VOLUME OF GROUNDWATER STORED IN THE MEREENIE AQUIFER SYSTEM

In the Pine Gap / Roe Creek to Rocky Hill / Ooraminna Region

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Background

The following notes provide background information for the estimates of the volume of groundwater in the Mereenie Aquifer System in the Pine Gap - Roe Creek area and Rocky Hill - Ooraminna area of the Amadeus Basin. These areas cover a region of approximately 80 kilometres by 30 kilometres, defined by Pine Gap in the west, the edge of the Northern Amadeus Basin in the east, Alice Springs to the north and the Ooraminna Ranges to the south.

Alice Springs is the major population centre in central Australia. Rainfall averages 250 mm per annum and evaporation is about 3,000 mm per annum and there is virtually no usable surface water in the region. Consequently, all present and future economic development depends on groundwater. Groundwater is pumped from the Roe Creek borefield located in the layered Amadeus Basin sediments approximately 12 kilometres to the south of the town (**Figure 1**).

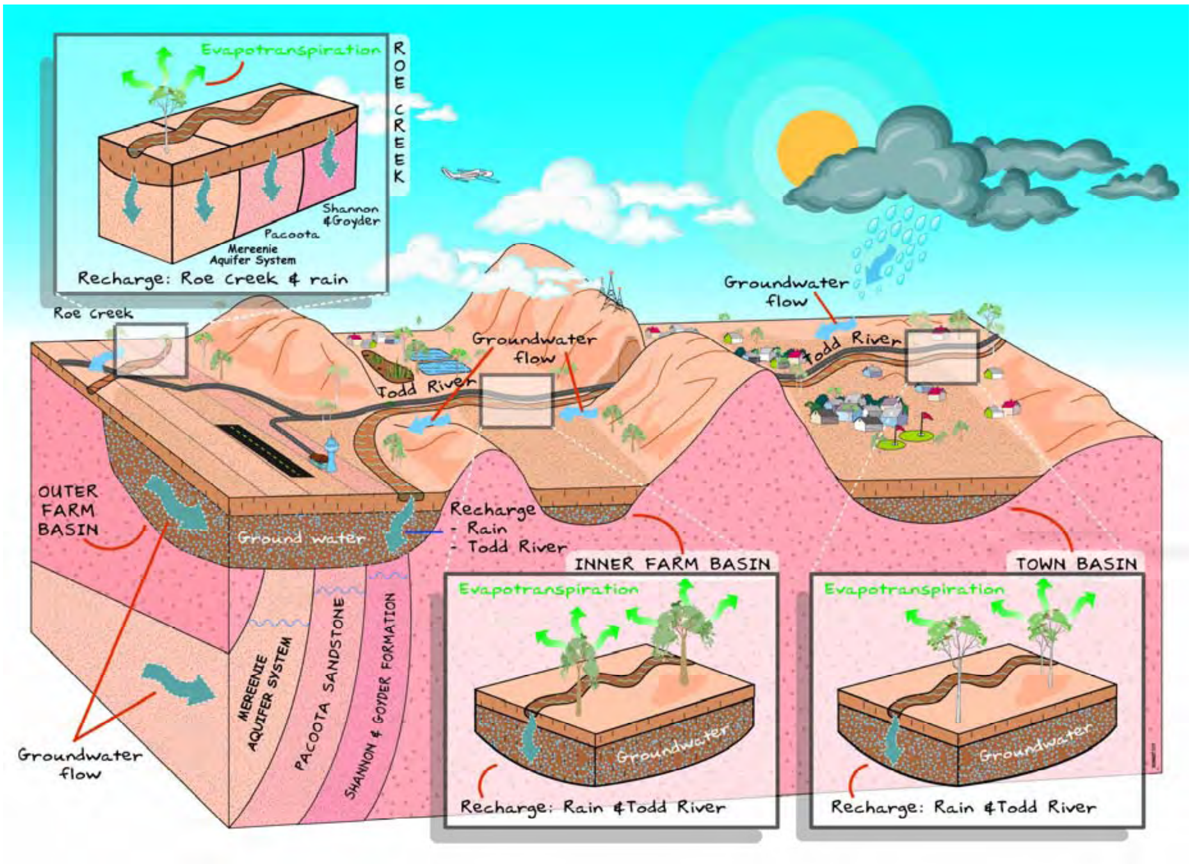

Figure 1 Diagrammatic representation of the water cycle and the location of the Mereenie Aquifer System in relation to Alice Springs.

The northern Amadeus Basin is a broad elongated (300 x 70 km) sedimentary basin, trending east - west. It consists of thick sedimentary units which are folded and faulted, forming deep synclinal troughs up to 14,000 metres deep. In the vicinity of Alice Springs the trough is up to 4000 metres deep (**Figure 3**).

The northern Amadeus Basin covers an area of approximately 21,000 square kilometres (**Figure 2**) and contains very large volumes of groundwater in storage. The most important aquifer system in the northern Amadeus Basin is the Mereenie Aquifer System.

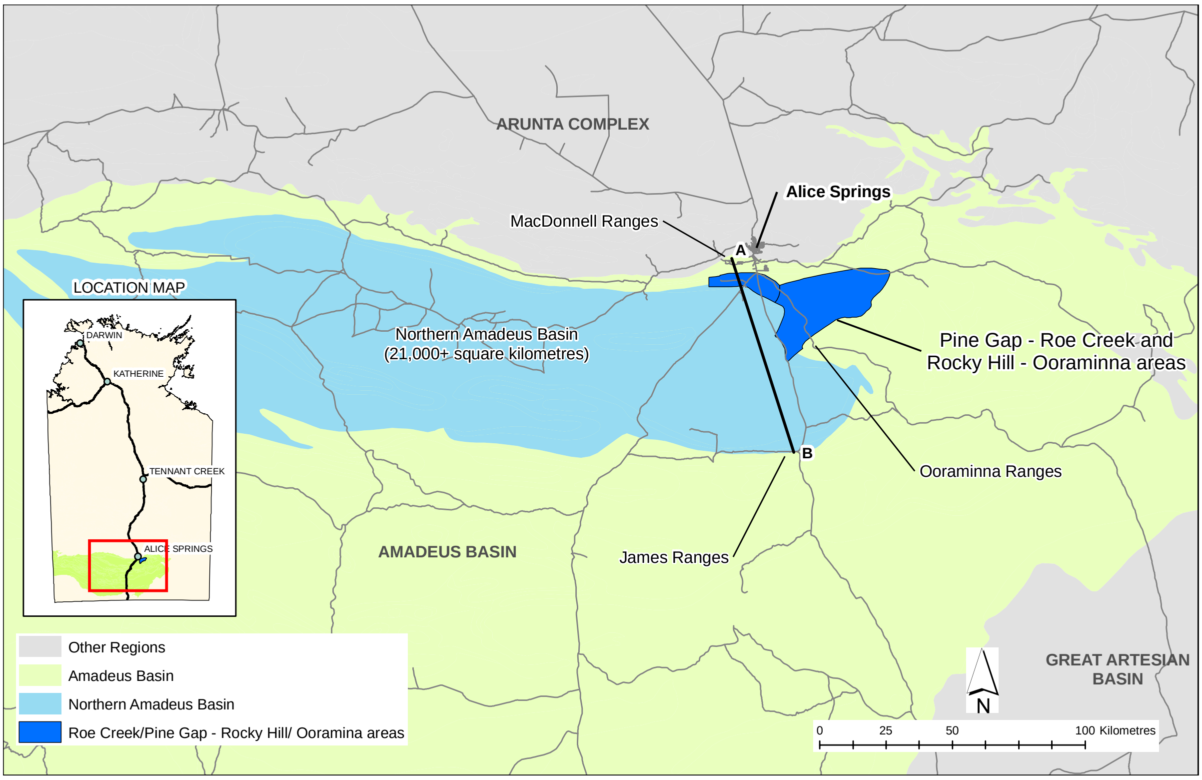

Figure 2 Location of the Northern Amadeus Basin and relationship to major geological provinces of Central Australia. The location of the cross-section presented in Figure 3 is also shown.

Aquifer Occurrence

The formations that comprise the Mereenie Aquifer System outcrop along some sections of the northern and southern "shoulders" of this trough for example near the MacDonnell, Waterhouse, James and Ooraminna Ranges.

The Mereenie Aquifer System is continuous between Pine Gap and Rocky Hill. There are differences in the porosity and permeability of the aquifer system in the two areas due to their different depositional, deformational and weathering history.

The Mereenie Aquifer System is the name given for the hydraulically connected geological formations of the Mereenie Sandstone, Ooraminna Sandstone and Hermannsburg Sandstone. In the Rocky Hill – Ooraminna area it comprises all three geological formations, whereas in the Pine Gap – Roe Creek area the Ooraminna Sandstone is absent. Lithologically these formations appear to be very similar, although they have differing hydrogeological characteristics.

At Pine Gap the Mereenie Aquifer System is steeply dipping to the south at around 60 degrees. Ten kilometres east of Pine Gap at Roe Creek, the Mereenie Aquifer System dips to the south at 35 degrees, east of the Alice Springs airport it dips at 20 degrees and at Rocky Hill it dips south at 10 degrees.

The variation in dip of the Mereenie Aquifer System means that in the Rocky Hill area it occurs close to the surface over a much greater area than in the Pine Gap – Roe Creek area (compare 60 square kilometres with 520 square kilometres). For this reason a much greater volume of the groundwater that is held in storage can be accessed by suitably sited production bores. There is also a higher potential for recharge from infiltration of flood waters from the Todd River and Roe Creek. The water level is closer to the surface in the Rocky Hill area because the ground surface is lower than in the Roe Creek area.

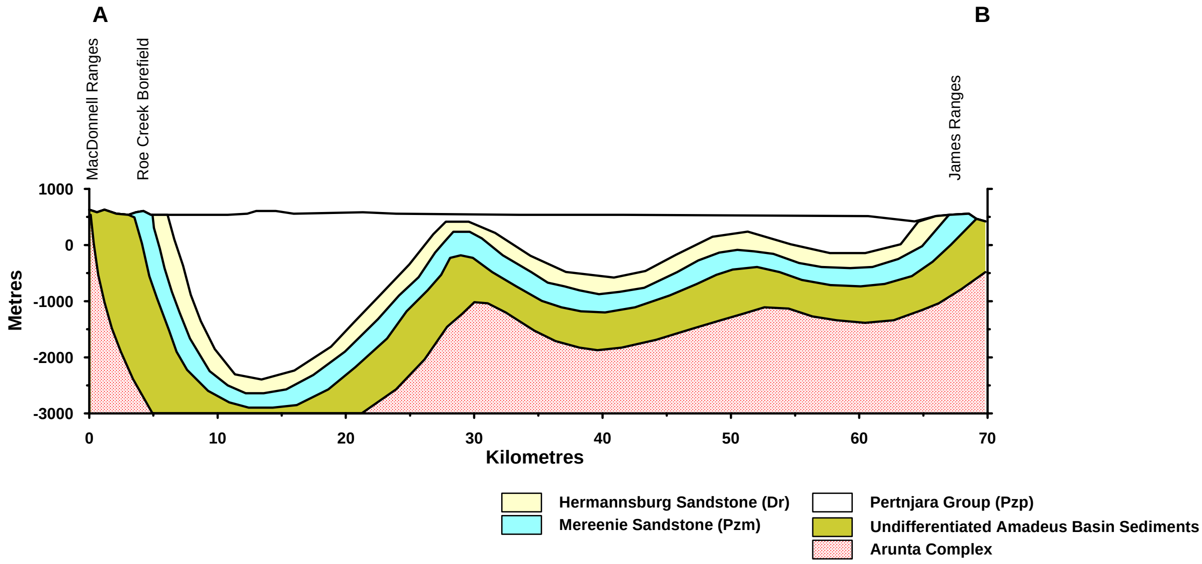

Figure 3 Simplified geological cross-section of the Amadeus Basin from MacDonnell Ranges to James Ranges.

Aquifer Characteristics

Fractures are the primary pathway for groundwater movement through the Mereenie Aquifer System, which is predominantly to the east. In the Pine Gap - Roe Creek area, the Mereenie Aquifer System is highly permeable and porous. In the Rocky Hill area it has a lower permeability and porosity.

Based on modelling by Jolly *et al*., (1994) a specific yield (the volume of water that can drain from a unit volume of rock under gravity as a proportion or ratio) of 20%, was estimated for the Mereenie Sandstone in the Pine Gap – Roe Creek area.

This modelling assumed that water did not drain from the Hermannsburg Sandstone. However, it is now recognised that water drains from the Hermannsburg in response to pumping in the Roe Creek borefield. The observed water decline in the borefield is now attributed to the Mereenie Aquifer System (ie storage is from both the Mereenie Sandstone and Hermannsburg Sandstone).

The geometry and modelled specific yield of the Mereenie Sandstone has been used to derive a storage estimate for the Mereenie Aquifer System in the Pine Gap – Roe Creek area. The area where the Mereenie Sandstone and Hermannsburg Sandstone occur close to the surface in the Pine Gap – Roe Creek area are roughly equally ie 30 square kilometres each. A specific yield of 20% for the Mereenie Sandstone used by Jolly *et al*., (1994), therefore, provides a conservative assumption of 10% specific yield for the Mereenie Aquifer System in the Pine Gap – Roe Creek area. The work undertaken by Lau, (1989) on core samples of the Mereenie Sandstone and Hermannsburg Sandstone supports the view that 10% is a conservative estimate for the specific yield of the Mereenie Aquifer System.

In the proposed Rocky Hill Borefield existing investigation work by Read and Paul, (2000) and Read and Paul, (2002), indicates that the sandstones comprising the Mereenie Aquifer System will release an amount of water equivalent to about 8 to10% of their volume.

In the Roe Creek Borefield an efficient production bore yields about 4 to 8 mega litres per day (ML/day) for a drop in water level inside the production bore of approximately 20 metres (a drop in water level inside the bore in comparison to the water level in the aquifer outside of the production bore is required to enable water to flow into the bore, this is known as “well loss”). In the proposed Rocky Hill Borefield an efficient production bore is expected to yield about 4 to 8 mega litres per day (ML/day) for a “well loss” of approximately 50 metres.

Recharge

These aquifers are recharged at discrete locations through stream beds in major flood events, but this is only of local significance**.** It has been estimated that 100 ML per year recharges the Mereenie Aquifer System from flows in Roe Creek in the Pine Gap – Roe Creek area (refer Jolly *et al*., 1994). The recharge in the Rocky Hill – Ooraminna area from flows in the Todd River and Roe Creek is estimated at between 1000 and 3000 ML per year.

Throughflow

Regional modelling undertaken by Jolly *et al.*, (1994) indicated that throughflow from the west into the Rocky Hill area from the regional aquifer developed in the Mereenie Aquifer System in the northern Amadeus Basin was of the order of 1800 ML per year.

Natural Discharge Mechanisms

Work reported on by Read and Paul, (2002) estimated the annual average discharge from the Mereenie Aquifer System to the east of Rocky Hill to be of the order of 2000 to 4000 ML per year. The discharge mechanisms are thought to be dominated by to evapotranspiration processes. Read and Paul, (2002) and Macqueen and Knott, (1982) also identified a discharge mechanism from Mereenie Aquifer System in the Roe Creek – Rocky Hill area to the south to the Deep Well area. The estimated discharge to the Deep Well area is of the order of 900 ML per year.

Extraction in the Pine Gap \ Roe Creek Area

There are two producing production bores in the Mereenie Sandstone at Pine Gap and 15 producing and standby production bores in the Roe Creek area. Some 254,000 ML (mega litres or million litres) have been extracted from the Mereenie Aquifer System over the previous 40 years (pumping commenced in 1964).

Prior to pumping the water level in the Pine Gap – Roe Creek borefield area was around 85 to 95 metres below ground level. Over the 40 year extraction period, the water level in the Mereenie Aquifer System has dropped approximately 60 metres in the Roe Creek - Pine Gap area to 150 metres below ground level (refer **Figure 4**).

Extraction in the Rocky Hill Area

Except for a few stock watering bores, the Ooraminna Bush homestead water supply bores, the new Rocky Hill horticulture water supply bores (table grape and melon farm with some other experimental crops) and the historic Ghan Railway bore there are no other production bores within this sub-basin.

During the decade of the 1970’s, 20 hectares of lucerne and various experimental crops were grown in the Rocky Hill area the water supply being provided from one production bore. A production bore extracted approximately 5000 ML over the 10 year period of use. Since this period the water level in the area has risen slightly above the 1970 pre-pumping level.

It is proposed that a future Alice Springs town water supply borefield will be constructed within the Rocky Hill area when it is cheaper to produce water from a new borefield rather than to produce water from the existing Roe Creek borefield.

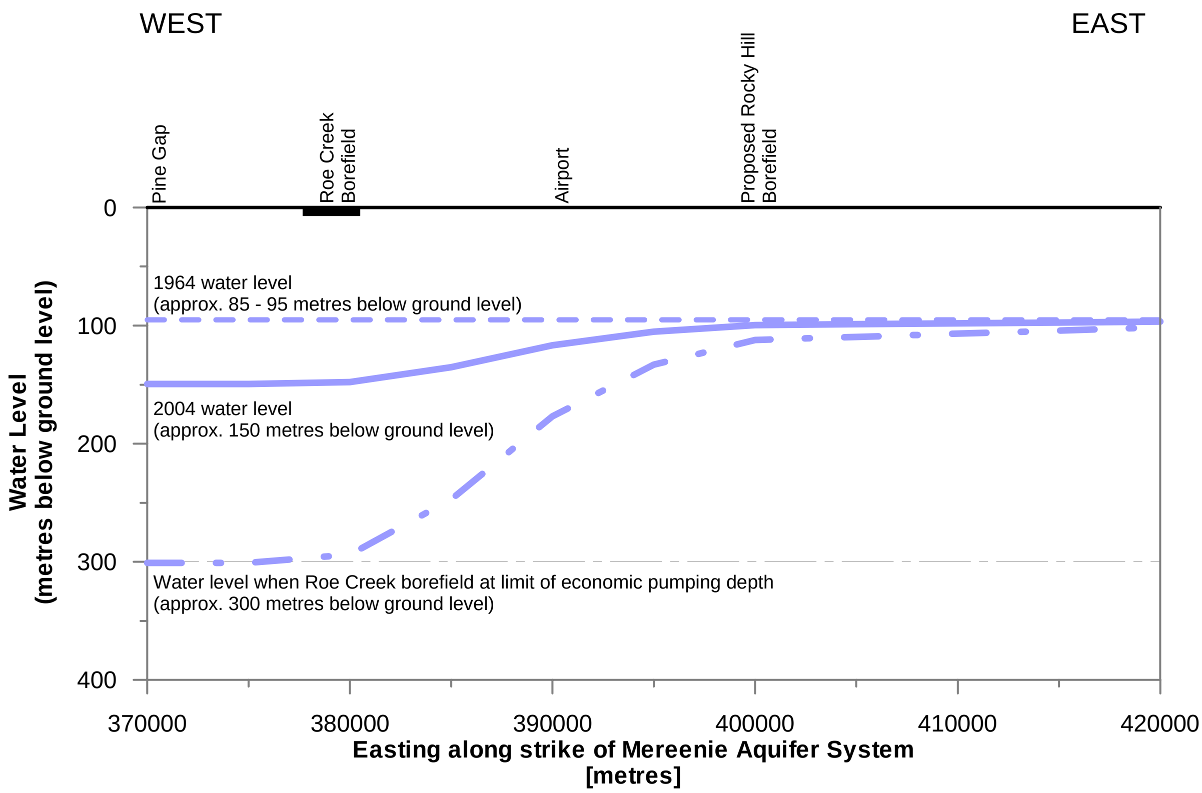

Figure 4 Cross-section along the strike of the Mereenie Aquifer System from Pine Gap to Rocky Hill, indicating the groundwater response to pumping in the Roe Creek borefield and at Pine Gap.

Water Quality

Generally water quality mapping and water quality assessments are made using the salinity of the groundwater or total dissolved solids (TDS), measured in milligrams per litre (mg/L). The Australian Drinking Water Guidelines (National Health and Medical Research Council and the Agriculture and Resource Management Council of Australia and New Zealand, 2004) state that TDS in drinking water should not exceed 500 mg/L.

Beneath Roe Creek in the Roe Creek Borefield the groundwater quality is around 350 mg/L. Immediately east of Roe Creek the water quality improves to 260 mg/L, at 5 kilometres to the east it slowly increases to 350 mg/L and by 15 kilometres to 500 mg/L. Currently the average total dissolved solids of the water extracted from the Roe Creek borefield is about 460 mg/L. The groundwater quality in the Pine Gap area averages 640 mg/L (**Figure 5**). Based on these figures the distribution of water quality of less than 500 mg/L and between 500 – 1000 mg/L is roughly 50:50, although it is expected that the borefield can be managed to provide a water quality of less than 500 mg/L for all available water in the Pine Gap – Roe Creek area.

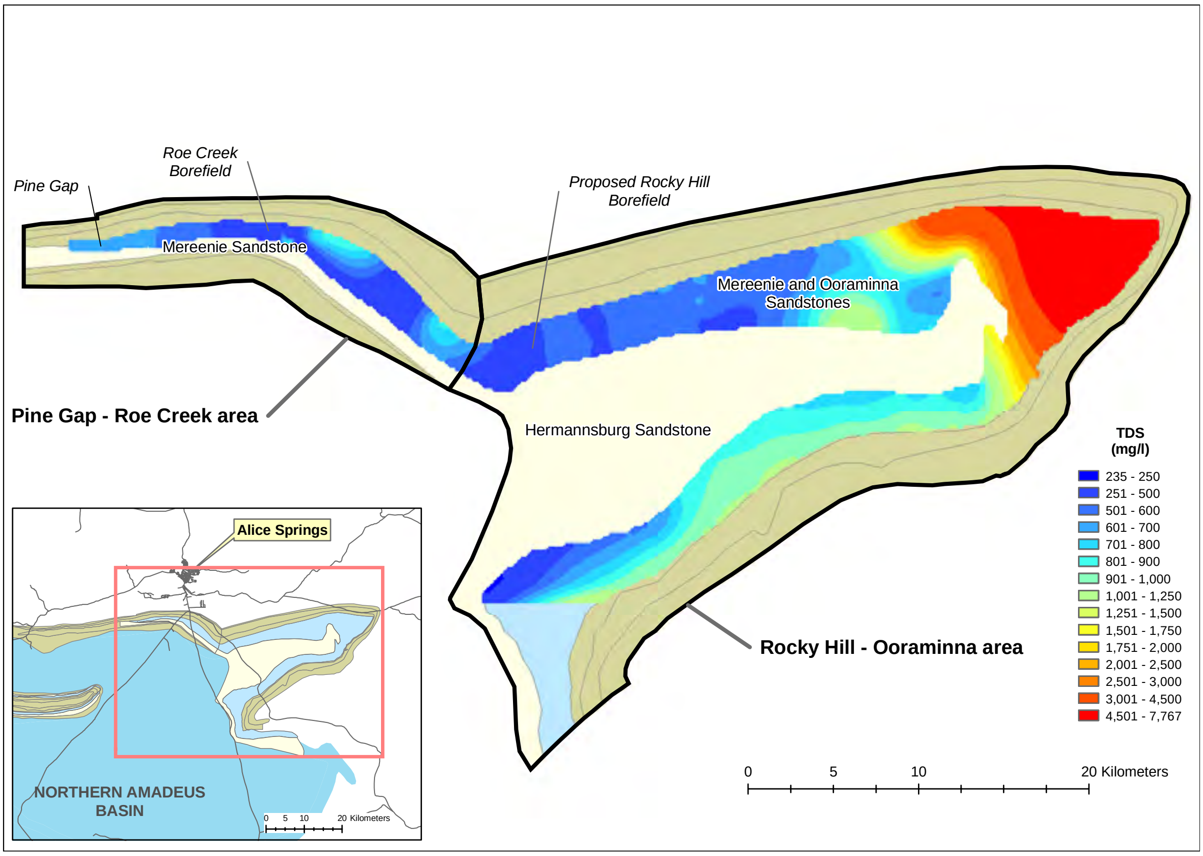

Figure 5 Bird's eye view of the water quality (TDS – mg/l) distribution in the Mereenie Sandstone and Ooraminna Sandstone.

VOLUME OF GROUNDWATER IN THE MEREENIE AQUIFER SYSTEM IN THE ROE CREEK – PINE GAP AREA

Three relatively simple but robust methods have been employed to estimate the available storage in the Pine Gap – Roe Creek areas, these are:

a) **Volume calculated from the *cumulative* extraction versus the decline in water level in the borefield.**

b) **Volume calculated from observed *current* annual decline in water level and *current* annual extraction.**

c) **Volume calculated from an effective specific yield of 10%, depth of 300 metres below ground level and surface area of the Mereenie Aquifer System.**

The first two methods employ the measured response of the groundwater level to pumping in the borefield (**Figure 6** and **Figure 7**) to estimate the volume of groundwater in storage; the latter uses the specific yield and the geometry of the aquifer system to determine the volume of groundwater in storage.

All methods assume that the economic saturated thickness is determined from the current depth of the groundwater below ground (150 metres) to the economic depth of pumping. The current economic pumping depth (lift) is based on a depth to groundwater of 300 metres below ground level at the end of the winter low demand season (as provided by the Power & Water Corporation). Water can be pumped from much deeper, however the greater the pumping head (lift) the higher the cost of pumping. Therefore, the available saturated thickness is approximately 150 metres (ie 300 - 150).

ESTIMATE "A"

Estimate "A" is based on the borefield performance presented by Jolly *et al.* (1994). The decline in groundwater level as measured in the borefield at the end of winter has been directly related to the cumulative volume of water extracted. The water levels at the end of the winter season have been chosen as production from the borefield is much lower than during the summer period and groundwater levels more accurately reflect aquifer water levels. In the vicinity of the Pine Gap – Roe Creek area, the decline in groundwater level is about 0.2 metres/1000 ML. The total volume available for extraction from the current 150 metres groundwater level to a depth of 300 metres below ground level is therefore 750,000 ML.

The proportion of groundwater in the Mereenie Aquifer System with TDS less than 500 mg/L, as discussed previously, is approximately 50%, the volume of groundwater in the two water quality ranges is presented in **Table 1**.

Water Quality	Volume '000 ML
less than 500 mg/L	375
500 – 1000 mg/L	375
TOTAL	**750**

Table 1: Volume of water in the Mereenie Aquifer System calculated from observed current rate of decline in water levels and current annual extraction volume

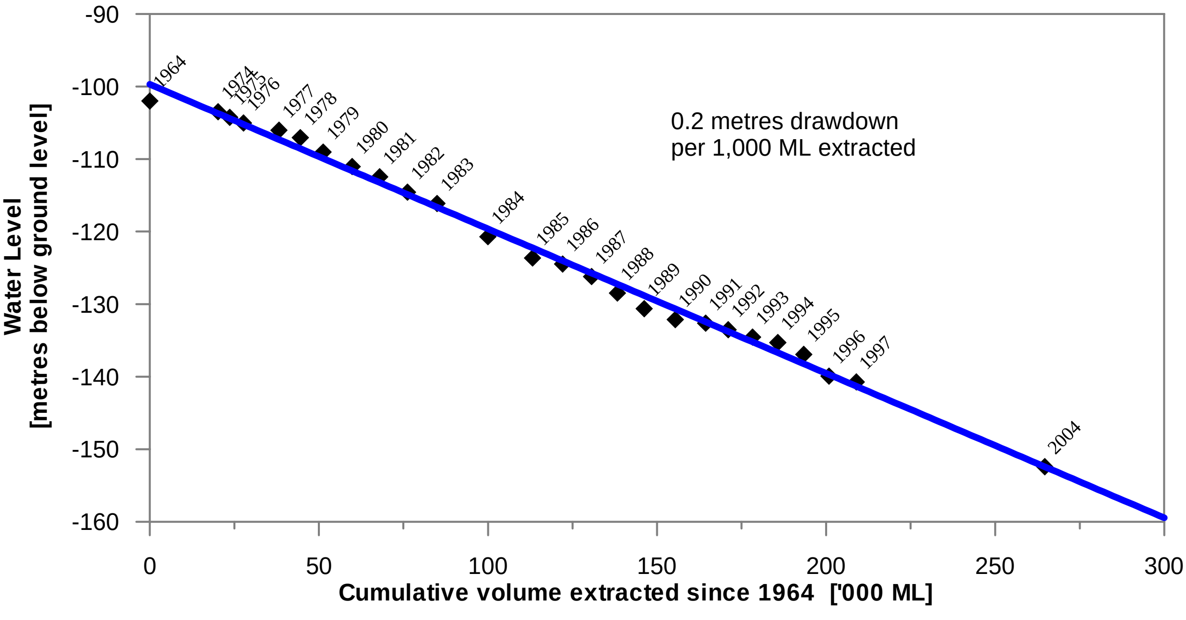

Figure 6 Decline in groundwater level in Roe Creek bore RN5731 compared to the cumulative extracted volume pumped from the borefield.

ESTIMATE "B"

Estimate "B" has been determined from the current observed response of the groundwater in the Pine Gap and Roe Creek borefields. It does not rely on the interpretation of the hydraulic characteristics of the Mereenie Aquifer System. Based on the ***current*** *average decline in water level of 1.34 metres/year* (**Figure 7**) and the current economic saturated thickness, there is approximately 112 years (150 metres/1.34 metres per year) of supply available at the current extraction rate of 8,000 ML per year. This equates to a total volume available for extraction to a depth of 300 metres below ground level of 900,000 ML.

The proportion of groundwater in the Mereenie Aquifer System with TDS less than 500 mg/L, as discussed previously, is approximately 50%, the volume of groundwater in the two water quality ranges is presented in **Table 2**.

Water Quality	Volume '000 ML
less than 500 mg/L	450
500 – 1000 mg/L	450
TOTAL	**900**

Table 2: Volume of water in the Mereenie Aquifer System calculated from observed current rate of decline in water levels and current annual extraction volume of 8,000 ML/yr.

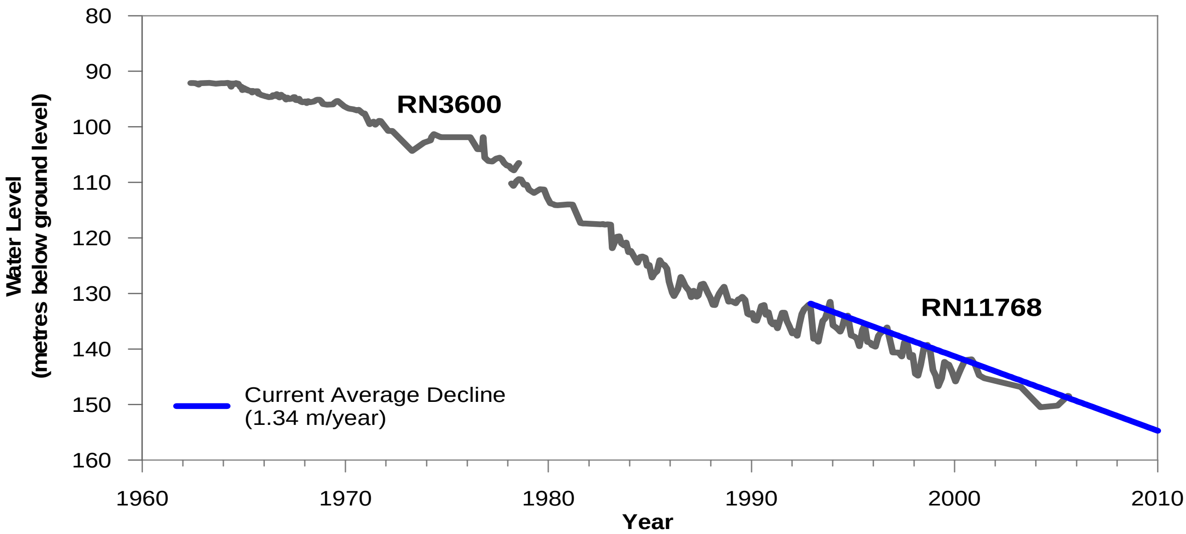

Figure 7 Typical 'drawdown' or drop in standing water level in two Roe Creek bores. The current average decline in the water level is also indicated. Note: RN is the 'registered number' that identifies each bore.

ESTIMATE "C"

Based on the previous discussion on aquifer characteristics, an effective specific yield of 10%, a surface area of 60 square kilometres for the Mereenie Aquifer System in the Roe Creek – Pine Gap area and a saturated thickness that varies across the area as indicated in **Figure 4** the total volume available for extraction to a depth of 300 metres below ground level in the Pine Gap - Roe Creek area is 1060,000 ML.

Water Quality	Volume '000 ML
less than 500 mg/L	530
500 – 1000 mg/L	530
TOTAL	**1060**

Table 3: Volume in storage in the Mereenie Aquifer System calculated from specific yield of 10% and the volume of saturated rock to 300 metres based on estimated outcrop and sub-crop area of 60 square kilometres.

The spread of calculations using methods “A”, “B” and “C” indicate that the volume of groundwater in storage in the Mereenie Aquifer System below the current water level to a depth of 300 metres below ground level is between 750,000 and 1,060,000 ML.

It is expected that the storage of 1,060,000 ML derived from method “C” provides the most representative estimate. This method integrates over the whole Mereenie Aquifer System, is based on the performance of the Roe Creek borefield and evaluates all the available storage in the area, as opposed to methods “A” and “B”, which, only indicate the storage that can be intercepted by the borefields with their current configuration of bores (refer **Figure 4**).

VOLUME OF GROUNDWATER IN THE MEREENIE AQUIFER SYSTEM IN THE ROCKY HILL – OORAMINNA AREA

The calculated volume of groundwater in storage with a TDS less than 1,000 mg/L above a depth of 300 metres below ground surface in the Mereenie Aquifer System in the Rocky Hill – Ooraminna area is based on the work by Read and Paul, (2002). This work assumes an average specific yield of approximately 8 – 10%. The volume of water available in storage in the Rocky Hill – Ooraminna area with a TDS of less than 1,000 mg/L has been estimated by Read and Paul (2002) to be 3,750,000 ML.

In the Rocky Hill – Ooraminna area the Mereenie Aquifer System covers an area of 520 square kilometres. Based on sparse investigation drilling it is estimated that 20% of the Mereenie Aquifer System in the north eastern portion of this area has a TDS greater than 1,000 mg/L (**Figure 5**). This equates to a volume of 940,000 ML

The available data makes it difficult to accurately determine the water quality zones, mapping based on sparse drilling data indicate that 20% of the area with a TDS of less than 1000 mg/L has a TDS of approximately 500 mg/L.

Water Quality	Volume ‘000 ML
less than 500 mg/L	750
500 – 1,000 mg/L	3,000
Greater than 1000 mg/L	940
TOTAL	**4,690**

Table 4: Volume in storage in the Mereenie Aquifer System calculated from a specific yield of 8 – 10 % and pumping depth of 300 metres below ground level.

Summary

The total exploitable volume of groundwater of all salinities in storage above 300 metres in the Mereenie Aquifer System in the Pine – Gap and Rocky Hill – Ooraminna areas has been estimated to be **5,750,000 ML (**refer **Table 5)**.

The total volume of groundwater in storage in the Mereenie Aquifer System in both the Pine Gap – Roe Creek area and the Rocky Hill – Ooraminna area, with a TDS of less than **1000 mg/L,** has been estimated to be **4,810,000 ML**.

The total volume of groundwater in storage in the Mereenie Aquifer System both the Pine Gap – Roe Creek area and the Rocky Hill – Ooraminna area, with a TDS of less than **500 mg/L** has been estimated to be **1,280,000 ML**.

Location	Groundwater Storage '000 ML's	Water Quality
Pine Gap - Roe Creek area	530	less than 500 mg/L
	530	500 – 1000 mg/L
Sub-total	**1,060**	**less than 1000 mg/L**
Rocky Hill – Ooraminna area	750	less than 500 mg/L
	3,000	500 – 1000 mg/L
Sub-total	**3,750**	**less than 1000 mg/L**
	940	greater than 1000 mg/L
TOTAL Pine Gap – Roe Creek, Rocky Hill – Ooraminna	**5,750**	**all salinities**

Table 5: Combined storage estimates based on the volume of groundwater in storage above 300 metres below ground level and with a TDS of less than 1000 mg/L for the Mereenie Aquifer System in the Pine Gap - Roe Creek area and Rocky Hill – Ooraminna area.

The combined water balance for the Pine Gap – Roe Creek and Rocky Hill – Ooraminna areas based on the presented average rates of recharge, throughflow and discharge and the estimated total storage from **Table 5** is presented in **Table 6**.

Water Balance Component	Inflows ('000 ML/yr)	Storage ('000 ML)	Outflows ('000 ML/yr)
Recharge Pine Gap – Roe Creek area	0.1		
Recharge Rocky Hill – Ooraminna area	2		
Throughflow	1.8		
Storage		5,750	
Discharge Rocky Hill – Ooraminna area (evapotranspiration)			3
Discharge Deep Well area			0.9
TOTALS	**3.9**	**5,750**	**3.9**

Table 6: Current water balance for the Pine Gap – Roe Creek and Rocky Hill – Ooraminna areas using average estimates for the recharge and discharge components.

In the Roe Creek – Pine Gap area it is expected that with appropriate placement and operation of production bores the total volume of water with a TDS of less than 1000 mg/L (1,060,000 ML) can be delivered into the public water supply system with a TDS of approximately 500 mg/L. This is because a large percentage of the water in storage has a TDS very much less than 500 mg/L. However in the Rocky Hill – Ooraminna area most of the water in storage with a TDS of less than 500 mg/L is close to 500mg/L. Hence only the volume of 750,000 ML shown in **Table 5** as water with a TDS less than 500 mg/L can be delivered into the public water supply system with a TDS of less than 500 mg/L.

It is therefore estimated that the amount of water with a TDS less than 500 mg/L that can be delivered into the public water supply from the existing Roe Creek Borefield and proposed Rocky Hill Borefields, with above a depth of 300 metres below ground level, is 1,810,000 ML.

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Glossary

Aquifer	A body of rock that can store water and yield it to a bore.
Deformation	The changing of rocks shape and position by earth movements.
Dip	The slope of rock layers relative to the horizontal
Groundwater	Water stored underground in pores and cracks in rocks.
Hermannsburg Sandstone	The name given to a particular bed of sandstone in the Amadeus Basin. At Roe Creek it lies above the Mereenie Sandstone.
mg/L	milligrams per litre
Megalitre	1 million litres
Mereenie Sandstone	The name given to a particular bed of sandstone in the Amadeus Basin
ML	Megalitre or 1 million litres
Pacoota Sandstone	The name given to a particular bed of sandstone in the Amadeus Basin. At Roe Creek it lies below the Mereenie Sandstone.
Permeability	The ability of a rock to allow water to flow through it
Porosity	The proportion of a rock made up of pores
Sandstone	A rock composed of sand grains cemented together

Specific yield	The volume of water that can drain from a unit volume of rock under gravity as a proportion or ratio. In a rock with large pores this will be close to the porosity, with small pores it will be much less.
Synclinal	In the form of a syncline, *qv*
Syncline	A geological structure where the rock layers have been folded into a trough-shape.
TDS	Total dissolved solids, the mass of solids in a unit volume of water, measured in milligrams per litre.
Weathering	The process where rocks near (sometimes a few hundred metres) the surface are altered by reactions with water and oxygen.