area and the water levels for RN11852 and RN17540 are shown in Table 12.1.

Table 12.1 Water Levels in the Ooraminna Anticline Area

RN	Easting (MGA)	Northing (MGA)	RLMP (m AHD)	SWL (m bmp)	SWL (m AHD	Date & Time Measured
RN11852	396997.43	7342154.47	577.18	124.34	452.84	28/08/01 16:50
RN17540	398392.93	7334754.23	541.47	133.07	408.40	28/08/01 15:10

Investigation bore RN17540 was drilled to 211.0 m to the south of the Ooraminna anticline. The first water struck was at 168 metres and had a final yield of 1.5 L/s with a TDS of 650 mg/L at 211.0 metres. Table 12.1 shows the airlift yields and the TDS of the water. The Hermannsburg Sandstone / Ooraminna Sandstone Member boundary, from the geology and gamma log, is interpreted at 198 metres.

Table 12.2 RN17540 Air Lift Yields and TDS

Depth (mbgl)	Air Lift Yield (l/s)	TDS (mg/l)
168.5	Seepage	-
193.0	0.3	598
199.0	0.8	645
205.0	1.3	662
211.0	1.5	649

Macqueen and Knott, (1982) noted a similar occurrence at the north-eastern end of the Waterhouse Range, and attributed the water level difference to the absence of the Mereenie Sandstone to the north of the Waterhouse Range, with the Hermannsburg Sandstone lying directly on the Pacoota Sandstone. Although no thinning of the Mereenie Sandstone is known at the Ooraminna Anticline, Macqueen and Knott thought the Rocky Hill – Ooraminna / Deep Well anomaly might be a result of the thinning of the Mereenie Sandstone, or a reduction in permeability of the Mereenie Sandstone on the crest of the anticline.

The geological map for the area, Rodinga, was published in 1964 (Ranford *et al*,1964). This shows, around the Ooraminna anticline, the Hermannsburg Sandstone directly overlying the Mereenie Sandstone. The Ooraminna Sandstone Member was not a defined stratigraphic unit in 1964 and it is possible that what has been mapped as Mereenie Sandstone could be low permeability Ooraminna Sandstone Member. Some detailed field mapping should be carried out the Ooraminna Anticline area re-mapping the Hermannsburg, Ooraminna and Mereenie Sandstone units.

Deep Well Area
Mereenie Sandstone Potentiometric Surface
August 2001

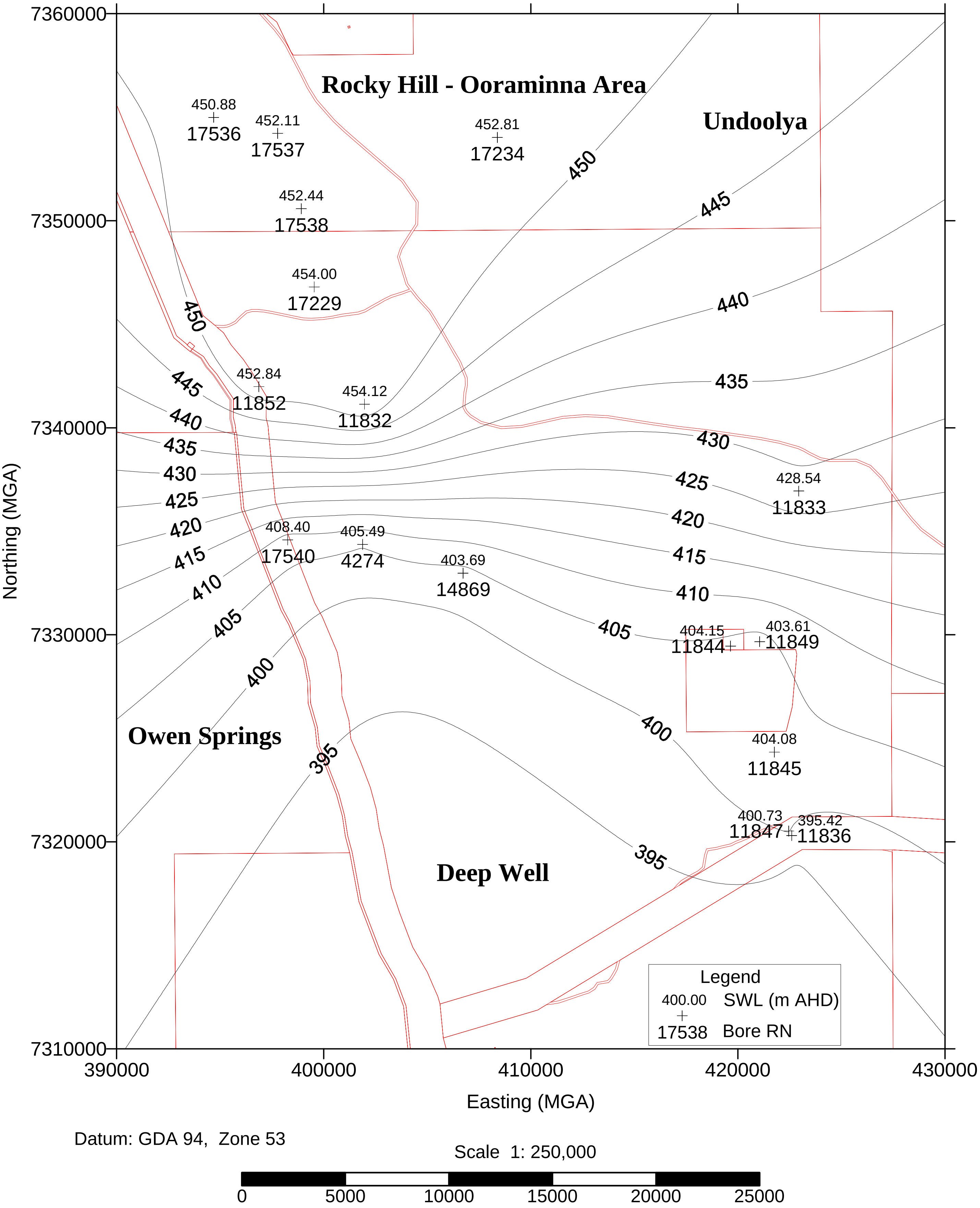


Figure 12.1

13 WATER ALLOCATION AND LICENSING

The Rocky Hill – Ooraminna area has been divided up into zones for water allocation purposes. The zones are based on water quality. Figure 13.1 shows the zones and recommended groundwater allocations.

The easiest way to improve estimates of the stored volume of the system is to license some development and observe drawdowns over about 10 years. For this reason 1 000 ML/year has been allocated to the Undoolya Rocky Hill Agricultural Block for horticultural development from Zone 1.

Zone 1 is the area of good quality water reserved for Alice Springs water supply with a buffer round it. The zone is based on the 600 mg/L TDS contour with a 500 metre buffer around it. There are no allocations for horticulture apart from the 1 000 ML/year already allocated to the Undoolya Rocky Hill Agricultural Block.

Zone 2, on the north side of the syncline, contains water under 1 000 mg/L. Up to 2000 ML/year could be allocated for horticulture.

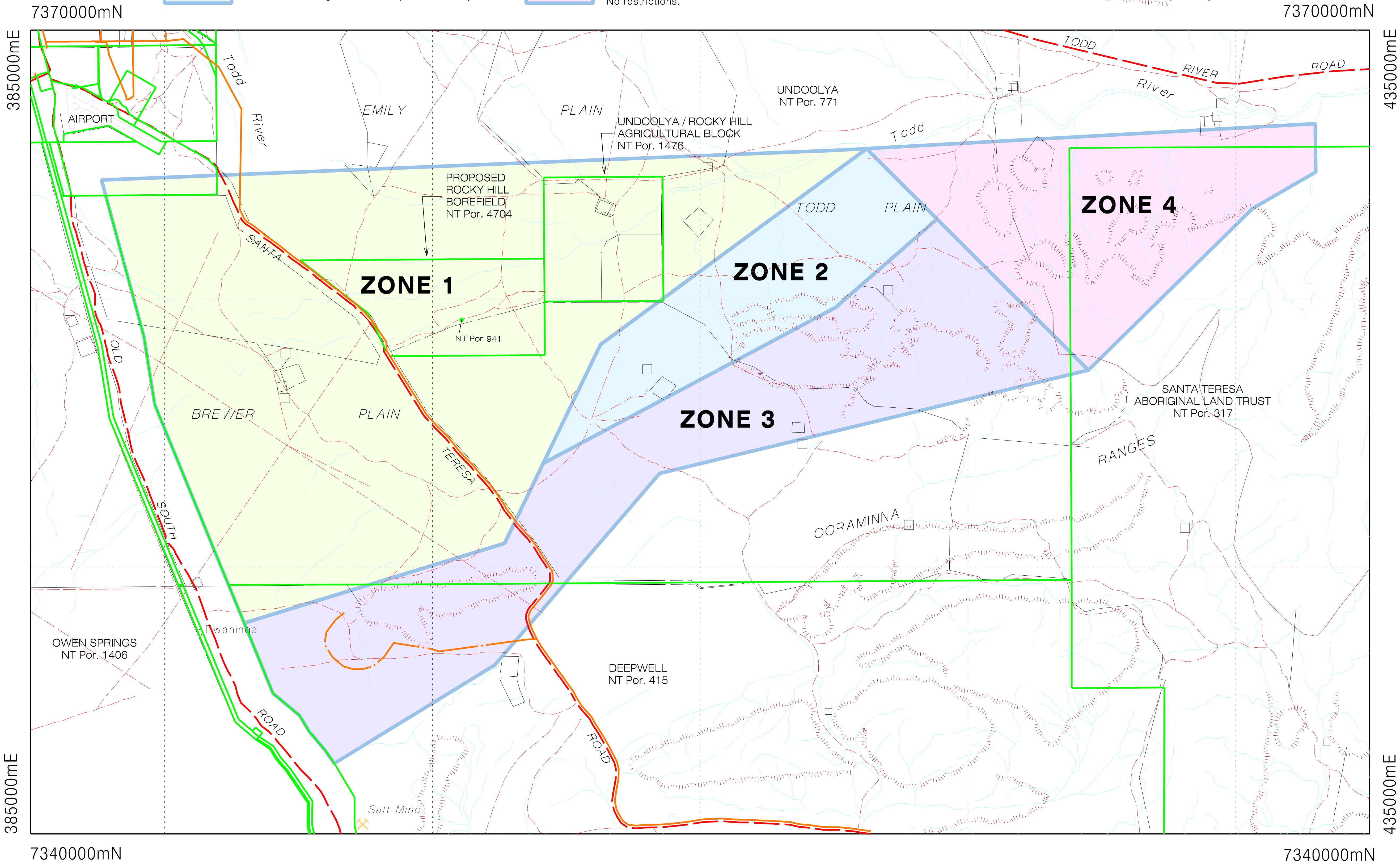
Zone 3, on the south side of the syncline, contains water under 1 000 mg/L. Up to 5000 ML/year could be allocated for horticulture.

Zone 4, at the eastern end of syncline, contains mostly saline water. No restrictions are necessary.

LEGEND

ZONE 1	Zone 1: Area of good quality water reserved for Alice Springs water supply and having a TDS less than 600 mg/L. No allocations apart from the 1000 ML/year allocated to the Rocky Hill Agricultural Block.
ZONE 2	Zone 2: North side of syncline, water between 600 and 1000 mg/L. Allocate up to 2000 ML/year.
ZONE 3	Zone 3: South side of syncline, water between 600 and 1000 mg/L. Allocate up to 5000 ML/year.
ZONE 4	Zone 4: Eastern end of syncline, water greater than 1000 mg/L. No restrictions.

Cadastral Boundary
Road
Track, Approx. Pos.
Fence
22kV Overhead Power Line
S.W.E.R Overhead Power Line
Ephemeral Stream
Range



SCALE 1 : 150 000 @ A3

kilometres 0 2 4 6 8 10 20 kilometres

Horizontal Datum: AGD 66
Vertical Datum: AHD
Projection: UTM Zone 53 (AMG 66)

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Drg. nrasp32

FIGURE 13.1

ROCKY HILL-OORAMINNA AREA - ZONES FOR WATER ALLOCATION

SECOND EDITION 06/10/00

nrd_library on 'lpws252'\corporate_lib\water\ reports\ 1998\ 16_rockyhill \dgn_files\nrasp32_zones.dgn

14 CONCLUSIONS

The Mereenie Sandstone at the proposed Rocky Hill borefield is thinner than at Roe Creek Borefield, perhaps as little as 100 m or less in places. It is overlain in part by the Ooraminna Sandstone Member, which is also an aquifer, and which is absent at Roe Creek Borefield. There is some uncertainty about the stratigraphy in the Rocky Hill – Ooraminna area, as it is difficult to distinguish the Mereenie Sandstone from the Ooraminna Sandstone Member, especially from drilling chip samples.

There are previously un-recognised aquifers in some members of the Hermannsburg Sandstone. These have potential for horticultural development.

Transmissivity in the Mereenie Sandstone ranges from about 20 m^2/day to 3 000 m^2/day, the higher values being in the more weathered zones near outcrop.

The aquifers in the Hermannsburg Sandstone have not been pump-tested, but air-lift yields of up to 30 L/s have been recorded during drilling.

Water of less than 500 mg/L is restricted to the part of the Mereenie Sandstone close to the Todd River and the Roe Creek floodout. This and high HCO_3/Cl ratios indicate that these are recharge zones.

Change in stored volume calculations show that recharge rates under present day conditions are of the order of 2 000 ML/year.

Management decisions must be made on the basis of the volume in storage.

The volume of groundwater in storage has been calculated from estimated specific yield values. The specific yield values used were 8% for the Ooraminna Sandstone Member and 10% for the Mereenie and Pacoota Sandstones.

Stored volume of water between 391 000 E and 422 000 E, the approximate extent of water under 1000 mg/L, was estimated with the following values obtained:

Depth of Dewatering	Volume in Storage All Aquifers	
	Total m3	Total GL
within 100 m of the surface	1.00E+09	1002
within 150 m of the surface	1.95E+09	1952
within 200 m of the surface	2.69E+09	2692
within 250 m of the surface	3.32E+09	3319
within 300 m of the surface	3.75E+09	3747
within 350 m of the surface	4.13E+09	4126

There is a large uncertainty in estimates of the stored volume because neither the effective porosity nor the aquifer geometry in the deeper parts of the syncline is known with any confidence. However there is sufficient water to license extraction of (say) 5 000 ML/year for horticulture for 100 years. The easiest way to improve estimates of the volume in storage is to license some development and monitor the results of pumping.

15 RECOMMENDATIONS

15.1 Future Work

The isotope bore, RN17333 should be sampled for isotopes and major ions. Bore RN17394 needs to be cleaned out and be re-cased with 150 mm ID steel casing inserted to case off the section with swelling clays.

Selected bores drilled in the 1970's in the Rocky Hill – Ooraminna area should be gamma logged with digital equipment. Further work is needed to try and correlate all gamma logs.

The cumulative borefield extraction from Roe Creek borefield should be plotted against borefield drawdown to see if the relationship, which was shown to exist for the period 1964 to 1989, is still valid.

A model for the Roe Creek borefield and a regional model (including the proposed Rocky Hill borefield) should be developed. There has been significant increase in the understanding of the area and a significant interval of monitoring data.

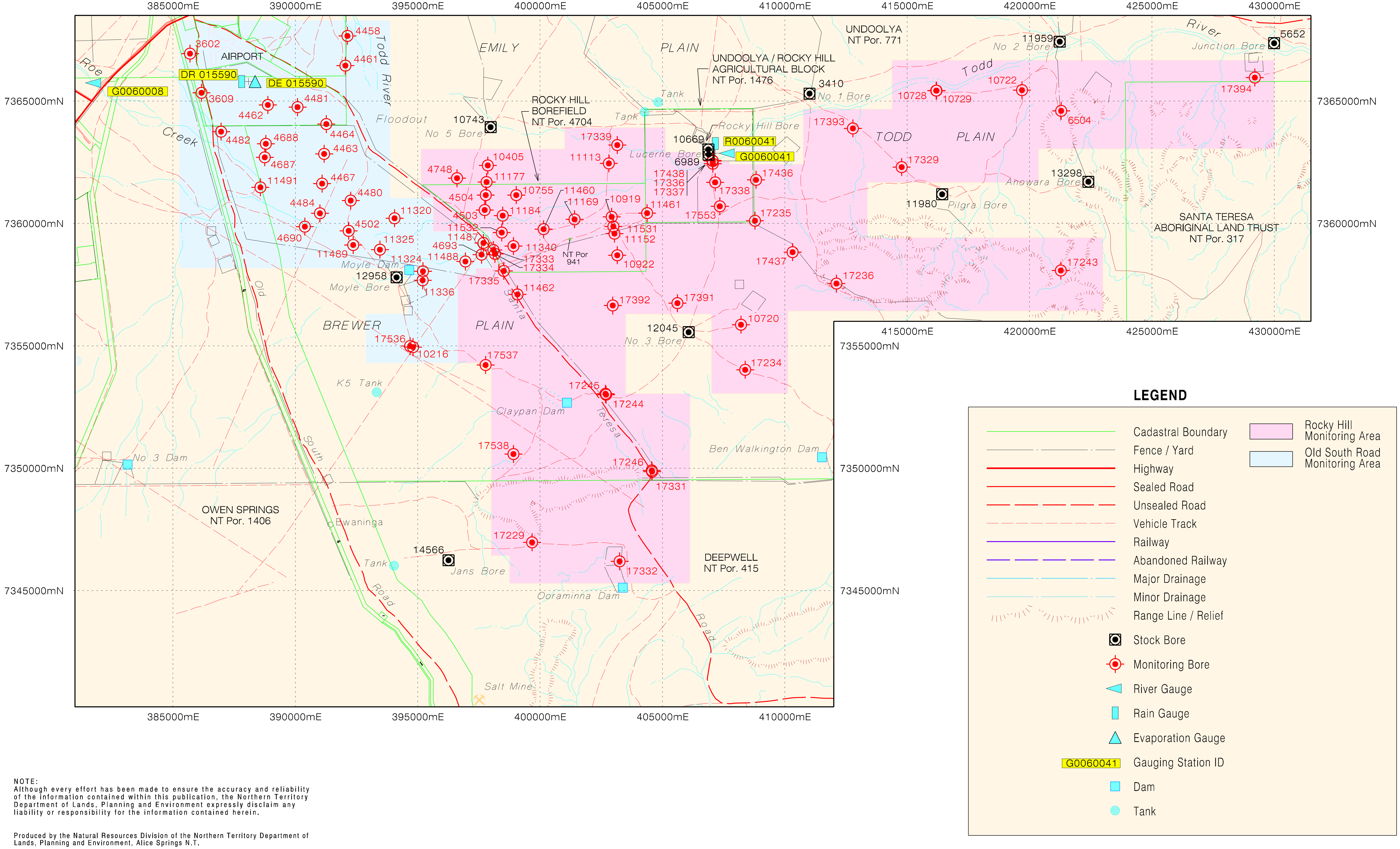
An appropriately sited cored hole would provide valuable data on the stored volumes in the Mereenie Sandstone. Currently a value of 10% has been assigned to the Mereenie Sandstone and 8% to the Ooraminna Sandstone Member. A cored hole will also help in clearing up the ambiguity in stratigraphy, and hence, a conceptual hydrogeological model of the area.

15.2 Groundwater Level Monitoring

Currently there are two monitoring areas, Rocky Hill monitoring area and Old South Road monitoring area, in the Rocky Hill – Ooraminna area (Figure 15.1). The bores are monitored, by Technical Services Branch, on an 8 weekly period, staff permitting. There are 29 bores within the Old South Road monitoring area of which four, RN4462, RN4463, RN4467 and RN4502, have had dry readings within the past seven years. There are 49 monitoring bores in the Rocky Hill monitoring area.

The bore locations and monitoring start date are given in Table 15.1 and 15.2, for the Old South Road and Rocky Hill monitoring areas respectively, and the monitoring bore locations are shown on Figure 15.1. The bores have been monitored recently on an eight weekly program.

A review needs to be carried out to see if all the monitoring bores are necessary as some are located close to other monitoring bores. The review also needs to look at the monitoring frequency as there are some bores that show little effect from recharge while others show good response to recharge events. Also the bores which have become dry will need to be reviewed to see if replacement monitoring bores need to be drilled.



NOTE:
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Produced by the Natural Resources Division of the Northern Territory Department of Lands, Planning and Environment, Alice Springs N.T.

NATURAL RESOURCES
LANDS PLANNING ENVIRONMENT
Northern Territory Government

SCALE 1 : 150 000 @ A3

kilometres 0 1 2 3 4 5 10 15 kilometres

Horizontal Datum: GDA 94 Vertical Datum: AHD Map Grid: MGA 94 - Zone 53

Projection: UTM - Central Meridian 135 deg. E Grid Interval: 5000 m

GDA

Drg. nrasp60

FIRST EDITION - 16/04/2002

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ROCKY HILL - OORAMINNA GROUNDWATER INVESTIGATION 2000

FIGURE 15.1

PRODUCTION AND MONITORING BORE LOCATIONS

Table 15.1 Old South Road Monitoring Bores

RN	Easting (MGA)	Northing (MGA)	Monitoring Start Date	Comments
RN003602	385698.8	7366936.5	24/05/1962	
RN003609	386162.8	7365334.5	16/10/1962	
RN004458	392131.8	7367661.5	06/08/1964	
RN004461	392045.7	7366445.8	06/08/1964	
RN004462	388877.8	7364837.5	06/08/1964	Dry. Last reading 09/12/1997
RN004463	391178.8	7362842.5	06/08/1964	Dry. Last reading 18/03/1999
RN004464	391264.8	7364057.5	06/08/1964	
RN004467	391091.8	7361626.5	13/08/1964	Dry. Last reading 22/10/1997
RN004480	392264.8	7360932.5	03/09/1964	
RN004481	390092.8	7364751.5	06/08/1964	
RN004482	386967.8	7363750.5	13/08/1964	
RN004484	391005.8	7360410.5	03/09/1964	
RN004502	392177.8	7359698.5	10/09/1964	Dry. Last reading 23/07/1996
RN004687	388752.8	7362701.5	19/09/1964	
RN004688	388797.8	7363249.5	15/04/1973	
RN004690	390387.8	7359870.5	28/11/1964	
RN004693	397608.8	7358724.5	03/09/1964	
RN010216	394810.8	7354945.3	21/10/1965	
RN011320	394055.8	7360212.5	07/07/1976	
RN011324	395218.8	7358047.5	13/04/1977	
RN011325	393458.8	7358930.5	07/07/1976	
RN011336	395205.8	7357673.5	13/04/1977	
RN011487	397685.8	7359201.5	13/04/1977	
RN011488	396946.8	7358444.5	13/04/1977	
RN011489	392362.8	7359115.5	13/04/1977	
RN011491	388571.8	7361475.5	17/08/1977	
RN017536	394687.72	7354990.44	11/07/2000	
RN017537	397776.90	7354217.50	11/07/2000	
RN017538	398913.74	7350579.27	11/07/2000	

Table 15.2 Rocky Hill Monitoring Bores

RN	Easting	Northing	Monitoring Start Date
RN004503	397737.8	7360547.5	24/09/1964
RN004504	397779.8	7361156.5	24/09/1964
RN004748	396604.8	7361846.5	01/10/1964
RN006504	421294.7	7364605.1	09/06/1977
RN010405	397865.8	7362367.5	17/10/1964
RN010720	408209.4	7355864.2	23/11/1977
RN010722	419690.7	7365441.5	09/06/1977
RN010728	416186.7	7365424.5	09/06/1977
RN010729	416207.7	7365380.5	09/06/1977
RN010755	399027.8	7361159.5	15/09/1974
RN010919	402954.7	7360273.5	04/02/1976
RN010922	403153.7	7358701.5	16/10/1975
RN011113	402809.7	7362453.5	04/02/1976
RN011152	403040.7	7359583.5	04/02/1976
RN011169	401408.7	7360167.5	04/02/1976
RN011177	397814.8	7361691.0	28/09/1976
RN011184	398475.8	7360321.5	01/03/1976
RN011340	398912.8	7359074.5	07/07/1976
RN011460	400145.8	7359764.5	13/04/1977
RN011461	404372.7	7360418.5	13/04/1977
RN011462	399077.6	7357102.7	13/04/1977
RN011531	402994.7	7359872.5	29/07/1977
RN011532	398482.8	7359640.5	18/08/1977
RN017229	399800.4	7347142.8	13/07/1999
RN017234	408385.4	7354022.9	03/09/1998
RN017235	408780.9	7360111.9	03/09/1998
RN017236	412108.7	7357542.0	03/09/1998
RN017243	421279.0	7358075.8	03/09/1998
RN017244	402700.8	7353000.0	13/07/1999
RN017245	402672.5	7353041.6	13/07/1999
RN017246	404564.9	7349913.2	13/07/1999
RN017329	414773.9	7362301.8	03/09/1998
RN017331	404579.1	7349860.7	03/09/1998
RN017332	403251.3	7346195.4	03/09/1998
RN017333	398090.6	7358914.9	12/07/1999
RN017334	398157.7	7358758.6	12/07/1999
RN017335	398519.7	7358061.0	12/07/1999
RN017336	407060.0	7362547.6	13/07/1999
RN017337	407059.8	7362437.6	13/07/1999
RN017338	407155.7	7361681.5	13/07/1999
RN017339	403157.5	7363204.0	13/07/1999
RN017391	405613.9	7356741.9	13/07/1999
RN017392	402971.9	7356648.1	13/07/1999
RN017393	412782.5	7363885.0	13/07/1999

Table 15.2 Continued

RN	Easting	Northing	Monitoring Start Date
RN017394	429204.8	7365961.5	13/07/1999
RN017436	408825.2	7361781.8	13/07/1999
RN017437	410320.4	7358828.5	13/07/1999
RN017438	407042.5	7362576.3	13/07/1999
RN017553	407346.4	7360702.0	02/11/2000

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APPENDIX A

PRE 2000 BORES IN ROCKY HILL – OORAMINNA AREA

Table A.1 Pre-2000 Bores.

RN	EASTING	NORTHING	BORE NAME	COMPLETION DATE	DRILLED DEPTH (m)	DRILLER	LOCATION
RN000969	387075	7361257	TEMPLE BAR WELL DUD	Not Known	76.2	Not Known	6.5 km S OF DCA. 50 m E OF STH RD
RN002465	386280	7360200	13 MILE BORE TEMPLE BAR NO 1	Not Known	111.3	Not Known	APX 5 km S OF D.C.A.
RN002466	386280	7360200	TEMPLE BAR NO.2 13 MILE BORE.	Not Known	125.0	Not Known	APX 50 m S OF MILL RN2465.
RN010742	392700	7365627	FLOOD OUT BORE NO EQUIPEMENT	Not Known	91.5	S Hayes	5 km NNW OF NO5 BORE.
RN010743	397851	7363763	NO 5 BORE	Not Known	54.9	S Hayes	8 km W OF ROCKY HILL FARM.
RN011589	421110	7367461	No2. SX BORE	Not Known	36.6	Not Known	11 km E OF NO1 RN3410.
RN003421	386300	7367490	AERODROME BORE.	01/01/1942	123.1	J Gorey	OLD TERMINAL.
RN016600	387116	7361249	[ABD] 6.7KM S OF OLD----	Not Known	123.0	Not Known	A/PORT & 100 m E OF ROAD
RN016603	387719	7359959	14 MILE BORE [PROD-ABD]	01/01/1949	140.2	Gorey & Cole	8 km S OF OLD AIRPORT&E OF ROAD
RN002692	414642	7347178	TIMS / TOMMY BORE	01/01/1952	60.3	Not Known	DEEP WELL
RN000655	391689	7369798	No3 ATT BUNGALOW RESERVE.	10/10/1955	66.4	JP Cole	AMOONGUNA.
RN003450	386460	7368250	JONES BORE (D.C.A.)	01/01/1956	98.5	Not Known	BLOCK 428
RN010010	387270	7369190	J.JONES NORTH BORE	01/01/1956	96.0	J Jones	BLOCK 428
RN000009	391820	7369710	NO6. DUD 180 LPH.	25/05/1956	68.0	AT Hillyer	AMOONGUNA.
RN000011	391208	7369936	No7 AMOONGUNA.	29/06/1956	91.0	AT Hillyer	ALICE SPRINGS.
RN003410	410885	7365276	NO.1 Bore	01/01/1957	-	Not Known	6 km NE OF ROCKY HILL.
RN010545	405925	7355440	UNDOOLYA NO 3,MILL BORE ABD	01/01/1957	115.8	E Hayes	7 km S OF ROCKY HILL.
RN002612	433000	7343000	YAM JUNCTION BORE	09/11/1957	44.8	M Robinson	SANTA TERESA MISSION
RN003490	391900	7369650	NO.3	01/01/1958	39.6	Not Known	AMOONGUNA
RN003563	388160	7367120	NO.2 ROSEWALL BORE.	01/01/1959	119.5	G Gorey	AIRPORT NEW TERMINAL .
RN001944	391420	7369940	No8 1st ATT. ABD	16/03/1960	132.6	JP Cole	AMOONGUNA.
RN001945	391208	7369936	No9 2nd ATT.	08/04/1960	137.8	JP Cole	AMOONGUNA.
RN010965	391440	7369850	JOB 21 1ST ATT No10 DUD	15/11/1960	31.1	Government	30 m N AMOONGUNA No 9
RN003773	391208	7369936	JOB 21 2ND ATT. NO.11	28/11/1960	153.9	Government	AMOONGUNA
RN002293	394000	7367000	POSSIBLE NO.13 BORE??.	07/01/1961	101.8	Not Known	AMOONGUNA
RN011959	421088	7367455	No2 COMET. STANBY BORE	01/07/1961	36.6	S Hayes	11 km E OF NO1. RN 11589
RN003598	385571	7366767	ZA	30/11/1961	148.7	Government	ROAD RESERVE.
RN003602	385571	7366766	ZE	18/01/1962	213.7	Government	MEREENIE AREA.
RN003601	390580	7368800	ZD	27/01/1962	163.1	Government	AMOONGUNA.
RN003011	424000	7352700	A30/1 1st ATT. DUD	22/08/1962	61.0	RS Brown	SANTA TERESA.
RN003609	386035	7365164	ZY	20/09/1962	194.8	Government	ROE CREEK
RN003171	424000	7351000	A30/1 JOB 83. 2nd ATT.	04/10/1962	114.3	RS Brown	SANTA TERESA MISSION
RN003610	386014	7364861	ZZ	05/10/1962	284.1	Government	QUARANTINE.
RN003540	386757	7362503	SHOT POINT 30.	12/10/1962	253.3	Government	QUARANTINE.

RN	EASTING	NORTHING	BORE NAME	COMPLETION DATE	DRILLED DEPTH (m)	DRILLER	LOCATION
RN003634	393000	7366000	NO.19	19/10/1962	13.7	Government	AMOONGUNA.
RN003635	393000	7366000	NO.20 DUD	20/10/1962	18.9	Government	100 YDS EAST OF NO 19
RN003636	393000	7366000	NO.21 DUD	23/10/1962	11.6	Government	100 YDS EAST OF N0 20
RN003637	393000	7366000	NO.22 DUD	24/10/1962	13.1	Government	100 YDS OF 21 DUD.
RN003638	393000	7366000	NO.23 DUD	26/10/1962	24.4	Government	100 YDS STH OF NO 22 DUD
RN003553	389395	7369580	63/1 HEENANS. [ABD]	01/01/1963	97.5	F Heenan	BLOCK 1892 PETRICK ROAD
RN003641	391890	7369350	NO.27	04/02/1963	314.2	Government	AMOONGUNA.
RN003877	414785	7343858	OORAMINNA NO 1 BORE	06/02/1963	80.8	S Hayes	5.4 km NW OF SANTA TERESA ROAD
RN010971	414785	7343858	OORAMINNA NO 1 OIL WELL	12/06/1963	1858.8	EXOIL	APX 200 m WSW OF MILL RN 3877
RN004017	393000	7366000	48	20/06/1963	98.5	Government	151 m SE CORNER OF AMOONGUNA BL
RN010216	394682	7354775	ALICE EXOIL #1	01/09/1963	2291.5	EXOIL	5 km S OF RN11487 (FZ27)
RN004458	392004	7367491	WRB INV 79Z56 2"GWP	29/06/1964	154.2	Government	MEREENIE GRID.
RN004461	391917	7366275	WRB INV 79Z52 2"GWP	02/07/1964	121.3	Government	ROE CREEK MEREENIE GRID.
RN004459	391831	7365060	WRB INV 79Z48 2"GWP	08/07/1964	111.6	Government	MEREENIE GRID.
RN004464	391137	7363887	WRB INV 77Z44 2"GWP	08/07/1964	133.5	Government	MOYLE DAM,MEREENIE GRID.
RN004463	391051	7362672	WRB INV 77Z40 2"GWP	13/07/1964	173.7	Government	MOYLE DAM,MEREENIE GRID.
RN004462	388750	7364667	WRB INV 69Z46 2"GWP	21/07/1964	222.8	Government	ROE CREEK MEREENIE GRID.
RN004481	389965	7364581	WRB INV 73Z46 2"GWP	24/07/1964	182.9	Government	1.3 km E OF RN4462 ROE CREEK.
RN004460	387553	7364753	WRB INV 65Z46 2"GWP	25/07/1964	101.5	Government	MOYLE DAM AREA ROE CREEK
RN004483	385053	7364318	57Z44	01/08/1964	128.5	Government	MEREENIE GRID POINT
RN004467	390964	7361456	WRB INV 77Z36 2"GWP	04/08/1964	149.0	Government	ROE CREEK MEREENIE GRID.
RN004465	391710	7365990	WRB INV 63Z36 [DUD]	07/08/1964	39.6	Government	MEREENIE GRID.
RN004482	386840	7363580	WRB INV 63Z42 2"GWP	10/08/1964	119.5	Government	4 km S ON OLD SOUTH ROAD
RN004480	392137	7360762	WRB INV 81Z34 2"GWP	27/08/1964	137.2	Government	2.7 km NE OF RN4484.
RN004484	390878	7360240	WRB INV 77Z32 2"GWP	28/08/1964	106.4	Government	MEREENIE GRID MOYLE DAM
RN004693	397481	7358554	99 Z 28	29/08/1964	140.5	Government	ROE CREEK
RN004502	392050	7359528	81 Z 30	02/09/1964	81.7	Government	ROE CREEK
RN004503	397610	7360377	WRB INV 99Z34 2"GWP	14/09/1964	157.6	Government	MEREENIE GRID, NO5 STOCK AREA
RN004504	397652	7360986	WRB INV 99Z36 2"GWP	19/09/1964	93.1	Government	MEREENIE GRID, NO5 STOCK AREA
RN004748	396477	7361676	95Z38	30/09/1964	168.2	Government	ROCKY HILL
RN010405	397738	7362197	99Z40	09/10/1964	181.4	Government	4.8 km N. AIRPORT.TOWN COMMON
RN004549	391810	7365840	NO12. JOB 66.	28/10/1964	129.5	JP Cole	4.8 km S OF AMOONGUNA
RN004688	388670	7363079	69 Z 39	03/11/1964	130.5	Government	ROE CREEK
RN004689	391710	7365990	WRB INV 73Z34 [DUD]	11/11/1964	61.6	Government	NO5 STOCK BORE AREA
RN004687	388625	7362531	69 Z 37	14/11/1964	111.3	Government	ROE CREEK
RN004690	390260	7359700	75 Z 30	26/11/1964	108.8	Government	ROE CREEK

RN	EASTING	NORTHING	BORE NAME	COMPLETION DATE	DRILLED DEPTH (m)	DRILLER	LOCATION
RN004658	391690	7366440	NO13. AMOONGUNA.PIPE PULLED	04/12/1964	137.2	JP Cole	606m NTH OF NO 12.
RN004706	391680	7366070	2nd ATT NO13. DUD	12/01/1965	106.7	JP Cole	303m NTH OF NO 12. AMOONGUNA.
RN004712	391660	7365840	NO13. 3rd ATT CASING REMOVED	18/02/1965	167.6	JP Cole	151m W OF AMOONGUNA NO 12
RN004778	390560	7368840	NO13. 4th ATT.	23/03/1965	167.6	JP Cole	5 mts N OF AMOONGUNA NO 5.
RN005652	431117	7367182	JUNCTION BORE REPLACEMENT	14/11/1966	61.0	Gorey & Cole	7 m N OF JUNCTION BORE.
RN006408	421160	7364416	WRB E.E.NO 1A FILLED IN N/CAS	12/12/1968	72.1	Government	17 m SW OF RN6504.
RN006504	421166	7364431	WRB EAST EMILY NO1,WRB INVEST.	20/01/1969	360.0	Government	3.4 km SSW OF RN11958 NO 2.
RN002466	386280	7360200	TEMPLE BAR NO.2 13 MILE BORE.	11/02/1970	125.0	Gorey & Cole	APX 50 m S OF MILL RN2465.
RN006987	407168	7362690	A7./8 ROCKY HILL STOCK NOI ABD	09/03/1970	93.0	Gorey & Cole	APX 350 m E OF RN10669 NO 3.
RN006989	406759	7362642	ROCKY HILL NO 1 A 70/1	10/03/1970	123.4	Gorey & Cole	UNDOOLYA
RN006988	407217	7362719	ROCKY HILL NO 2	12/03/1970	123.4	Gorey & Cole	UNDOOLYA
RN010328	397260	7348140	A70\10 COMMODORE BORE (MONO)	05/02/1972	125.0	Gorey & Cole	2.5 km NTH OF TOURIST RN 14566
RN010324	406707	7362939	GC 1/72.ROCKY HILL DUD,N/TRACE	22/02/1972	48.8	Gorey & Cole	200 m N OF A 70/7.
RN010325	405000	7363000	GC 2/72 ROCKY HILL DUD N/TRACE	23/02/1972	47.2	Gorey & Cole	1 km NW OF GC 1/72 RN10669.
RN010326	406953	7363200	GC 3/72 ROCKY HILL DUD,N/TRACE	24/02/1972	54.9	Gorey & Cole	400 m NNE OF GC 1/72.
RN010327	405000	7362000	GC 4/72 ROCKY HILL.3600GPH DUD	25/02/1972	68.6	Gorey & Cole	300 m NNE OF GC 1/72.
RN010473	389130	7369450	DUD	10/10/1972	152.4	Gorey & Cole	SOUTH WEST END OF FARM
RN010669	406749	7362851	ROCKY HILL PRODUCTION NO 3	01/03/1973	94.2	Gorey & Cole	303 m N OF ROCKY HILL NO 1.
RN010720	408081	7355692	WRB INV, OORAMINNA FARM N01,8"	24/10/1973	157.0	Government	ROCKY HILL
RN010722	419563	7365271	WRB INVESTIGATION EE,NO2,8"	09/11/1973	119.0	Government	3.2 km S OF NO 2 UNDOOLYA BORE
RN010724	416074	7365254	WRB INVESTIGATION EE,NO3,8"	29/11/1973	138.0	Government	4 km SW OF NO 2 BORE UNDOOLYA.
RN010725	416220	7365135	WRB INVESTIGATION EENO4,DUD	01/12/1973	70.0	Government	4 km SW OF NO 2 BORE UNDOOLYA.
RN010728	416059	7365254	WRB INVESTIGATION EE N05,8"	07/12/1973	96.0	Government	4 km SW OF UNDOOLYA NO 2 BORE.
RN010729	416080	7365210	WRB INVESTIGATION EE NO6,8"	13/12/1973	108.0	Government	4 km SW OF UNDOOLYA NO 2 BORE.
RN010748	397133	7364125	FZI WRB INV 11MX5"CAS U/S	18/03/1974	102.0	Government	1.6 km NW OF ROCKY HILL.
RN010750	399563	7364025	WRB INVESTIGATION FZ2 12"CAS	21/03/1974	126.0	Government	8.2 km W OF ROCKY HILL.
RN010752	399879	7362286	WRB INVESTIGATION FZ3 5MX8"	02/04/1974	216.0	Government	1.6 km SE OF NO 5 BORE ROCKY HILL
RN010755	398900	7360989	ROCKY HILL FZ 4 WRB INV	26/04/1974	228.0	Government	3 km SE NO 5 ROCKY HILL.
RN010907	402690	7361546	WRB INVESTIGATION FZ5 DUD	01/04/1975	76.0	Government	4 km SW OF ROCKY HILL NO 1.
RN010906	402657	7361680	FZ6 WRB INVESTIGATION DRY DUD	08/04/1975	71.0	Government	4.5 km SW OF ROCKY HILL NO 1.
RN010919	402827	7360103	WRB INV FZ7 8"CAS	16/04/1975	219.0	Government	MEREENIE ROCKY HILL
RN010922	403026	7358531	ROCKY HILL FZ 8 WRB INV	24/04/1975	260.0	Government	MEREENIE ROCKY HILL
RN010923	402844	7363238	ROCKY HILL FZ 9 WRB INV	02/05/1975	100.0	Government	MEREENIE ROCKY HILL AREA
RN011113	402682	7362283	FZ11 ROCKY HILL WRB INV.	11/10/1975	170.0	Government	2.3 km N OF RN10919 ROCKY HILL
RN011152	402913	7359413	ROCKY HILL FZ12 WRB INV	17/10/1975	234.3	Government	700 m S OF RN10919 ROCKY HILL
RN011169	401281	7359997	ROCKY HILL FZ13 WRB INV	27/10/1975	176.2	Government	500 m E OF DCA TOWERS
RN011177	397687	7361521	ROCKY HILL FZ14 WRB INV	04/11/1975	167.0	Government	1.2 km N OF RN4503.

RN	EASTING	NORTHING	BORE NAME	COMPLETION DATE	DRILLED DEPTH (m)	DRILLER	LOCATION
RN011184	398348	7360151	ROCKY HILL FZ 15 WRB INV	13/11/1975	223.0	Government	MEREENIE ROCKY HILL AREA
RN011183	395939	7361177	ROCKY HILL FZ 10 WRB INV	17/11/1975	77.5	Government	MEREENIE
RN011192	395924	7360841	ROCKY HILL FZ 16 WRB INV	22/11/1975	160.3	Government	MEREENIE ROCKY HILL AREA
RN011320	393928	7360042	ROCKY HILL FZ 17 WRB INV	05/03/1976	99.7	Government	MEREENIE
RN011324	395091	7357877	ROCKY HILL FZ 18 WRB INV	09/03/1976	229.9	Government	MEREENIE ROCKY HILL AREA
RN011335	390986	7359084	ROCKY HILL FZ 20 WRB INV	29/03/1976	313.2	Government	MEREENIE ROCKY HILL AREA.
RN011336	395078	7357503	ROCKY HILL FZ 21 WRB INV	03/04/1976	225.2	Government	MEREENIE ROCKY HILL AREA.
RN011339	402797	7360142	ROCKY HILL FZ 22 WRB INV	09/04/1976	132.6	Government	MEREENIE ROCKY HILL AREA
RN011340	398785	7358904	ROCKY HILL FZ 23 WRB INV	13/04/1976	222.4	Government	MEREENIE ROCKY HILL AREA
RN011325	393331	7358760	ROCKY HILL FZ 19 WRB INV	21/04/1976	176.6	Government	MEREENIE ROCKY HILL AREA
RN011408	393300	7358700	ROCKY HILL FZ 19 (B) 0BS,WRB	20/07/1976	98.9	Government	MEREENIE ROCKY HILL AREA
RN011459	400755	7359531	ROCKY HILL FZ 13 OBS WRB INV	15/10/1976	140.4	Government	MEREENIE ROCKY HILL AREA
RN011460	400018	7359594	ROCKY HILL FZ 24 WRB INV	21/10/1976	207.7	Government	MEREENIE
RN011461	404245	7360248	ROCKY HILL FZ 25 WRB INV	27/10/1976	218.5	Government	MEREENIE
RN011462	398950	7356931	ROCKY HLIL FZ 26 WRB INV	29/10/1976	150.8	Government	MEREENIE
RN011487	397558	7359031	ROCKY HILL FZ 27 WRB INV	06/11/1976	144.7	Government	APX 7 km N OF ALICE OIL WELL.
RN011488	396819	7358274	ROCKY HILL FZ 28 WRB INV	12/11/1976	277.5	Government	ROCKY HILL AREA
RN011489	392235	7358945	ROCKY HILL FZ29	20/11/1976	185.9	Government	MEREENIE
RN011491	388444	7361305	ROCKY HILL FZ 30 WRB INV	29/11/1976	300.4	Government	MEREENIE
RN011538	397519	7358999	FZ27 OBS WRB INV	10/03/1977	98.8	Government	UNDOOLYA ROCKY HILL
RN011531	402867	7359702	ROCKY HILL FZ 31 WRB INV	26/03/1977	263.7	Government	MEREENIE
RN011532	398355	7359470	ROCKY HILL FZ 32 WRB INV	01/04/1977	240.8	Government	MEREENIE
RN011569	398306	7359457	ROCKY HILL FZ 33 WRB INV	29/04/1977	100.0	Government	MEREENIE
RN011534	386300	7349850	P148.URANERZ.	17/01/1977	108.0	AFRAC	4.8 km E OF NO 3 DAM.
RN011535	386100	7349850	P150. URENERZ.	17/01/1977	88.0	AFRAC	3.2 km E OF NO 3 DAM.
RN011537	386200	7349500	P149.URENERZ	17/01/1977	66.0	Rockdril	3.2 km E OF NO 3 DAM.
RN011728	385000	7359000	ALP 5.AGIP DRY DUD	18/10/1977	193.0	AFRAC	7 km SE OF 12 MILE DAM.
RN011729	386000	7359000	ALP 6.AGIP 0.4 LPS	19/10/1977	193.0	AFRAC	7.5 km SE OF 12 MILE DAM.
RN011730	385000	7359000	ALP 7.AGIP DRY DUD	20/10/1977	193.0	AFRAC	7.5 km SE OF 12 MILE DAM.
RN011887	389025	7352825	P1.URANERZ TDS 12,000+++	01/07/1977	190.0	AFRAC	8.5 km ESE OF 13 MILE BORE.
RN011894	390000	7354000	A141/1 URANERS 7,TDS	01/07/1977	50.0	AFRAC	8 km STH EAST OF 13MILE RN 2465
RN011896	389200	7352250	EW56.URANERZ TDS 12,000+++	01/07/1977	141.0	AFRAC	8.5 km SSE OF 13 MILE BORE,
RN011897	389525	7353200	EW 63.URENERZ TDS 430	01/07/1977	102.0	AFRAC	8.5 km SSE OF 13 MILE BORE.
RN011898	389350	7353675	E W 64.URANERZ TDS 2,200	01/07/1977	130.0	AFRAC	7 km SSE OF 13 MILE BORE.
RN011899	389450	7354025	EW 65.URANERZ TDS 2,600	01/07/1977	90.0	AFRAC	7.5 km SSE OF 13 MILE BORE.

RN	EASTING	NORTHING	BORE NAME	COMPLETION DATE	DRILLED DEPTH (m)	DRILLER	LOCATION
RN011900	389350	7354225	EW 66.URANERZ TDS 2,000	01/07/1977	80.0	AFRAC	7 km SSE OF 13 MILE BORE.
RN011901	389350	7354675	EW 67.URANERZ TDS 830	01/07/1977	100.0	AFRAC	6.5 km SSE OF 13 MILE BORE.
RN011902	389350	7355475	EW 69.URANERZ TDS 680	01/07/1977	53.8	AFRAC	6 km SSE OF 13 MILE BORE.
RN011903	389460	7353100	EW 79.URENERZ TDS 12000++	01/07/1977	114.0	AFRAC	8.5 km SSE OF 13 MILE BORE.
RN011904	388840	7352875	EW 92.URENERZ TDS 4.100	01/07/1977	216.1	AFRAC	7.5 km SSE OF 13 MILE BORE.
RN011722	399100	7355000	AER 1 AGIP DRY DUD	21/10/1977	78.0	AFRAC	3.5 km NE of RN10216
RN011723	400000	7356000	AER 2 AGIP DRY DUD	21/10/1977	86.0	AFRAC	5.0 KM NE of RN10216
RN012955	389500	7352425	EW 42.URANERZ 4"PVC	Not Known	84.0	Not Known	BORE IN CENTRE OF TRACK.
RN012956	389250	7352015	EW 246.URANERZ 6"PVC G/SUPPLY	Not Known	100.0	Not Known	7.3 km SSE OF 13 MILE BORE.
RN012957	389100	7352600	EW 370.URANERZ 6"PVC	Not Known	160.0	Not Known	7.3 km SSE OF 13 MILE BORE.
RN011980	416873	7361067	A 70/16 PILGERA.	22/08/1978	116.0	Gorey & Cole	10 km SE OF NO 1 BORE.
RN012045	405935	7355450	A 70/17 REPL OF No3 BORE.	07/02/1979	109.0	Gorey & Cole	16 m SE OF MILL RN10545.
RN012958	394335	7358340	MOYLE DAM BORE (MONO)	26/10/1980	120.0	Gorey & Cole	700 m NORTH OF MOYLE DAM
RN013021	401531	7354602	WALLABY WATER BORE.	21/06/1981	81.0	Gorey & Cole	16 km S OF AIRPORT.
RN013167	401650	7354560	WALLABY No1 OIL WELL.	16/08/1981	2425.6	PANCON	100 m E OF RN13021.
RN013298	422195	7361409	A 70/22.ANOWARA	13/11/1981	104.0	Gorey & Cole	6.5 km S OF NO 2 BORE RN11959.
RN014566	395494	7346804	A141/6 TOURIST BORE (MONO)	17/09/1985	189.0	Bowman & Hughes	29 km ON OLD SOUTH ROAD
RN014653	389260	7369650	G LIDDLE BORE	19/02/1986	61.0	Bowman & Hughes	BLOCK 1896 R/COURSE ESTATE
RN015088	402800	7360100	PRE COLLAR FOR DIAMOND DRILL	24/07/1987	51.8	Government	37M SW OF FZ7 RN10919
RN015089	386260	7364010	RN 15089 (SUC)	31/08/1987	332.7	Government	840m S OF RN3610
RN015101	391198	7347655	WRB GHAN RAILWAY BORE	01/06/1988	392.5	Government	50M WNW OF EWANINGA SIDING
RN014749	388738	7369551	G.T. TAYLORS MILL BORE	14/12/1991	102.0	Gorey & Cole	30M S OF NORTH GATE.
RN015452	389730	7369800	RN15452 LOT1876 SCHABER ROAD	01/06/1989	86.0	Gorey & Cole	20M W OF HOUSE.
RN016254	389220	7369570		14/06/1992	49.5	B Lewis	EAST FENCE & 37m FROM S FENCE
RN016612				29/12/1995	38.0	B Lewis	LOT 1895 PETRICH ROAD
RN016613				18/01/1996	4.3	B Lewis	LOT 1895 PETRICH ROAD
RN016614				30/01/1996	5.0	B Lewis	LOT 1895 PETRICH ROAD
RN016615				30/06/1996	37.0	B Lewis	LOT 1895 PETRICH ROAD
RN017229	399550	7346790		18/07/1997	333.2	Government	5 km E of RN 14566
RN017234	408256	7353851	Investigation 1998 1	01/04/1998	200.0	Government	3 km SE of RN 12045
RN017235	408652	7359940	Investigation 1998 2	03/04/1998	201.6	Government	3.5 km SE of RN 10669
RN017236	411980	7357370	Investigation 1998 3	07/04/1998	301.3	Government	7.5 km SE of RN 10669
RN017243	421151	7357905	Investigation 1998 8	23/07/1998	304.4	Government	5 km SE of RN 11980
RN017244	402572	7352829	Investigation 1999 4	30/03/1999	330.9	Government	2 km SE of RN 13167
RN017245	402544	7352870	Investigation 1999 5	17/04/1999	149.9	Government	2.1 km SE of RN 13167
RN017246	404436	7349741	Investigation 1999 6	24/04/1999	251.4	Government	5.5 km SE of RN 13167

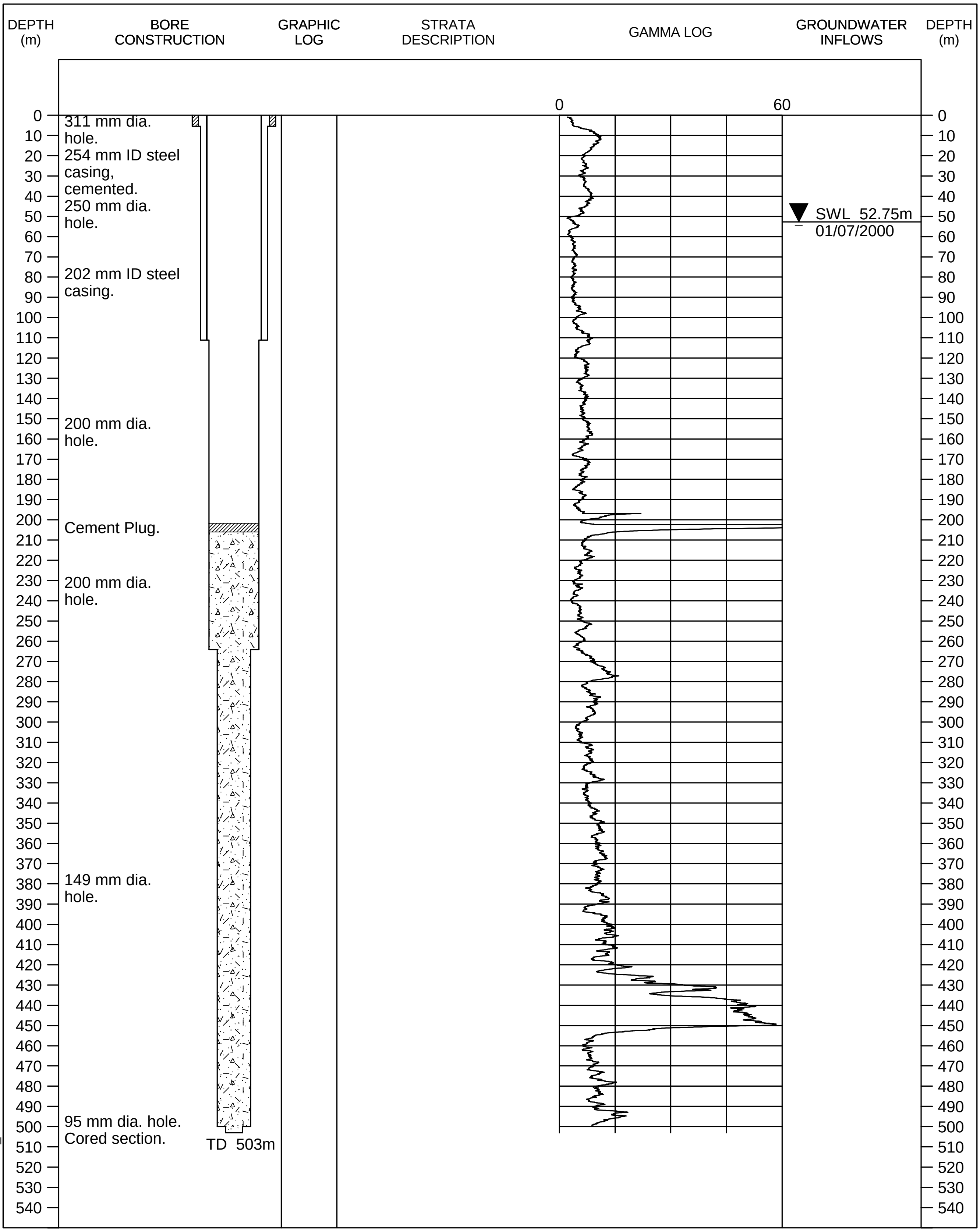
RN	EASTING	NORTHING	BORE NAME	COMPLETION DATE	DRILLED DEPTH (m)	DRILLER	LOCATION
RN017329	414646	7362131	Investigation 1998 4	18/06/1998	199.9	Government	5 km SE of RN 3410
RN017330	403075	7346631	Investigation 1998 5	22/06/1998	163.9	Government	3.5 km E of RN 17229
RN017331	404451	7349690	Investigation 1998 6	25/06/1998	223.9	Government	5.6 km SE of RN 13167
RN017332	403123	7346025	Investigation 1998 7	26/06/1998	120.0	Government	3.5 km ESE of RN 17229
RN017333	397962	7358743	Investigation 1999 7	12/05/1999	70.6	Government	0.5 km SE of RN 11487
RN017334	398029	7358587	Investigation 1999 8	14/05/1999	72.8	Government	0.6 km SE of RN 11487
RN017335	398391	7357889	Investigation 1999 9	21/05/1999	72.4	Government	1 km SE of RN 11487
RN017336	406931	7362376	Investigation 1999 10	22/05/1999	54.3	Government	600 m S of RN 10669
RN017337	406931	7362266	Investigation 1999 11	25/05/1999	54.4	Government	700 m S of RN 10669
RN017338	407027	7361510	Investigation 1999 12	26/05/1999	55.0	Government	1.4 km S of RN 10669
RN017339	403029	7363032	Investigation 1999 13	27/05/1999	60.6	Government	300 m SE of RN 10923
RN017391	405485	7356570	Investigation 1999 14	06/05/1999	192.3	Government	1 km NNE of RN 12045
RN017392	402843	7356476	Investigation 1999 15	18/05/1999	269.8	Government	3 km ENE of RN 12045
RN017393	412654	7363713	Investigation 1999 16	24/05/1999	173.6	Government	2 km SE of RN 3410
RN017394	429076	7365790	Investigation 1999 17	27/05/1999	144.6	Government	1.5 km SSW of RN 5652
RN017436	408696	7361610	Investigation 1999 1	19/03/1999	108.5	Government	2.5 km ESE of RN 10669
RN017437	410191	7358657	Investigation 1999 2	30/03/1999	193.5	Government	5.5 km SE of RN 10669
RN017438	406914	7362405	Investigation 1999 3	30/03/1999	75.6	Government	0.5 km S of RN 10669

APPENDIX B

COMPOSITE LOGS AND GEOLOGICAL LOGS

Northern Territory Government
Department of Infrastructure, Planning and Environment

NATURAL RESOURCES
COMPOSITE LOG OF BORE



DATE(S) DRILLED 7/4/ - 5/6/2000 Constructed 27/6/2000

Rocky Hill - Ooraminna 2000

RN17354 final

COMP_LOG_GAMMA ROCKY_00.GPJ NTWTRES.GDT 10/11/04

GEOLOGICAL LOG
RN17354

Depth (m)		Description
0	3	SAND: silty, calcareous, dark reddish brown (10R 3/4), very fine grained to medium grained (0.05 – 0.5 mm), sub rounded to rounded, moderately sorted, mainly quartz sand.
3	18	SANDSTONE: silty, calcareous, slightly clayey, moderate reddish orange (10R 6/6) to pale red (10R 6/2), very fine grained to medium grained (0.05 – 0.5 mm), sub rounded to rounded, moderately sorted, mainly quartz sand. Colour getting lighter with depth.
18	21	CALCRETE: white (N9) to very light grey (N8), calcrete matrix around quartz sand.
21	30	SAND: kaolinitic, white (N9), very fine grained to medium grained (0.05 – 0.5 mm), sub rounded to rounded, moderately sorted, mainly quartz sand.
30	50	SAND: kaolinitic, white (N9) with minor pale yellowish orange (10YR 8/6) colour, very fine grained to medium grained (0.05 – 0.5 mm), sub rounded to rounded, moderately sorted, mainly quartz sand.
50	53	Cored
53	56	Lost circulation
60	75	SANDSTONE: kaolinitic, white (N9) to very light grey (N8), very fine grained to medium grained (0.05 – 0.5 mm), sub rounded to rounded, moderately sorted, mainly quartz sand.
75	84	SANDSTONE: kaolinitic, very light grey (N8) to light grey (N7) with minor pale yellowish orange (10YR 8/6) colour, very fine grained to medium grained (0.05 – 0.5 mm), sub rounded to rounded, moderately sorted, mainly quartz sand.
84	87	SANDSTONE: kaolinitic, pale yellowish orange (10YR 8/4), very fine grained to medium grained (0.05 – 0.5 mm), sub rounded to rounded, moderately sorted, mainly quartz sand.
87	100	Lost Circulation.
100	103	Cored
103	114	Lost Circulation.
114	138	SANDSTONE: kaolinitic, white (N9) to very light grey (N8), very fine grained to medium grained (0.05 – 0.5 mm), sub rounded to rounded, moderately sorted, mainly quartz sand.
138	150	SANDSTONE: kaolinitic, very light grey (N8) to light grey (N7) with minor pale yellowish orange (10YR 8/6) colour, very fine grained to medium grained (0.05 – 0.5 mm), sub rounded to rounded, moderately sorted, mainly quartz sand.
150	153	Cored
153	200	SANDSTONE: light grey (N7) to medium light grey (N6) with, very fine grained to medium grained (0.05 – 0.5 mm), sub rounded to rounded, moderately sorted, mainly quartz sand with minor iron staining and cementing.
200	203	Cored
203	225	SANDSTONE: light yellowish grey (5Y 8/1), very fine grained to medium grained (0.05 – 0.5 mm), sub rounded to rounded, moderately sorted, mainly quartz sand.

225	246	SANDSTONE: light yellowish grey (5Y 8/1) to pale red (10R 5/2), very fine grained to medium grained (0.05 – 0.5 mm), sub rounded to rounded, moderately sorted, mainly quartz sand. Pale red colour causes by iron staining of quartz grains.
246	250	Lost Circulation.
250	253	Cored
253	261	Lost Circulation.
261	300	SANDSTONE: light yellowish grey (5Y 8/1) with rare pale red (10R 5/2), very fine grained to medium grained (0.05 – 0.5 mm), sub rounded to rounded, moderately sorted, mainly quartz sand. Pale red colour causes by iron staining of quartz grains.
300	303	Cored
300	500	Lost Circulation
350	353	Cored
400	403	Cored
450	453	Cored
500	503	Cored

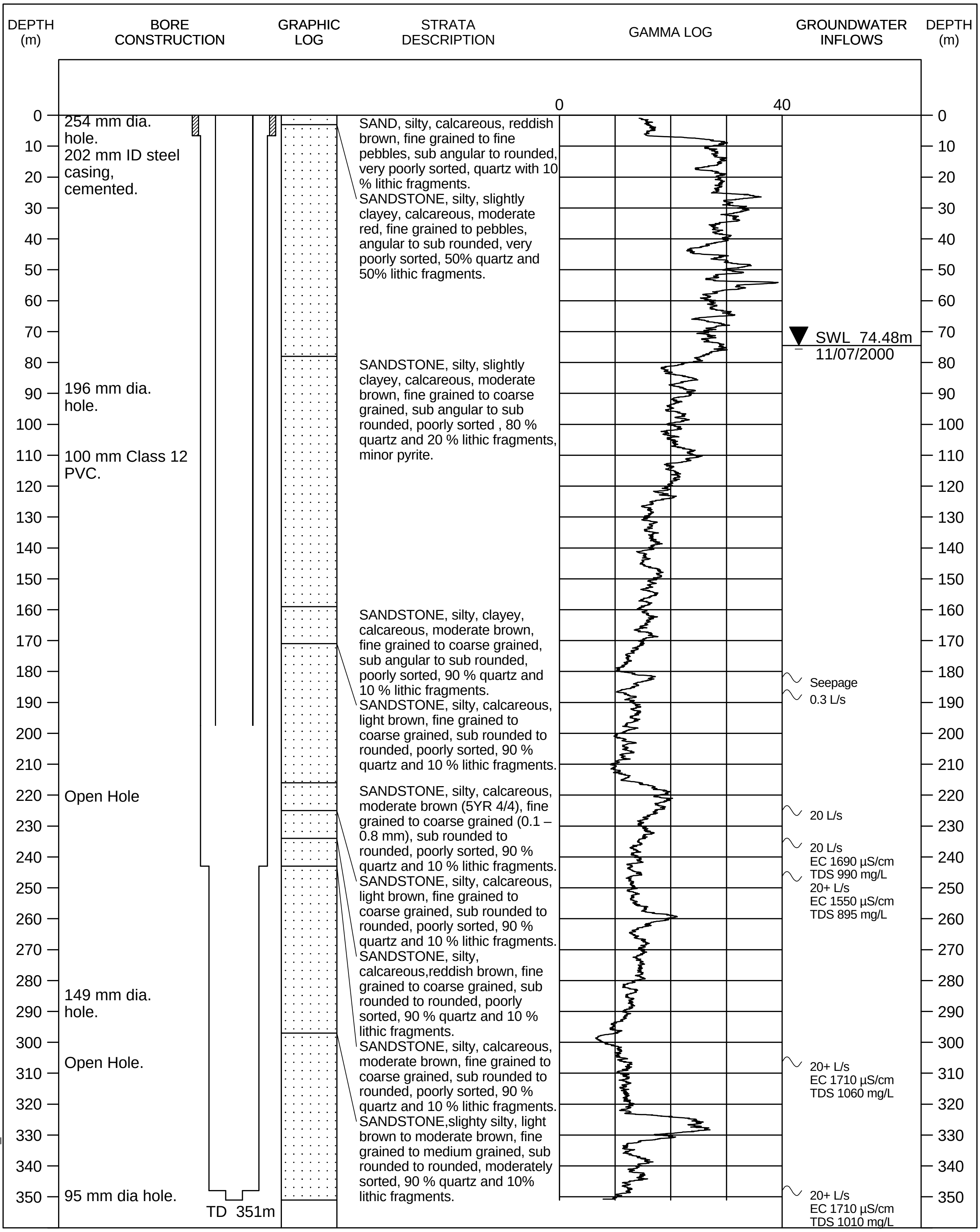
Colours described from wet samples.

SUMMARY

0 – 6 metres	Cainozoic
6 – 200 metres	Hermannsburg Sandstone
200 – 280 metres	Ooraminna Sandstone
280 – 420 metres	Mereenie Sandstone
420 – 503 metres	Pacoota Sandstone

R. J. Paul
Hydrogeologist, Alice Springs
04 December, 2000

NATURAL RESOURCES
COMPOSITE LOG OF BORE



Bore construction

254 mm dia. hole.
202 mm ID steel casing, cemented.
196 mm dia. hole.
100 mm Class 12 PVC.
Open Hole
149 mm dia. hole.
Open Hole.
95 mm dia hole.

Strata description

SAND, silty, calcareous, reddish brown, fine grained to fine pebbles, sub angular to rounded, very poorly sorted, quartz with 10 % lithic fragments.

SANDSTONE, silty, slightly clayey, calcareous, moderate red, fine grained to pebbles, angular to sub rounded, very poorly sorted, 50% quartz and 50% lithic fragments.

SANDSTONE, silty, slightly clayey, calcareous, moderate brown, fine grained to coarse grained, sub angular to sub rounded, poorly sorted , 80 % quartz and 20 % lithic fragments, minor pyrite.

SANDSTONE, silty, clayey, calcareous, moderate brown, fine grained to coarse grained, sub angular to sub rounded, poorly sorted, 90 % quartz and 10 % lithic fragments.

SANDSTONE, silty, calcareous, light brown, fine grained to coarse grained, sub rounded to rounded, poorly sorted, 90 % quartz and 10 % lithic fragments.

SANDSTONE, silty, calcareous, moderate brown (5YR 4/4), fine grained to coarse grained (0.1 – 0.8 mm), sub rounded to rounded, poorly sorted, 90 % quartz and 10 % lithic fragments.

SANDSTONE, silty, calcareous, light brown, fine grained to coarse grained, sub rounded to rounded, poorly sorted, 90 % quartz and 10 % lithic fragments.

SANDSTONE, silty, calcareous,reddish brown, fine grained to coarse grained, sub rounded to rounded, poorly sorted, 90 % quartz and 10 % lithic fragments.

SANDSTONE, silty, calcareous, moderate brown, fine grained to coarse grained, sub rounded to rounded, poorly sorted, 90 % quartz and 10 % lithic fragments.

SANDSTONE,slighty silty, light brown to moderate brown, fine grained to medium grained, sub rounded to rounded, moderately sorted, 90 % quartz and 10% lithic fragments.

Groundwater inflows

SWL 74.48m
11/07/2000

Seepage
0.3 L/s

20 L/s

20 L/s
EC 1690 µS/cm
TDS 990 mg/L

20+ L/s
EC 1550 µS/cm
TDS 895 mg/L

20+ L/s
EC 1710 µS/cm
TDS 1060 mg/L

20+ L/s
EC 1710 µS/cm
TDS 1010 mg/L

DATE(S) DRILLED 7/6 - 12/6/2000

Rocky Hill - Ooraminna 2000 RN17536

GEOLOGICAL LOG
RN17536

Depth (m)		Description
0	3	SAND: silty, calcareous, reddish brown (10R 4/4), fine grained to fine pebbles (0.2 – 4.0 mm), sub angular to rounded, very poorly sorted, quartz with 10 % lithic fragments.
3	78	SANDSTONE: silty, slightly clayey, calcareous, overall colour moderate red (10R 5/3), fine grained to pebbles (0.2 – 4 mm), angular to sub rounded, very poorly sorted, 50% quartz and 50% lithic fragments.
78	81	SANDSTONE: silty, slightly clayey, calcareous, moderate brown (5YR 4/4), fine grained to coarse grained (0.1 – 1.0 mm), sub angular to sub rounded, poorly sorted , 60 % quartz and 40 % lithic fragments, minor pyrite.
81	87	SANDSTONE: silty, slightly clayey, calcareous, greyish red (5R 4/2), fine grained to coarse grained (0.1 – 1.0 mm), sub angular to sub rounded, poorly sorted, 70 % quartz and 30 % lithic fragments.
87	111	SANDSTONE: silty, slightly clayey, calcareous, moderate red (5R 5/3), fine grained to coarse grained (0.1 – 1.0 mm), sub angular to sub rounded, poorly sorted, 70 % quartz and 30 % lithic fragments.
111	120	SANDSTONE: silty, slightly clayey, calcareous, reddish brown (10R 4/4), fine grained to coarse grained (0.1 – 1.0 mm), sub angular to sub rounded, poorly sorted, 70 % quartz and 30 % lithic fragments.
120	132	SANDSTONE: silty, slightly clayey, calcareous, moderate reddish brown (10R 4/6), fine grained to coarse grained (0.1 – 0.6 mm), sub angular to sub rounded, poorly sorted, 80 % quartz and 20 % lithic fragments.
132	141	SANDSTONE: silty, slightly clayey, calcareous, moderate brown (5YR 4/4), fine grained to coarse grained (0.1 – 0.6 mm), sub angular to sub rounded, poorly sorted, 80 % quartz and 20 % lithic fragments.
141	159	SANDSTONE: silty, slightly clayey, calcareous, moderate reddish brown (10R 4/6), fine grained to coarse grained (0.1 – 0.6 mm), sub angular to sub rounded, poorly sorted, 80 % quartz and 20 % lithic fragments.
159	171	SANDSTONE: silty, clayey, calcareous, moderate brown (5YR 4/4), fine grained to coarse grained (0.1 – 0.6 mm), sub angular to sub rounded, poorly sorted, 90 % quartz and 10 % lithic fragments.
171	207	SANDSTONE: silty, calcareous, light brown (5YR 5/4), fine grained to coarse grained (0.1 – 0.8 mm), sub rounded to rounded, poorly sorted, 90 % quartz and 10 % lithic fragments.
207	216	SANDSTONE: silty, calcareous, light brown (5YR 6/4), fine grained to coarse grained (0.1 – 0.8 mm), sub rounded to rounded, poorly sorted, 90 % quartz and 10 % lithic fragments.
216	225	SANDSTONE: silty, calcareous, moderate brown (5YR 4/4), fine grained to coarse grained (0.1 – 0.8 mm), sub rounded to rounded, poorly sorted, 90 % quartz and 10 % lithic fragments.
225	234	SANDSTONE: silty, calcareous, light brown (5YR 5/6), fine grained to coarse grained (0.1 – 0.8 mm), sub rounded to rounded, poorly sorted, 90 % quartz and 10 % lithic fragments.
234	237	SANDSTONE: silty, calcareous, dark reddish brown (10R 3/4), fine grained to coarse grained (0.1 – 0.8 mm), sub rounded to rounded, poorly sorted, 90 % quartz and 10 % lithic fragments.

237	243	SANDSTONE: silty, calcareous, reddish brown (10R 4/4), fine grained to coarse grained (0.1 – 0.8 mm), sub rounded to rounded, poorly sorted, 90 % quartz and 10 % lithic fragments.
243	279	SANDSTONE: silty, calcareous, moderate brown (5YR 3/4), fine grained to coarse grained (0.1 – 0.8 mm), sub rounded to rounded, poorly sorted, 90 % quartz and 10 % lithic fragments.
279	297	SANDSTONE: silty, calcareous, moderate brown (5YR 4/4), fine grained to coarse grained (0.1 – 0.8 mm), sub rounded to rounded, poorly sorted, 90 % quartz and 10 % lithic fragments.
297	315	SANDSTONE: silty, calcareous, light brown (5YR 6/4), fine grained to medium grained (0.1 – 0.5 mm), sub rounded to rounded, moderately sorted, 90 % quartz and 10% lithic fragments.
315	318	SANDSTONE: silty, calcareous, moderate brown (5YR 3/4), fine grained to coarse grained (0.1 – 1.0 mm), sub rounded to rounded, poorly sorted, 80 % quartz and 20 % lithic fragments.
318	321	SANDSTONE: silty, calcareous, light brown (5YR 6/4), fine grained to medium grained (0.1 – 0.5 mm), sub rounded to rounded, moderately sorted, 90 % quartz and 10% lithic fragments.
321	330	SANDSTONE: silty, calcareous, moderate brown (5YR 3/4), fine grained to coarse grained (0.1 – 1.0 mm), sub rounded to rounded, poorly sorted, 70 % quartz and 30 % lithic fragments.
330	333	SANDSTONE: silty, calcareous, light brown (5YR 6/4), fine grained to medium grained (0.1 – 0.5 mm), sub rounded to rounded, moderately sorted, 90 % quartz and 10% lithic fragments.
333	336	SANDSTONE: silty, calcareous, moderate brown (5YR 3/4), fine grained to coarse grained (0.1 – 1.0 mm), sub rounded to rounded, poorly sorted, 70 % quartz and 30 % lithic fragments.
336	339	SANDSTONE: silty, calcareous, light brown (5YR 6/4), fine grained to medium grained (0.1 – 0.5 mm), sub rounded to rounded, moderately sorted, 90 % quartz and 10% lithic fragments.
339	345	SANDSTONE: silty, calcareous, moderate brown (5YR 3/4), fine grained to coarse grained (0.1 – 1.0 mm), sub rounded to rounded, poorly sorted, 70 % quartz and 30 % lithic fragments.
345	348	SANDSTONE: silty, calcareous, light brown (5YR 6/4), fine grained to medium grained (0.1 – 0.5 mm), sub rounded to rounded, moderately sorted, 90 % quartz and 10% lithic fragments.
348	351	SANDSTONE: moderate brown, fine grained (0.1 – 0.3 mm), sub rounded to rounded, well sorted, mainly quartz with 2% lithic fragments.

Colours described from wet samples. Cored from 348 to 351 metres.

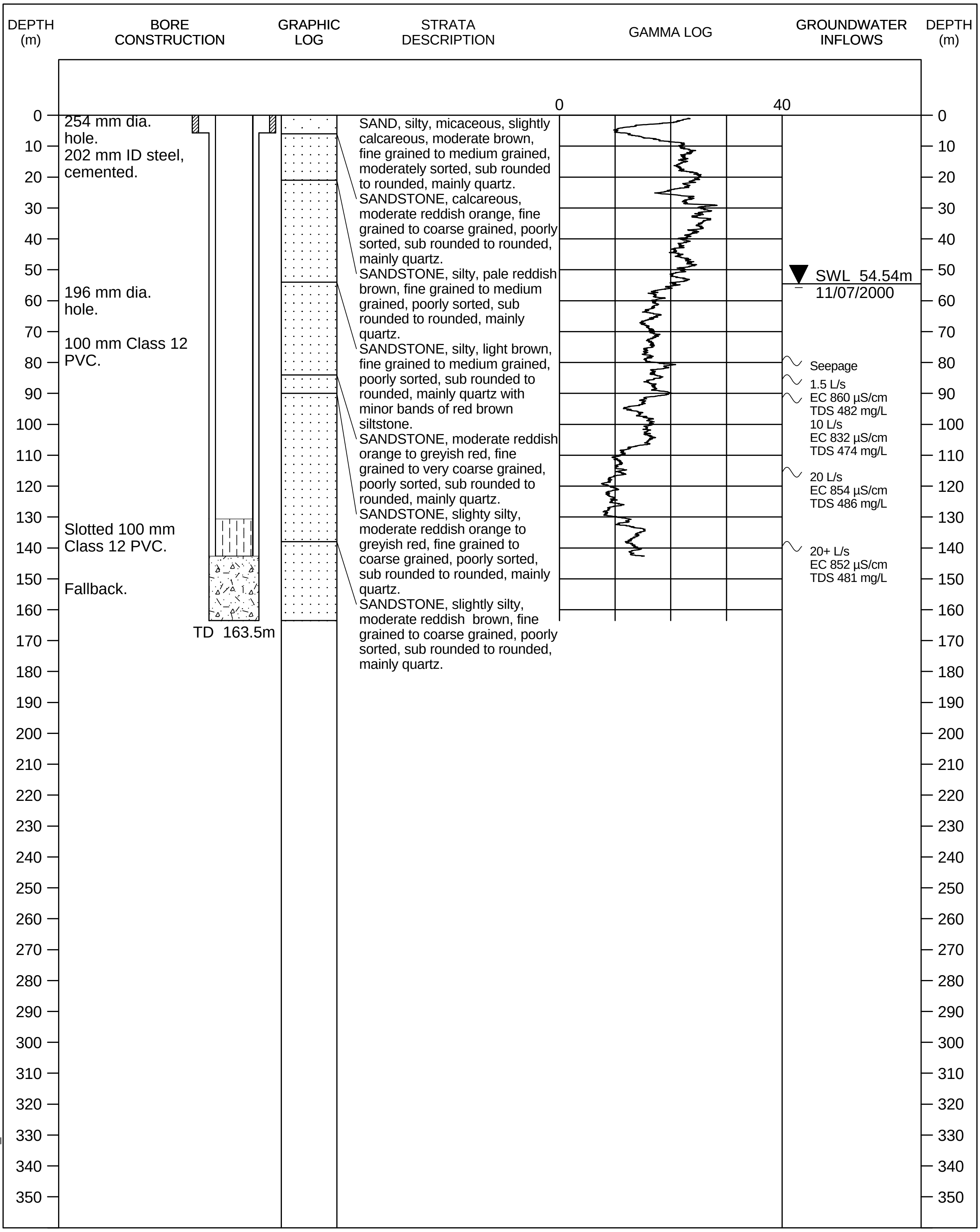
SUMMARY

0 – 3 metres	Cainozoic
3 – 120? metres	Brewer Conglomerate
120? – 297 metres	Hermannsburg Sandstone
297 - 351 metres	Ooraminna Sandstone

R. J. Paul
Hydrogeologist, Alice Springs
04 December, 2000

Northern Territory Government
Department of Infrastructure, Planning and Environment

NATURAL RESOURCES
COMPOSITE LOG OF BORE



SAND, silty, micaceous, slightly calcareous, moderate brown, fine grained to medium grained, moderately sorted, sub rounded to rounded, mainly quartz.

SANDSTONE, calcareous, moderate reddish orange, fine grained to coarse grained, poorly sorted, sub rounded to rounded, mainly quartz.

SANDSTONE, silty, pale reddish brown, fine grained to medium grained, poorly sorted, sub rounded to rounded, mainly quartz.

SANDSTONE, silty, light brown, fine grained to medium grained, poorly sorted, sub rounded to rounded, mainly quartz with minor bands of red brown siltstone.

SANDSTONE, moderate reddish orange to greyish red, fine grained to very coarse grained, poorly sorted, sub rounded to rounded, mainly quartz.

SANDSTONE, slighty silty, moderate reddish orange to greyish red, fine grained to coarse grained, poorly sorted, sub rounded to rounded, mainly quartz.

SANDSTONE, slightly silty, moderate reddish brown, fine grained to coarse grained, poorly sorted, sub rounded to rounded, mainly quartz.

DATE(S) DRILLED 13/6 - 19/6/2000

Rocky Hill - Ooraminna 2000 RN17537

GEOLOGICAL LOG
RN17537

Depth (m)		Description
0	6	SAND: silty, micaceous, slightly calcareous, moderate brown (5YR 4/4), fine grained to medium grained, (0.1 – 0.5 mm), moderately sorted, sub rounded to rounded, mainly quartz.
6	21	SANDSTONE: calcareous, moderate reddish orange (10R 5/6), fine grained to coarse grained (0.2 – 1.0 mm), poorly sorted, sub rounded to rounded, mainly quartz.
21	54	SANDSTONE: silty, pale reddish brown (10R 5/3), fine grained to medium grained, (0.1 – 1.0 mm, mostly < 0.6 mm), poorly sorted, sub rounded to rounded, mainly quartz.
54	84	SANDSTONE: silty, light brown (5YR 6/4), fine grained to medium grained (0.1 – 0.8 mm, poorly sorted, sub rounded to rounded, mainly quartz with minor bands of red brown siltstone.
84	87	SANDSTONE: moderate reddish orange (10R 5/6), fine grained to very coarse grained (0.2 – 2.0 mm), poorly sorted, sub rounded to rounded, mainly quartz.
87	90	SANDSTONE: greyish red (10R 4/2), fine grained to very coarse grained (0.2 – 2.0 mm), poorly sorted, sub rounded to rounded, mainly quartz.
90	93	SANDSTONE: moderate reddish orange (10R 5/6), fine grained to coarse grained (0.2 – 1.0 mm), poorly sorted, sub rounded to rounded, mainly quartz.
93	114	SANDSTONE: slightly silty, greyish red (10R 5/2), fine grained to coarse grained (0.2 – 1.0), poorly sorted, sub rounded to rounded, mainly quartz, minor lithic fragments, minor iron cementing.
114	117	SANDSTONE: slightly silty, moderate reddish orange (10R 5/6), fine grained to coarse grained (0.2 – 1.0 mm), poorly sorted, sub rounded to rounded, mainly quartz
117	120	SANDSTONE: slightly silty, greyish red (10R 5/2), fine grained to coarse grained (0.2 – 0.8 mm), moderately sorted, sub rounded to rounded, mainly quartz.
120	123	SANDSTONE: slightly silty, moderate reddish orange (10R 5/6), fine grained to coarse grained (0.2 – 1.5 mm), poorly sorted, sub rounded to rounded, mainly quartz.
123	126	SANDSTONE: slightly silty, greyish red (10R 5/2), fine grained to coarse grained (0.2 – 1.0 mm), moderately sorted, sub rounded to rounded, mainly quartz, minor pyrite cementing.
126	129	SANDSTONE: slightly silty, moderate reddish orange (10R 5/6), fine grained to coarse grained (0.1 – 1.5 mm), poorly sorted, sub rounded to rounded, mainly quartz
129	132	SANDSTONE: slightly silty, greyish red (10R 5/2), fine grained to coarse grained (0.1 – 1.0 mm), moderately sorted, sub rounded to rounded, mainly quartz.
132	135	SANDSTONE: slightly silty, moderate reddish orange (10R 5/6), fine grained to coarse grained (0.1 – 1.0 mm), poorly sorted, sub rounded to rounded, mainly quartz.

135	138	SANDSTONE: slightly silty, greyish red (10R 5/2), fine grained to medium grained (0.1 – 0.5 mm), moderately sorted, sub rounded to rounded, mainly quartz.
138	163.5	SANDSTONE: slightly silty, moderate reddish brown (10R 4/6), fine grained to coarse grained (0.1 – 1.0 mm), poorly sorted, sub rounded to rounded, mainly quartz.

Colours described from wet samples.

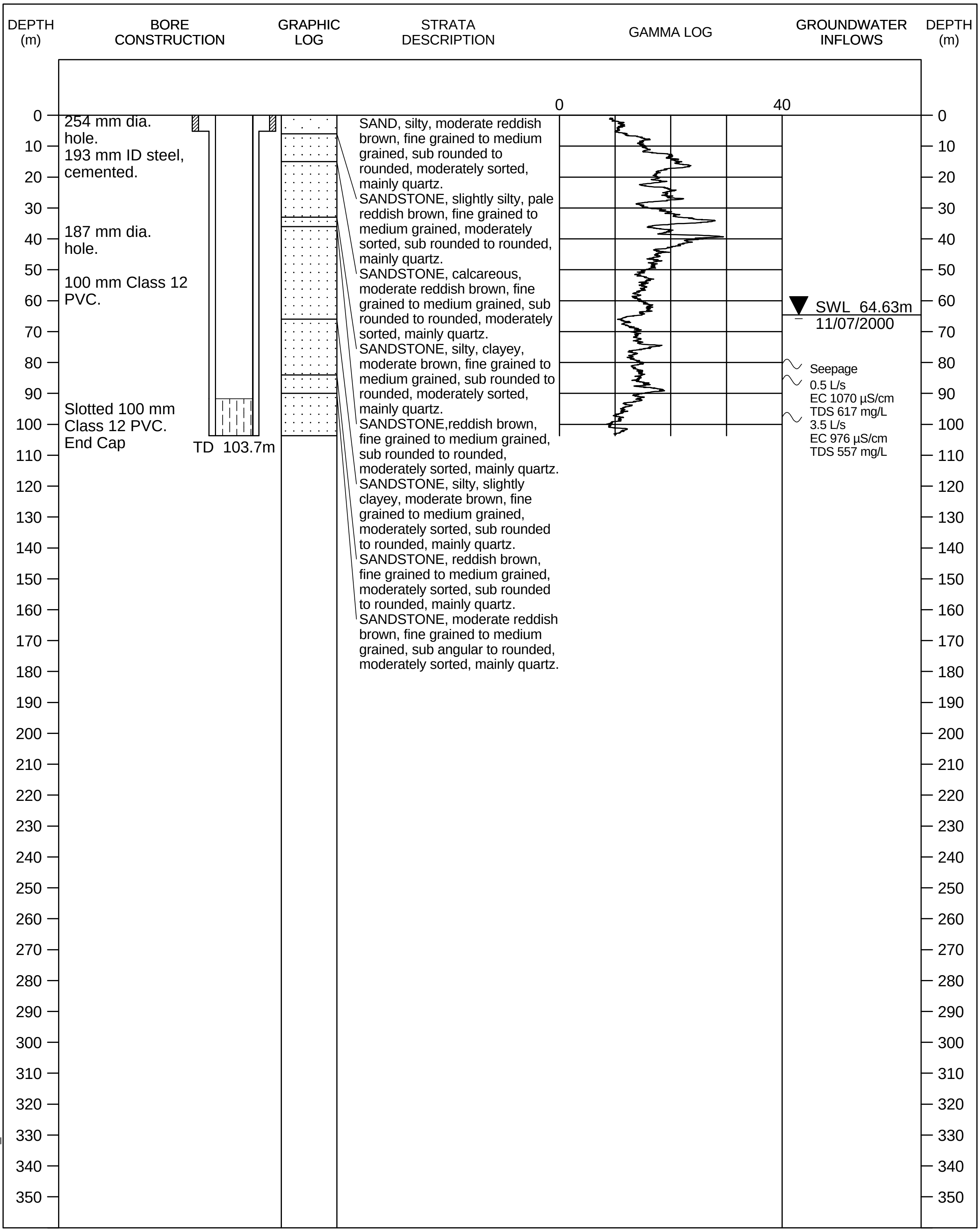
SUMMARY

0 - 6 metres	Cainozoic
6 – 163.5 metres	Hermannsburg Sandstone

R. J. Paul
Hydrogeologist, Alice Springs
04 December, 2000

Northern Territory Government
Department of Infrastructure, Planning and Environment

NATURAL RESOURCES
COMPOSITE LOG OF BORE



SAND, silty, moderate reddish brown, fine grained to medium grained, sub rounded to rounded, moderately sorted, mainly quartz.

SANDSTONE, slightly silty, pale reddish brown, fine grained to medium grained, moderately sorted, sub rounded to rounded, mainly quartz.

SANDSTONE, calcareous, moderate reddish brown, fine grained to medium grained, sub rounded to rounded, moderately sorted, mainly quartz.

SANDSTONE, silty, clayey, moderate brown, fine grained to medium grained, sub rounded to rounded, moderately sorted, mainly quartz.

SANDSTONE,reddish brown, fine grained to medium grained, sub rounded to rounded, moderately sorted, mainly quartz.

SANDSTONE, silty, slightly clayey, moderate brown, fine grained to medium grained, moderately sorted, sub rounded to rounded, mainly quartz.

SANDSTONE, reddish brown, fine grained to medium grained, moderately sorted, sub rounded to rounded, mainly quartz.

SANDSTONE, moderate reddish brown, fine grained to medium grained, sub angular to rounded, moderately sorted, mainly quartz.

DATE(S) DRILLED 19/6 - 21/6/2000

Rocky Hill - Ooraminna 2000 RN17538

COMP_LOG_GAMMA ROCKY_00.GPJ NTWTRES.GDT 10/11/04

GEOLOGICAL LOG
RN17538

Depth (m)		Description
0	3	SAND: silty, moderate reddish brown (10R 4/6), fine grained (0.1 – 0.5 mm), sub rounded to rounded, moderately sorted, mainly quartz.
3	6	SAND: moderate reddish brown (10R 4/6), fine grained to medium grained (0.1 – 0.6 mm), sub-rounded to rounded, mainly quartz.
6	15	SANDSTONE: slightly silty, pale reddish brown (10R 5/4), fine grained to medium grained (0.2 – 0.8 mm), moderately sorted, sub rounded to rounded, mainly quartz.
15	27	SANDSTONE: calcareous, moderate reddish brown (10R 6/6), fine grained to medium grained (0.1 – 0.8 mm), sub rounded to rounded, moderately sorted, mainly quartz.
27	33	SANDSTONE: calcareous, moderate reddish brown (10R 5/6), fine grained to medium grained (0.1 – 0.8 mm), sub rounded to rounded, moderately sorted, mainly quartz.
33	36	SANDSTONE: silty, clayey, moderate brown (5YR 4/4), fine grained to medium grained (0.1 to 1.0 mm).
36	42	SANDSTONE: pale reddish brown (10R 5/4), fine grained to medium grained (0.1 – 0.6 mm), sub rounded to rounded, moderately sorted, mainly quartz.
42	66	SANDSTONE: moderate reddish brown (10R 5/6), fine grained to medium grained, 0.1 – 0.8 mm), sub rounded to rounded, moderately sorted, mainly quartz.
66	81	SANDSTONE: silty, slightly clayey, moderate brown (5YR 4/4), fine grained to medium grained (0.1 – 0.5 mm), moderately sorted, sub rounded to rounded, mainly quartz.
81	84	SANDSTONE: silty, moderate brown (5YR 4/4), fine grained to medium grained (0.1 – 0.5 mm), moderately sorted, sub rounded to rounded, mainly quartz.
84	90	SANDSTONE: reddish brown (10R 4/4), fine grained to medium grained (0.1 – 0.8 mm), moderately sorted, sub rounded to rounded, mainly quartz.
90	103.7	SANDSTONE: moderate reddish brown (10R 5/6), fine grained to medium grained (0.1 – 0.8 mm), sub angular to rounded, moderately sorted, mainly quartz.

Colours described from wet samples.

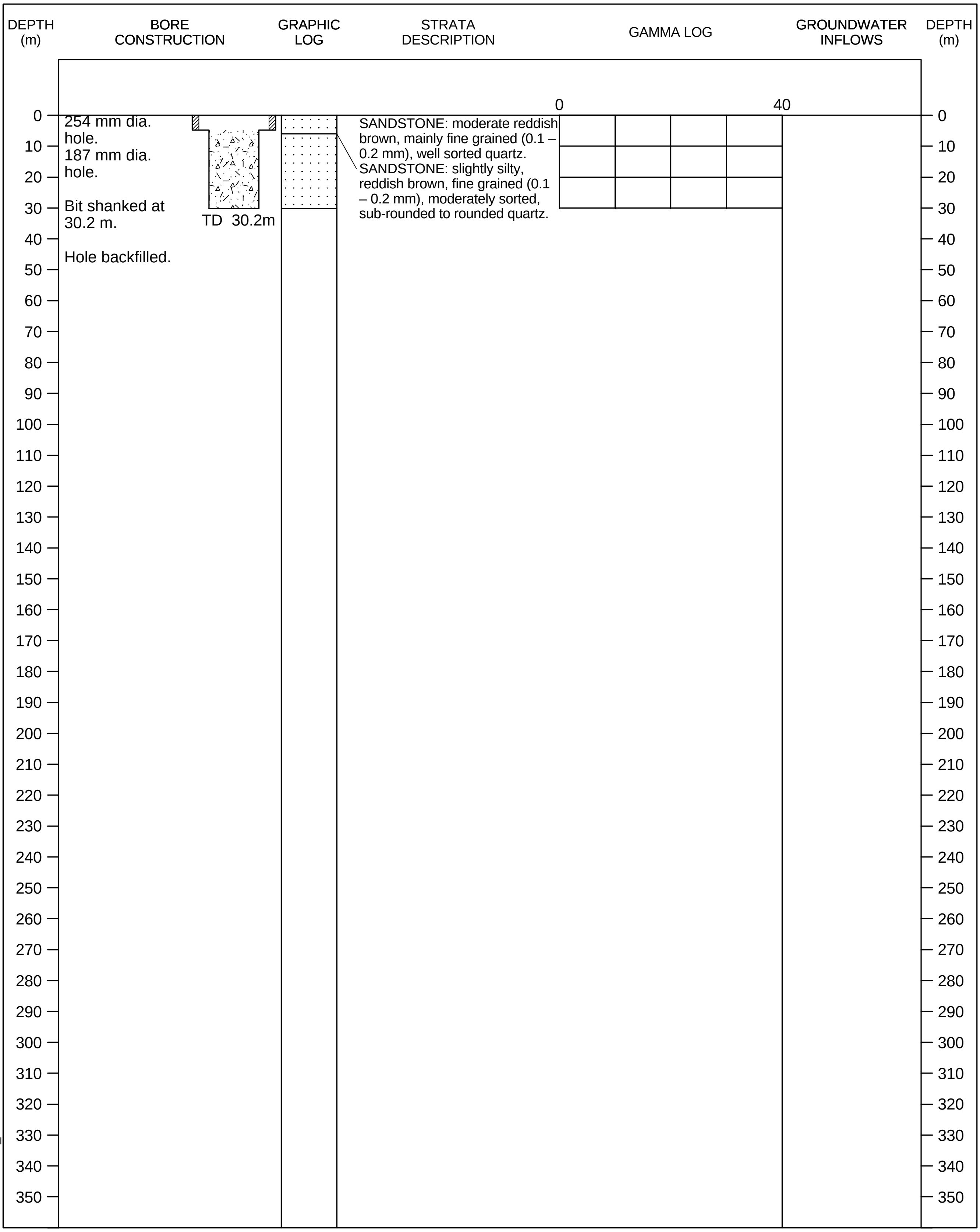
SUMMARY

0 - 6 metres	Cainozoic
6 – 103.7 metres	Hermannsburg Sandstone

R. J. Paul
Hydrogeologist, Alice Springs
04 December, 2000

Northern Territory Government
Department of Infrastructure, Planning and Environment

NATURAL RESOURCES
COMPOSITE LOG OF BORE



254 mm dia. hole.
187 mm dia. hole.

Bit shanked at 30.2 m.

Hole backfilled.

SANDSTONE: moderate reddish brown, mainly fine grained (0.1 – 0.2 mm), well sorted quartz.

SANDSTONE: slightly silty, reddish brown, fine grained (0.1 – 0.2 mm), moderately sorted, sub-rounded to rounded quartz.

DATE(S) DRILLED 22/6/2000

Rocky Hill - Ooraminna 2000 RN17539

COMP_LOG_GAMMA ROCKY_00.GPJ NTWTRES.GDT 10/11/04

GEOLOGICAL LOG
RN17539

Depth (m)		Description
0	6	SANDSTONE: moderate reddish brown (10R 4/6), mainly fine grained (0.1 – 0.2 mm), well sorted quartz.
6	30.2	SANDSTONE: slightly silty, reddish brown (10R 5/6), fine grained (0.1 – 0.2 mm), moderately sorted, sub-rounded to rounded quartz.

Colours described from wet samples.

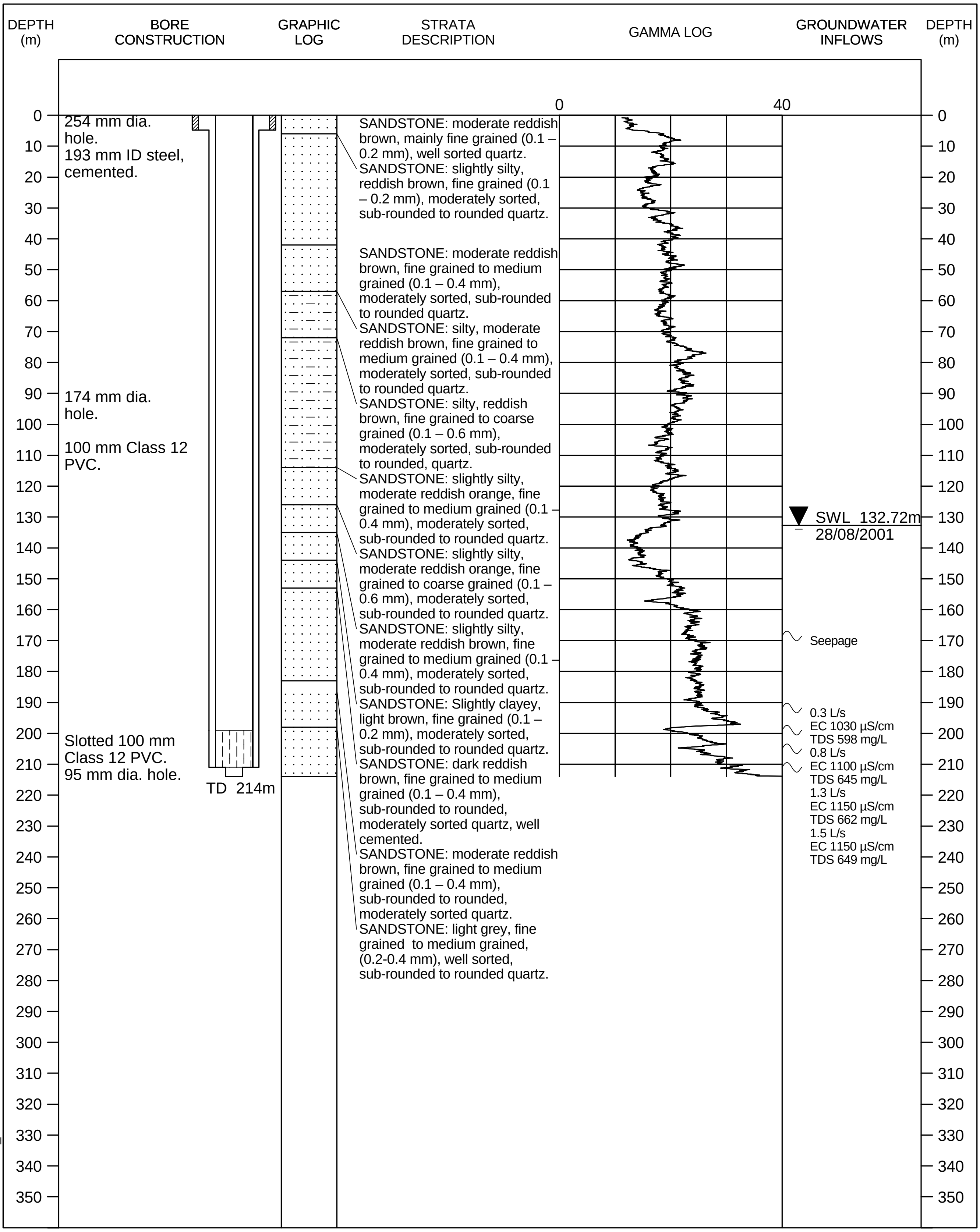
SUMMARY

0 - 3 metres	Cainozoic
3 – 30.2 metres	Hermannsberg Sandstone

R. J. Paul
Hydrogeologist, Alice Springs
04 December, 2000

Northern Territory Government
Department of Infrastructure, Planning and Environment

NATURAL RESOURCES
COMPOSITE LOG OF BORE



SANDSTONE: moderate reddish brown, mainly fine grained (0.1 – 0.2 mm), well sorted quartz.
SANDSTONE: slightly silty, reddish brown, fine grained (0.1 – 0.2 mm), moderately sorted, sub-rounded to rounded quartz.

SANDSTONE: moderate reddish brown, fine grained to medium grained (0.1 – 0.4 mm), moderately sorted, sub-rounded to rounded quartz.
SANDSTONE: silty, moderate reddish brown, fine grained to medium grained (0.1 – 0.4 mm), moderately sorted, sub-rounded to rounded quartz.
SANDSTONE: silty, reddish brown, fine grained to coarse grained (0.1 – 0.6 mm), moderately sorted, sub-rounded to rounded, quartz.
SANDSTONE: slightly silty, moderate reddish orange, fine grained to medium grained (0.1 – 0.4 mm), moderately sorted, sub-rounded to rounded quartz.
SANDSTONE: slightly silty, moderate reddish orange, fine grained to coarse grained (0.1 – 0.6 mm), moderately sorted, sub-rounded to rounded quartz.
SANDSTONE: slightly silty, moderate reddish brown, fine grained to medium grained (0.1 – 0.4 mm), moderately sorted, sub-rounded to rounded quartz.
SANDSTONE: Slightly clayey, light brown, fine grained (0.1 – 0.2 mm), moderately sorted, sub-rounded to rounded quartz.
SANDSTONE: dark reddish brown, fine grained to medium grained (0.1 – 0.4 mm), sub-rounded to rounded, moderately sorted quartz, well cemented.
SANDSTONE: moderate reddish brown, fine grained to medium grained (0.1 – 0.4 mm), sub-rounded to rounded, moderately sorted quartz.
SANDSTONE: light grey, fine grained to medium grained, (0.2-0.4 mm), well sorted, sub-rounded to rounded quartz.

DATE(S) DRILLED 22/6 - 26/6/2000

Rocky Hill - Ooraminna 2000 RN17540

GEOLOGICAL LOG
RN17540

Depth (m)		Description
0	6	SANDSTONE: moderate reddish brown (10R 4/6), mainly fine grained (0.1 – 0.2 mm), well sorted quartz.
6	42	SANDSTONE: slightly silty, reddish brown (10R 5/6), fine grained (0.1 – 0.2 mm), moderately sorted, sub-rounded to rounded quartz.
42	57	SANDSTONE: moderate reddish brown (10R 5/6), fine grained to medium grained (0.1 – 0.4 mm), moderately sorted, sub-rounded to rounded quartz.
57	72	SANDSTONE: silty, moderate reddish brown (10R 4/6), fine grained to medium grained (0.1 – 0.4 mm), moderately sorted, sub-rounded to rounded quartz.
72	114	SANDSTONE: silty, reddish brown (2.5YR 4/4), fine grained to coarse grained (0.1 – 0.6 mm), moderately sorted, sub-rounded to rounded, quartz.
114	126	SANDSTONE: slightly silty, moderate reddish orange (10R 6/6), fine grained to medium grained (0.1 – 0.4 mm), moderately sorted, sub-rounded to rounded quartz.
126	135	SANDSTONE: slightly silty, moderate reddish orange (10R 6/6), fine grained to coarse grained (0.1 – 0.6 mm), moderately sorted, sub-rounded to rounded quartz.
135	144	SANDSTONE: slightly silty, moderate reddish brown (10R 4/6), fine grained to medium grained (0.1 – 0.4 mm), moderately sorted, sub-rounded to rounded quartz.
144	153	SANDSTONE: Slightly clayey, light brown (5YR 5/6), fine grained (0.1 – 0.2 mm), moderately sorted, sub-rounded to rounded quartz.
153	183	SANDSTONE: dark reddish brown (10R 3/3), fine grained to medium grained (0.1 – 0.4 mm), sub-rounded to rounded, moderately sorted quartz, well cemented.
186	198	SANDSTONE: moderate reddish brown (10R 4/6), fine grained to medium grained (0.1 – 0.4 mm), sub-rounded to rounded, moderately sorted quartz.
198	211	SANDSTONE: light grey (10YR 7/2), fine grained to medium grained, (0.2-0.4 mm), well sorted, sub-rounded to rounded quartz.
211	214	Cored, recovered 2 metres. 211 – 212 SANDSTONE: light grey (10YR 7/2), fine grained to medium grained, (0.2-0.4 mm), well sorted, sub-rounded to rounded quartz showing bedding. 212 – 213 as before but bedding indistinct and sandstone friable.

Colours described from wet samples.

SUMMARY

0 - 198 metres	Hermannsburg Sandstone
198 - 214 metres	Ooraminna Sandstone

R. J. Paul
Hydrogeologist, Alice Springs
04 December, 2000

APPENDIX C
GEOTECH REPORT - SPECIFIC RETENTION AND WATER PERMEABILITY OF CORE SAMPLES

ROCKY HILL PROJECT SPECIFIC RETENTION AND WATER PERMEABILITY OF CORE SAMPLES

Prepared by:
Khiam Ooi – Manager Petrophysics Division

Prepared for:
Bob Paul
Department of Lands Planning and Environment

September 2000

GEOTECH
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Locked Bag 27, Cannington, Western Australia. 6987
Email: geotech@geotechnical-services.com.au
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ACN 050 543 194
Quality System
Quality Endorsed Company
ISO 9002 Lic 10551
Standards Australia
ABN 58 050 543 194

Sample Preparation

A total of 10 core plugs, with diameter sizes of 3.80cm or 2.54 cm were cut from core sections sent to us. The core plugs were cleaned by solvent extraction using hot methanol in a Soxhlet apparatus to remove residual salts.

Extracted plugs were dried at 95°C in a top-ventilated, fan-forced convection oven until constant weights were achieved. They were then allowed to cool to room temperature at 25°C in an evacuated desiccator prior to helium injection measurements.

Helium Injection Porosity

Ambient helium porosities were measured in a matrix cup using a Coberly-Stevens porosimeter. Pore volumes were calculated from Boyle's Law (ie. $P_1V_1=P_2V_2$) and expressed as a fraction of the bulk volume.

$$\phi = (V_p/BV) \times 100$$

where ϕ = porosity (%)
V_p = pore volume (cm^2)
BV = bulk volume (cm^2)

Bulk volumes were determined by the mercury displacement technique using a customized digital displacement pump. Grain densities were then calculated from the expression

$$GD = W/GV$$

where GD = grain density (g cm^{-3})
W = dry weight of sample (g)
GV = grain volume (cm^3)

Water Permeability

After porosity measurements, the samples were loaded into a saturator and evacuated overnight. The samples were then pressure saturated overnight at 2000 psi with degassed 5% KCl brine. The saturated samples were individually loaded into a core holder and a hydrostatic pressure of 400psi was applied. KCl brine was then injected into the samples in both forward and reverse directions. The flow rate of the brine was used to calculate the permeabilities using Darcy's equation.

$$\text{Permeability (mD)} = (14700 \times L \times \mu \times V) / P \times A \times T$$

where L = length of core plug (cm)
μ = viscosity of KCl brine (centipoise)
V = volume of KCl (cm)
P = pressure (psi)
A = area (cm^2)
T = time (sec)

Specific Yield Measurements using the porous plate method.

The fully saturated samples were loaded into a porous plate cell and humidified air at 10kpa was introduced into the cell. The brine displaced from the samples was monitored using a pipette placed horizontally. When the samples attained equilibrium, that is when no more brine is being displaced, the samples were unloaded from the cell and weighed. The process was repeated for the samples at 33 kpa and 240 kpa.

The specific yield was calculated using the expression

Specific Yield (%) = volume of brine removed (cm^2) / bulk volume of sample (cm^2) X 100

The method described above is similar to that by Colman, E.A. (1947) except for the following:

1)Air pressure instead of vacuum was used to displace water from the sample
2)Solid core plugs were used instead of sieved soil samples.

Discussion of Results

The results are tabulated in Table 1.

The forward water permeability vary from less than 0.01 mD to a maximum of 1032 mD. The forward and reverse permeabilities for all the samples are fairly similar, except for sample RN17354, 500.70m, where the reverse permeability (50mD) is substantially higher than the forward permeability (38 mD). This indicates potential flow problems due to movement of mobile fines. These mobile fines eg. silts block up the pore throats, reducing the permeability. When the flow direction is reversed, movement of the water in the opposite direction removes the mobile fines from the pore throats, resulting in an increase in permeability.

Grain density of 2.64 to 2.66 g cm^{-3} is consistent with the sandstone lithology. Higher grain densities exhibited by some of the reddish brown, brown samples may perhaps be due to the presence of iron bearing minerals.

The specific yield is proportional to its respective permeability; samples with higher permeability have higher yield and vice-versa.

References

Colman, E.A. (1947) except for the following: A laboratory procedure for determining the field capacity of soils. *Soil Science* 63::277-283.

Table 1

Client: Dept of Lands Planning and Environment
Project: Rocky Hill
File No:CA0062
Date: Sept 2000

SUMMARY OF LABORATORY TEST RESULTS

Registered Number	Depth (m)	Diameter (cm)	Length (cm)	Pore Volume (cm^3)	Bulk volume (cm^3)	Helium Porosity (%) @ ambient	Grain Density (g cm^{-3})	Forward water permeability (mD) @ ambient	Reverse water permeability (mD) @ ambient	Specific Yield (%) of Bulk Volume @ 10 kpa	Specific Yield (%) of Bulk Volume @ 33 kpa	Specific Yield (%) of Bulk Volume @ 240 kpa
RN 17354	101.10	2.52	3.66	3.796	17.850	21.3	2.65	70	67	3.5	10.0	14.2
RN 17354	152.40	2.53	5.02	4.629	24.405	19.0	2.64	35	35	1.6	9.3	13.0
RN 17354	200.00	3.82	4.92	12.919	55.579	23.2	2.66	214	204	2.7	14.7	16.6
RN 17354	251.75	3.82	5.20	12.041	58.638	20.5	2.66	36	32	1.0	7.7	11.4
RN 17354	302.30	3.82	5.15	14.393	57.914	24.9	2.65	1032	997	14.2	18.9	20.2
RN 17354	351.30	3.82	5.17	13.191	58.865	22.4	2.66	153	153	1.1	13.7	15.5
RN 17354	400.40	3.82	5.20	5.812	59.496	9.8	2.82	<0.01	<0.01	0.0	0.0	1.3
RN 17354	450.80	3.82	5.26	4.906	59.908	8.2	2.72	28	28	1.6	5.8	6.5
RN 17354	500.70	3.82	2.25	5.812	59.872	9.7	2.71	38	50	2.9	7.1	7.8
RN 17536	349.40	2.37	3.66	4.088	15.742	26.0	2.65	778	786	13.5	20.3	22.1

GEOTECH

APPENDIX D

ROCKY HILL - OORAMINNA WATER LEVELS – JULY 2000

RN	EASTING (GDA)	NORTHING (GDA)	DATE MEASURED	RLMP (m AHD)	SWL (mbmp)	RL SWL (m AHD)
RN003609	386163.8	7365334.8	20/06/2001	540.740	107.36	433.38
RN004480	392265.7	7360932.8	20/06/2001	524.570	76.68	447.89
RN004482	386968.8	7363750.8	20/06/2001	535.500	96.16	439.34
RN004484	391006.7	7360410.8	20/06/2001	526.110	81.94	444.17
RN004503	397738.7	7360547.8	21/06/2001	514.460	61.88	452.58
RN004504	397780.7	7361156.8	21/06/2001	515.280	62.22	453.06
RN004687	388753.7	7362701.8	20/06/2001	531.940	92.30	439.64
RN004688	388798.7	7363249.8	20/06/2001	532.980	93.80	439.18
RN004690	390388.7	7359870.8	20/06/2001	526.830	78.77	448.06
RN004693	397609.7	7358724.8	20/06/2001	514.230	62.82	451.41
RN006504	421294.7	7364601.8	26/06/2001	491.330	42.38	448.95
RN010216	394810.7	7354945.8	20/06/2001	529.160	78.12	451.04
RN010720	408209.7	7355862.8	21/06/2001	505.010	52.18	452.83
RN010722	419691.7	7365441.8	26/06/2001	477.830	28.59	449.24
RN010729	416208.7	7365380.7	26/06/2001	481.050	31.03	450.02
RN010755	399028.7	7361159.8	21/06/2001	512.290	58.50	453.79
RN010919	402955.7	7360273.8	21/06/2001	506.880	54.32	452.56
RN011113	402810.7	7362453.8	21/06/2001	506.630	51.99	454.64
RN011152	403041.7	7359583.8	21/06/2001	506.590	53.83	452.76
RN011169	401409.7	7360167.8	21/06/2001	508.130	55.56	452.57
RN011184	398476.7	7360321.8	21/06/2001	513.050	60.54	452.51
RN011320	394056.7	7360212.8	20/06/2001	521.520	70.55	450.97
RN011324	395219.7	7358047.8	20/06/2001	519.400	71.85	447.55
RN011325	393459.7	7358930.8	20/06/2001	522.240	76.28	445.96
RN011336	395206.7	7357673.8	20/06/2001	519.640	72.20	447.44
RN011340	398913.7	7359074.8	21/06/2001	515.930	63.18	452.75
RN011460	400146.7	7359764.8	21/06/2001	510.990	58.51	452.48
RN011461	404373.7	7360418.8	21/06/2001	503.740	51.10	452.64
RN011487	397686.7	7359201.8	20/06/2001	515.270	63.03	452.24
RN011488	396947.7	7358444.8	20/06/2001	518.030	67.01	451.02
RN011489	392363.7	7359115.8	20/06/2001	523.419	79.25	444.17
RN011491	388572.7	7361475.8	20/06/2001	530.920	86.27	444.65
RN011531	402995.7	7359872.8	21/06/2001	506.390	53.71	452.68
RN011532	398483.7	7359640.8	21/06/2001	514.090	61.80	452.29
RN017229	399672.7	7346971.9	21/06/2001	571.690	117.69	454.00
RN017234	408384.7	7354021.8	21/06/2001	509.490	56.68	452.81
RN017235	408780.7	7360110.8	26/06/2001	508.330	55.59	452.74
RN017236	412108.7	7357540.8	26/06/2001	525.900	72.52	453.38
RN017243	421279.6	7358075.9	26/06/2001	529.320	78.92	450.40
RN017244	402700.7	7352999.8	21/06/2001	505.020	52.20	452.82
RN017246	404564.7	7349911.8	21/06/2001	524.200	70.92	453.28
RN017329	414774.7	7362301.7	26/06/2001	499.580	49.09	450.49
RN017333	398090.7	7358913.8	21/06/2001	515.090	62.59	452.50
RN017334	398157.7	7358757.8	21/06/2001	515.550	61.91	453.64
RN017335	398519.7	7358059.8	21/06/2001	513.150	60.56	452.59
RN017336	407059.7	7362546.7	26/06/2001	498.640	45.69	452.95
RN017337	407059.7	7362436.7	26/06/2001	499.590	46.66	452.93
RN017338	407155.7	7361680.8	26/06/2001	502.280	49.37	452.91
RN017339	403157.7	7363202.8	21/06/2001	505.820	41.65	464.17
RN017391	405613.7	7356740.8	21/06/2001	503.920	51.29	452.63
RN017392	402971.7	7356646.8	21/06/2001	505.540	52.81	452.73
RN017393	412782.7	7363883.7	26/06/2001	489.650	37.06	452.59
RN017394	429204.6	7365960.9	26/06/2001	459.390	24.48	434.91
RN017436	408824.7	7361780.7	26/06/2001	509.860	56.88	452.98
RN017437	410319.7	7358827.8	26/06/2001	518.520	65.50	453.02
RN017438	407042.7	7362575.7	26/06/2001	498.080	45.21	452.87