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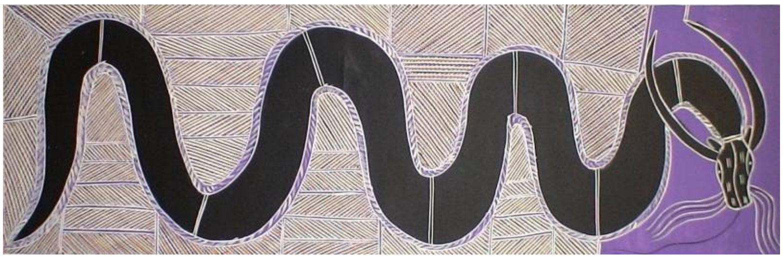
Gulf Water Study

Roper River Region



Australian Government
Water Smart Australia

Front cover:

Painting of the Rainbow Serpent by Rex Wilfred.

(see Appendix A for the story of the painting)

Satellite image of the Roper River.

Yawurrwarda Lagoon.

GULF WATER STUDY

Early morning at Roper Bar, Roper River

WATER RESOURCES OF THE ROPER RIVER REGION

REPORT 16/2009D

U. ZAAR

DARWIN NT

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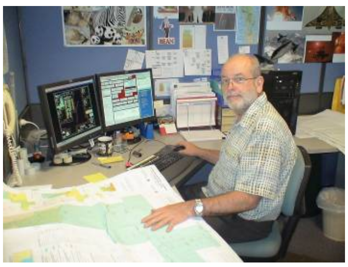
This project was co -funded through the Australian Government Water Smart Australia Program and the Northern Territory Government Department of Natural Resources, Environment the Arts and Sport.

I would like to thank my colleagues who provided help on this project: Peter Jolly (now retired) who instigated this project; Des Yin Foo for his generous support as our team manager; Anthony Knapton, my co-worker on this project who provided technical and field assistance; Steve Tickell, Danuta Karp and Jon Sumner for their technical advice; Lynton Fritz for his outstanding cartographic skills in drawing up the maps; Renee Ramsay for the production of the GIS and collation of the DVD and our experienced technical team – Rodney Metcalfe, Steve Hester, Roger Farrow and Rob Chaffer for all their efficient fieldwork. A special thanks also to Phil O'Brien who not only provided enthusiastic field assistance but wise advice.

I take pleasure in also thanking members of our technical working group; Max Gorringe - the manager of Elsey Station, Frank Shadforth – the manager of Seven Emu Station and Glenn Wightman – ethnobiologist who all kindly took the time to provide advice at our meetings. All were always ready to help.

I am very much indebted to the local people in the region. I thank the traditional owners for sharing their knowledge of water resources and providing excellent guidance in the field; in particular Stephen Roberts, Robert Roberts and Walter Rogers. I thank the station owners and managers who were generous with their time in providing key information on the region and were very hospitable.

I would like to thank the Northern Land Council who provided liaison assistance particularly Bobby Nununmadjbarr, the Roper Gulf Shire (Ngukurr and Minyerri) and the Yugul Mangi Rangers for their assistance.



Lynton Fritz

Technical working group

Yugul Mangi Rangers

SUMMARY

This report provides details of the groundwater and Dry season surface water resources of the Roper River region of the Gulf as depicted on the accompanying water resource map. It is one of five regions which make up the mapping area of the Gulf Water Study (Figure 1.1). The study was co-funded by the Australian Government Water Smart Australia Program and the Northern Territory Department of Natural Resources, Environment, the Arts and Sport.

The purpose of this work is to provide readily accessible and easily understandable information on water resources in the region. The project was undertaken with the dual perspective of western science and indigenous knowledge and both are represented in the products of this study. It is hoped that common understandings will develop between indigenous people and land managers about water in the region. The key aim is to provide a fundamental data set to guide sustainable development of water resources, maintaining social values, healthy groundwater systems and rivers as well as the ecosystems which depend upon them.

The groundwater resource has been classified into five aquifer types:

- Fractured and Karstic Rocks (yields up to 10 L/s)
- Fractured and Weathered Rocks – carbonate rocks (yields 0.5 – 10 L/s)
- Fractured and Weathered Rocks – carbonate rocks (yields 0.5 – 5 L/s)
- Fractured and Weathered Rocks (yields 0.5 – 5 L/s)
- Fractured and Weathered Rocks with minor groundwater resources (yields 0 - 1 L/s)

The area is generally poor in groundwater. Of the better yielding aquifers, the fractured and karstic rock aquifers are minor in extent and have not been drilled, and the fractured and weathered carbonate rock aquifers are local in scale but are an important resource as they supply the largest settlement in the area, Ngukurr. Across the area small groundwater discharges host water dependent ecosystems often marked by lush vegetation pockets.

Given the generally poor and limited groundwater prospects, water supplies are often sought from surface water sources; from rivers, waterholes, springs and dams. The Roper River and its tributaries dominate the map sheet. A number of cattle stations as well as Ngukurr draw supplies from the Roper River. River flow has been classified according to the minimum recorded flow at the end of the Dry season during a dry period. There are four categories that describe river flow;

- River with a minimum flow greater than 100L/s at the end of the Dry season
- River with a minimum flow of between 10 and 100L/s at the end of the Dry season
- River with permanent waterholes and minimum flows up to 10 L/s at the end of the Dry season
- River which is dry at the end of the Dry season

Only the upper reaches of the Roper River fits into the highest flow category. Most of the rivers in the area fit into the latter two categories reflecting the lack of groundwater discharge (baseflow) provided by ‘fractured and weathered rock’ aquifers which cover almost the entire map area.

Dry season discharges (baseflow) of the Roper River and its tributary the Wilton River, are sourced from springs (groundwater discharges) which lie in their headwaters outside the map sheet. These rivers and ecosystems that depend on their baseflow are therefore groundwater dependent. Dry season flow in these rivers decreases with downstream distance due to evapotranspiration losses. In drier periods such as in the 1960's these rivers can cease to flow for kilometres upstream from the Roper estuary. The amount of freshwater input into the estuary influences the location of the freshwater/saltwater interface in the estuary. In drier times the interface can move more than 70 kilometres upstream causing the usually fresh reaches of the estuary to turn salty, thus effecting Ngukurr's water supply. This outlines the crucial role of groundwater discharge in maintaining the dynamic natural environment as well as community water supplies. To sustainably manage the Roper River requires consideration of the whole groundwater catchment supplying water to the river as well as the surface water catchment of the Roper River.

Recorded rainfall, groundwater level and river baseflow were correlated on a yearly basis and strong trends emerged. From the long term rainfall and river flow record it was observed that there were dry periods and wet periods. 1952 to 1967 was a dry period in which every year the Roper River ceased to flow at Roper Bar by the end of the Dry. The last decade however has been a wet period with exceptionally high rainfall resulting in high groundwater levels and river baseflows. In fact, the flow at Roper Bar, which is situated at the head of the Roper river estuary, has hardly dropped below 1 m^3/s since 1998. Such high variability needs to be taken into account in water allocation planning so the health of the river system is maintained.

As part of the Gulf Water Study, an integrated surface water / groundwater computer model has been developed which analyses the surface water and groundwater elements, and their interplay, in the entire Roper River catchment. This work has been undertaken by A. Knapton and will provide vital information to water allocation planning in the region currently underway as there is high demand for water in the Mataranaka region. His reports provide a greater level of detail on the Roper River catchment and the modelling of water resources within it. (See Knapton, 2009)

Indigenous knowledge on specific sites has been provided by traditional owners and is documented in this report. Many of the sites are shown on the map. To provide a background to this knowledge an overview on how indigenous people in the region view land and water is discussed. Indigenous people believe that the Spirit Ancestors created their environment as well as a charter that is the Law for existence. Through this law all land, water, plants, animals, natural phenomena, people and the Spirit Ancestors (Dreamings) are inextricably connected. It is through these intricate connections that indigenous people relate to water and everything else. Water sites not only have a physical entity and a purpose in the connected environment but also social, emotional, cultural and spiritual significance. Effective management of land and water therefore involves consideration of all these realms. Much can be learnt from their holistic view as it engenders responsible land and water management.

Aside from the maps and reports other products from the Gulf Water Study include a geographic information system (GIS), posters and spatial photographic and video collection which are all available on DVD data disc.

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ABBREVIATIONS

Cumecs	Cubic metres per second
NRETAS	Northern Territory Department of Natural Resources, Environment, The Arts and Sport
Est	Estimated

1. INTRODUCTION

This report provides details of the groundwater and Dry season surface water resources of the Roper River region of the Gulf of Carpentaria as depicted on the accompanying water resource map. It is one of five regions which make up the mapping area of the Gulf Water Study (Figure 1.1). The study was co-funded by the Australian Government Water Smart Australia Program and the Department of Natural Resources, Environment, the Arts and Sport of the Northern Territory Government.

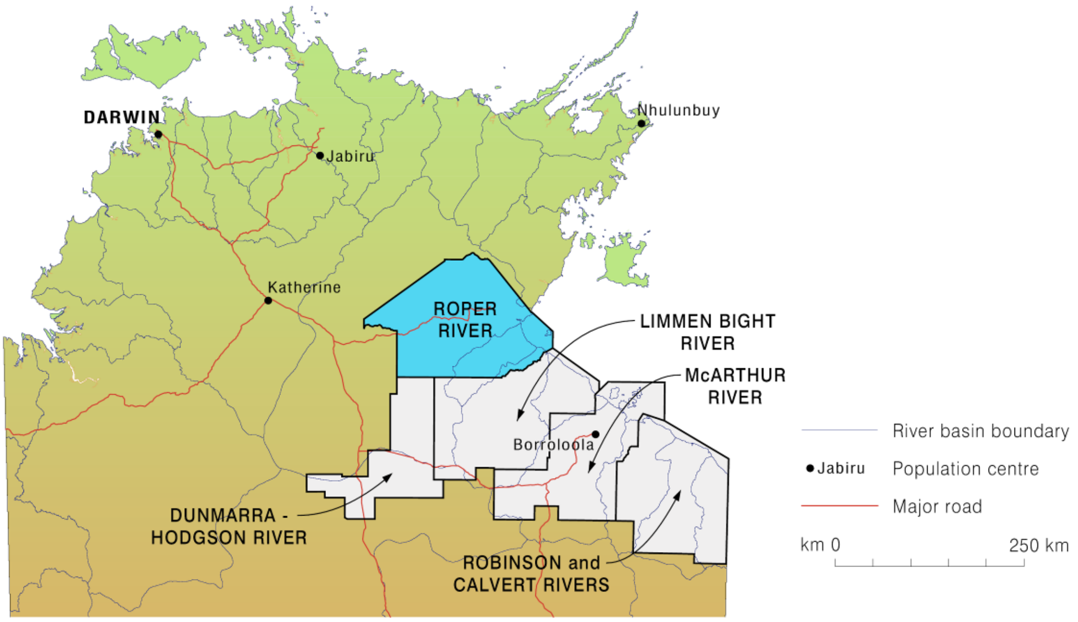


Figure 1.1 Study Regions

Ancillary to this report and map are posters, geographic information system (GIS) and a spatial photographic and video collection. All products from the study are available on DVD data disc.

The purpose of this work is to provide readily accessible, easily understandable and user friendly information products on water resources in the region. The project was undertaken with the dual perspective of western science and indigenous knowledge and both are represented in the products of this study. It has been targeted to inform all stakeholders from station managers, traditional owners and land developers through to water planners and government bureaucrats. It is hoped that common understandings will develop between indigenous people and land managers about water in the region. The key aim is to provide a fundamental data set to guide sustainable development of water resources, maintaining social values, healthy groundwater systems and rivers as well as the ecosystems which depend upon them.

The water resources map is an interpretation of the regions geology, topography, bore data, stream flows and vegetation patterns. Where data was lacking investigations were carried out including water quality sampling, stream gauging, drilling, site visits, and aerial photo interpretation . The contribution from local people, in particular their knowledge of the waterways has been vital to this mapping exercise, especially in areas where access was difficult and scientific information scant.

2. LOCATION

In the Roper River Region there are two main communities. These are Ngukurr with a population of 1589 and Minyerri with a population of 340 people (Bushtel, 2007). Ngukurr is situated within Arnhem Land and services numerous outstations within the district and the small community of Rittarangu with a population of 100 (Bushtel, 2007). Rittarangu or Urapunga is located on the Urapunga Aboriginal Land Trust. Minyerri is located on the Alawa 1 Aboriginal Land Trust which was previously known as Hodgson Downs Station. The north west of the map sheet is dominated by cattle stations on pastoral land. Of interest is Wongalara Station which was purchased in 2007 by the Australian Wildlife Conservancy (AWC). Although it is continued to be run as a cattle station the AWC will be addressing conservation of wildlife on the station. In the south east is the Limmen National Park.

Access to the region is by the Roper Highway from Mataranka which is partly bituminised. The highway ends near Roper Bar, 180 km east of Mataranka. From there, an unsealed road leads through Arnhem Land to Ngukurr and on to Numbulwar, and another unsealed road, namely the Nathan River Road, leads south through the Limmen National Park to Cape Crawford and Borroloola. Services are available at Minyerri, Ngukurr and the Roper Bar Store.

The Roper River runs from west to east through the centre of the map sheet and is the largest river in the Gulf of Carpentaria within the Northern Territory. (Figure 2.1). The Limmen Bight (Port Roper) Tidal Wetlands System situated around the mouth of the Roper River covering an area of 185,000 ha is the only wetland in the region listed in the Directory of Important Wetlands in Australia (Environment Australia, 2001).

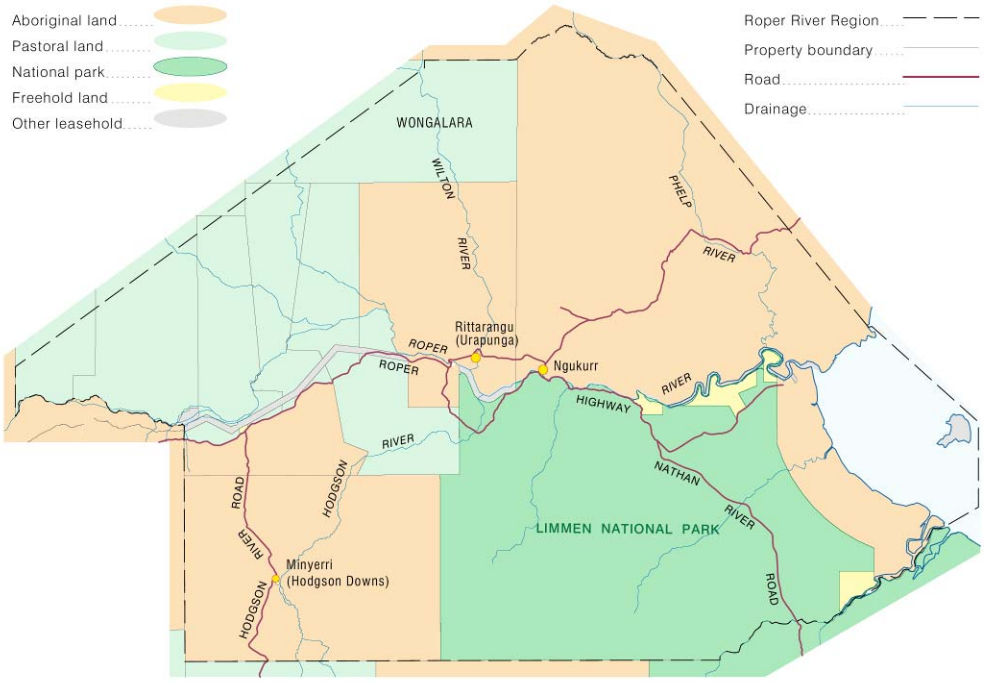


Figure 2.1 Land use in the Roper River Region

3. CLIMATE

The Roper River region lies in the Wet/Dry tropics. With 6 months of negligible rain in the Dry season most streams cease to flow unless they are groundwater fed. Annual evaporation exceeds rainfall. The last decade has been the wettest for the last 118 years, since records have been kept.

The Roper River region has a tropical savanna climate with a marked Wet season from November to April and Dry season from May to October (Figure 3.1). The southern part of the region has an average annual rainfall of between 600 - 800 mm whereas the northern part receives between 800 – 1000 mm rainfall per annum on average (Figure 3.2). Annual rainfall has varied widely over the period of record (Figure 3.3).

For example at Ngukurr the average annual rainfall from 1968 – 2008 was 840 mm but the long term average from 1890 to 2008 was 761 mm (based on Bureau of Meteorology (BOM) Silo Data Drill data for Ngukurr site; www.longpaddock.qld.gov.au/silo). The higher average for the last 40 years, and in particular the last decade with 1039 mm average, has resulted in unusually high Dry season river flows in the region (See Section 7.3).

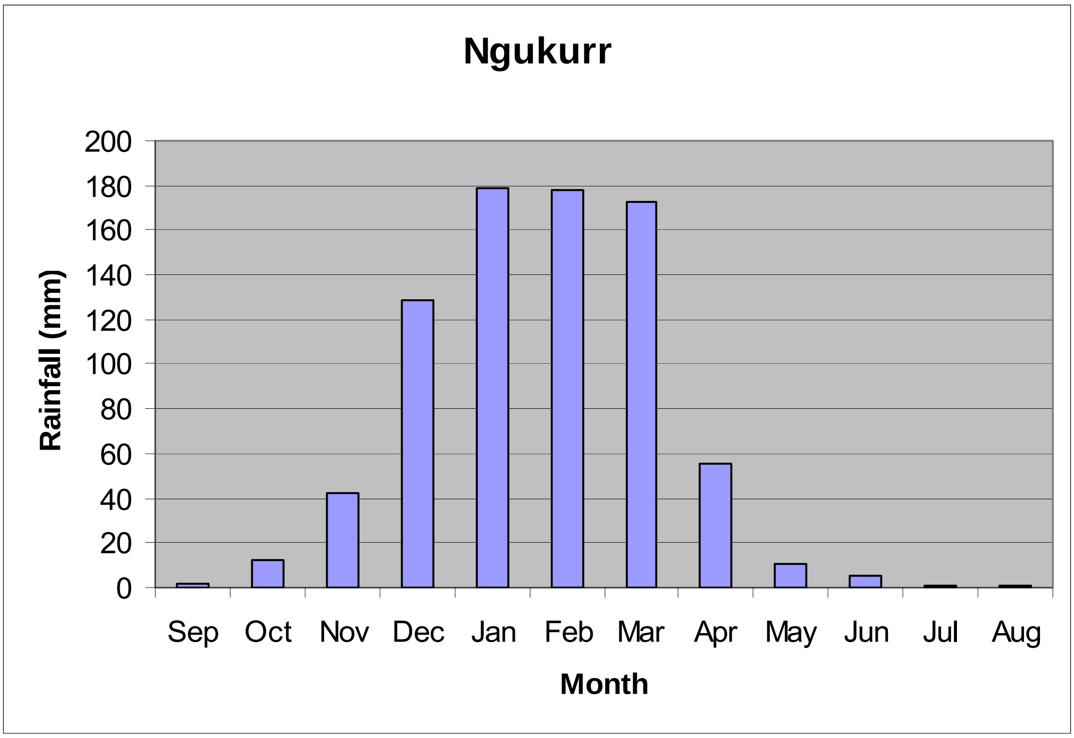


Figure 3.1 Average monthly rainfall for Ngukurr (Station Number DR014609)
(From Bureau of Meteorology web site: www.bom.gov.au/climate/averages)

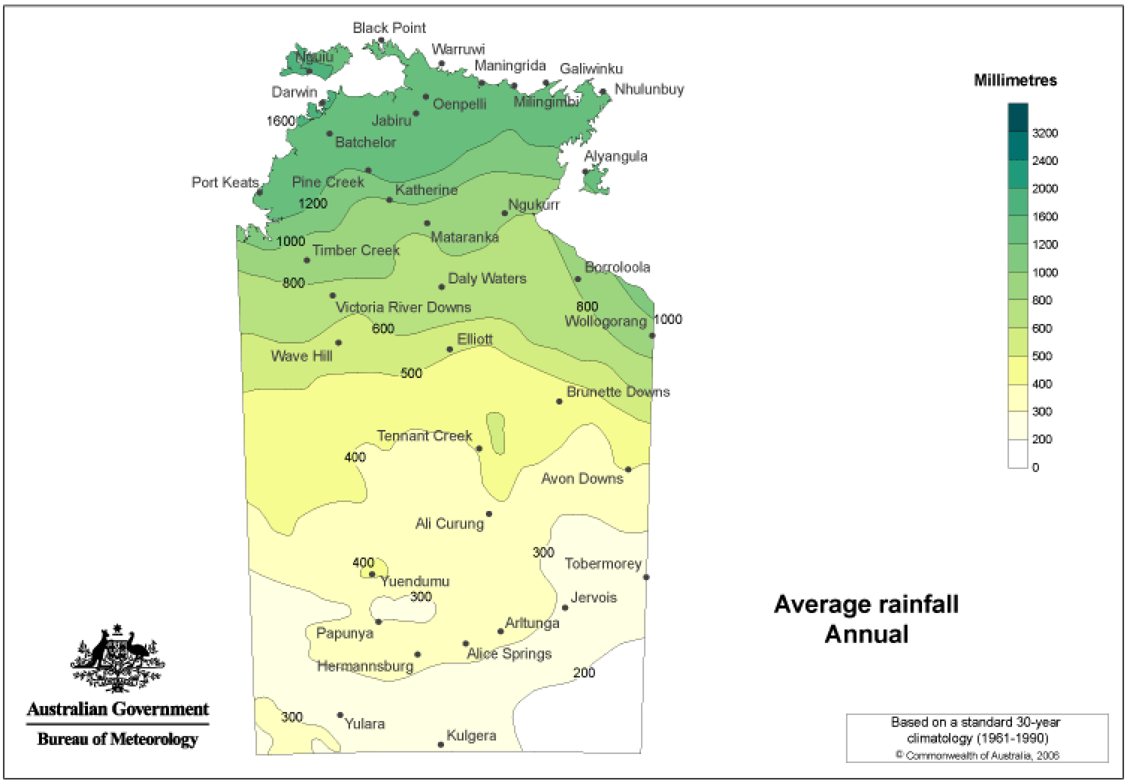


Figure 3.2 Average annual rainfall for the Northern Territory
(From BOM website: www.bom.gov.au/jsp/ncc/climate_averages/rainfall)

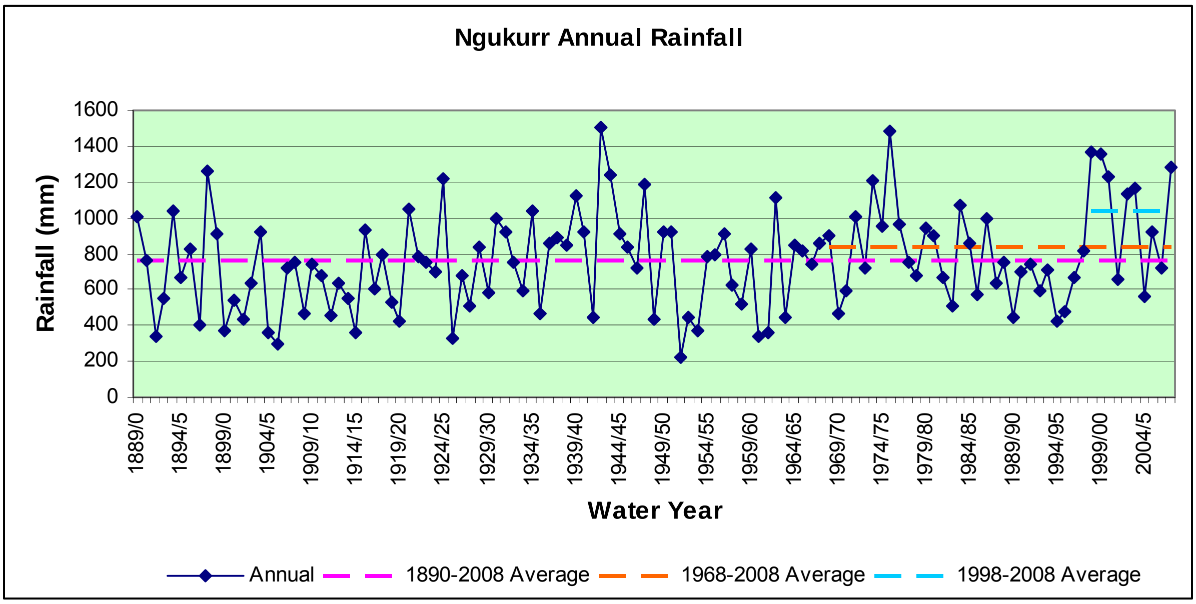


Figure 3.3 Ngukurr annual rainfall. Calculated over the Water year, September to August of the following year. (Bureau of Meteorology Data Drill data for Ngukurr site; www.longpaddock.qld.gov.au/silo).

Mean monthly minimum temperature varies from 15 - 26°C and maximum from 30 – 39°C (Figure 3.4). Average annual evaporation is about 2400 mm for the region which exceeds the annual rainfall in even the wettest of years. Mean monthly 3 pm humidity varies from 24 – 56 percent (Figure 3.5).

The Wet/Dry season contrast has significant implications for water resources. The monsoon brings wet season rainfall but cyclones, and the lows before and after cyclones, bring large rainfall events (Figure 3.6). These events cause major flooding and can provide good recharge to aquifers. Although the Wet season brings significant rainfall over a short period, the ensuing Dry, with months of negligible rain, results in most rivers in the region ceasing to flow unless they are groundwater fed, such as the Roper, Wilton and Phelp rivers.

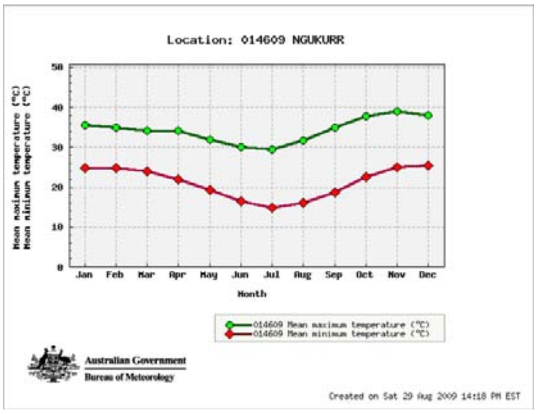


Figure 3.4 Ngukurr mean maximum and minimum temperature.

(From BOM website: www.bom.gov.au/jsp/ncc/cdio/cvg)

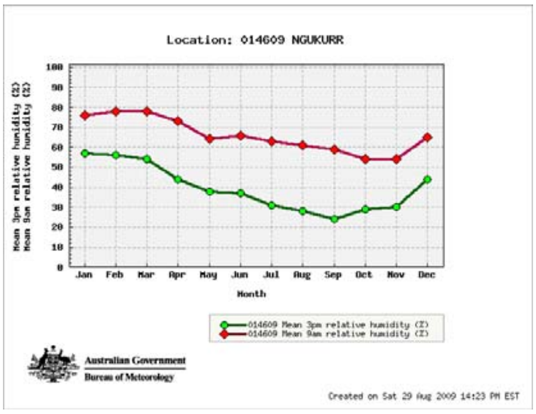


Figure 3.5 Ngukurr mean 9am and 3pm humidity.

(From BOM website: www.bom.gov.au/jsp/ncc/cdio/cvg)

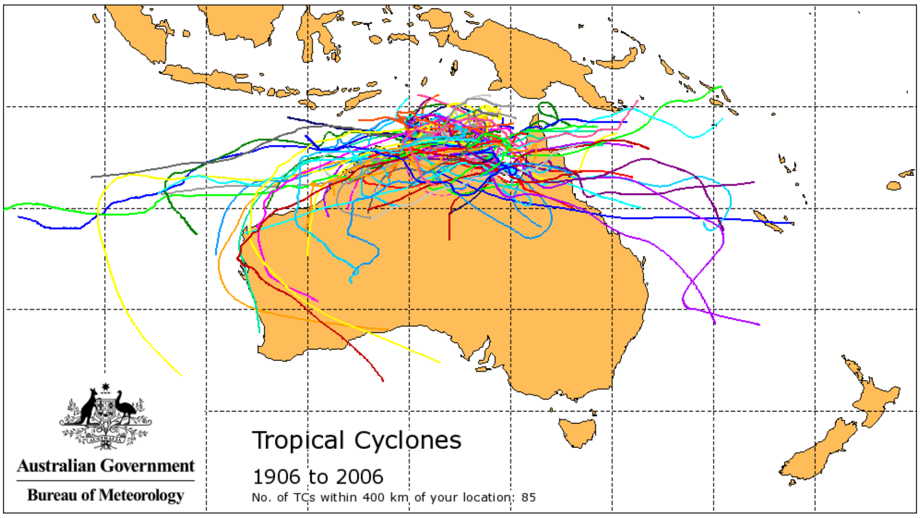


Figure 3.6 Tropical cyclones between 1996 – 2006 in the map region

(From BOM website: www.bom.gov.au/cgi-bin/silo/cyclones)

4. CURRENT WATER USAGE

The level of water usage in the region is low, with bores, rainwater (tanks and dams), natural waterholes and rivers providing water for domestic usage and cattle grazing. The Roper River provides an essential water resource to the area.

Groundwater is used for domestic supplies wherever possible. The major population centres of Minyerri, Urapunga and Ngukurr all use groundwater. However, Ngukurr, the largest community in the region, supplements its supply with Roper River water (Plate 4.1). Outstations use bores, springs, river water or lagoons for their domestic water supply (Table 4.1). The cattle stations use bores, rainwater tanks or river water for their domestic supply (Table 4.1). Cattle are watered through bores, dams, river water and natural water holes. Cattle stations have reported dams drying up late in the Dry season due to months of no rain and high evaporation rates. The main industry in the area is cattle grazing. Tourism is developing in the region at the Limmen National Park. Even with this low level development, securing water supplies can be problematic due to the lack of permanent surface water and lack of knowledge about groundwater in a very difficult hydrogeological environment. The Roper River undoubtedly is a key water resource in the region.

Plate 4.1 Pumping water from the Roper River at Ngukurr to supply the community.

Table 4.1 Current water use in the Roper River Region.

Location	Water Supply	Water supply to cattle
Awunbunji outstation	Waterhole/soak	
Badawarrka outstation	Roper River	
Big River cattle station	Rain water tank, Roper River	Roper River, natural waterholes, dams
Boomerang Lagoon outstation	Bore	
Bringung (Abandoned)	Roper River	
Costello outstation	Billabong of Turkey Lagoon Creek	
Flying Fox cattle station	Rain water tank, Roper River	Roper River, creeks, natural waterholes
Ganiyarrang outstation	Bore	
Gondooloo cattle station		Roper River, natural waterholes, dams
Jawa/Jowar	Bore	
Lake Katherine outstation	Lagoon of the Phelp River	
Larrpayanji outstation	Creek fed by permanent spring	
Lonesome Dove cattle station	Roper River.	Roper River, creek, natural waterholes, dams.
Maria Lagoon outstation	Lagoon of the Limmen Bight River	
Minyerri community	Bores	
Moroak cattle station	Bore	Roper River, creeks, natural waterholes, dams, bore
Mt Mc Minn cattle station	Rainwater tank, Roper River	Roper River, creeks, natural waterholes, dams, bore
Namul Namul cattle station	Bore	Dams, bores, natural waterholes.
Ngukurr community	Bores, Roper River	
Nulawan outstation	Roper River	
Nummerloori outstation	Lagoon	
Roper Valley	Waterhole supplied by a permanent spring	
Turkey Lagoon outstation	Billabong	
Urapunga community	Bores	
Wanmari outstation	Lagoon of the Pelp River	
Wongalara cattle station	Roper River	Roper River, creeks, natural waterholes

5. INDIGENOUS KNOWLEDGE

To indigenous people water sites not only have a physical entity and a purpose in the connected environment, but also social, emotional, cultural and spiritual significance. Effective management of land and water therefore involves consideration of all these realms.

'… nothing is without meaning, because to have no meaning would be to have no Law, if something has no Law it has no place and this cannot be for Indigenous plants and animals, (and land and water) all have ngalki, they have essence or substance that relates them to all other living things including humans.' (Bradley et al. 2006)

Western science provides a view of water resources in terms of its physical characteristics. On the water resource map, rivers are classified according to their minimum flow, groundwater classified according to aquifer type and waterholes depicted as to whether they are permanent or intermittent. Aboriginal people however view and classify the natural environment differently and kinship plays a major role. Just as any scientific based management of water requires an understanding of scientific principles and classification, so too indigenous environmental management requires an understanding of indigenous views and classification of the environment.

To begin to comprehend the indigenous perspective is no easy task when coming from a Western European perspective. '*Many cross-cultural differences exist in relation to environmental perceptions, knowledge of scientific practices, spirituality and language. Bradley notes that it was only after he had become quite fluent in Yanyuwa that he began to really understand how the Yanyuwa view their environment.*' (Bradley et al. 2006) Bradley is an anthropologist who has worked with the Yanyuwa people since 1980. The work of Bradley and others is presented following as it gives a clear overview of how one language group, the Yanyuwa view the environment, thus providing an example of indigenous perspectives in the Gulf region. The Yanyuwa people are one of several language groups situated in the Gulf Region. Other groups include Alawa, Marra, Warndarrang, Mangarrayi, Ngalakgan, Garawa, and Gudanji as well as others. Cultural differences exist between the language groups but the underlying world view often has similarities. Yanyuwa traditional country is situated north-east of Borroloola and encompasses the Sir Edward Pellew Group of islands.

The following overview has been heavily resourced and quoted from Bradley et al. 2003 and Bradley et al. 2006 and is denoted by the grey font. The information presented is the result of years of research by Bradley.

For Yanyuwa people the environment is both a physical, spiritual and cultural landscape. To begin to understand their interconnected view of the environment it is necessary to explain their view on how life and land came into being.

The Yanyuwa believe all was created by the Spirit Ancestors, commonly called Dreamings or in Yanyuwa *Yijan* '*who rose up from the earth or travelled from distant places, and created and /or changed geographical features and placed different plants and animals on the earth'*.

'*The Spirit Ancestors also created a charter that is the Law for existence. … The Law is the reason why things are as they are, or are done in a particular fashion*'. *As 'the Spirit Ancestors set out the forms of Law, and established the natural order and shape of the landscape they also left their creative potency. At some point in time, most of the Spirit Ancestors changed into a number of forms. Some became life forms or phenomena, as we know them today, such as certain species of plant and animal, celestial bodies, winds and tides. Others transformed themselves into rocks, trees and watercourses, and their power became localized at certain sites'.*

'*The Yanyuwa believe that these Spirit Ancestors and their power still exist in the land. They also believe that their power is still active and that through ceremony, song and certain forms of ritual action, they can be contacted. It is because of this that the country is said to be able to 'hear', that a rock for example, can make certain things happen, and that places when visited can be describes as being happy, sad, generous or ungiving'*.

The land and water is '*criss-crossed with the tracks or paths of these Spirit Ancestors, and these tracks are marked with places where the Spirit Ancestors danced, ate, fought, slept, urinated and so on. All of these places are seen to be repositories of power and the consciousness of the Spirit Ancestors. Thus the whole landscape is seen as a vast network of interconnected meaning'*. An example is provided in Figure 5.1 which provides a listing of the Spirit Ancestors and shows their tracks in the Foelsche and Wearyan Rivers area (south-eastern Gulf). Figure 5.2 shows the place names associated with these Spirit Ancestors for the same area. Figure 5.3 provides part of one of the dreaming stories for this area, namely that of Walalu, the Stranger Rainbow Serpent. This area forms part of the Law that comes from the Mainland.

The tracks that the Spirit Ancestors took *'are also the song cycles, kujika, which are sung during ceremonial performances. The song cycles for the travelling Spirit Ancestors follow a particular track and have offshoots that diverge from the main track to bring into the song all the stationary Spirit Ancestors that may be associated with a particular tract of land. Both the songs and the creatures can be called kujika, as they play a creative role*.' It is believed that '*the songs are still moving through country even if no one is singing them, it is like they have a life of their own. People who know the Kujika can join in and sing, and once they start singing it is like the country is singing through that person.*' *The Spirit Ancestors and their songs are inseparable from each other and from the sites that they created through the action of singing. Thus, the Spirit Ancestors are the creators, the singers of songs, which sang the Yanyuwa environment into being*. *Everything they did is recorded in these songs: the names of country, fauna, flora, events and names of people and places are all recorded'.*

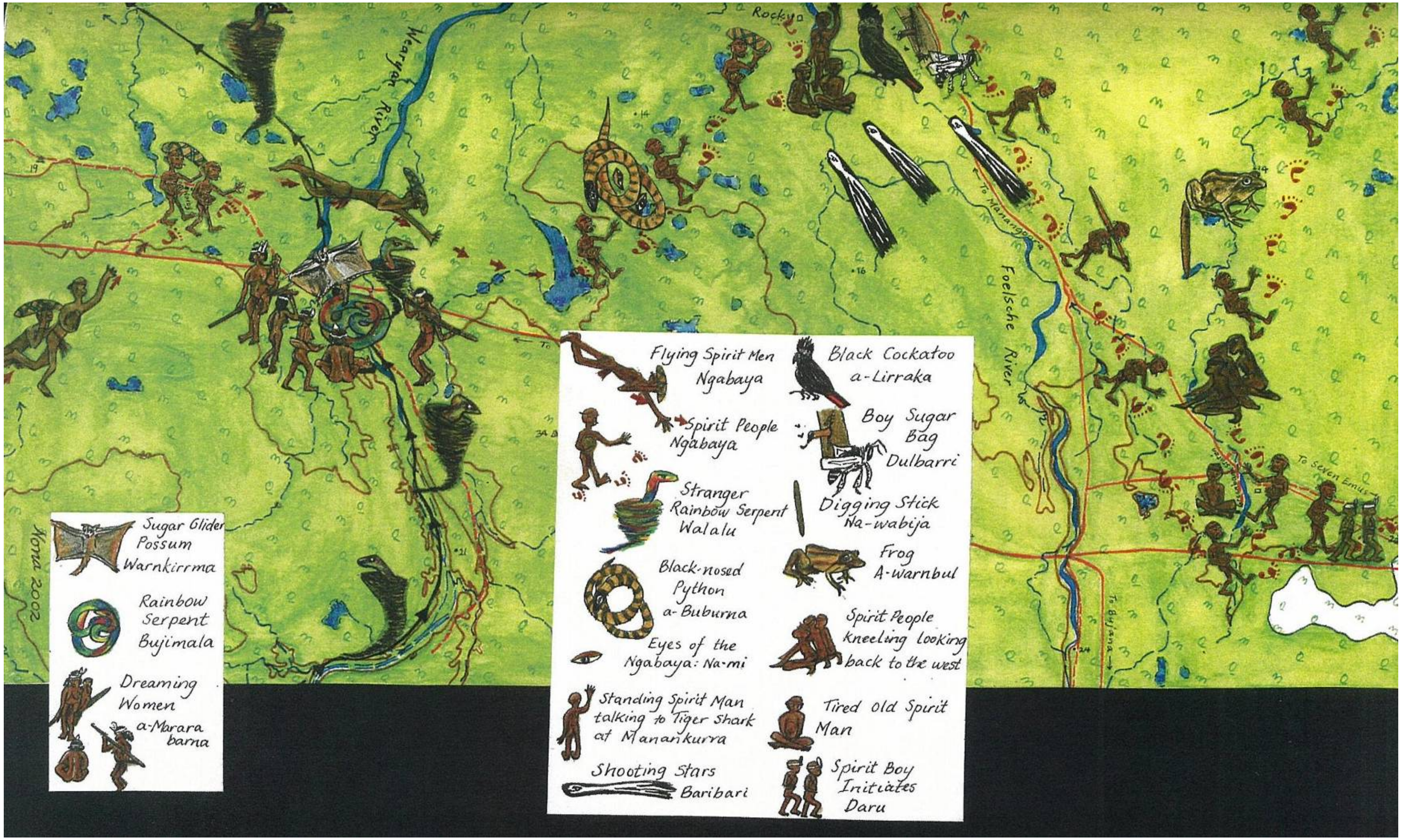


Figure 5.1 **Spirit Ancestors and their tracks in the Foelsche and Wearyan Rivers area**. (From Bradley et al, 2003)

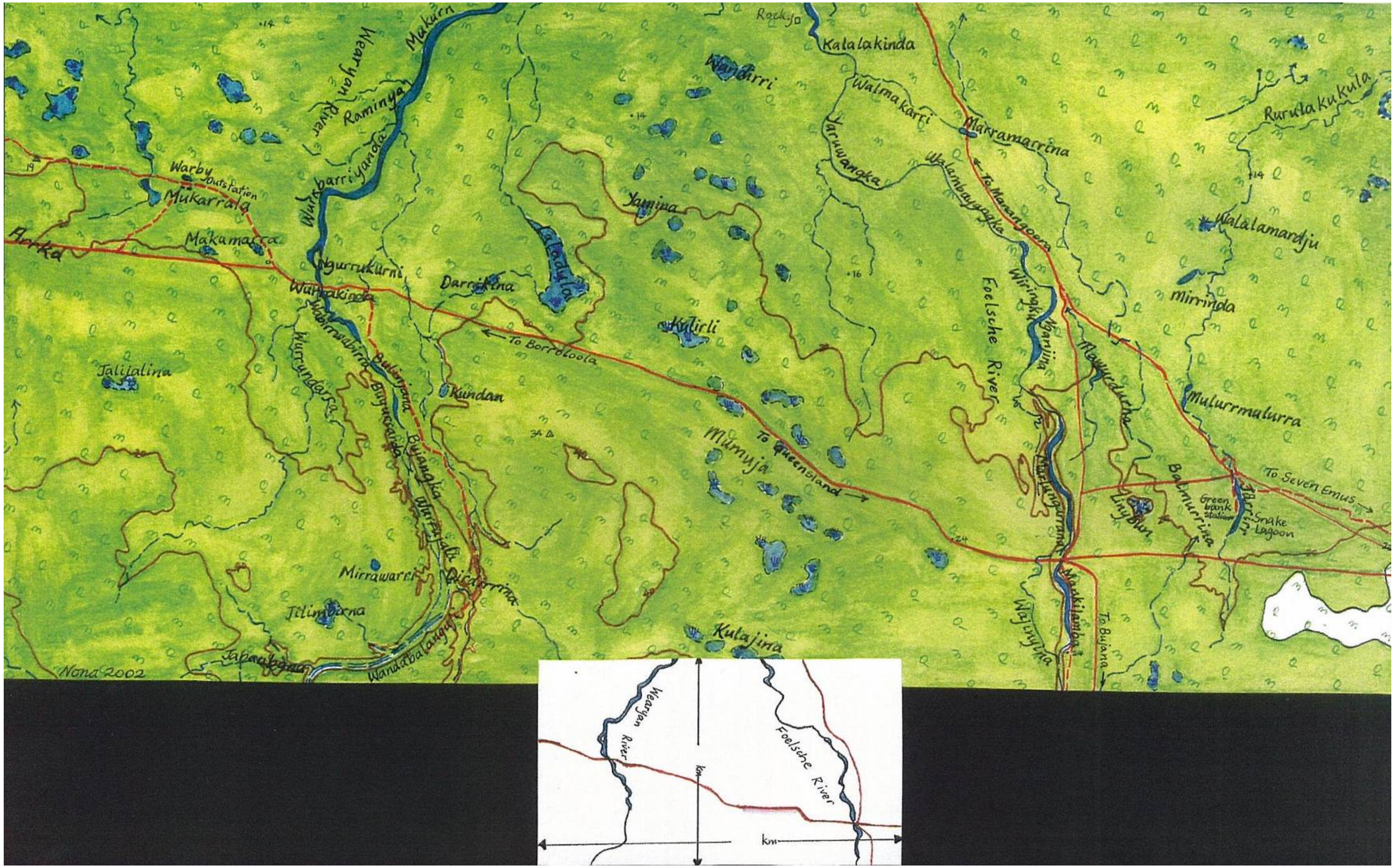


Figure 5.2 Place names associated with the Spirit Ancestors and their tracks in the Foelsche and Wearyan Rivers area.
(From Bradley et al, 2003)

Other Stories:

1.The story of the Walalu, Stranger rainbow Serpent is very important and very sacred. The Walalu is really important to the a-Kunabibi ceremony and the story of his journey and the things he did are really sacred. His *kujika* is also very important and very sacred. The stories told here are all outside versions of his travels. The Walalu is sometimes called *Yankarra* which is Yanyuwa for "the Stranger", he is called this because he came from such a long way away and, once he moves through Garrwa and Yanyuwa country he keeps moving all the way into Marra country, he moves through Alawa and Mangarrayi country, and finishes his journey at the Mataranka hot springs which is far to the west.
The Walalu has many other different names that are sung in his *kujika* but these names are only known to men. Some of the Walalu's journey is sung in the public *kujika* used in the a-Mamdiwa initiation ceremonies.
(see *Wandayarra a-yabala* and the Mambaliya *kujika* in particular)

2.The *ma-jabanda* forked pole is seen by men, women and children at the end of the a-Kunabibi ceremony. It is stood up on the women's ceremony ground.

3.Wabirrwabirra is the Yanyuwa name for this important rock hole, in Garrwa this place is called Wabirrwabirrnyina. Some places have two names like this when they are near places where one language takes over from another language. The Wearyan River is a place where in the old days Yanyuwa and Garrwa people were always moving together.

4.The Walalu is an important figure in the a-Kunabibi ceremony, but this ceremony does not just belong to the Yanyuwa people. When this ceremony is being held on Yanyuwa country people from many other communities have to be asked to attend. Garrwa people come from Doomadgee and Robinson River, Marra and Alawa people come from Roper River, Nunggubuyu people come from Rose River and Gudanji people from the Tablelands. It is not just men that have to come because women too, have their own very important ceremonies that belong to a-Kunabibi. Today these people travel by car, plane and motor boat to come to this ceremony, in the old days they travelled by foot and dugout canoe. Once this ceremony starts all of these different people have to come, this ceremony has a lot of power and is very sacred. In Yanyuwa the words for power are *wurrama* which is like "authority" and *wirrimalaru* which is like "spiritual power".

MAP: Foelsche and Wearyan Rivers
DREAMING: Walalu, Stranger Rainbow Serpent
CLAN: Mambaliya

The Walalu, Stranger Rainbow Serpent came far from the east, from Mangkabarra which is in the sea near Massacre Inlet in Queensland. He travelled from the east, as a whirlwind, passing over the Calvert, Robinson, Foelsche, Wearyan and McArthur Rivers.1. Just to the east of the Foelsche River is the large long lake called Kalajangku, it is not far from the Manangoora turn off. The Walalu created that lagoon and then came to the Foelsche River at Bujana where the outstation is now located. He then headed southwest and came to the Wearyan River. He arrived at the Wearyan River at Bulukwanja and then began going down stream and came to Jabanbana where he left behind a sacred ma-jabanda forked pole.2. He then passed through Dirdirrina, Wurrujala, Bujangka, Buyurranda, Bulinjana and then came to Wabirrwabirra.3.
At Wabirrwabirra he met up with a lot of Dreaming Women [a-Mararabarna], which had also come up out of the sea at Mangkabarra, but they had been trying to keep away from the Walalu Stranger Rainbow Serpent because they were brother and sister and they should have been avoiding each other. At Wabirrwabirra they danced together very important dances from the a-Kunabibi ceremony. The Sugar Glider Possum [warnkirrma] is also a Dreaming at this place. Today there is a very large rock hole at Wabirrwabirra and there is a Rainbow Serpent Dreaming there that was left behind by the Walalu. The Walalu kept going downstream and came to the Wurrakinda where the road now crosses the Wearyan River, he then came to a small creek on the west bank of the Wearyan River called Wurrbarriyanda and this is where he left the Wearyan River and continued to travel west, heading towards Kawurrukuma near Marrinybul.4. (see Map Fletcher and McPherson Creek.)

Figure 5.3 Dreaming story. (From Bradley et al, 2003). Right: one of the dreaming stories relating to the Foelsche and Wearyan Rivers area. Left: other stories associated with that Dreaming, Walalu. This story in particular has been presented here because, as detailed under 'Other Stories 1' the story of Walalu travels right across the Gulf region and ends at Bitter Springs at Mataranka, thereby traversing several language groups and providing an example of how the stories link people from different language groups.

'The Kujika is said to preserve the way the country was in the Dreaming and how it still is, and how the old people would like it to stay.' The songs are also about power and the sound of the song creates power that can make things happen. For example, Stephen Roberts, a senior elder living at Minyeri, in talking to Zaar about the rain dreaming at Mambilila spring, located south of Ngukurr, explained:

"If the heavy storm come, you can stop that rain (by) singing, … (sings song). That's how you stop that rain, he wont come rough. You sing … backwards. (sings song) You sing like that. You stop that rain, never come. That cloud will go right back Minimeer, that's all. (Stephen Roberts, pers. comm.)

An example of part of a *Kujika* is provided in Figure 5.4. These are the final verses from a *kujika* which has in it Walalu, the Stranger Whirlwind Rainbow Serpent Dreaming amongst others. The *kujika* starts at *Marrinybul* rockhole.

Bradley explains that '*every kujika has its own Ngalki'. 'Ngalki is a very complex word that identifies and gives distinction to its owner or owners. It is often translated as 'essence', 'skin' or 'sweat'. For example the ngalki of a flower is its smell; of food, its taste and a songs' ngalki is its tune. The Yanyuwa believe that the Spirit Ancestors were imbued with ngalki, which was also a classifying agent that divided all things into one of four clans*[1]'. As the Spirit Ancestors called and named places, animals, plants and other environmental features they also classified them, with a *ngalki*, which places them within the Yanyuwa clan system. The names of these four clans are:

- Wurdaliya,
- Wuyaliya,
- Rrumburriya and
- Mambaliya-Wawukarriya.

The interrelationship between *Kujika, Ngalki*, Dreaming and clans is portrayed in the following example: *'the kujika starting at Manankurra belongs to the Tiger Shark Dreaming and the Tiger Shark Dreaming is Rrumburriya. Rrumburriya is the name of the ngalki, it is also the name of the clan that owns the Manankurra Kujika.'*

The map in Figure 5.5 shows Yanyuwa clan areas and Table 5.1 provides a listing of plants and animals according to the clan classification. This clan classification is not restricted to the Yanyuwa, and other language groups in the Gulf identify with it. An example is provided by the Aboriginal land trust named 'Mambaliya Rrumburriya Wuyaliya Aboriginal Land Trust' which is situated on the McArthur River and is connected with a number of language groups. The trust has used clan names rather than language group names for identification. The four clans can be called different names in different languages. When Zaar undertook field work with indigenous people from differing language groups, they often referred to land and water areas in terms of the four clan names.

1 Baker (1999) describes the social groups of the Yanyuwa as consisting of two moieties which each have two semi-moieties. The semi moiety groups are equivalent to the clan groups noted by Bradley et al. (2006)

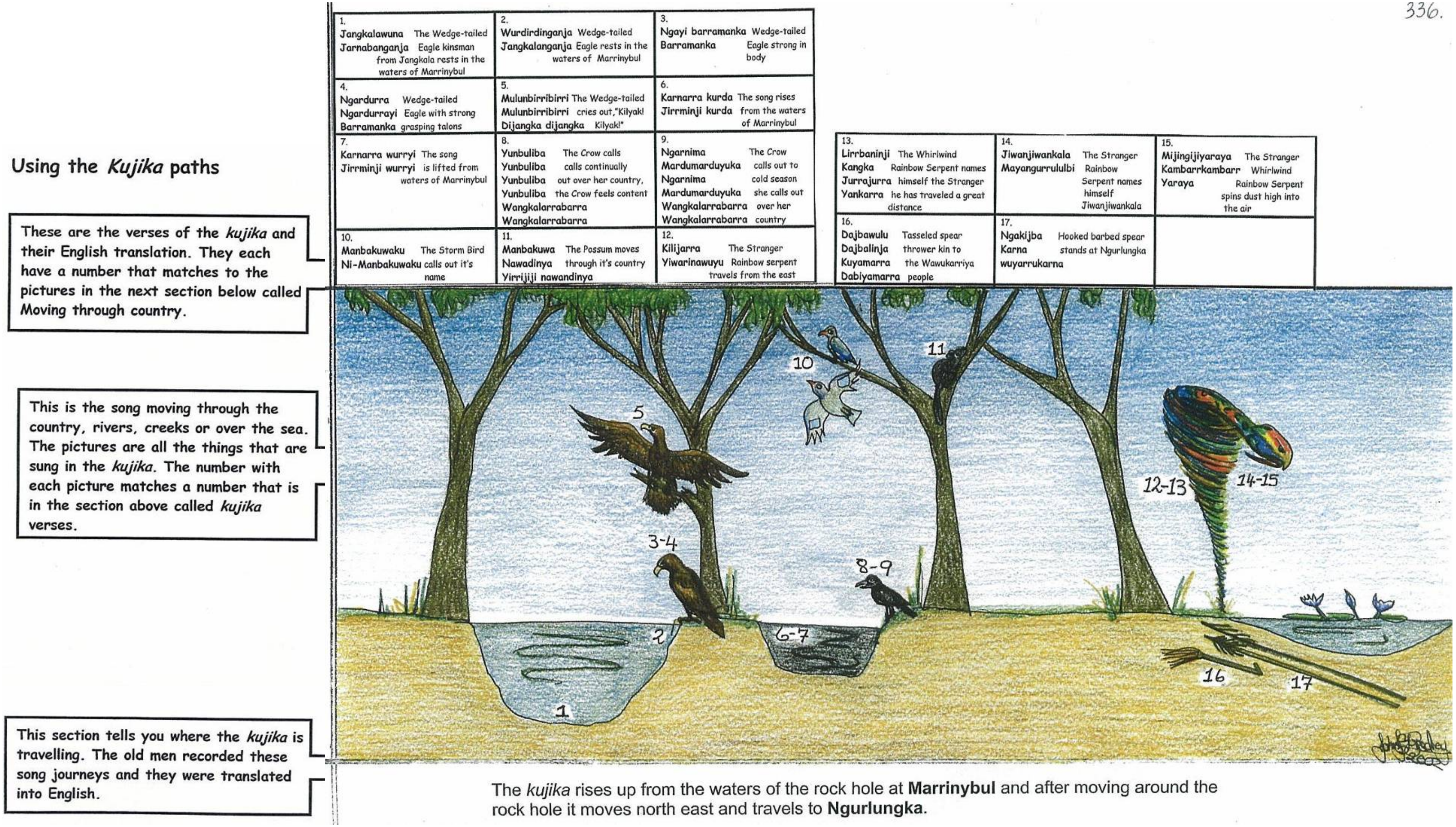
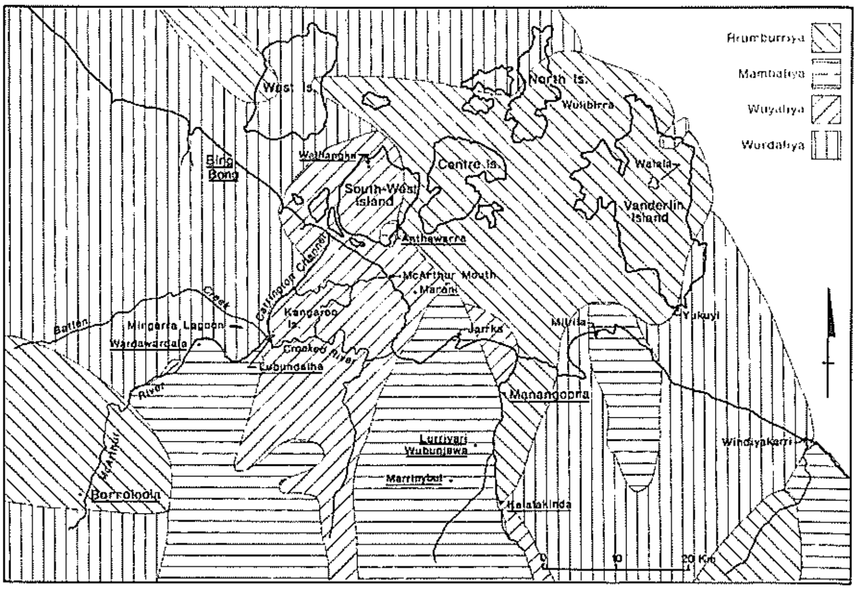


Figure 5.4 **The beginning versus of the Mambaliya-Wawukarriya Kujika.** It travels from Marrinybul rockhole to Jarrka.



Rrumburriya
Mambaliya-Wawukarriya
Wuyaliya
Wurdaliya

Figure 5.5 Clan areas in the Borroloola area. (Baker, 1999)

Table 5.1 Examples of Yanyuwa clan classification (Bradley et al., 2006, p12)

Rrumburriya	**Mambaliya-Wawukarriya**	**Wurdaliya**	**Wuyaliya**
li-maramaranja dugong hunters	*murndangu* long necked turtle	*malurrba* green turtle	*wardali* dingo
warriyangalayawu hammerhead shark	*kurdarrku* brolga	*karrubu* hawksbill turtle	*a-kuridi* groper
ngurdungurdu tiger shark	*a-kilyarrkilyarr* wedge-tailed eagle	*a-wurrkayny* large bodied mosquito	*kirdil* sandfly
ma-arnbaka cycad palm	*kinybutha* little read flying fox	*ngabaya* spirit man	*li-jakarambirri* blue ringed octopus
a-warranyuka black flying fox	*wakuwaku* cyprus pine	*balubalu* pelican	*ma-lhalhaki* northern kurrajong tree

People also carry *ngalki.* A person follows the *ngalki* of their father and father's father. There are *four terminological lines of descent, which are distinguished at a grandparental level* and which can be matched to a clan. These are:

- *Father's father*
- *Mother's father*
- *Father's mother's (brother)*
- *Mother's mother's (brother)*

This is the basis of Yanyuwa kinship. *'The clans are categories that codify relationships of importance in ritual activity and in daily life.'* For example '*the Yanyuwa are ngimarringki for their father's country and jungkayi for their mother's country. The former is usually translated into English as 'owner' and the latter term is translated by the Yanyuwa into English as 'manager'.* (Baker, 1999) People relate to country after the relatives that come from it; if, for example they were Rrumburriya, and they were referring to land that was Rrumburriya, they would call it 'country of my father's father'.

As mentioned earlier, the Spirit Ancestors set out the Law and the Law that belongs to country provides the rules for how people should interact with their environment and with others. It also determines how ceremonies are to be performed and what each person's role is in a ceremony. This again is interrelated to a person's clan. For example *'the secret and sacred a-Kunabibi ceremony is for the Mambaliy-Wawukarriya and Rrumburriya clans and they are ngimarringki while the Wuyaliya and Wurdaliya clans are jungkayi'.* Each has particular responsibilities in the ceremony. Hence '*everyone is dependent on others to carry out the life-sustaining ceremonies associated with the land'* (Baker, 1999). This was noted by Zaar when in conversation with Donald Blitner, a Marra man from Ngukurr who said:

"I am the last child from my uncle and father who taught me the Willy Wagtail ceremony and song. If it's a dry time, my old people used to sing the rain song and my uncle and brother in law would sing at the cold weather time for rain. The Jungayi, that is, the Joshua family for the area have passed away so no ceremony is done anymore. That's the way it goes. My eldest brother knew more than me but he has passed away". (Donald Blitner, pers. com.)

Because people, land, animals, plants and other natural phenomena all belong to a clan, a person belonging to one clan will know how to relate to everything else in their natural environment. Hence the existence of an intricate web of spiritual, cultural and social relationships between people and their environment. For example: '*The Brolga is Mambaliya-Wawukarriya so people from this clan are ngimarringki for the brolga and call it father's father, while people from the Wuyaliya and Wurdaliya clans will be jungkayi for it because it is either their mother or father's mother. Rrumburriya people call the brolga, mother's mother*'.

Aside from the spiritual and social way in which Yanyuwa view their environment they also view it in terms of the *'physical landscape and the habitat an organism occupies'*. They have developed habitat classifications; birds for example are classified into many habitats including mangroves, freshwater and lagoons amongst others. They have divided the '*physical landscape into distinctive 'land units' reflecting topography, soil and vegetation.*' One of these units is presented in Figure 5.6. In it freshwater is associated with riparian vegetation such as river pandanus and paperbark trees which is a familiar association also in Western science. The Yanyuwa are aware of how their seasons and animal and food resources all interact with the land units and habitats. They are acutely aware of environmental changes and the causes.

Land and water management for the Yanyuwa incorporates the intricate web of physical, spiritual and cultural connections. Examples of how indigenous people manage the environment sustainably include:

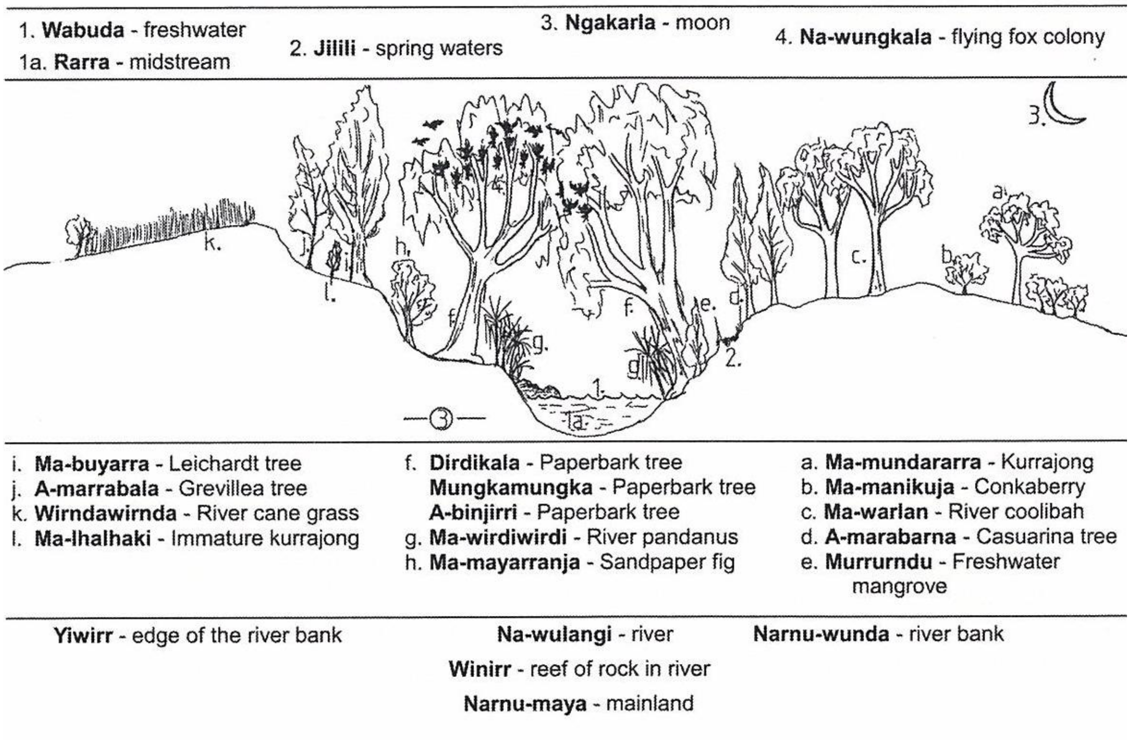


Figure 5.6 Some of the land units associated with the mainland as identified by Yanyuwa. (Bradley et al., 2006) The land unit is listed at the bottom of the diagram ie *Yiwirr*, environmental detail is listed above this, and other environmental detail is provided at the top.

- There is total prohibition on some species and, typically, these are attributed with the power to preserve particular resources. For example, the survival of the 'quiet' water snake is thought to maintain waterholes. (Baker, 1993)
- Permission from the ngimarringki is required to hunt in areas. These rights are jealously guarded in areas of plentiful resources, such as small islands rich with bird or turtle eggs. (Baker, 1999)
- Undertaking log coffin funeral practices to return spirits to the land and revitalize the country. This practice has ceased amongst the Yanyuwa and hence people say the 'land's getting weak, (because) no people, no spirit come back now'. (Baker, 1999)

Now let's look specifically at water in relation to the above dissertation on the indigenous perspective of the environment. Let's take the example of a waterhole, any waterhole. Each waterhole has been named and created by a Spirit Ancestor as it travelled on its path. The waterhole would be named in one or more songs which would have a particular tune. The songs would explain what events occurred at the waterhole. The waterhole would have its unique *Ngalki* or essence. The waterhole would be part of land belonging to a clan. There would be owners and managers for the waterhole. Each of these people would carry responsibilities in relation to caring for the waterhole. Ceremonies may take place at the waterhole. There may be a particular way in which people must interact with the waterhole as determined by the law. The waterhole forms part of a land unit, a habitat that is used by flora, fauna and people. The waterhole has a purpose. The waterhole would be managed in a sustainable way because it has a role to play in the interconnected spiritual, social and physical realm of the indigenous people. In fact management of the waterhole includes all these aspects.

Les Hogan Warramurru a Garawa elder from Borroloola had similar words to say when interviewed by Zaar:

"Every waterhole has a story of how it was created. It got story that one. Every lagoon, every waterhole, all the way down (the river) all that story, that one. We know (the story). We show our children when we go there. We tell them. This is the country that dreaming been say, he's here somewhere, something like that. We show them the right waterhole, the dreaming there. Some places all right (to visit), when that dreaming been talk, he's all right, they still can fish or catch turtle. (When going to a waterhole we talk to the dreaming) I'm here, I'm the boss for this country, you got to talk yourself. You tell the old people (the ancestors), they belong to there, they are there somewhere but you can't see them." (Les Hogan, pers. com.)

Plate 5.1 Les Hogan Warramurru

The West has in recent decades become more aware of interconnections of water and the environment through such fields as hydroecology; it recognises the beneficial uses of water which include cultural and environmental uses and it realises people have to be responsible in managing the environment. This has been the awareness of the indigenous people for thousands of years only their world view takes one step further – that of the spiritual. Their holistic view engenders responsible land and water management.

As a means of presenting indigenous knowledge on water, indigenous waterhole names collected as part of this study are marked on the water resource maps and information pertaining to the waterholes and who provided that information is given in Appendix A. This information, which has often been provided by elders, provides a little insight into the significance of water to indigenous people in this map area. It presents a fragment of the indigenous knowledge of the vast Gulf region that has been passed on through generations by word of mouth, song, dance, painting and ceremonies. It is hoped that this introduction which has very much simplified what is really an interconnected complex system, has provided enough background so that the information in Appendix A can be put into perspective.

Ancillary to this report, indigenous knowledge has also been documented through photographs and video and is available on The Gulf Water Study DVD.

6. GROUNDWATER

6.1 The Water Cycle

To understand the groundwater system, it helps to have an understanding of the water cycle (Figure 6.1). When rainfall hits the ground, some of it runs off into streams and creeks (surface runoff), some of it evaporates and some of it seeps into the ground (infiltration). The amount of water that infiltrates depends on many factors, including the soil and rock type, the slope of the land and the intensity and duration of rainfall. As the water infiltrates it wets up the soil and moves down. Some of this water will be evaporated or used by plants, and the rest will move downwards until it reaches the watertable to become groundwater. The process of adding water to the groundwater system is called recharge. Porous rocks and soil allow the groundwater to slowly move from high areas to low areas, usually discharging to the surface at some point. If a useful amount of water can be extracted from a rock unit, then it is referred to as an aquifer.

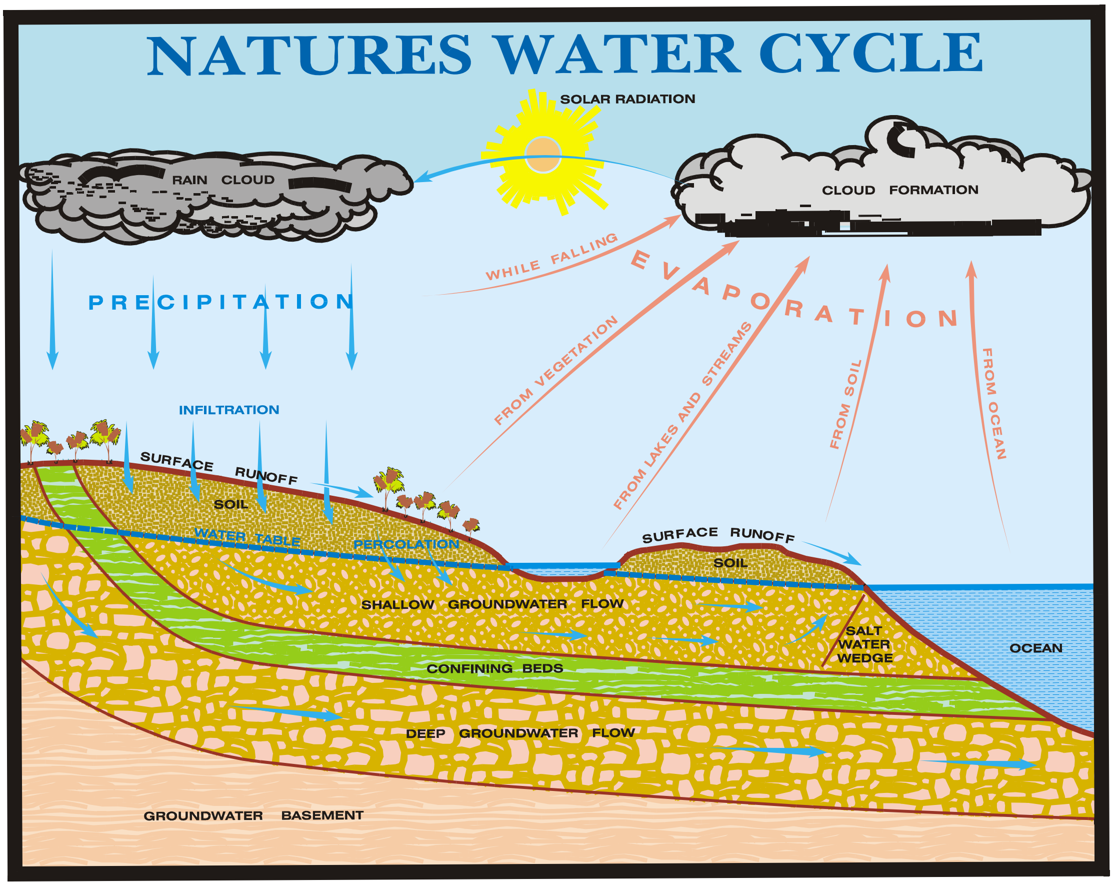


Figure 6.1 The Water Cycle

6.2 Geology

Geology is the science of rocks and its characteristics. Rock type and geological structure are some of the main factors influencing groundwater occurrence and the location of springs.

6.2.1 Rock Formations

Rock Formations are made up of one or several rock types. These are shown on geology maps. The groundwater potential of each Formation is assessed and those with similar aquifer characteristics are grouped together and mapped under one of the aquifer types shown on the water resources map.

Rocks are classified into rock formations as characterised by their physical and chemical features. Rock Formations can consist of one or several rock types i.e. sandstone, dolomite. When a number of rock Formations have common characteristics, they are grouped together to form a rock group. The age of the rock is categorized by a geologic time frame. Table 6.1 provides a broad outline of the rock groups and Formations of the region and their ages.

Table 6.1 Rock groups, Formations and their ages.

GROUP	ROCK FORMATION	AGE: IN MILLIONS OF YEARS	GEOLOGIC TIME FRAME
	Undifferentiated alluvium and colluvium	0 - 65	(Youngest) Cenozoic
	Undifferentiated Cretaceous	65 - 145	Cretaceous
	Antrim Plateau Volcanics	488 - 542	Cambrian
	Derim Derim Dolerite	542 - 2500	Proterozoic
Roper	Includes: Chambers River Formation Bukalorkmi Sandstone Kyalla Formation Velkerri Formation Bessie Creek Sandstone Corcoran Formation Munyi Member Hodgson Sandstone Jalboi Formation Arnold Sandstone Phelp Sandstone		
Nathan	Walmudga Formation Yalwarra Volcanics Knuckey Formation Mount Birch Sandstone		
Vizard and McArthur			
	Urapunga Granite and Mt Reid Rhyolite		(Oldest)

The extent of each Rock Formation is depicted on geology maps. The Roper River Region is covered by the following 1:250000 scale geology maps:

- URAPUNGA-ROPER RIVER SPECIAL
- HODGSON DOWNS
- MOUNT YOUNG

A number of the Rock Formations noted in Table 6.1 will be referred to in this report. The groundwater potential of each Formation has been assessed and Formations with similar aquifer characteristics are grouped together under one of the aquifer types. The geology maps, which show the area covered by each Formation, are used to map out the area of each aquifer type shown on the water resource map (Figure 6.2). Put simply, Formations with similar aquifer characteristics are mapped together under one of the aquifer types. Aquifer type delineates the groundwater resources on the water resource map.

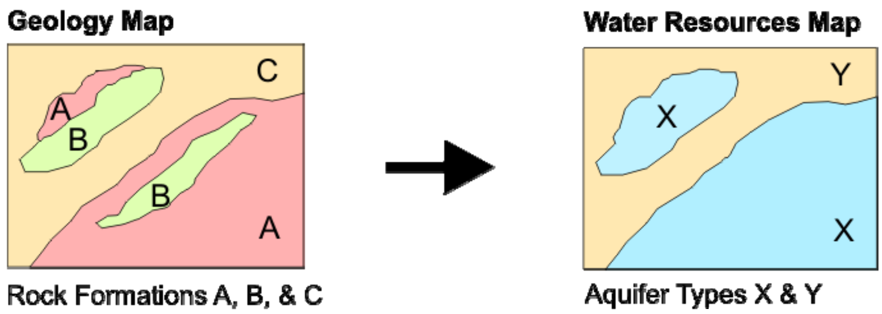


Figure 6.2 Example of grouping of Rock Formations into aquifer type. Here Formations A and B have similar aquifer characteristics whereas Formation C is different.

6.2.2 Geologic Structure and Land Units

The Roper River region is dominated by old Proterozoic rocks from the northern McArthur Basin. These consist of sandstones, siltstones and mudstones of the Roper Group overlying dolomitic mudstones, siltstones, sandstones and basalt of the Nathan Group (Table 6.1). The Roper Group has been intruded by the Derim Derim Dolerite as sills or dykes in fault zones (Abbott et al, 2001, P47). Overlying these older rocks are pockets of Cretaceous sediments consisting largely of sandstone. The most recent deposits are the Cenozoic sands and alluvium located along the coastal plain, river valleys and floodplains. They may be only several metres thick but mask the underlying rocks.

Major faults in the region run in an east-west direction and are associated with the Urapunga Fault Zone or run in a north-south direction as associated with the Walker and Phelp River Fault Zone. Dolerite has intruded into faults (Abbott et al, 2001, P53). Faults and fractures can increase the permeability of rocks and hence bore yield. They provide a secondary porosity to the rock.

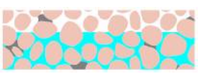
In terms of physiography, the Gulf Fall and the Coastal Plain are the two dominant units in the area. The Gulf Fall consists of a dissected terrain that drains into the Gulf of Carpentaria and is characterised by low rubbly hills of Proterozoic rocks and broad alluvial plains of the Roper River and its tributaries. (Abbot, 2001 pp1). The highest elevation, around 250m, lies in the northern part of the map sheet on the Wilton River Plateau, which is an extensive upland area belonging to the Gulf Fall. The Coastal Plain is characterised by extensive coastal flats of low elevation. The Roper River lies in the centre of the map area and runs from west to east with tributaries joining from the north and south.

6.3 Aquifer Type

An Aquifer is a body of rock that contains water and releases it in useable quantities. The rock contains water-filled spaces that are sufficiently connected to allow the water to flow through the rock. The spaces can develop from fractures, rock dissolution or occur naturally due to voids between the grains in the case of sandstone. Aquifers are classified according to the type of spaces within the rock.

When assessing the groundwater resource potential of a Rock Formation, bore yields, springs, water quality, sinkholes and importantly rock type and the nature of the spaces in the rock is taken into account. The latter delineates aquifer type. The properties of the spaces determine how extensive an aquifer is, how easily water moves through it, and how much water can be stored in it. Aquifer type is related to rock type. There are three main aquifer types (Table 6.2).

Table 6.2 Aquifer types and their characteristics. (Adapted from Tickell, 2008)

Aquifer type	**Description**	**Rock type that contains this aquifer type**
Fractured 	Networks of fractures in the rock provide space for water to collect and move through. The degree of fracturing can vary greatly. Fractures are normally very small, less than a millimetre, but if there are enough of them an aquifer can exist. Where fracturing is extensive and interconnected throughout a formation a widespread aquifer results. Localised fracturing results in a localised aquifer which is usually not very productive.	All rock types. It is the main aquifer type for hard, impermeable rocks such as granite, schist, dolerite and silicified sandstone.
Fractured and Karstic 	This aquifer is created by the dissolution of the rock by water passing through it. It forms in carbonate rocks – limestone or dolomite. Over geological time frames these rocks are slightly soluble in water. As water moves through fractures, it gradually enlarges them as the rock is slowly dissolved. The process can form caverns but more commonly openings of millimetre to centimetre in scale.	Carbonate rocks – Limestone and dolomite 
Sedimentary Porous rock 	This aquifer occurs in sands and sandstone. Pore spaces between the grains provide storage and a flow path for water. Not all sandstones have suffic-ient intergranular porosity to form an aquifer. Also over time, minerals may fill or partially fill the pore spaces hence the younger the sandstone the more likely it is to have its intergranular porosity intact.	Sands and sandstones 

The effects of weathering can increase aquifer development and therefore has been included in the description of aquifer type. Weathering is the physical disintergration and chemical decomposition of rock. Physical weathering occurs from the alternate expansion and contraction due to temperature changes, and chemical weathering produces new minerals. Weathering can cause the development of new fractures or enhance existing fractures, resulting in better aquifers. Weathering can also cause the narrowing of fractures reducing aquifer development. The most productive aquifers commonly occur near the base of the weathered rock.

Weathering can be accelerated or enhanced by fracturing. When rock is fractured, open spaces develop in the rock mass, and water collects in the spaces. Aquifers can exist in rocks due to fracturing alone. Fracturing can occur in all rock types but the degree of fracturing can vary greatly. Faults are marked on geology maps but the degree of fracturing is not indicated. Fractures can be targeted for potential water supplies but specialist scientific advice should be sought.

Aquifers can consist of combinations of the main aquifer types.

6.3.1 Flow system description of aquifers

Aquifers can be described according to the distance groundwater moves through the aquifer, from where it enters the ground (recharge areas) to where it discharges back to the surface (discharge areas) (Figure 6.3). The distance it flows depends on the extent of the aquifer. It can vary from hundreds of kilometres to less than a kilometre. The scale of groundwater flow has been categorized by Coram and others (2000). These are termed groundwater flow systems (Table 6.3) and are used to describe the aquifers on the water resource map.

Table 6.3 Aquifer flow systems (Coram et al, 2000)

Groundwater flow system	Flow path distance of groundwater	Example
Local	< 5 km	Fractured rock aquifers in granite often have a short flow path because the aquifer is only as extensive as the group of fractures.
Intermediate	5 to 50 km	Carbonate rocks that extend for tens of kilometres can have longer flow paths as provided by the interconnected caverns.
Regional	> 50 km	In large sedimentary basins, like the Great Artesian Basin, the flow path is long because the sediments have been deposited over a very large area and remain connected. These aquifers may have high permeability.

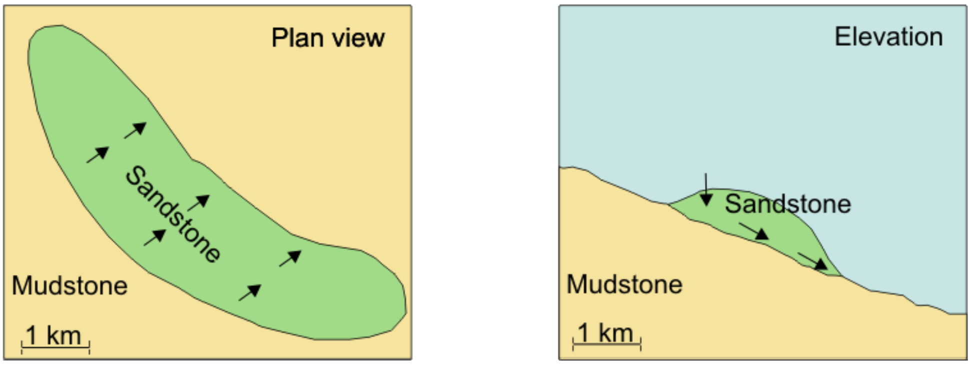


Figure 6.3 Flow path of water in a fractured rock aquifer. This is a local system.

The rate at which groundwater flows is usually very slow compared to river flows. It can vary from a few millimetres to several metres per year. Karstic aquifers are an exception where water can flow almost like a river through caverns when they exist. Depending on the size and type of an aquifer, it can take days to thousands of years for rainwater to complete its journey through an aquifer from when it infiltrates into the ground to when it discharges. The water we drink from some springs could be very old indeed.

6.3.2 Mapped aquifers / Groundwater Resources

In the Roper River region five aquifer categories have been identified and drawn on the water resource map (Table 6.4). Each category has been determined by its aquifer type, flow system, typical bore yield and whether or not it consists of carbonate rock. Carbonate rocks impart a particular water quality to groundwater (See section 6.4).

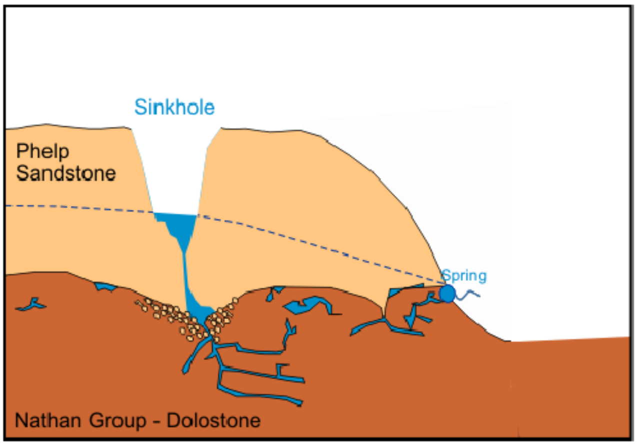
Table 6.4 Aquifer categories in the Roper River Region represented on the water resource map.

Representative colour on the map	Diagram of aquifer type	Aquifer Type	Flow system	Typical bore yield
		Fractured and karstic rocks – carbonate rocks	Local to intermediate scale	Up to 10 L/s may be encountered
		Fractured and weathered rocks – Carbonate rocks	Local scale	0.5 – 10 L/s (2 categories) 0.5 – 5 L/s
		Fractured and weathered rocks	Local scale	0.5 – 5 L/s
		Fractured and weathered rocks with minor groundwater resources	Local scale	0 – 1 L/s

The occurrence and characteristics of each of these aquifers is detailed below. The extent of each of the aquifers has been determined by use of the geological maps and grouping together rock formations that contain the same aquifer type. Drilling information is used to confirm the interpretation of aquifer type and its extent. All water bores drilled in the Northern Territory are identified by a Registration Number (RN) and these are plotted on the water resource map. Details of each bore are provided in Appendices I and J.

Fractured and Karstic Rocks

This aquifer type is located south of Ngukurr and in the north-east of the map and is situated in the Nathan Rock Group. In these areas the Phelp Sandstone, with thickness between 40 - 80 m, overlies the Nathan Group which contains carbonate rocks ie dolostone (Figure 6.4). To access the aquifer one needs to drill through the Phelp Sandstone and into the Nathan Group.



In general cavity development in karst formations is most extensive near the surface. Here the Phelp Sandstone would have preserved the cavities developed near the surface of the Nathan Group. Cavity development is evidenced by several large sinkholes in the Phelp Sandstone. The sinkholes 'indicate the collapse of the flat-lying Phelp Sandstone into cavities formed in dolomitic rocks of the underlying Nathan Group' (Abbott et al 2001, P26).

Figure 6.4 Karstic aquifer development in the Nathan Group.

The Nathan Group in the north east is potentially saturated since the sinkholes in the overlying sandstone are known to permanently hold water. Satellite imagery indicates there is a spring discharging from the southern end of the aquifer running into a creek connecting with the Phelp River. The aquifer south of Ngukurr also exhibits sinkholes and the largest spring in the region, Manbilila spring with a carbonate water quality, emerges from the aquifer. These factors provide evidence for the existence of karstic aquifers but further investigations, such as drilling, would provide confirmation. No bores have been drilled at the locations, however, it is anticipated that yields up to 10 L/s or more are possible.

Fractured and weathered rocks – carbonate rocks

Carbonate rocks under the fractured and weathered rocks aquifer type have been identified separately because they impart a very distinct water quality to the rocks. Carbonate rocks have the potential to be karstic but karstic development has not been identified in the formations listed under this aquifer category. Carbonate is present in the form of dolomite in the formations. Through detailed drilling investigations around Ngukurr and Urapunga, aquifer characteristics of the carbonate formations in the area were determined. (Sumner, 2008). It was found that a number of the carbonate formations supplied higher yields compared with other carbonate formations. Hence fractured and weathered carbonate rock aquifers are separated into two categories, distinguished by their difference in yield.

Fractured and weathered rocks – carbonate rocks (Yields 0.5-10L/s)

The Mount Birch Sandstone

Sumner (2008) reports that an aquifer was intersected in the Mt Birch Sandstone on the northern side of the Roper River in a weathered, coarse grained, feldspathic band amongst quartz sandstones. The upper part of the sandstone exhibited poorer porosity due to silicification. The high pump test yields, greater than 10 L/s, were considered sustainable as water level logging demonstrated a direct connection between the bore in the feldspathic sandstone and the river (Sumner, 2008). On the southern side of the river RN35728 was also drilled into the Mt Birch Sandstone and airlifted 10 L/s in a similarly weathered sandstone (Plate 6.1).

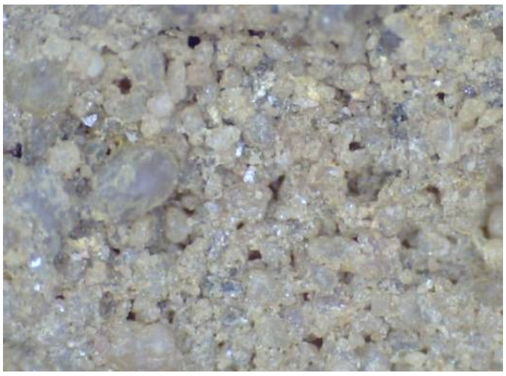


Plate 6.1 Weathered sandstone from 15-18 m interval from RN 35728. Note the pore spaces.

Bores drilled into the Mt Birch Sandstone are located either on or in close proximity to faults so fracturing would be a major factor in these high yields. It was notable that water quality tests showed high barium levels in two bores drilled either side of the river: RN35721 and RN35728. This is attributed to mineralisation along fractures associated with the Mt Birch Fault which cuts across the river and through the Mt Birch Sandstone. It is possible that the high yields are a localised phenomena associated with the river and fault.

The contact zone between the Yalwarra Volcanics and the Knuckey Formation

The Ngukurr region has been extensively investigated for groundwater in order to provide potable water to Ngukurr. The most recent investigations were undertaken in 2007 in response to the borefield supplying increasingly poorer quality water. The investigation concluded that the borefield, located northwest of Ngukurr, was drawing in river water through saline paleochannels (Sumner, 2008). The aquifer that hosts the borefield is situated at the contact zone between the weathered basal sandstones of the Yalwarra Volcanics and the weathered dolomite in the upper Knuckey Formation (Figure 6.5). The investigations found that this was a major aquifer in the region. Yields between 5-10 L/s were generally attained from this contact zone. Although the Knuckey Formation contains dolomitic rocks, no evidence of karst development within the formation was found (Sumner, 2008).

Fractured and weathered zones wholly within the Yalwarra Volcanics were also found to be water bearing and a production bore (RN035316) was therein completed. The Yalwarra Volcanics are limited in extent to the Ngukurr region and largely consist of sandstone and basalt. Bore yields up to 5 L/s are attained.

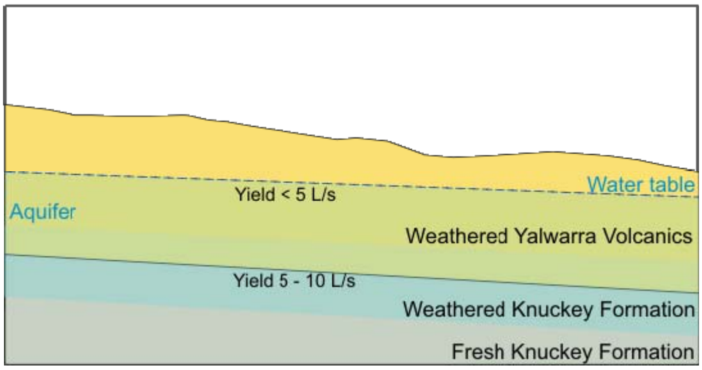


Figure 6.5 Aquifers situated in the Yalwarra Volcanics and along its contact with the Knuckey Formation.

The Nathan Group overlain by Cretaceous deposits

This aquifer is located in the upper (northern) section of the Phelp River. Although this area was not surveyed due to poor access there are a number of factors which suggest this aquifer exists. The geology is similar to that of the contact zone aquifer noted above, but in this instance Cretaceous deposits rather than Yalwarra Volcanics overly dolomitic rocks of the Nathan Group. Walter Rogers, an Aboriginal elder from Ngukurr, explained that the perennial flow in the Phelp River came from this area, which indicates groundwater as a source, and water quality measurements of the Phelp River (EC > 500, pH > 7.6) downstream from the area indicate water is discharging from a carbonate aquifer. Cretaceous deposits generally do not have a high carbonate content indicating this water quality is sourced from the underlying Nathan Rock Group.

Fractured and weathered rocks – carbonate rocks (Yields 0.5-5L/s)

The Walmudja Formation, the Knuckey Formation when in outcrop and the Nagi Formation (Vizard Group) were identified in the investigations at Ngukurr to be lower yielding (Sumner, 2008) and hence have been grouped together in this category. All other carbonate Formations in the area were classified under this category as they are silicified and/or are largely untested. Silicification is where pore spaces and cavities are filled with the silica mineral resulting in a hard rock with poor permeability.

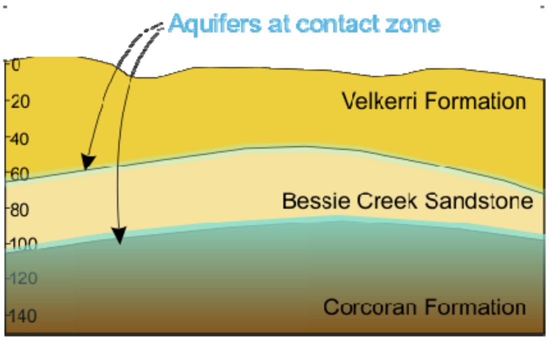
Fractured and weathered rocks

This aquifer type occurs in a variety of rock formations consisting primarily of sandstone. They lie throughout the Roper River Region. Bores typically yield between 0.5 – 5 L/s.

Five formations are mapped under this category. These are the Bessie Creek Sandstone, the Bukalorkmi Sandstone, the Arnold Sandstone, the Hodgson Sandstone and the Bukalara Sandstone. All these formations are old Proterozoic or Cambrian rocks which have become indurated (cemented) so little primary porosity remains. The effects of weathering however, has developed secondary permeability features in the rocks allowing aquifer development. Each aquifer is detailed following.

The Bessie Creek Sandstone

From drilling investigations undertaken at Minyerri (Table 6.5) it was established that ‘aquifers exist at the contact zone of the Bessie Creek Sandstone with the overlying Velkerri Formation and underlying Corcoran Formation’ (Jamieson, 1992)(Figure 6.6). The latter was found to be the more productive of the two aquifers. Most of the production bores were drilled through both aquifers so as to gain a supply from each aquifer. Pump tests undertaken have recommended pump rates in these aquifers of below 1 L/s. The Bessie Creek Sandstone was mapped under this aquifer category as an indication to the location of the two contact zones. The Bessie Creek Sandstone can vary in thickness but is generally less than 60 m in the map area. When drilling into the Bessie Creek Sandstone and only a minimal supply is attained from the top contact zone it is worthwhile drilling through the Sandstone (pending on the angle of dip/thickness) to target the lower contact zone aquifer.



Aquifers exist in the contact zone between the Bessie Creek Sandstone and the Velkerri and Corcoran Formations. The aquifers have developed due to weathering and fracturing. Investigations found that ‘the weathering process had extended to such a depth along the Corcoran contact zone as to cause a significant increase in permeability to a depth of about 100m’ (Jamieson, 1992). Variations in permeability within these aquifers were largely attributed to localised fracturing.

Figure 6.6 Aquifers at the contact zone between the Bessie Creek Sandstone and the Velkerri and Corcoran Formations.

Table 6.5 Bores drilled into the Bessie Creek contact zone aquifers. (Jamieson, 1992) See Appendix I for further bore details.

RN007322	RN008503	RN008504	RN022806	RN022807	RN022808	RN022809
RN023161	RN023162	RN023163	RN025383	RN026145	RN027901	RN027902
RN027905	RN027906	RN027907	RN027908	RN027909	RN027960	RN027961

The Bukalorkmi Sandstone

The Bukalorkmi Sandstone was most likely encountered in RN35878, RN35879 and RN036300 under about 100 m cover of shales and fine sandstone belonging to the Chambers River Formation. The bores airlifted 5 L/s however pump tests undertaken on RN35879 and RN36300 recommended rates at 0.7 and 0.5 L/s respectively. One bore likely to have been drilled into outcropping sandstone is

RN003850, where there was seepage. The Bukalorkmi Sandstone Formation is only between 10 – 20 m thick. These are the only bores that have probably been drilled into this sandstone. The results indicate that small supplies (0.5 L/s) are attainable from the sandstone, particularly when under cover. Results from drilling showed that the sandstone appeared to have some remaining primary porosity (Matthews, 2008).

The Arnold Sandstone

No water bores appear to have been drilled into the Arnold Sandstone within this region. It has however been investigated and drilled in the Borroloola area where individual bores supply between 5 – 10 L/s to the town. At Borroloola Woodford and Yin Foo (1995) consider that 'the aquifer is generally of low permeability at depth, but has undergone enhancement near its outcropping margins' probably due to weathering effects and dissolution of the carbonate cementing medium in the sandstone. Given these positive results the Arnold Sandstone has been mapped under this aquifer category because it presents as a fair possibility for groundwater supply.

The Hodgson Sandstone

Bores drilled within the Hodgson Sandstone in the region have had variable airlift yields ranging between 0 – 2 L/s (RN027816 2L/s, RN008769 1.2L/s, RN035799 0.5L/s, RN027817 0L/s, RN027818 0L/s). The Hodgson Sandstone is similar to the Arnold Sandstone although its permeability is considered as variable (Woodford et al 1995).

Most springs and seeps in the Roper River region are located in the Bukalorkmi, Hodgson or Bessie Creek Sandstones (see section on springs). This provides further evidence that these Formations are likely to contain aquifers.

Fractured and weathered rocks with minor groundwater resources

A number of Rock Formations in the region consist of siltstone, mudstone, fine grained sandstone, dolerite and granite. These rocks are often only sparsely fractured and therefore contain only low yielding aquifers. Bores generally yield less than 0.5 L/s. Often extensive drilling is required to gain a supply from these rocks. For example, at Moroak Station 28 bores were drilled into these rock types and only three bores yielded a sufficient supply to warrant constructing a production bore. Of these only one bore appropriately called 'Lucky Bore' airlifted a minimum of 1 L/s that was fit for human consumption. Water quality can be marginal in these rock types because of their low recharge rate.

6.3.3 Other groundwater supplies

Alluvial deposits and sand dunes can also provide minor groundwater supplies. These unconsolidated sediments belong to the sedimentary porous rock aquifer type (Table 6.3). They are limited in extent are not shown on the map. Bores generally yield less than 0.5 L/s.

Aquifers can be found in alluvial deposits built up along rivers or on floodplains, particularly where sediments consist of well rounded gravels and are well sorted (of similar size). RN028623, located along the Roper River on Moroak Station, exploits an alluvial aquifer. The airlift yield from this bore was 2 L/s with the river providing continuous recharge to the sediments. Bores drilled in alluvial deposits have a low success rate because of their limited extent, variability in thickness, and gravel, silt and sand content, making construction difficult.

Small supplies can be attained from aquifers in sand dunes. Although sand dunes or cheniers exist within the map sheet they have not been drilled for water supply. Infiltration galleries rather than bores are recommended for extracting water from sand dunes to ensure water quality is maintained. These have been installed at Wuyagiba which is located along the coast just north of the map region.

As reported by station owners and managers of Elsey, Moroak, Flying Fox and Lonesome Dove Stations, whilst digging dams at some locations the groundwater table was intercepted and the dam filled with water without rain (Figure 6.7). A high water table at some locations has also been recorded on some bore reports. Appendix I provides standing water levels of all bores in the area. This is fortuitous, but it must be remembered that water table level changes over time and we are currently experiencing high groundwater levels due to a wet period.

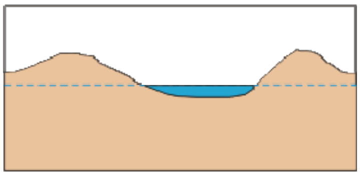


Figure 6.7 Interception of water table by dam

6.4 Groundwater Quality

Groundwater quality is effected by evapotranspiration of rainfall and rock type.

Rainwater contains salts. As rainwater moves down through the soil to the water table evapotranspiration concentrates the salts. Salts are made up of ions. For example table salt (Sodium Chloride) is made up of the ions Sodium and Chloride. Common ions used to describe water quality are listed in Appendix J. If recharge is low then the salts can become so concentrated that the water becomes unsuitable for human consumption. Low recharge can be due to low rainfall but it is also related to rock type. Mudstones for example would have low recharge because the small particle size of the rock allows little water through.

Rock type affects water quality because, as water moves through them, it picks up (dissolves) salts from the surrounding rock. This process is particularly evident in limestone and dolomite because they contain high amounts of calcium or magnesium carbonate which dissolve in acidic conditions (Plate 6.2) and our rainfall is naturally acidic. When these rocks dissolve, calcium, magnesium and bicarbonate ions are released into the water. Hence groundwater rich in these ions has most likely come from a limestone or dolomite formation.

Plate 6.2 A drop of acid dissolving limestone as shown by the fizz. This is a common field test for carbonate rocks.

6.4.1 Water quality measurements

In order to describe the quality of water and its suitability for drinking or other use, a number of parameters can be measured in the field and in the laboratory. One of these parameters is Total Dissolved Solids (TDS) which is a measure of the saltiness of the water. It is usually described in terms of the number of milligrams of salt in a litre of water (mg/L).

The Australian Drinking Water Guidelines (ADWG, 2004) define good quality drinking water for human consumption from the perspective of health and aesthetics. The guidelines state that good drinking water has a TDS of less than 500 mg/L, and that a TDS of 500 – 800 mg/L is fair. A TDS of greater than 1000 mg/L is considered unacceptable. High TDS may be associated with excessive scaling, and unsatisfactory taste. A simple way of estimating TDS in the field is by measuring the water's electrical conductivity (EC). Salt present in the water will make it more conductive for an electrical current, which can be easily measured with a small field probe (Plate 6.3). EC is measured in microSeimens per centimetre, μS/cm. TDS is approximately equal to 0.6 x EC.

Plate 6.3 U.Zaar measuring the EC with a meter.

Water can also be described as being 'hard' or 'soft'. 'Hard' water requires more soap to produce suds than 'soft' water, and is generally associated with groundwater occurring in limestone and dolomite aquifers. These aquifers contain calcium or magnesium rich waters. Water having more than 150 mg/L calcium carbonate can deposit scale in pipes and water heaters under favourable conditions.

Another parameter which can be easily measured in the field, and give an immediate indication of water quality and suitability is pH. pH is a measure of the hydrogen ion concentration. Water is said to be either acidic or alkaline, depending on the relative concentration of hydrogen ions. A pH of 7 indicates neutrality, a pH of less than 7 indicates an acidic water, and a pH of greater than 7 indicates an alkaline water (Table 6.6). A low pH can be caused by high levels of dissolved carbon dioxide. Acidic water is corrosive to metal bore casing and pipes, but is still suitable for consumption if plastic or PVC bore casing and pipes are used to distribute the water. Alternatively, the water can be treated by aeration, which allows the dissolved carbon dioxide to be released to the atmosphere, causing the pH to increase. Alkaline water is generally associated with limestone or dolomite aquifers, and is a good indicator of the aquifer rock type. High alkaline waters can also be treated to lower pH. It should be noted that pH measurements taken from airlifted water during the drilling process may not give a true indication of the pH.

Table 6.6 pH and water quality observed in the study area

Acidic	Neutral	Alkaline
pH < 7 Often due to high levels of dissolved carbon dioxide	pH = 7	Ph > 7 Can be due to high carbonate content sourced from dolomite or limestone
Generally EC < 150 μS/cm indicating low mineral content in the water. The surrounding rocks may be inert.		Generally EC > 300 μS/cm indicating that the water may contain dissolved minerals from the surrounding rock.

Measurement of pH in the field is important, as during sampling, storage and transportation to a laboratory, there may be changes in pH due to chemical reactions. Field measurement is easy, and generally done by using a small probe which can give excellent results if regularly calibrated.

Besides undertaking field measurements of water quality parameters, water samples were also taken from a number of springs, creeks and bores prior to and during this project. These samples were then analysed in a laboratory where the quantity of common ions in the water was determined. These results are detailed in Appendices J and L. The water quality could then be characterised for a stream or an aquifer.

Most of the bores which have supplied salty water have been drilled close to the sea, estuary or salty mangrove and swamp areas. Near the coastline or tidal streams, fresh water in aquifers can become mixed with sea water. This can happen naturally on a seasonal basis, or when water is pumped from an aquifer close to the ocean. These waters can be distinguished by high TDS, sodium and chloride concentrations.

6.4.2 Water Quality and Aquifer Type

Below is a basic description of water quality for each of the aquifer types denoted on the water resource map.

Fractured and karstic rocks

Manbilila spring emerges from this aquifer type south of Ngukurr and it has an EC = 650 µS/cm and pH = 8, which is typical of carbonate aquifers. This aquifer type situated in the north east of the map was not visited due to poor access conditions. It is expected however to have a similar water quality.

Fractured and weathered rocks - carbonate rocks

Water quality in aquifers of this category around the Ngukurr region are detailed in Table 6.7.

Table 6.7 Water quality in aquifers around the Ngukurr area.

Aquifer	pH	EC	Bores in this Formation
Yalwarra Volcanics	7.4 – 8.1	655 - 840	RN031989, RN35302, RN035512, RN035315, RN035316
Contact zone between the Yalwarra Volcanics and Knuckey Formation	6.8 – 7.7	675 - 2010	RN005955, RN006035, RN021481, RN030405, RN032802, RN031986, RN034909, RN035301, RN035317, RN035510
Contact zone between the Cretaceous Sandstone and Undivided Nathan Group	> 7.6	526 - 537	No bores drilled into this aquifer. Water quality inidicated by Phelp River.
Mt Birch Sandstone	7.9 – 8.1	570 – 600	RN035319, RN035720, RN035721

Currently groundwater to the Ngukurr community is supplied from the aquifer located in the contact zone between the Yalwarra Volcanics and the Knuckey Formation (RN005955, RN006035, RN021481, RN030405, RN032802). The water quality from the borefield has steadily worsened since its inception due to high pump rates drawing water from the river through saline paleaochannels (Sumner, 2008). Hence the high variation in EC and pH noted in Table 6.7 for this aquifer. The aquifer has high EC, hardness (Calcium Carbonate) and Chloride levels which are considered marginal for drinking water (Moretti, 1992). The hardness of the water is attributed to the dissolution of the calcium carbonate in the dolomite of the upper Knuckey Formation (Sumner, 2008). Bores drilled into this aquifer away from the current borefield have a better water quality (RN035317, RN35301). Appendix J provides detailed water quality information on all bores.

Fractured and weathered rocks

The Bessie Creek contact zone aquifers generally have low TDS (<100 mg/L) and low pH (5 – 7). This water is corrosive and hence inert materials, such as PVC piping, should be used for water reticulation. With depths over 100 m the water quality is less corrosive as pH was above seven (7.3 – 8.2) but TDS also increased (up to 400 mg/L) (Jamieson et al., 1992). The water has a high iron and moderate manganese content (Appendix J). This affects taste and causes staining of washing and cookware.

The water from the Bukalorkmi Sandstone aquifer had a pH between 6.3 – 7.2 and EC between 264 and 399 µS/cm (Matthews, 2008). The Hodgson Sandstone has not been extensively drilled; water quality analysis is provided for one bore, RN027816 which had a pH = 7.8 and EC = 820 µS/cm showing suitability for drinking. The Arnold Sandstone has not been investigated in this map region. It is however, considered similar to the Hodgson Sandstone. These two sandstones have been extensively drilled at Borroloola (McArthur River map region) where the characteristic water quality was pH 5.3 – 8.2 and EC 45 – 240 µS/cm. In general the main concern regarding water quality of these sandstone aquifers is the corrosive nature of the water to metal reticulation.

Fractured and weathered rocks with minor groundwater resources

The water quality in these aquifers has a very wide variation and it is not unusual for the TDS to exceed the guideline value, with rock type and poor recharge being the likely causes. For example, on Moroak Station four of the 10 bores where water quality analysis was undertaken had unacceptably high TDS (Appendix J). The high chloride content in the four bores indicated evapotranspiration (poor recharge) as the mechanism for salt concentration.

Reviewing the water quality data available for the region (Appendix J), in general these aquifers have a pH > 7 and EC > 500.

6.5 Recharge

Recharge is where water is added to an aquifer. It is important to carefully manage areas where recharge occurs to ensure groundwater quality is maintained. Recharge can be observed by monitoring water levels in bores.

Recharge is where water is added to an aquifer (Figure 6.1). It occurs during the wet season. Recharge amounts vary with rainfall, soil and geology. It occurs through three main mechanisms; diffuse, point source and stream bed. Diffuse recharge is the widespread downward seepage of rainwater, point source recharge occurs through an opening in the ground such as a sinkhole allowing direct drainage to the aquifer, and stream bed recharge is where water drains from a stream to an aquifer (the water level of the aquifer must be lower than river level for this to occur).

High rainfall usually results in better recharge. Recharge is indicated by the rise of groundwater levels and can be observed in bores which are monitored. Currently there are no bores being monitored in the Roper River map region but there is a little historic data available for Minyerri. In RN027906

(Figure 6.8) the groundwater level fell over the years 1995 to 1997 due to low rainfall, but with better rainfall in 1998 and 1999 the groundwater level significantly increased. To better show how groundwater level fluctuates with rainfall, continuous height data from RN029429 is shown in Figure 6.8. When rainfall is sufficient note how quickly recharge occurs in RN029429 and how the water level slowly recedes over the dry season. Poor annual rainfall can result in no recharge and a continued decline in water level from the previous year. Long term trends in rainfall can provide an indication of variations in groundwater level (Figure 7.8).

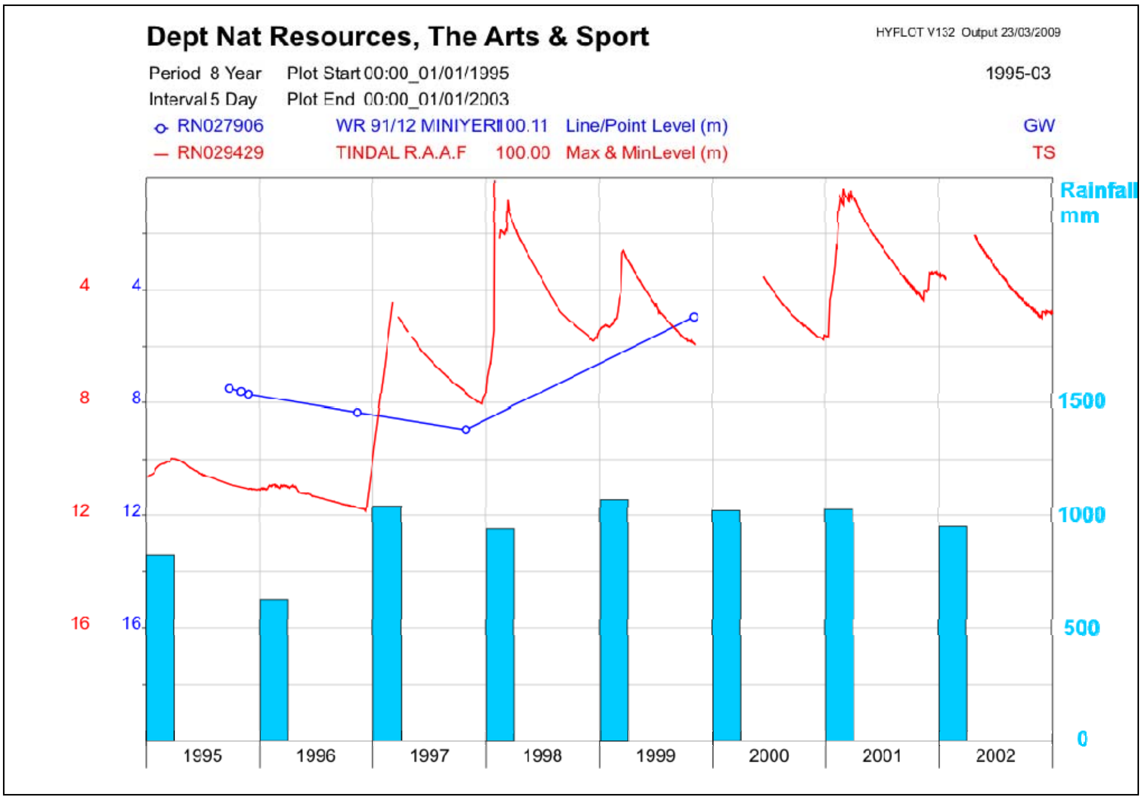


Figure 6.8 **Recorded water levels (from local ground level) in RN027906 at Minyerri and for comparison RN029429 at Tindall RAAF base over the years 1995 to 2002.** Annual rainfall (mm) at Mataranka is shown as an indication of rainfall at Minyerri as no rainfall data is available for Minyerri for these years.

Recharge is affected by geology or rock type and soil type. The amount of water that reaches an aquifer is dependent on the rock types or soils that overly the aquifer as well as the rocks that make up the aquifer. Water moves through some rocks and soils better than others, that is, they have a better permeability. Permeability is affected by the size and shape of the voids in the rock and how well the voids are interconnected. A coarse sand, for instance, has a high permeability whereas a mudstone or a poorly fractured granite has a low permeability. If a sand is overlain by a mudstone or clay, then it will be poorly recharged, but if it is unconfined it will be better recharged (Figure 6.9). When an aquifer is confined the recharge area can be restricted to the area where the rock is in outcrop (Figure 6.9). Recharge areas should be managed to ensure water quality is maintained. For example, sewage works should not be located over recharge areas.   Recharge is often described as the amount of rainfall entering an aquifer in mm/year or by the rise in water level in an aquifer in metres. Up to 20% of annual rainfall results in groundwater recharge.

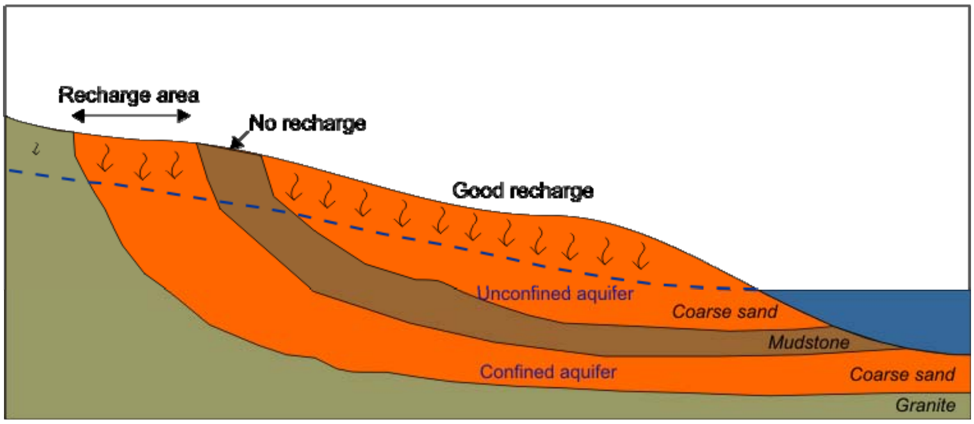


Figure 6.9 Recharge to a confined and unconfined aquifer.

The sustainable yield of an aquifer can be considered as that amount that can be extracted from an aquifer without adversely affecting the environment and reducing the average groundwater level in that aquifer. In other words the extraction rate should be less than the average recharge rate. Hence the importance of determining recharge rates.

When detailed water resource investigations are carried out recharge and permeability values are determined. Appendix B provides a summary of the results of such investigations for Minyerri and Ngukurr.

6.6 Groundwater discharge and dependent ecosystems

All isolated springs in the map area maintain lush vegetation pockets which are refuges for wildlife. These are groundwater dependent ecosystems.

One way groundwater discharges is through springs. Springs and seeps are marked on the water resource map. Manbilila spring located south-west of Ngukurr is a localised spring as it discharges from one point but groundwater can also discharge as diffuse flow along a river bed. Diffuse or streambed seepage is where a stream cuts through an aquifer allowing water to drain into the stream. The area of drainage forms the discharge zone, which is marked by a gradual downstream increase in river flow. Another less obvious way in which groundwater discharges is through evapotranspiration. Plants can tap into groundwater when it is shallow enough and similarly groundwater can be directly evaporated through the soil when it is within metres of the surface.

Springs occur where the water table is at or above the ground surface. They can be permanent (perennial) or periodic (ephemeral) due to fluctuations in the local water table. Invariably denser vegetation communities (ie rainforests) occur at these springs. Such communities are dependent on groundwater. Riparian (riverbank) vegetation can also be reliant on groundwater although it may not be situated in a spring area. O'Grady et al. (2002) in their study along the Daly River found Silver-leaved Tea Tree (Melaleuca argentea) and Freshwater Mangrove (Barringtonia acutangula) were associated with river banks with shallow water tables and were shown to be reliant on groundwater. O'Grady et al. (2002) state that 'further work is required to fully assess the level of groundwater dependency and the environmental flow requirements of riparian vegetation'.

Localised springs and streambed seepages located outside of the map area provide perennial flow to the upper Roper and Wilton Rivers. Water loving ecosystems have flourished along these rivers and can be considered dependent on the groundwater. Rainforest vegetation communities associated with riparian zones and springs have been mapped throughout the Top End (Russell-Smith, 1991) and are shown on the Water Resource maps. These are likely groundwater dependent ecosystems.

The lack of spring discharges in the map region reflect the generally low recharge rates in aquifers with low permeability and storage capacity. Most springs in the region discharge less than 10 L/s by the end of the Dry. Four types of springs have been recognised in the mapped region and an overview is provided below.

Contact Spring

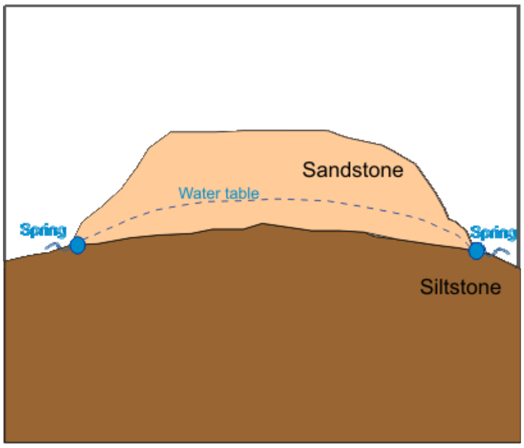


Figure 6.10 Springs resulting from a more permeable rock overlying a less permeable rock.

Plate 6.4 Example of a contact spring: Seep discharging from the Hodgson Sandstone which overlies the impervious dolerite. The spring is marked by the lusher vegetation. (Google Earth)

This type of spring arises where a more permeable rock such as sandstone, lies above a less permeable rock such as siltstone or dolerite (Figure 6.10). Water stored in the upper layer seeps out at the contact between the two rock types because it is unable to penetrate into the lower layer. This is generally in the form of a seepage zone or swampy area at the contact. Seepage over an area will eventually coalesce to form a creek. Occasionally there will be a discrete spring or permanent waterhole. These springs are often seen at the base of escarpments and provide water to rainforest pockets (Plate 6.4).

At times the groundwater in sandstone escarpments does not break out in the form of a spring but comes close to the surface. These areas are often marked with lusher vegetation as tree roots find their way to the watertable (Plate 6.5). Such vegetation can effectively be considered a groundwater dependent ecosystem.

Plate 6.5 Vegetation flanking Bukalorkmi sandstone escarpment.
(Google Earth)

Depression Spring

This type of spring results when the water table is intersected by a low point in the landscape such as a valley or creek bed allowing drainage to occur from the surrounding rock, such as fractured and weathered sandstone (Figure 6.11). Sometimes the low point in the landscape is resultant of a fracture or fault and the aquifer can be very localised to that feature. Locating faults and fractures often requires specialist advice. Not all bores drilled in fractures will yield a water supply. The springs can be a temporary feature after periods of good rainfall.

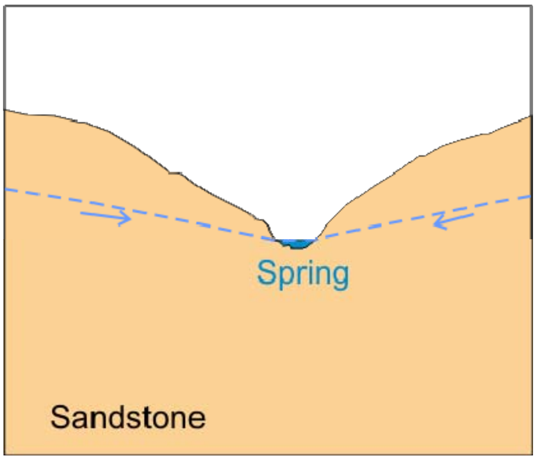


Figure 6.11 Spring emerging from a low point in the landscape.

Karst Spring

In this spring type the aquifer that feeds the spring is developed in the more permeable underlying rock, and in this particular case that rock is dolomitic. Acidic recharge waters dissolve the dolomite resulting in karstic development such as caverns and sinkholes allowing an aquifer to develop. The spring emerges where the dolomite outcrops.

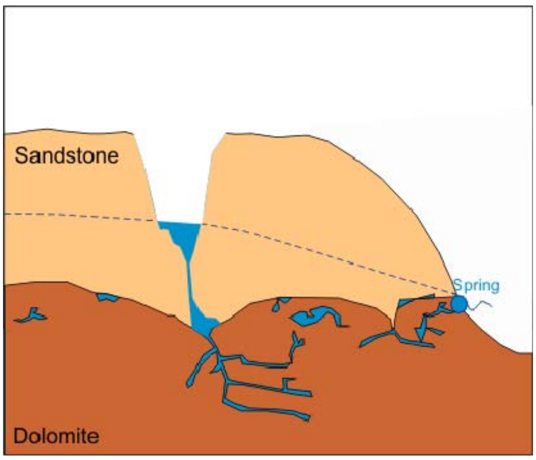


Figure 6.12 Spring discharge from a karstic aquifer

Fault Spring

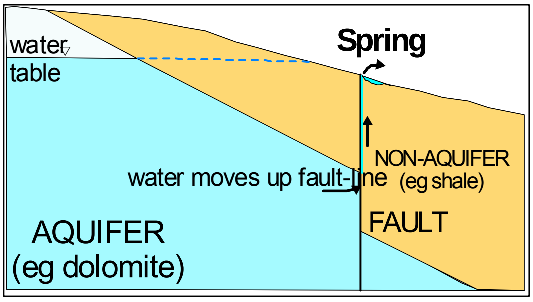


Figure 6.13 Spring discharge from a fault.

This type of spring occurs when a geological fracture or fault provides a pathway to allow groundwater to rise to the surface, in areas where it is normally confined beneath a low permeability rock. Sometimes hot water emerges from these springs because they are sourced from some depth below the surface.

6.6.5 Occurrence of springs

Contact and depression springs occur in the Bukalorkmi, Hodgson, Bessie Creek and Bukalara Sandstones. There is some void space in these sandstones, due to fractures and weathering, but since the voids are only small, only a small amount of water is able to be stored and can only move through slowly. In other words it has a low permeability. This means that the springs that emerge from these sandstones have small discharges. Examples follow.

The Bukalorkmi Sandstone

Plate 6.6 Spring fed waterhole which supplies Roper Valley

At Roper Valley Station springs emerge from the Bukalorkmi Sandstone which lies above the Kyalla Formation (siltstone and mudstone). The springs maintain a waterhole which supplies Roper Valley Station (Plate 6.6). In September 2007, discharge was less than 1 L/s with an EC = 50μS/cm. The Bukalorkmi Sandstone is also present on Flying Fox Station where seeps emerge from the escarpment and maintain small rainforest pockets. In fact it is the lusher vegetation around a seep that provides an indication of its existence.

The Hodgson Sandstone

The Hodgson Sandstone overlays the Jalboi Formation which consists of fine grained sandstone and siltstone. Angus Spring and the springs at Jawa discharge from the Hodgson Sandstone (Plate 6.8). At Jawa discharge in one channel was estimated at 1 L/s in September, 2007 with an EC = 34μS/cm (Plate 6.7). There are many seeps associated with this sandstone in the Roper River region.

Plate 6.7 Clara Hall, standing by a spring fed creek at Jawa.

Plate 6.8 Satellite image showing the lush vegetation lining the spring discharges at Jawa. (Google Earth)

At Wongalara Station the seeps noted on the water resource map all discharge from the Hodgson Sandstone. Many of the seeps are also associated with faults. Faults or fractures provide added permeability to rocks. Fractures are clearly evident also at Jawa.

The Bessie Creek Sandstone and the Bukalara Sandstone

The Bessie Creek Sandstone overlays the impermeable Corcoran Formation and hosts the springs at the Ruined City. The small spring flow at Bella Glen Creek discharges from the Bukalara Sandstone (Plate 6.9). The flow was estimated at less than 1 L/s in September, 2007 and EC = 75µS/cm.

Plate 6.9 Spring fed waterhole on Bella Glen Creek

Karst springs are likely to occur in the areas marked with aquifer type 'Fractured and Karstic Rocks'. In these areas the aquifer has developed in the connected cavities of the dolomitic Nathan Rock group which lies beneath the Phelp Sandstone. Manbilila spring is the largest spring in the Roper River Region. The spring may be an example of a karst spring however because it is located at the intersection of several faults it could be a combination of a karst spring and fault spring. It is possible that in this region the faults have not only enhanced the permeability of the aquifer but also provided a conduit for groundwater to flow from this aquifer and converge at Manbilila spring. The spring supplies water to Larrpanyanji outstation and discharges to Tollgate Creek. In September 2007 it was discharging 118 L/s with a typical dolomitic water quality (EC=649μS/cm).

Plate 6.10 Manbilila Spring.

Although not visited by the survey team, the spring called Wamarlirr that Stephen Roberts describes as being so hot that you can make tea from it is likely to be an example of a fault spring. Stephen explained it was located near Peter Yard and indeed a number of faults are located in this area.

7. SURFACE WATER

The major surface water resource in the area is the Roper River. Dry season flow in this river is supplied by groundwater discharges outside the map so within the map area the river is a losing stream which can cease to flow in its lower reaches. Most of the other rivers dry out or cease to flow by the end of the Dry season limiting supplies to waterholes.

Surface water occurs as rivers, springs, lakes and billabongs and can be characterised into two main sources: directly from rainfall and rainfall runoff; or from groundwater discharge which provides baseflow to many rivers in the Top End (Figure 7.1).

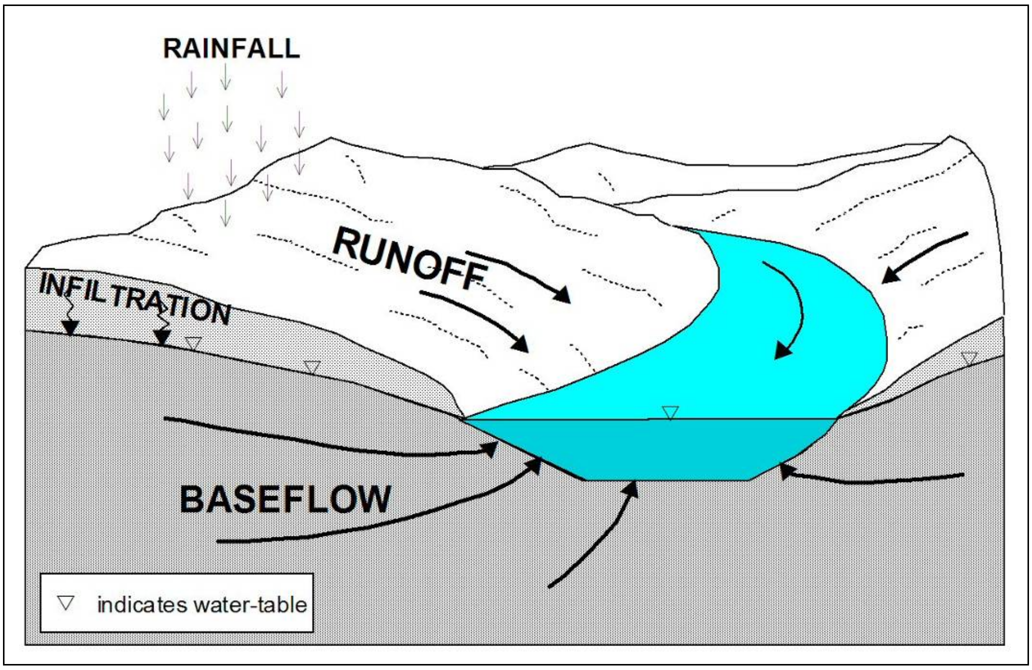


Figure 7.1 Runoff and Baseflow Components of Surface Water

When examining surface water occurrence it is important to distinguish between these two sources. Surface water derived only from wet season rainfall and runoff will only persist if storage is adequate to last through the Dry season: waterholes, lakes, dams all need to be deep enough to account for the high evaporation rate and months of negligible rain. It is the baseflow component that keeps rivers and creeks flowing through the long Dry season.

Flow in a river is often presented as a hydrograph, which usually shows daily or monthly variations in water flow or height. Figure 7.2 depicts the variation in flow for Roper River at Red Rock in 1995. The two components of baseflow and runoff are easily distinguished. The baseflow component of flow slowly diminishes as the Dry season progresses. This is because less groundwater discharges to the river due to the lowering of the water table (Figure 7.3).

One way a river can be classified is by whether it gains water as it flows downstream, which is called a gaining stream or loses water as it flows downstream which is called a losing stream. In gaining streams water is often sourced from groundwater discharging as springs or as diffuse flow (see section 6.6). In losing streams water is often lost through evaporation and transpiration. The Roper River, Wilton River and Flying Fox Creek are losing streams in the mapped area.

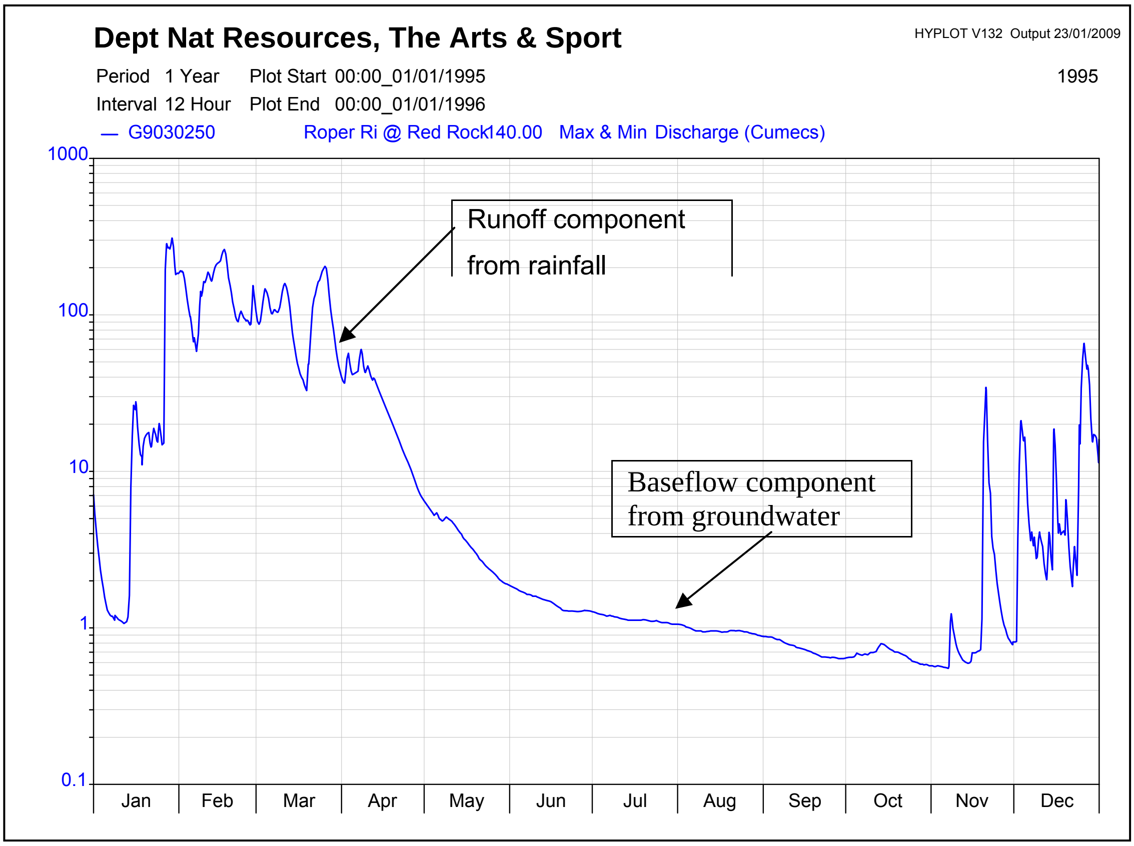
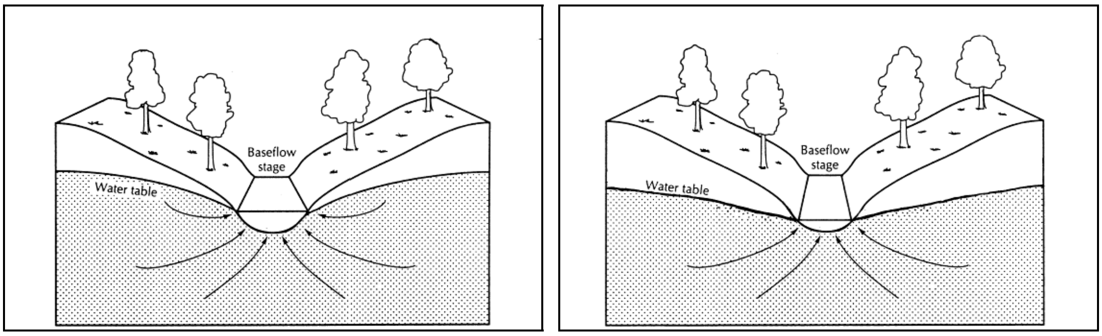


Figure 7.2 **Discharge hydrograph in the Roper River at Red Rock G9030250 in 1995.**



High water table = large flow in river **Low water table = low flow in river**

Figure 7.3 **Effect of Water Table Level on River Flow** (Adapted from Fetter, 1994)

7.1 How surface water sites are recorded

All NRETAS surface water sites have a unique 'gauge station', 'G' number and name eg. G9030250 Roper River at Red Rock. A listing of all the NRETAS surface water sites within the mapped area is provided in Appendix K. The amount of data collected at each site can vary greatly: from one water quality record to detailed water level and quality records over several decades.

The surface water sites marked with a 'G' number on the map include:

- Gauging stations where river height has been continuously recorded and flow measurements made. (See Glossary)
- Gauge sites where a number of flow measurements have been made
- Springs where water quality and flow measurements have been made
- Permanent waterholes where water quality measurements have been made.

The continuous height record generally spans from 1963 to 1986 (See Appendix K for details). G9030250 Roper River at Red Rock is the only site in the map area where river level is still continuously recorded. The tidal limit of the river is approximately 8 km downstream from G9030250 at Roper Bar. Here the river is subject to water level changes due to tidal influences but is normally not salt water. Usually the water begins to become brackish another 70 km further downstream from Roper Bar. G9030250 is therefore a key site on the river as it provides height and flow data at the lowest reach of the river above the influence of the tide. Similarly G9030012 Roper River Police Station[2] is a key site as it was located just upstream from Roper Bar.

7.2 River Catchments

…I observed a green belt of trees … and on riding towards it, I found myself on the banks of a large fresh water river from 500 to 800 yards broad, with not very high banks…The water was slightly muddy, as if a fresh had come down the river; and the tide rose full three feet. It was the river Mr. Roper had seen two days before, and I named it after him… Ludwig Leichhardt (1847)

The Roper River catchment dominates this map. The map covers approximately one third of the entire surface water catchment of the Roper River centred on the lower reaches of the river including

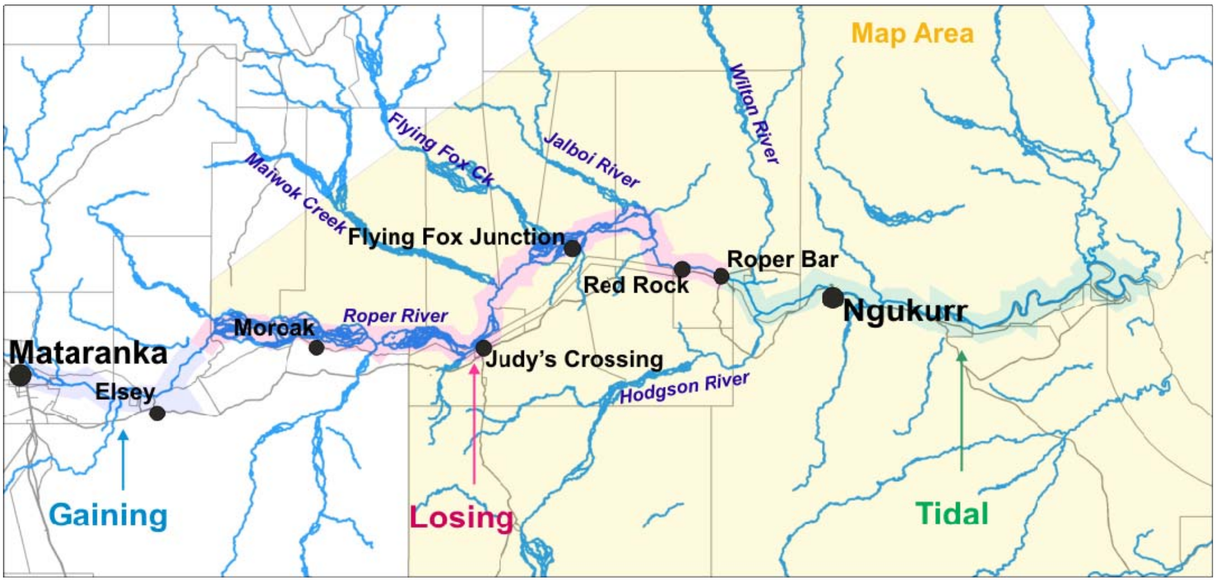


Figure 7.4 Roper River and tributary location map. Gaining, losing and tidal sections of the Roper river.

[2] In the early years flow and level measurements were made at G9030012, but this site was abandoned and replaced by G9030250 for this lower stretch of the river from 1966.

its estuary and mouth. Areas of other smaller catchments are represented in the south-east of the map; the Towns River and the Limmen Bight River. Little surface water information is available on these smaller catchments, which by the end of the dry season contain little if any flowing water. Within the map area, only the upper reaches of the Roper River are perennial whilst most of the adjoining tributaries cease to flow in most years. These tributaries include Maiwok Creek, Hodgson River, Flying Fox Creek, Jalboi River and Wilton River (Figure 7.4). Of these, the Flying Fox Creek and the Wilton River can continue to flow throughout the year in wet eras. Flow data for the site on the Wilton River G9030146 and Hodgson River G9030102 is presented in Appendix K. Perennial tributaries in the region, Tollgate Creek and Phelps River have limited flow measurements (Appendix K). These two rivers are perennial in their upper reaches buttheir flow does not always reach the Roper River.

7.3 Availability of river water

7.3.1 Mapping minimum baseflows

To gain a perspective on water availability from a river, it is necessary to examine the variability in annual minimum flow at sites along a river over the years. This work has only been undertaken for the Roper River, in section 7.3.3, because of its perennial reaches and good data availability. Most of the adjoining tributaries within the mapped region cease to flow in most years. To provide an overview of water availability all rivers on the Water Resources map have been plotted according to their minimum flow, thereby reflecting the environment at its driest. It is intended to raise awareness of how supplies from these rivers can be limited. In cases where there was little recorded data, site visits, flow gaugings and local knowledge were used to determine minimum flows. Local knowledge proved vital to this task as this project was conducted during a period of above average rainfall and higher than minimum flows were observed in most rivers. The minimum flow categories of some rivers have been estimated from anecdotal evidence or scientific interpretation, as not all sites could be visited during the project duration. There are four categories of minimum flow shown on the water resource map:

River with a minimum flow of 100 L/s at the end of the Dry season

Only the upper Roper River is listed under this category. The river section shown on the Water Resource map is dominated by braiding.

Plate 7.1 Roper River adjacent to Moroak Station.
Rodney Metcalfe measuring the flow at site G9030123.

River with a minimum flow between 10 and 100 L/s at the end of the Dry season

Plate 7.2 Tollgate Creek

Tollgate Creek, the upper Phelp River, the upper Wilton River and a section of the Roper River are marked under this category.

River with permanent waterholes or flows up to 10 L/s at the end of the Dry season

Plate 7.3 Wilton River

Rivers in this category have potential to provide small supplies. It includes rivers which cease to flow, but maintain permanent waterholes which can provide a supply throughout the year. The lower reaches of the Wilton and Roper Rivers have been included in this category because in drier periods they cease to flow.

River which is dry at the end of the Dry season

Plate 7.4 Turkey Lagoon Creek

These rivers are not suited to supply water reliably throughout the year. Although most of the rivers in this category are dry by the end of the Dry season some of them may continue to flow throughout the year after periods of average and above average rainfall, but will dry out in drier times. Rivers which can have long stretches of dry riverbed with only the occasional waterhole are also marked under this category. Where possible these isolated permanent waterholes are marked on the map.

The water resource map is dominated by rivers which are dry or have permanent waterholes or flows up to 10 L/s by the end of the Dry season. This reflects the major aquifer type in the region, that being 'Fractured and Weathered Rocks'. These aquifers have low yields and hence supply minimal groundwater discharges to rivers which drain from them.

7.3.2 Baseflow Water Quality

Baseflows of major rivers within the map sheet are sourced from carbonate aquifers which lie outside of the map sheet. The baseflow in the Roper River is sourced from the Tindall Limestone aquifer, and the Wilton River and Flying Fox Creek (when flowing) source their baseflow from the Dook Creek Formation which is a dolomitic Formation. The baseflows of the Phelp River and Tollgate Creek are also sourced from carbonate aquifers. The baseflow water quality for these rivers reflect their carbonate content with pH > 7and EC >300µS/cm. Water quality details of sites along each river are provided in Appendix L. Baseflow water quality readings are those undertaken in the Dry season.

7.3.3 The Roper River

There is a foreseeable high demand for groundwater in the Mataranka region by horticulturists for irrigation. It is this groundwater, that discharges from the Tindall Limestone aquifer, that provides baseflow to the Roper River. It follows that if you extract the groundwater then there is less supply to the river. In order to establish how much water can be made available for extraction, first the dynamics of the river and the ecosystems that depend on it must be understood. We need to ask: how much water is required to maintain this healthy river system? To make a start to answering this question we need to know:

- How much water is used by the natural environment along the river and
- What happens if there is less flow in the river?

The answers to these questions is discussed following.

Environmental flow losses along the Roper River (Baseflow variation along the Roper River)

Around Mataranka the Roper River is a gaining stream however once the river no longer crosses the Tindall aquifer (on Elsey station) there are no further groundwater discharges to the river and the river becomes a losing stream (Figure 7.4). In wetter years some tributaries do add flow to the river downstream from Elsey station, but overall the river continues to loose flow. The amount of flow loss to the environment in sections of the river can be calculated because flow has been measured at sites along the river between Mataranka and Red Rock in a number of years. Table 7.1 provides the data for the driest periods when flow gaugings have been undertaken. Note the increase in flow between Mataranka G9030176 and Elsey Station G9030013, and then how flow decreases. The data shows that when flow is about 1 m^3/s at Mataranka G9030176 or 2.5 m^3/s at Elsey G9030013, there is no flow at Red Rock G9030250 or Police Station G9030012, and when flow falls below 2.5 m^3/s at Elsey then no flow occurs further upstream of Red Rock. One report from 1970 (Water Resources file; G9030123, F21[3]) states:

[3] F21 denotes the Folio or page number in the file. Files are kept by NRETAS.

'…the flows indicate that Moroak is the lowest station down the river with a guaranteed perennial flow with an assumed reliable flow of about 12 cfs (0.34 m^3/s). It appears that when Moroak is reduced to about 19 cfs (0.54 m^3/s) then Judy Crossing has CTF (cease to flow)'

Although there is only one file record of Judy Crossing (G9030010) at cease to flow (CTF) (1963), the low flows in 1953, 1955 and 1962 at Mataranka and Elsey infer that CTF occurred at Judy Crossing in these years as well (Table 7.1). These records make us aware that CTF conditions can exist in the river not only at Roper Bar but for 65 kilometres upstream at Judy Crossing. After two decades of minimal or no flow at the end of the Dry, it was not until 1975 that good baseflows returned to the river following 3 years of well above average rainfall.

Table 7.1 Recorded flows (m^3/s) at sites along the Roper River in the driest periods.
In these years the river ceased to flow or came close to ceasing to flow at G9030250 or G9030012. Sites are ordered from upstream to downstream. The date the measurement was made is provided under each record. Flows marked in red have been ascertained from the water level record.

	Mataranka **G9030176**	Elsey **G9030013**	Moroak **G9030123**	Judy Crossing **G9030010**	Flying Fox Junction **G9030011**	Red Rock **G9030250**	Police station **G9030012**
1953		0.589 10/9/53					0 Inferred from low upstream flow
1955		2.15 4/9/55					0 Jul- Sep Noted F6 G9030012
1962	0.765 24/10/62						0 Late March Noted F34 G9030250
1963	0.99 24/10/63	2.35 24/10/63	0.396 24/10/63	0 October Noted F21 G9030123	0 October Noted F21 G9030123		0 30/10/63 Noted F32 G9030012
1964	0.821 2/9/64	2.18 3/9/64	0.411 3/9/64				0 July Noted F34 G9030250
1966	0.963 7/7/66					0 13/11/66 Noted F9	
1967	1.09 12/8/67	2.52 18/8/67	1.55 14/8/67			0 16/11/67 Noted F19	
1968	0.985 4/11/68	2.52 4/11/68	1.08 4/11/68			0.13 Dec	
1969	1.08 4/12/69	2.79 4/12/69	1.01 4/12/69	0.462 3/12/69	0.309 30/11/69	0.04 Dec	.084 29/11/69 Noted F59 G9030012
1970	0.852 17/10/70	2.07 25/11/70	0.705 7/12/70	0.263 16/10/70	0.102 17/10/70	0 10/9/70 Noted F58/9	
1971	0.977 13/8/71	2.53 13/8/71	1.16 17/8/71	0.759 13/8/71	0.532 12/8/71	0 Oct	

All recession (low flow) gaugings undertaken at successive sites along the Roper River are provided in Table C1 (Appendix C). An overview of baseflow variation over the years is shown in Figure 7.5: note the large differences in flow between 1963 and 2007. In 2007 and 2008 the flow at Roper Bar did not drop below 2 m^3/s. These are the largest annual minimum flows recorded at Red Rock and Roper Bar (Appendix C).

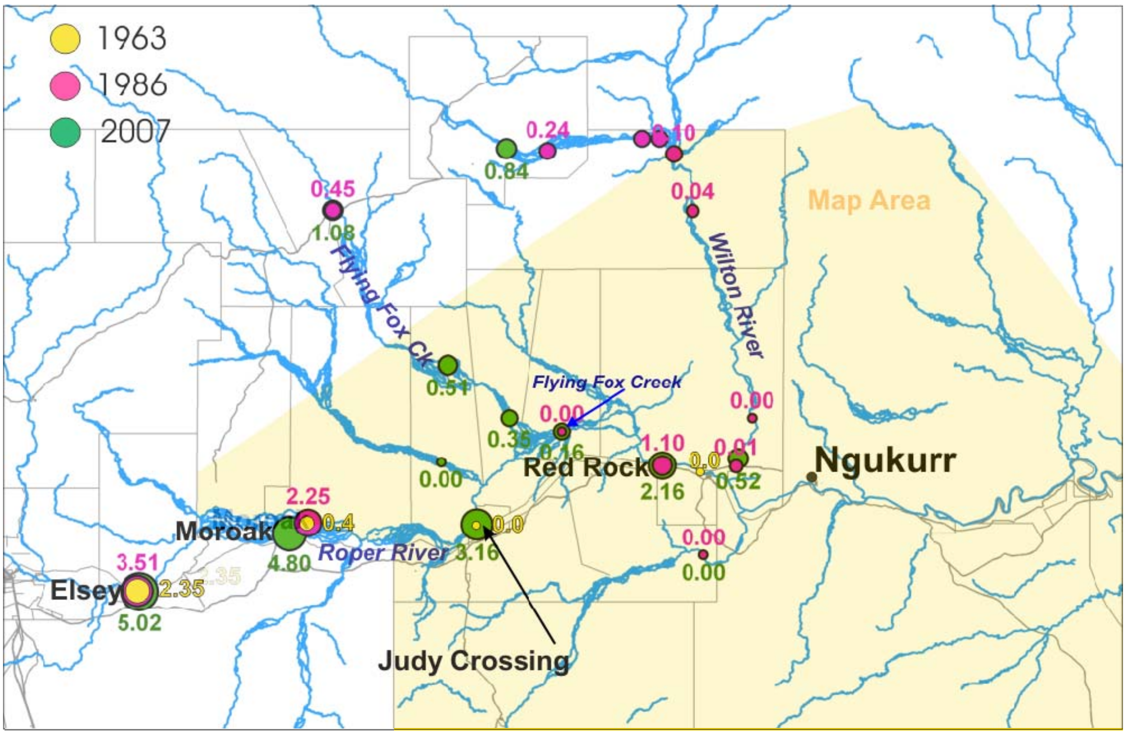


Figure 7.5 Measured discharge in m^3/s (cumecs) in the Roper River catchment in 1963 (October), 1986 (May-June) and 2007 (November).

Analysis of flow losses and environmental water use in sections of the Roper River

To improve our understanding of flow losses and environmental water use along the Roper River each section of the river between gauge sites was analysed separately. Regression analysis of flow between two gauge sites (x was the upstream site and Y the downstream site) was undertaken. The y-intercept from the regression analysis can provide an estimate of the loss between each section. The average difference in flow was also calculated (Appendix D). In analysing all the available low flow data as listed in Table C1 (Appendix C), two distinct groups emerge (Figure D1); 1963 – 1991 data in which the average rainfall is equivalent to the long term average rainfall, and 2007 – 2008 data which was part of an extremely wet period which ran from 1997-2008 (Table D1, Appendix D). Data analysis was undertaken for each period separately. Table 7.2 provides a summary of the results for the 1963-1991 period only, as it better reflects the characteristics of the environment under average conditions. A detailed discussion of results for each river section for each period is provided in Appendix D.

As water flows along the river it is evaporated from the surface and used by riparian vegetation through transpiration. As riparian vegetation typically occurs as a relatively thin strip close to the river, the water lost to evaporation can provide an estimate of the environmental losses (Table 7.2). This can then be compared to the actual flow losses. Losses due to stock and domestic use were not considered here as it would have minimal impact on the flow.

Table 7.2 Losses between gauging sites on the Roper River (m3/s). Statistics calculated on gaugings undertaken between 1963 to 1991. Details provided in Appendix D.

River Section:	**A Elsey - Moroak**	**B Moroak - Judy Crossing**	**C Judy Crossing - Upstream Flying Fox junction**	**D Downstream Flying Fox junction - Red Rock**	**Total Elsey-Moroak**
Regression Analysis:					
Y-intercept (m^3/s)	**-1.51**	**-0.34**	**-0.12**	**-0.31**	**-2.28**
Gradient	1.03	0.93	0.83	1.26	
R squared	0.72	0.94	0.91	0.97	
Average difference in measured flow (m^3/s)	**-1.42**	**-0.47**	**-0.25**	**-0.16**	**-2.3**
Evaporation calculation					
Approximate distance between sites(km)	55	40	41	35	
Estimated river width (m)	60	60	60	60	
Evaporation loss at 7mm/day over section (m^3/s)	-0.3	-0.2	-0.2	-0.2	
Evaporation loss due to Wetland (m^3/s)	-0.9				
Total Evaporation loss (m^3/s)	**-1.2**	**-0.2**	**-0.2**	**-0.2**	**-1.8**
Comment	Large wetland followed by braids for 2/3 of the section	Well braided in about 1/3 of this section	Well braided in about 1/3 of this section	Two main channels in upstream part of section	

Between the Elsey and Moroak sites there is a large wetland situated north and south of Red Lily Lagoon. Evaporation losses from this wetland are significant and have been estimated at 0.9 m^3/s (Appendix D). The results in Table 7.2 show that evaporation can account for most of the loss in flow between each river section. The evaporation estimate is particularly similar to the average decrease in measured flow for sections A, C and D. Section B shows greater disparity however this could be due to the effects of braiding (See Appendix D). An areal overview of measured loss and estimated evaporation loss between sites is provided in Figure 7.6. The total evaporation loss (-1.8 m^3/s) is close to the total average difference in measured flow (-2.3 m^3/s) and the total loss based on the regression analysis intercepts (-2.28 m^3/s). Considering measurement errors, extra losses to transpiration and estimates in the evaporation calculations (evaporation rate, estimated river length and width, braiding), the calculations do provide evidence that evaporation is the primary cause for the decreasing flow along the river. In summary, the natural environment through evaporation and transpiration can account for the 2.3 m^3/s decrease in flow in the Roper River between Elsey Station and Red Rock.

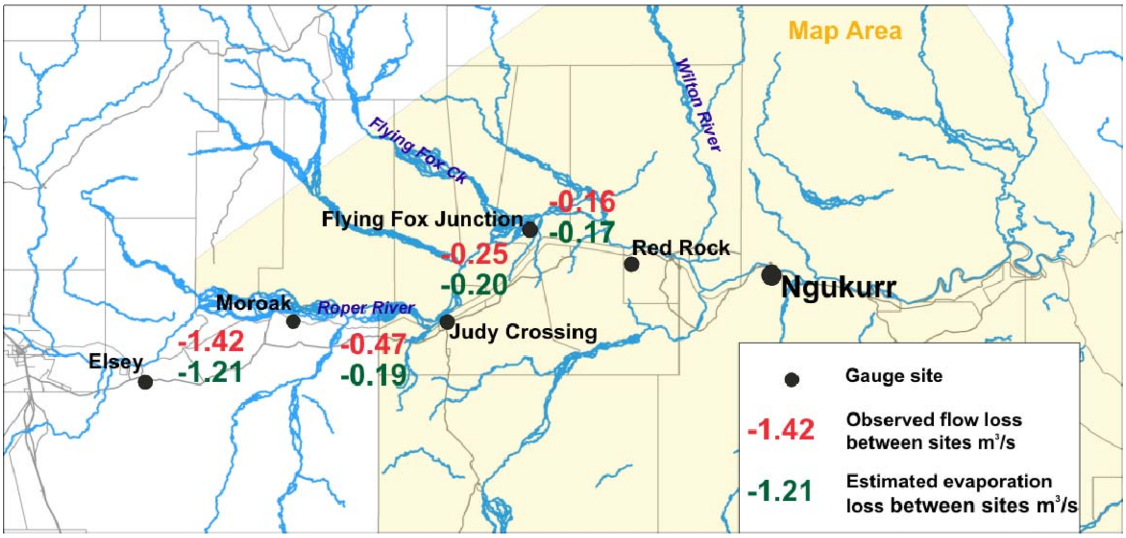


Figure 7.6 Average measured loss and estimated evaporation loss between gauging sites on the Roper River. (Assuming one river channel)

In each section between Moroak and Red Rock the flow losses are higher in the wet period compared to the average rainfall period (Appendix D). Put simply, the higher the flow the higher the loss. This may be due to the river spilling over into more channels in the braided sections of the river when flow is greater resulting in a greater water surface area and higher evaporation losses.

Baseflow variation in the Roper River at Red Rock

The previous section detailed how flow varied along the Roper River between Elsey and Red Rock. This section examines how low flow has varied at one site, that being Red Rock, over the years. This site is well placed in providing annual minimum flow information for the river as it is located approximately 10 kilometres upstream of the tidal section of the Roper River. The variability in minimum flow is important when determining how much water is available to be extracted from the river. The gauging station at Red Rock has a long height and flow record dating back to 1967. The continuous record of flow[4] for this site is provided in Figure 7.7 which shows that in the late 60's and early 70's the Roper River at the site either ceased to flow or had a low minimum flow, whereas in the late 90's and early 2000's it had a high annual minimum flow, mostly over 1 m^3/s. This variation is due to variations in rainfall.

[4] Continuous flow record isobtained from translation of continuous height record at G9030250 by use of a (rating) table which relates height to flow. The table is produced from actual flow measurements and height records.

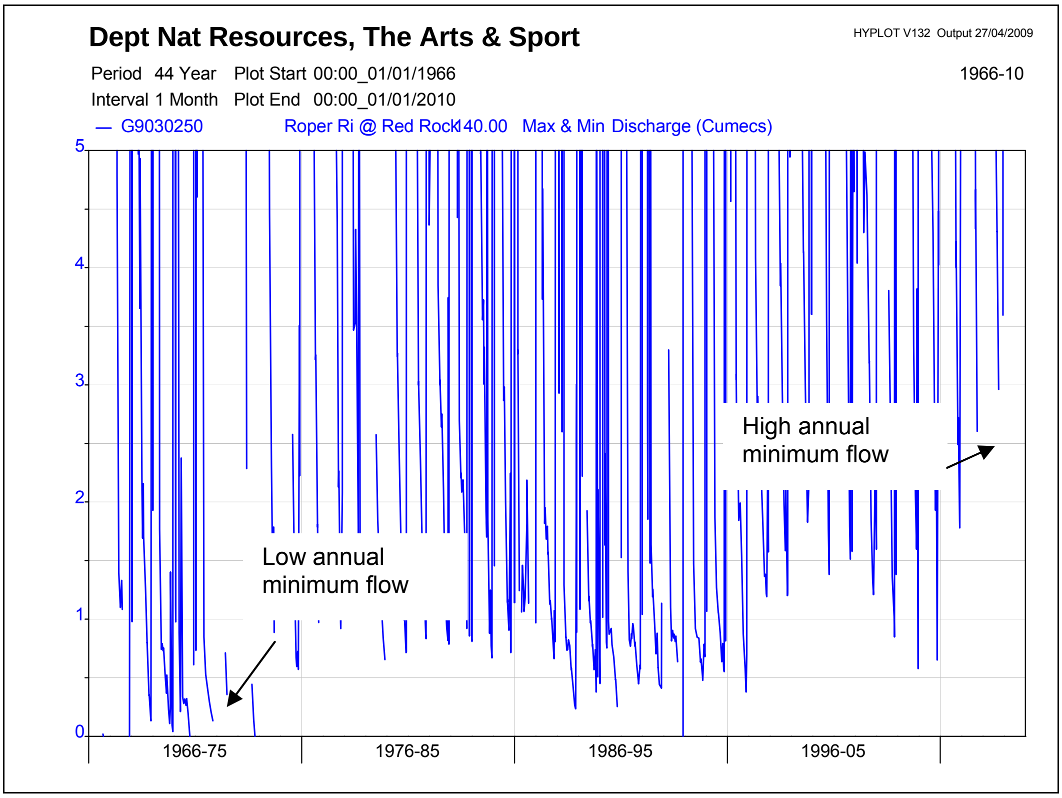


Figure 7.7 Flow in the Roper River at Red Rock GS9030250 since 1967.

In years of high rainfall, such as the late 90's, there was better recharge to the Tindall aquifer resulting in higher groundwater levels, thereby providing higher baseflows and minimum annual flows to the Roper River. This rainfall[5] – groundwater level – minimum annual river flow relationship is depicted in Figure 7.8. The 5 year moving average[6] of rainfall is provided in the figure to smooth out the year by year fluctuations and show the trend clearly. Because no long term groundwater level data is available for the Tindall aquifer at Mataranka, levels from RN022006 which is situated in the aquifer, although in the Venn district, are shown in the figure (See also Appendix F). Note how the trend in rainfall parallels the variation in recorded groundwater level in RN022006 and the recorded minimum river flow at Red Rock. The cumulative effect of high rainfall and recharge since the 90's has resulted in exceptionally high groundwater levels and minimum flows in the 21st century.

As part of the Gulf Water Study a computer based water resource (integrated surface water – groundwater) model was developed which models the surface water and groundwater resources, and their interplay, in the entire Roper River catchment. This work is described in Knapton (2009). The model can predict groundwater level and river flow based on rainfall. Predictions from the model are provided in Figure 7.8 for the available rainfall record thereby providing a historical perspective. Note how well predicted and observed values coincide.

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[5] Mataranka rainfall obtained from Bureau of Meteorology Data Drill rainfall data for Mataranka location. Details are provided in Appendix 3.

[6] The 5 year moving average rainfall for year X = sum of the rainfall for year X and the previous 4 years divided by 5.

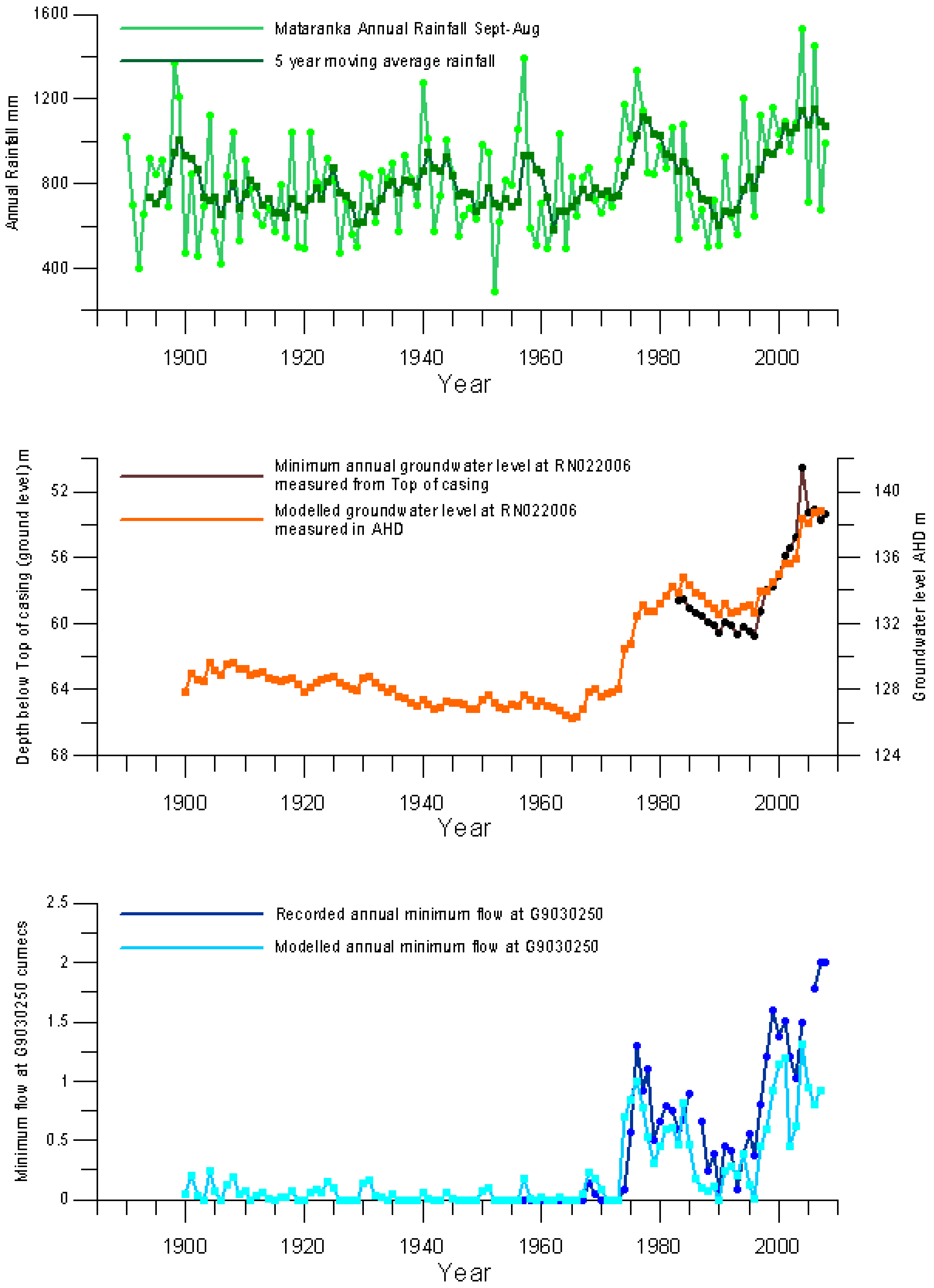

Figure 7.8 Comparison of Mataranka annual and 5 year moving average rainfall to actual and modelled groundwater level and minimum flow in the Roper River at G9030250. Predictions were provided by the water resource computer model and supplied by Knapton (2009)

The results show that for the last decade we have been living in times of unusually high rainfall whereas a drier environment with accompanying lower groundwater levels and river flows is more the norm for the Roper catchment. In fact, results from the model have shown that cease to flow conditions at Red Rock are relatively common; occurring in 48 of 107 years since 1900. The model also showed that no flow occurred for approximately 5% of the time over the 107 years; this equates to 18 days of no flow in an average year (Knapton, 2009). The long term record generated by the model has implications for water use planning and any water allocations must consider the drier times and the water requirements of the environment.

What happens when the Roper River ceases to flow

In the 1950's the water at Ngukurr became too salty to drink. The river at Roper Bar had stopped flowing and the salt water came upstream. Because of this, people in the community had to move to where fresh water was available. Women and children from Ngukurr Mission went to Nyawurlbarr (Mission Gorge) where there is a permanent spring.

(Transcription from interview with Walter Rogers)

Plate 7.5 Ursula Zaar interviewing Walter Rogers.

No flow at Roper Bar can have dramatic consequences to the river as explained by Walter Rogers. Walter's story is substantiated by mission records:

'..at the Roper River drought conditions in 1952 led to the transfer of such Aborigines … to Mission Gorge … In 1954 the Mission experienced further famine as a result of continued drought. Because the river had gone salt the gardens could not be watered' Cole (1968)

As Walter explained, the water quality in the tidal section of the Roper River, which begins at Roper Bar, is dependent on the freshwater input from the river. The amount of freshwater that enters the estuary during both the dry and wet seasons determines the location of the freshwater/saltwater interface in the river. When the interface is stable at a location then there is a balance between freshwater outflow and salt water inflow. From a study undertaken by Knapton and others (2005) it was determined that in 2002 the interface was located approximately 9 km upstream of Kangaroo Island in the Dry season. At this time the minimum flow was 1 m^3/s which was equivalent to the evaporation rate of the upstream freshwater pool (situated between Roper Bar and the interface) hence stabilising the location of the interface. When there is no or little freshwater inflow, the balance is disturbed and the interface migrates up the estuary (Figure 7.9). In years where there was no flow for several months such as those in the 1950's and 1960's (Appendix G), the interface migrated so far up the estuary that Ngukurr community's river water supply was affected. In the 1960's the mission resorted to carrying water from the Wilton River for its supply (Kneebone 1960).

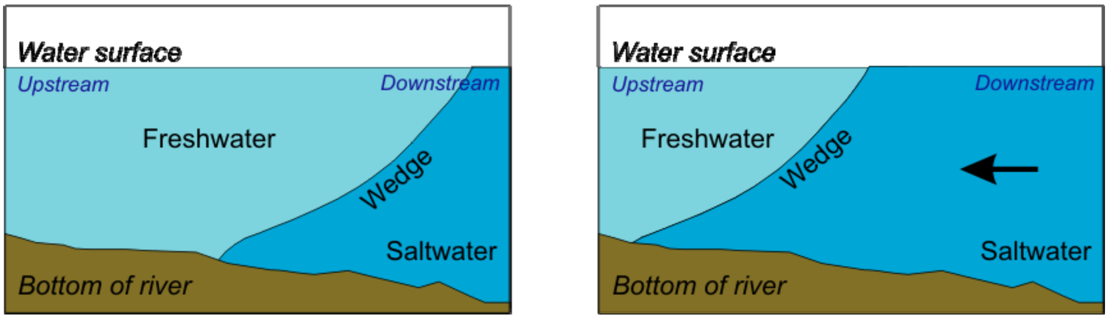

Figure 7.9 The salt water/freshwater interface (wedge) moves upstream when inflow is sufficiently reduced or ceases for a period. Because saltwater has a greater density than freshwater, it moves upstream in the form of a wedge with the leading edge on the river base.

This migration of the salt water/freshwater interface is also well known by indigenous people. The term *wurrunkurrun* is used by the Yanyuwa to describe the brackish water where the salt and fresh water merge. (Baker, 1993) Indigenous people recognise that the location of the interface varies with the seasons and can move upstream as the Dry season progresses. This dynamic is not only recognised in the Roper but also at the McArthur River.

Roper River baseflow water availability

Jolly (2004) undertook a study examining the amount of baseflow available from the Roper River for beneficial uses other than environment. He considered not only the Roper River but also the Tindall aquifer which supplies baseflow to the Roper River.

In his study he undertook a direct analysis of gauging data from Elsey (G9030013) and Red Rock (G9030250) and arrived at a loss of 2.47 m^3/s between the sites, which is similar to the results in Section 7.3.3. Jolly used this relationship to determine the availability of groundwater (equivalent to the baseflow in the Roper River) for extraction based on 80% of flow being maintained at Red Rock. This is one of four approaches that he considers in determining the water available for extraction. All his approaches are based on the then NRETAS water allocation policy in the absence of a water allocation plan. His analysis showed that 'the amount of water available … depends on what location in the river the principles (policy) are applied to'. When he considered the maintenance of Ngukurr's water supply (as Ngukurr pumps from the Roper River) then in 30% of years no groundwater (river baseflow) should be extracted. This shows the critical nature of groundwater extraction and the necessity for effective water allocation planning at Mataranka.

The integrated water resource modelling, undertaken as part of this Gulf Water Study, provides further analysis on this subject. The model shows quantitatively the effects of varying rainfall, as well as the effects of groundwater and surface water extraction, has on groundwater levels and river flow. The model will prove essential to water allocation planning at Mataranka to ensure healthy rivers.

To sum up, significant groundwater extraction in the Mataranka area during a drier period can:

- result in less discharge to the river (less spring flow to the river)
- which results in less flow downstream in the losing section of the river
- which can cause the river to cease to flow at Roper Bar and further upstream (because of environmental water losses)
- which reduces water availability to users (stations) upstream of Roper Bar
- and which can cause the salt water interface to migrate upstream in the estuary affecting Ngukurr's water supply and potentially the ecology of the Roper River of which we know little about.

In context of modelling results showing cease to flow occurring 48 of 107 years, this would be an expected occurrence.

Water allocation planning for the Roper River must ensure maintenance of the ecological communities that depend on it.

In contrast to limited water availability during drier periods, the wetter periods can present a very different scenario (Plate 7.6). In the last decade there has been exceptional rainfall and correspondingly high baseflows in the Roper River. In fact the flow at Red Rock has hardly dropped below 1 m^3/s. This emphasises the large variation of baseflow in the river.

Plate 7.6 Roper Bar in times of high baseflow. Photo taken 21.7.07.

7.4 Wet Season Flows

In the Wet season, river flows increase due to rainfall runoff. Figure 7.10 provides an example showing how flow in the Roper River at G9030250 Red Rock increases with rainfall events at Mataranka. The increase in flow at a point along the river is dependent upon the rain that has fallen in the catchment upstream from that point. For the same amount of rainfall, larger catchments have larger flows. Major catchment boundaries are shown on the Water Resource Map. Appendix K provides plots of the flow record for the gauging stations with a continuous record. Note the large variations in maximum flow over the years. Very large quantities of rainfall runoff discharge along the Roper and its major tributaries most years. This presents a substantial resource.

For further information on rainfall runoff The CSIRO North Australia Sustainable Yields (NASY) project is best referenced. (www.environment.gov.au/water/policy-programs/sustainable-yields) It assesses surface water and groundwater resources in the Roper River under varying scenarios including the historical, recent (last 10 years) and predicted future (2030) climates.

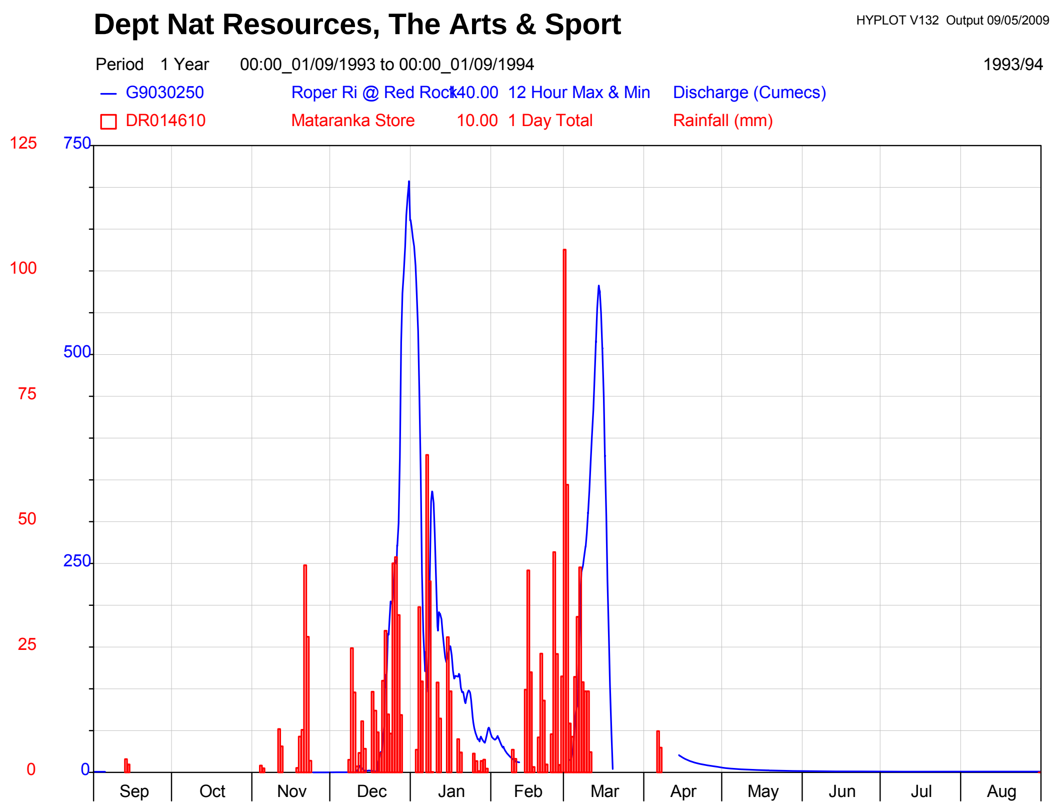

Figure 7.10 Flow increases in the Roper River in response to rainfall.

8. WATER RESOURCE DATA AND AVAILABILITY

NRETAS reports pertaining to this map area are listed in Appendix H and many are available in digital format.

The Water Resource Map that accompanies this report was produced by NRETAS. It can be reprinted at any time and made available to interested parties.

All products of the Gulf Water Study are available in digital format on DVD. The DVD titled 'The Gulf Water Study' contains the following products:

- This report and the reports for the other regions of the study
- Posters pertaining to the study area
- A GIS which uses the program Arc Explorer
- A photographic and video database which is geo referenced

The DVD is available through the Natural Resources Division of NRETAS.

All detailed information on surface water sites is kept on the NRETAS 'Hydstra' database. Requests for such data can be made to: Spatial Data and Mapping Branch, NRETAS Phone (08) 8999446, Email: DataRequests.NRETA@nt.gov.au

All bore reports are available through the internet site www.nt.gov.au/nretamaps. These are regularly updated.

Plate 8.1 Shantelle Tapp enjoying the Roper River.

9. GLOSSARY

Airlift Yield: The rate at which water is extracted from a bore using compressed air down hole.

Aquifer: A body of rock which is sufficiently permeable to conduct groundwater and to yield useable quantities of groundwater to bores and springs

Baseflow: The groundwater contribution to a stream. Baseflow often maintains the flow in a stream over the Dry season.

Catchment: Area in which rainfall collects to form the flow in a river.

Confined aquifer: A confined aquifer occurs where an aquifer is overlain by a confining bed. The confining bed prevents upward movement of the groundwater. Such aquifers are usually completely saturated with water which is commonly under pressure. Therefore when a bore intersects the aquifer, water rises up the bore. If the pressure is sufficient to drive the groundwater above the ground level, the bore is called artesian.

Carbonate rock: A rock such as limestone or dolomite, consisting largely of the carbonate minerals; calcium carbonate or calcium magnesium carbonate.

Consolidate: Any process whereby soft or loose earth materials become firm, for example the cementation of sand or the compaction of mud.

Dhuwa and Yirritja: These are the two moiety names often used in Arnhem Land. Everyone and everything is either Dhuwa or Yirritja. This is one of the fundamentals of Aboriginal culture.

Dolomite: A sedimentary rock composed mainly of the mineral dolomite (calcium magnesium carbonate)

Electrical conductivity, **EC**: The measure of the ability of water to conduct electrical current. The magnitude is directly related to the dissolved mineral content of the water. EC is measured in microseimens per centimetre, µS/cm.

Ephemeral: A creek or river that dries up in the dry season.

Evaporation: The process whereby liquid water turns to vapour. It accounts for the movement of water to the air from sources such as the soil, canopy interception, and waterbodies.

Evapotranspiration: The sum of evaporation and plant transpiration from the Earth's surface to the atmosphere. Transpiration accounts for the loss of water from plants as vapour through its leaves.

Fractured: A fractured rock is one that is broken by joints, cracks or faults.

Gauging station: Site on a stream where direct observation of water velocities, heights or quality are made and recorded. Pictured – gauging station with well, recording river height.

Geology: Science of earth's composition, crust, rocks, origin, structures, historical changes and processes.

Geographic Information System (GIS): A computer system that captures, stores, analyses, manages and presents data that is linked to location. Data can be viewed and accessed using a computerised map.

Geophysics: The use of specialised surveys to give an indication of underlying rock type. Techniques such as magnetics, gravity, electro-magnetics, and seismics can be used on the earth's surface in order to indicate geology.

Groundwater: Water beneath the surface of the earth that is in the saturated zone.

Groundwater dependent ecosystems: A community of plants and animals that rely partially or completely on groundwater for its existence.

Groundwater Discharge: The release of groundwater to the surface by seepage, evaporation or transpiration (from plants).

Hardness: A measurement of the level of calcium carbonate in water.

Hydrograph: A graph that shows water levels or flow in a stream, or the watertable level in a bore.

Impermeable: An impermeable soil, rock or sediment is that in which fluid (water) is unable to pass through.

Jungkayi: People who have responsibilities to their mother's clan, ritual managers of one's mother's country. The term can be translated in English as 'manager', 'caretaker' or 'policeman'.

Karst: A term describing typical geologic/topographic attributes of limestone or dolomite resulting from mineral solution such as caves and sinkholes.

Monitoring/Observation bore: A bore used for measuring groundwater levels.

Ngimarringki: Yanyuwa term for traditional land owners.

Perennial: A stream, lake or waterhole which retains water throughout the year.

Perennial flow: Flow that is retained throughout the year.

Permeability/Permeable: The capability of sediments and rocks to allow water to move through them.

pH: A measure of acidity (low pH) or alkalinity (high pH). A pH of 7 indicates neutrality whereas lower pH levels indicate acidity.

Porosity: The total amount of pore space in a soil or rock.

Primary porosity: Voids in a rock formed when the rock was deposited. The spaces between sand grains are an example of primary porosity.

Recession: The part of the hydrograph where the water level or flow diminishes.

Recharge: Addition of water to an aquifer to become groundwater.

Runoff: Rainwater that leaves an area as surface flow.

Sandstone: A sedimentary rock composed of sand grains cemented together.

Spring: Outflow points for groundwater where the watertable is near or above the ground surface.

Secondary porosity: Voids in a rock formed after the rock has been deposited; not formed when the rock was formed, but later due to other processes.

Siltstone: A sedimentary rock composed of silt sized particles.

Standing Water Level: The level below ground surface, to which groundwater rises in a bore.

Surface Water: Water that is on the earth's surface, such as a stream, river, lake or reservoir.

Sustainable: maintain (without adverse effect)

Topography: The shape and height of the land surface.

Total Dissolved Solids (TDS): The amount of dissolved material in water, usually expressed as milligrams per litre (mg/L).

Unconsolidated: A sedimentary deposit in which the particles are not cemented together.

Water table: Level of the surface of the groundwater. It is often measured in observation bores.

Water quality: Physical, chemical, biological characteristics of water and how they relate to it for a particular use.

Water Year: The water year splits the year from September of one year to August of the next year. Hence the total Wet season rainfall is accounted for.

Wetland: Land which remains wet for a large part of the year.

Yield: Amount of water which can be supplied by an aquifer or pumped from a bore over a certain time period.

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APPENDIX A: INDIGENOUS KNOWLEDGE

'In the Roper, places which are named constitute the manifest embodiment of the Ancestral Creator Beings. What non-Indigenous people to the area call the 'Hodgson River', the locals think of simultaneously as the track of the Mermaids gilyirringgilyirring.' (Baker, 2002)

All cultural perspectives need to be recognised when undertaking land and water management and development. In an effort to present the indigenous cultural perspective pertaining to water, care has been taken to present indigenous place names on the maps and detail cultural information relevant to the places in this report. All indigenous place names relate to the people, their ancestors and the country. It is hoped that aside from producing a cross-cultural user friendly map, non-indigenous readers can gain some insight into the rich heritage of the indigenous people of this region.

The following information was collected during field trips when Traditional Owners were interviewed or accompanied field workers and guided them to water sites. At all times when collecting indigenous knowledge, it was made clear that the information would be public, so culturally sensitive information was not recorded. Where possible, the language of the place name was recorded. Efforts were made to transcribe the names correctly and the Ngukurr Language Centre was very generous in this respect.

Where substantial information was offered by the Traditional Owner, the information is presented individually in alphabetical name order. Some personal details and a photo of the Traditional Owner is shown and this is followed by detailed information and photos of some sites. A table is then provided with location and transcription details of all sites the Traditional Owner discussed. Information from other individuals is presented in tabular form at the end of the Appendix. In the tables it is noted if the site was visited with the Traditional Owner or the location only estimated by use of maps and through discussion. Where there is too much uncertainty on location, no co-ordinates were supplied.

Indigenous and non-indigenous people provided information on water resources and their dynamics that has helped with mapping and scientific understandings. This information such as spring locations and whether or not waterholes are permanent or intermittent is knowledge gained through experience and observation. Such information has been invaluable, particularly as such a vast area was covered and access difficult.

Ancillary to this report, indigenous knowledge has also been documented through photographs and video and is available on the Gulf Water Study DVD.

Sandy August (deceased)

In September 2007 Zaar met with Sandy August and Stephen Roberts at Minyerri to discuss water resources in the region. As the two men related dreamtime creation stories, differences in the stories emerged. Sandy's knowledge is presented here. Stephen Roberts agreed with part of the story sequences.

The journey of the goanna

The goanna travelled along waterholes on Mountain Creek and then further afield. It went from *Mangurwala lagoon to Nyalajirr, Wunduluerr, *Yumanji and then Yilbiya.

*These are the sites Stephen Roberts agreed with.

The journey of a mermaid

The mermaid travelled from *Nyadagarinna to *Jawalada to *Wadamada to Larrdan, Six Mile Waterhole, *Alinginji and then on to Inbarrwa and continued on.

*This part of the journey was related initially by Stephen Roberts but Sandy agreed with it and added the latter part of the journey.

Table A1 Indigenous place names and details supplied by Sandy August

Indigenous name	Site	Comment	Easting	Northing	Transcribed
Alinginji					Naomi Wilfred
Inbarrwa					Naomi Wilfred
Larrdan					Naomi Wilfred
Manguwala	Lagoon/ Waterhole	On Mountain ck			Naomi Wilfred
Nyalajirr	Waterhole				Naomi Wilfred
Wunduluerr	Waterhole				Naomi Wilfred
Yilbiya	Waterhole				Naomi Wilfred

Donald Blitner Warmurringya

Plate A1 Donald Blitner at Ngukurr

Donald is a spokesperson for the Marra area which is located along the coast south of the Roper River. Donald's name 'Warmurringya' relates to Port Roper and the file snake, Donald says 'That's me now'. Donald talked about life in the early days in the Marra area. A summary transcription of this dialogue is presented below.

Ngaralpur is my area, my clan. When the old people passed away Ngukurr had two ceremonies. Both ceremonies are connected to the Roper River. Marra ceremony starts from Port Roper which is Willy Wagtail country and salt water shark country. The salt water shark ended up at Vanderlin Island. I am the last child from my uncle and father. They taught me the ceremony and song, the Willy Wagtail song. It it's a dry time, my old people used to sing the rain song and my uncle and brother in law would sing at the cold weather time for rain. The Jungayi, that is Joshua family for the area have passed away so no ceremony is done anymore. I tell my children about the country and visit it when I can. But no more ceremony. That's the way it goes. My eldest brother knew more than me but he has passed away.

The Marra country was a hard place for water in the old days – the Limmen and Towns River area. We had to go to the special places where there was water, which had to last until we got to the next waterhole. We used to have ceremonies at the main waterholes where we knew water would last us for a couple of months. This was around the Ngukurr and Limmen Bight area. The coastal area was not good for water. We carried water with us in the canoe. We travelled along areas where there was water. We went from Wabarra to the well at Nayarinji then to Namawungu (Port Roper) where a well is, and then on to Gururrulinya (Green Island). Nama-ungu is Willy Wagtail country – that's me. We have a connection with Vanderlin Island.

When travelling up the Limmen Bight River we would get water from Wamungu and then travel to Namanuwal for water.

In the 50's when I grew up I chose to be a ringer. It was in the 40's 50's, 1947 that the river (Roper River) became salty. The jellyfish went right up to Roper Bar. We were not allowed to go to Mission Gorge. All the single boys had to stay here at Yawurrwarda. We used to sterilise the water, get rid of the dust. We would boil it and then put flour or something into the water and that would make all the dust fall down and we would have clean water.

Table A2 Indigenous place names and details supplied by Donald Blitner

Indigenous name	Site	Comment	Easting	Northing	Transcribed
Gururrulinya	Green Island	Water supply here was a swamp. It was the only water supply till Port Roper where there was a well. Wandarang area	512400 As located on Topo map.	8366500	Ursula Zaar
Magarinji	Creek /spring	There are permanent waterholes along this creek.	521100	8332000	Ursula Zaar Spelt Magaranyi on topo map.
Najamarra		Mouth of the Roper River. Marra country.	541000 Location estimated	8373000	Ursula Zaar Marra language
Namawungu	Port Roper	Willy Wagtail country. Marra country.	541000 Location estimated	8373000	Ursula Zaar Marra
Nawarlbur	Waterhole G9045001	Permanent waterhole. This is where my ceremony finishes, it went from the coast to here.	530300	8324000	Existent on Topographic map
Nayarinji	Towns river	Marra country. It is a big area. From the coast to the highway. At the coast there is a well.	540100 Location estimated	8348000	Ursula Zaar
Wabarra	Lake	This is permanent water.	541500	8331000	Existent on Topographic map
Walanbarrungnu	Creek	Site where the highway crosses the Towns river. There are permanent waterholes along the creek.	522800 Location estimated	8337000	Ursula Zaar
Warlngudu (Site was also noted by S. Roberts)	Old St Vidgeon Station	This is my fathers mother country. My grandmother, she is from here. My father was born there.	467700 Location estimated	8337700	Naomi Wilfred
Wamungu	Area	Limmen River at the mouth. We got water from here.	574000 Location estimated	8330000	Ursula Zaar
Wurrumala		Permanent waterhole. Ceremonies took place here. Marra ceremonies.	536900	8309000	Existent on Topographic map
Yumanji	CountryLittle Towns River	There are permanent waterholes along this creek.	519000	8337700	Existent on Topographic map

Cherry Daniels

Plate A2 Jill, Grace and Cherry Daniels at Nyawurlbarr

Cherry Daniels is the senior ranger at Ngukurr. She remembers when the Roper River went salty and they had to live at Nyawurlbarr. She had the following to say about water issues in the area.

The main issues are destruction by pigs, buffalo and pollution by visitors. The rangers have been cleaning these places and fenced three billabongs. These are at Costello, Namiliwirri and Nulawan. Weeds are being controlled such as Mimosa, Parkinsonia, Bellyache Bush and Rubber Bush. The program started in 2005. To kill the weeds we have to camp out in the bush and walk and spray poison.

Arnold Duncan

Arnold Duncan lives at Urapunga. He is a key elder for the Wilton River area. He is a fit man who has worked with cattle most of his life and continues to do so. He guided the field survey team to a seep at Ganggnurngur and discussed water in the area.

Plate A3 Arnold Duncan at Gangngurngur seep

Gangngurngur

This place is called Gangngurngur. Sometimes there is no water here. This was the place where people stopped to get water when they walked form Ngukurr to Urapunga. When the tide is up the spring runs. When it is low tide there is no water seeping.

Table A3 Indigenous place names and details supplied by Arnold Duncan

Indigenous name	Site	Comment	Easting	Northing	Transcribed
Dalkanda	Spring	Permanent running small spring on the eastern side of the Wilton River. Near Ah Cup waterhole.			Ursula Zaar
Damererri	spring	Located further up from Ah Cup waterhole on the western side.			Ursula Zaar
Gangngurngur	Seep	This is where people stopped for water when they walked between Urapunga and Ngukurr.	458941 Visited	8375079	Ursula Zaar
Ginburronni	Waterhole	This is a big waterhole on the Roper River			Ursula Zaar
Laddiladdi	spring	Permanent flowing small spring on western side of Wilton River. Near Ah cup waterhole up the gorge.			Ursula Zaar
Wallanji	Billabong	This is a sacred area that you cannot visit. It never dries, even in the 1950's it didn't dry.			Ursula Zaar
Youlo / Youleu	Lake Allen?	Big permanent waterhole			Ursula Zaar
	Spring at Sandy creek	Permanent spring on Sandy creek. Close to Urapunga station.			Ursula Zaar
	Spring next to pumpkin yard				Ursula Zaar

Roy Hammer (deceased)

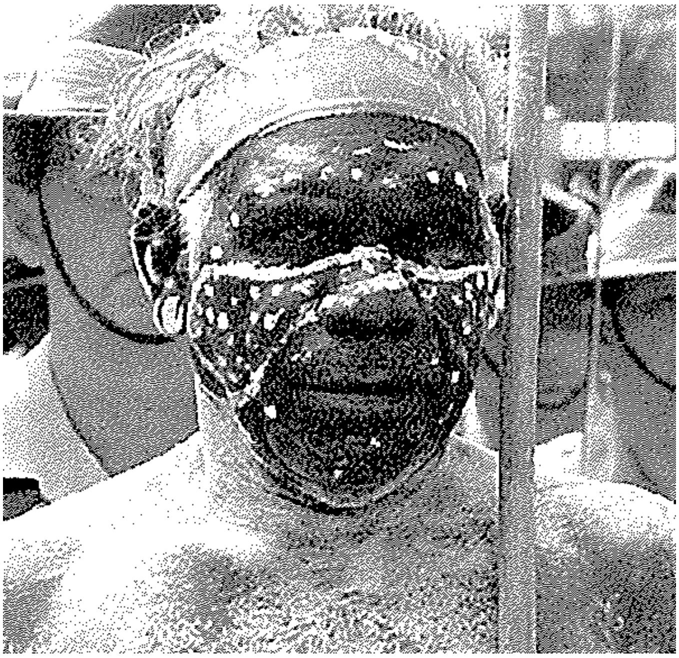

Plate A4 Roy Hammer
(Photo supplied by and with the permission of his wife Violet Hammer)

It was late in November 2007 that Zaar finally met with Roy Hammer. He was an elder of the Marra clan and had worked as a stockman for most of his life. He spent a lot of his time as a stockman on Bauhinia, Billengarah, Nathan River, Hodgson, Nutwood, Tanumbirini, Bing Bong stations and numerous other stations. He was the head stockman at Bauhinia for many years and actually took on the name Hammer after Ken Hammer who was then the owner of Bauhinia. Roy's proper surname is Riley. Roy was a great jockey and was the first man to win the Borroloola cup races twice. He was a very well respected man by all people. He was the Borroloola council President for 6 years. He was well known for his beliefs in, and faultless knowledge of, aboriginal law. He travelled to Japan to show the world his Traditional Dancing. (Information provided by Frank Shadforth, pers. Comm. and memorial service notes) When Zaar interviewed Roy she was impressed by his excellent memory and how he was able to read maps and locate water sites very quickly, naming and describing them. Some of his knowledge of water sites is recorded below.

Wabarra

Plate A5 **Satellite image of Wabarra Lake**
(Google Earth)

This is a permanent freshwater lake located between the Towns and Limmen Bight Rivers. Roy explained that according to traditional indigenous culture the lake was made by a python. The black nosed python (Bubunahdda) came from the Bye Hills and travelled to Wabarra Lake, then to Ngaldja swamp, past Nahwugunnya where the wells are, and on to the reef. Stephen Roberts also agreed that this is the only permanent water for miles.

Wurrumala

Plate A6 & A7 **Wurrumala**
Satellite image (Google Earth) and at site

This is a fresh permanent lake. It is known also as Lake Mary. It is Black nose python dreaming. Wurrumala is a Marra and Yanyuwa word.

Table A4 Indigenous place names and details supplied by Roy Hammer

Indigenous name	Site	Comment	Easting	Northing	Transcribed
Lamahda	Spring	This spring has bubbling fresh water. Roy used to travel by canoe from Namanuwal waterhole which was their camp, to Lamahda spring to get water and then return.	554600 Location estimated.	8316600	Ursula Zaar
Leguldu	Waterholes	These waterholes are permanent	526100 As per 50K topo map	8306000	Already noted on 50K topo map.
Magaranyi River		This river is related to the Barramundi in the dreamtime	503300 As per 50K topo map	8300000	Already noted on 50K topo map.
Nahwugunnya	well	The wells are in the sand along the coast. You have to dig for the water. The wells are located near the pandanus.	557500 Location estimated	8340000	Ursula Zaar
Ngaldja	Swamp				Ursula Zaar
Wabarra	Lake	Lake was made by the Black Nosed Python. Name confirmed by Roy.	541500 From topo map	8331000	Already noted on 50K topo map.
Wamungku	waterhole	This waterhole is permanent and provides water to Maria Lagoon.	547700	8308500	Already noted on 50k topo map
Wunuwanji	Spring	This is a permanent bubbling spring located north east of Maria Lagoon community. It is the plain kangaroo dreaming.	545800 Location estimated.	8310100	Ursula Zaar
Wurrumala	Lake Mary	This is the Black Nose Python dreaming. Name confirmed by Roy.	536900 From topo map	8309000	Already noted on 50K topo map. Marra and Yanywa word.

Stephen Roberts

Plate A8 Stephen Roberts

Stephen Roberts is a well respected elder of the Budal clan. He lives in Minyerri. Having being born in 1925, he experienced a traditional upbringing learning about, and living his culture as it was for thousands of years. He also saw the changes that came with the Europeans. In talking with Stephen one quickly recognises that he has an extensive knowledge of the waterholes over a vast tract of country as he related the names and dreamtime stories of waterholes and their interconnections. The knowledge of the region he provided is documented below.

I lived at the old Mission before it got washed away by the big flood. Then I lived at Old St Vidgeon, Warlngudu. That's where I learnt to be a stockman. Those were the hard times. We did do ceremony. We used to cart salt from Port Roper in the wagon to Warlngudu. We got the salt from a little creek, Naryulgai. Narmawungu is on the Towns River. My old father made a well there for freshwater. Then I went to Nutwood Downs to work. Old Jimmy Gibbs went to Urapunga. That was the time of no money, Johnny cake and corned beef. Hard work but good times. Most of my life I worked on cattle stations. I also worked for the army. I did all sorts of jobs when I was young.

Most places are good for visiting by all people. There are only some important places that people cannot go to. My three grandsons know this – I taught them. The O'Keefe's. I have taught them ceremony and all. They know how to muster cattle. They know the places and the rain song. The Red legged Jabiru, *Garrinji*, rain, kangaroo, sandridge goanna. The three boys are *jungkayi* for this, the master of ceremony. If I tell them to start ceremony then they start. This ceremony no women and kids can see.

Roper river area

The 1950's was the only time that the Roper River went salty at Ngukurr. When travelling by foot from Ngukurr to Minyerri you crossed the Roper River at Roper Bar or you crossed at other locations by canoe and then walked down the Hodgson River. There were always waterholes along the way where you could drink. When we travelled up Mountain Creek we carried a billy can of water because there were long distances between waterholes. When I was young there were lots of ceremonies that took place. Nowadays people smoke gunja and drink grog and they forget about ceremony.

Wadangarda

Plate A9 Wadangarda Lagoon

Stephen was born here in 1925. His father lived in a paperbark humpy here. The dreamtime story relates how the lightning struck here to make the lagoon. This is the same lightening as at Manbilila.

The journey of the quiet snake.

Yurrlu is the top area of the Wilton river. The quiet snake came from here and travelled to Jennewerri and then on to Jawa. From Jawa it then went to Wangananji, then to Larrlingnu
and then to Wamarlirr. Wamalirr is located near Peter Yard. It is a permanent hot water spring that is so hot you can make tea with it. It is smoking. Downstream from it is a permanent cold waterhole. At Wamalirr is the old station, before St Vidgeon, Jimmy Gibbs old station.

The journey of a big mob of mermaids.

The mermaids came from Burrunju and travelled to Nyawurlbarr. From there they travelled to Wallanji swamp then crossed the Roper River to another swamp located at the side of a hill and then on to Wurdawawa where they created the swamp and stayed there for a while. Wurdawawa is an important swamp where ceremonies are held. They continued on to Rocky Crossing, the old wagon crossing on the Hodgson River where a footprint was left, then travelled up the Hodgson River to Wangananji. They met up with the quiet snake there and then went separate ways. There is a lot of black rock there which is related to the crow. The quiet snake went south and made a whirlwind. The mermaids continued to Nyardangarina and Injawan which is a permanent waterhole on the Hodgson river. They then went to Jawalada known as Grassmere Billabong, then to Wadamada waterhole on the Hodgson River. Their travels continued to Alinginji where there is a spring, Mardugurru, Wurrunnalda at Mc Donald lagoon, then to the bottom of Minimere waterhole, a place called Yunbulloy, back to Mc Donald

lagoon, up a gorge to an island Yaldjamandja, to Narliboy Creek and on to Injay waterfall at Hodgson River station. As they danced there they made the waterfall. They danced on the Yindiyindi plain. Their journey finished upstream from Nutwood Downs Station, the Hodgson River being the last part of their journey. The mermaids made the places, they mark the path of the mermaids.

Plate A10 Wurdawawa

The journey of the mermaid (Wandimurrungga).

The mermaid came from Warlngudu and travelled to Wulainji and Yingayin. This is a spring which the mermaid created and where some perished. Then it went to Wurdwurdlajinji and made another spring where it left red ochre and travelled on to Yumanji which is a permanent waterhole on the Little Towns River which has barramundi in it. Some went down the Little Towns river to Garjarlarmirr. This is dry country. They got speared by the mosquitoes there and many were killed. Three of the mermaids went to Wunuloy cave and sat there for a while. When there were no mosquitoes they got up from the cave and went between Nalajirr Hill which is near the main Towns River and Awurrlyarra, the main Towns River. The three mermaids stood up with a pillar on their heads and continued to Yanbarraboyerr on the Cox River and Wanabarlirr. Wanabarlirr is a big swamp and only *jungkayi* can go there. From there they went to Pumpkin Yard plain – Warranyinna, followed a little creek which runs into the Cox River up to Barruganda and went down and stopped.

Part of the journey of another mermaid, emu and brolga.

It travelled to Langaban and then on to Yumanji creek. From here it went to Milgawirri near Peter Yard, which is a flat area and there it left white paint. It then travelled to Wirranna which is a spring right at the top of the Towns River, and then on to Anarwunban.

The journey of the catfish

The catfish came from an island near Groote Eylandt and travelled to Wuyagiba. From there it went to Burrunju, then Wonmarri and then to Lumairrma which is the lagoon at St Vidgeon. The catfish made this permanent waterhole. From here it travelled on to Winnarda, then Lijarwan and on to Namarlil where its journey ended.


Plate A11 & 12 Namarlil and Wanmari Waterholes

Manbilila


Plate AI3 & 14 Manbilila spring and discharge channel

I am the *Ngimarringki* for rain at Mambilila. Manbilila spring was created at the time of the big rain and the lightning struck and created the spring. That's the dreamtime story from my two fathers. The rain dreaming, the spring down here. I have the rain song on my tongue. If I sing I can stop the lightning. If that heavy storm comes we can stop that rain with singing. (Stephen started singing). That's only a short rain, he won't come (in) rough. The spring is located at the Larrpayanji outstation and supplies water to Tollgate creek.

The Red legged Jabiru

The Red legged Jabiru came from Minimere and its journey ended at Spring Creek Station. It started from Marlringa, a swamp near Old Newcastle Waters near Elliot and then went to Minimere. If you bring that helicopter I can take you to these places.

Table A5 Indigenous place names and details supplied by Stephen Roberts

Indigenous name	Site	Comment	Easting	Northing	Transcribed
Alinginji	spring	This is a spring. The mermaid came from Wadamada to Alinginji and then to Yirrakbunji.			Naomi Wilfred.
Anarwunban	Place	Part of the route of the mermaid.			Ursula Zaar
Arunjun	Permanent waterhole.	6 mile waterhole. It is 6 miles from Minyerri. Related to the goanna.	406100 Location estimated	832200	Ursula Zaar
Awurrlyarra	River	Towns River. Mermaids travelled near here.			Ursula Zaar
Balubalumani	spring and creek north of Roper Valley G9035423	Perennial creek on Roper Valley station. The Minyerri road crossed over the creek. Even when there is no water at the road there is still water at the permanent spring upstream. The Rock Kangaroo made the spring. This area belongs to Sammy.	393511 Visited	8351929	Rembarrnga language
Bamberlierwa		Word for permanent water, any big river.			Naomi Wilfred. Alawa language.
Barruganda	Creek	A little creek which runs into the Cox River. Track of the mermaids.			Ursula Zaar
Burburbur		Word for a creek that can dry up.			Naomi Wilfred. Alawa language.
Burrdanenni spring		The red kangaroo went there. It is south of McDonald lagoon.			Ursula Zaar
Burrunju	Ruined city rock formation	From Wuyagiba the catfish travelled to Burrunju and then to Wanmari. The mermaid travelled from here and travelled to Nyawurlbarr.	491500 Location estimated	8422500	Naomi Wilfred
Darban	Duck Ponds Billabong	Permanent. The billabong relates to the black duck or wood duck story. People go there to hunt black duck at the time of the first storms.	395000 Location Estimated	8358700	Naomi Wilfred. Rembarrnga language.
Garjarlarmirr	Site	Dry country near the little Towns River. Track of the mermaid.			Ursula Zaar
Gum creek	Sherwin Ck	Can completely dry out. It is Ngalakgan country till the Roper River.	424358 Visited	8375075	Ursula Zaar Ngalakgan language.
Inindanda	Spring	This is a spring which has a round stone at the site. It is located along the old wagon track. The mermaid came from Yumanji to here.			Ursula Zaar
Injawan	Waterhole	Permanent waterhole on Hodgson River. The mermaid came from Nyardangarina to Injawan, then to Jawalada.			Ursula Zaar
Injay	Waterfall	The mermaid came from Narliboy to Injay where it danced and made the waterfall. It is located at Hodgson River Station.	402700 Location estimated	8276700	Ursula Zaar

Indigenous name	Site	Comment	Easting	Northing	Transcribed
Jawa	Spring near Jowar / Jawa community G9035424	Perennial spring. The dreamtime story states that five snakes come through here. The snake made the spring. On another meeting, Stephen said that only one snake came through here. It was the quiet snake and it came from Yurrlu to Jennewirri waterhole to Jawa. From Jawa it went to Wangaranidji - which is associated with the black crow.	438719 Site of creek near spring	8371197	Naomi Wilfred. Ngalakgan language.
Jawalarra Jawalada	Grassmere Billabong	The mermaid travelled from Injawan to here and on to Wadamarda. Stephen added later that this is a permanent and important lagoon but no-one will drink the water.	420700 Location estimated	8345000	Naomi Wilfred
Jennewerri		The quiet snake came from Yurrlu to here and then on to Jawa. It is located upstream from Badawarrka Outstation.			Ursula Zaar
Langaban		The mermaid went from Langaban to Yumanji Creek.			Ursula Zaar
Larrlingnu		The quiet snake came from Wangananji to here and then on to Wamarlirr.			Ursula Zaar
Lijarwan		After Winnarda the catfish came here and then travelled to Namarlil.			Naomi Wilfred
Linlinji	Permanent waterhole.	Permanent waterhole on a tributary to the Hodgson River.	455800 Location estimated	8353600	Naomi Wilfred. Alawa language.
Lumairrma	lagoon, at st Vidgeon	From Wanmari the catfish came here and made this permanent waterhole. From here the catfish went to Winnarda			Naomi Wilfred
Manbilila	Spring G9035417	Spring at Larrpayanji Outstation.	465549 Visited	8365709	Naomi Wilfred. Alawa.
Mardugurru		The mermaid came to this site from Yirrakbunji and travelled on to Wurrunnalda.			Ursula Zaar
Milgawirri	Flat area	The mermaid travelled from Yumanji creek to here and then to Wirranna. Milgawirri is a flat area near Peter Yard, where it left white paint.			Ursula Zaar
Minyerri	Waterhole at Community	Permanent waterhole, related to the goanna and dingo. Guyal tribe.	401700 From map	8317100	
Mirrinjinenni		Permanent waterhole just across the hill from Minyerri.			Ursula Zaar
Mungamunga		word for mermaid			Naomi Wilfred. Marra language.
Nabururluyu	Mountain ck at hwy. Also known as St Vidgeon crossing.	The river can dry right up from here to Nyawuddi	477800 Location Estimated	8366700	Naomi Wilfred. Marra language.

Indigenous name	Site	Comment	Easting	Northing	Transcribed
Namarlil	Permanent waterhole G9035420	Stephens mothers country. After Lijarwan the catfish arrived here and made the waterhole. This is where its journey stopped.	469610 Visited	8370780	Naomi Wilfred. Marra language.
Nalajirr	Hill	Near the Towns River. Mermaids travelled past here.			Ursula Zaar
Narliboy	Creek	The mermaid came from Yaldjamandja to Narliboy creek which is near Hodgson River airstrip, and then to Injay.			Ursula Zaar
Narlumbulumbu	Country name	Related to swordfish / combfish. Near the wreck of the Young Australian. The Blue tongue sucked them under drowning the boat.	465692 Visited	8368880	Naomi Wilfred. Alawa language.
Nawarlburr	Waterhole	Stephen said the waterhole can dry out but Sandy said it is permanent.	530300	8324000	
Ngaragarlil	Waterfall	Upstream of Ngardjirri? Mountain Creek area?	?		Naomi Wilfred. Alawa language.
Ngarchall		Word for spring			Alawa language.
Ngardjirri	Permanent waterhole.	Permanent waterhole on a tributary to the Hodgson River.	458300 Location estimated	8350100	Naomi Wilfred. Alawa language.
Nyardangarina	Waterhole on the Hodgson R	Permanent long waterhole. The name means big flat rock. There are lots of barra there. Felix lived there, but now he's at Hodgson downs. From Wangananji the mermaid journeyed here then travelled to Injawan.	444000 Location estimated	8355800	Naomi Wilfred. Alawa language.
Nyawuddi	Permanent waterhole located at the side of Mountain Ck.	A permanent spring but not running. It belongs to a group of mermaids. The area was used by the Murrunggun tribe - part of Alawa clan.	466600 Location estimated	8343700	Naomi Wilfred. Alawa language.
Raerweng	Site at Wire Yard, Hodgson R.	Site name.	439200 Location estimated	8353800	Naomi Wilfred
Rocky Crossing	Crossing on the Hodgson river.	This is south of the highway crossing on the Hodgson river. The mermaid came from Wurdawawa to here where she left her footprint and travelled to Wangananji	451600 Location estimated	8353400	
Uradbungu	Tributary to Hodgson River	The creek marks the path of the quiet snake - python. It is the name of the python. All waterholes in this creek dry out.	442800 Location estimated	8354800	Naomi Wilfred
Urralda	Area name	Area from here to hodgson River. There is an old story related to swordfish which made a swamp.	458160 Visited	8359276	Naomi Wilfred. Alawa language.
Urrlirlinji	Caves in Sandstone	East of Warlngudu waterhole. The Devil Devil and kingfisher made the cave. It has 3 doors and is a big cave with bones in it.	467700 Location estimated	8337700	Naomi Wilfred. Alawa language.

Indigenous name	Site	Comment	Easting	Northing	Transcribed
Wadamarda	Permanent waterhole?	Waterhole on the Hodgson river between Jawalarra and Minyerri. There is a spring on top. King Browns are in that country. On one occasion Stephen said Wadamarda is the same as Jawalarra and another time it was Hamilton Lagoon	413700 Location estimated at Hamilton Lagoon	8330000	Naomi Wilfred. Alawa language
Wadangarda	Permanent lagoon G9035421	Stephen was born here in 1925.	467826 Visited	8370399	Naomi Wilfred
Wallanji	The swamp near Wallinji hill or Alligator Bluff.	The mermaid came from Nyawurlbarr to here.	457700 Location estimated	8366800	Naomi Wilfred. Marra and Wandarrang language.
Wallinji	Alligator Bluff - hill	Hill. The site is related to the mermaid.	459400 Location estimated	8367300	Naomi Wilfred. Marra and Wandarrang language.
Wamarlirr	Permanent hot water spring.	The quiet snake came from Larrlingnu to here. This is where the journey ended. Wamarlirr is a permanent hot water spring near Peter Yard. It is so hot you can make tea with it. It is smoking. Downstream from it is a permanent cold waterhole. Location estimated.	449300 Location estimated	8301700	Ursula Zaar.
Wanabarlirr	Swamp	A big swamp that only jungkayi can go to. Track of the mermaids.			Ursula Zaar
Wangananji / Wangaraninji	Waterhole on Hodgson River	Permanent waterhole. The name means crow and the crow created the waterhole. There is black round stone there that marks the place where the crow stopped. On another meeting Stephen explained that the quiet snake came from Jawa to here and then went to Larrlingnu. And that a mermaid came from Rocky Bar Crossing on the Hodgson River to here and travelled on to Nyardangarina.	446100 Location estimated	8355300	Naomi Wilfred. Alawa and Ngalakgan language.
Warlba		Word for creek			Naomi Wilfred. Alawa language.
Warlngudu	Waterhole on Mountain creek.	At the old St Vidgeon station. The mermaid came through here, but didn't stay travelling on to Yingaiyin. The devil devil came through.	467700 Location estimated	8337700	Naomi Wilfred
Warranyinna	Plain	Pumpkin Yard plain. Track of the mermaid.			Ursula Zaar
Winnarda		From Lumairrma the catfish came here and then travelled to Lijarwan.			Naomi Wilfred
Wirranna	Spring	The mermaid travelled from Milgawirri to Wirranna spring which is on the Towns river. It is right on top.			Ursula Zaar

Indigenous name	Site	Comment	Easting	Northing	Transcribed
Wanmari Wonmarri	Waterhole at community Wanmari	From Burrunju the catfish came to Wanmari and then to Lumairrma.			
Wulainji	Waterhole on Mountain ck	Part of the track of the mermaid.			Naomi Wilfred
Wunuloy	Cave	Three mermaids stayed here for a while.			Ursula Zaar
Wurdawawa	Swamp G9035419	Important permanent swamp where ceremony takes place.	453116 Visited	8356977	Naomi Wilfred. Alawa and Ngalakgan.
Wurdwurdlajinji	Spring	Spring was made by the mermaid. There is red ochre there.			Ursula Zaar
Wurlinawu	Permanent waterhole.	Big permanent waterhole at the top of the Ngaragarlil waterfall. The kingfisher and wild devil devil made the waterhole. Two big hils mark the track from these two. The country belonged to Joshua (deceased). Mountain Creek area?			Naomi Wilfred. Alawa language.
Wurrunnalda	Mc Donald Lagoon.	Permanent waterhole. The mermaid came from Mardugurru to here then travelled to the bottom of Minimere waterhole and then turned back to Mc Donald lagoon.	414500 Location estimated.	8298500	Ursula Zaar
Wuyagiba		The catfish came from an island near Groote Island, then to Wuyagiba and on to Burrunju.			
Yaldjamandja	Island in a gorge in general area of Hodgson River	The mermaid came up a gorge to Yaldjamandja then to Narliboy creek.			Ursula Zaar
Yanbarraboyerr	River	Cox River. Track of the mermaids.			Ursula Zaar
Yandajanda	Waterhole on Hodgson River	Waterhole on upstream side Hodgson River at Hwy crossing.	453200 Location estimated	8355200	Naomi Wilfred. Alawa and Marra Language.
Yindiyindi plain	Plain	This is where the mermaids danced.			Ursula Zaar
Yinggaiyin	Spring. Five Mile Spring	The mermaid (Wandimurrungga) came from Warlngudu to Wulainji & travelled to Yingayin. This is a permanent spring which the mermaid created by hitting the rock with a yam stick after which she perished. It is located along the old wagon track. On another occasion Stephen said that a mermaid then went to Umanji from Yinggaiyin.	469200 Location estimated	8334800	Naomi Wilfred.
Yirrakbunji	Spring	This is a spring in the area of McDonald Yard. The mermaid came from Alinginji to here.			Ursula Zaar

Indigenous name	Site	Comment	Easting	Northing	Transcribed
Yulmunoorga		Hill along Mountain creek.	470000 Location estimated.	8344000	
Yumanji / Umanjji	Permanent waterhole	Yumanji is a permanent waterhole with barramundi in it. It is on the little Towns River along the old wagon track. The mermaid travelled from Yingayin to here and on to Inindanda. A goanna came from Wunduluerr to here and then on to Yilbiya.	464500 Location estimated	8316700	Naomi Wilfred.
Yumanji creek.	creek	A mermaid travelled from Langaban to here and then to Milgawirri.			Naomi Wilfred.
Yunbulloy	Waterhole	Minimere Waterhole	415000 Location estimated	8295000	Ursula Zaar
Yurdbunji	Hill at Roper Bar store	The hill marks the Red Kangaroo tracks. From here it is Ngalakgan country till Hodgson River. After Hodgson River is Alawa country. Alawa and Marra country east of Hodgson River.	449800 Location estimated	8370200	Naomi Wilfred. Ngalakgan.
Yurrlu / Yurrlurr		This is the beginning of the journey of the quiet snake. Yurrlu is the top area of the Wilton river. The quiet snake came from here and travelled to Jennewerri.			Ursula Zaar
Yurrmurrnugga	Permanent waterhole near Mt Young				Ursula Zaar.
	Cheon Creek	Dry. Soak only. Dries out when the hot weather comes.			
	Ngalakgan Country		423142	8372999	
No name given	Deadman spring	A small permanent spring upstream of where Deadmans creek crosses the Minyerri road.	391400 Location estimated	8343200	
No name given.	Creek and spring	Known as Bullock Yard Creek. Dry creek. Rembarrnga country. There is a perennial spring up top, on the pack horse road. The spring flows into Bullock yard ck.	412000 Location estimated	8368000	

Roger Rogers

On 28.10.1998 Roger Rogers and Henry Rogers accompanied Water Resources officers (Roger Farrow) to water sites north of the mouth of the Roper River. The information is presented here. The sites and names coincide with those of Walter Rogers.

Table A6 Indigenous place names and details supplied by Roger Rogers

Indigenous name	Site	Comment	Easting	Northing	Transcribed
Alirranya	Spring G9035151	Flow was 0.3 L/s on 28.10.98	538585 Visited	8391512	Roger Farrow
Arraruru	Waterhole G9035150	Permanent waterhole with no discharge. Many feral animals especially buffalo visit this waterhole which looked degraded. The waterhole has the same name as another about 1 km away. Roger said that the level for this time of year is lower compared to 5 years ago. At that time the water was clear with water lilies. There are old stock yards here.	547450 Visited	8383893	Roger Farrow
Allunbunji	Permanent soak G9035152		538591 Visited	8397499	Roger Farrow

Plate A15 Alirranya Spring

Alirranya spring provides the first permanent waterhole in a creek. Seepage was from the base of a rocky hill. Roger explained that the place was in the 'Bushtime' a main waterhole. They used to camp here often.

Walter Rogers

Plate A16 Walter Rogers

For Ngukurr and the region north of Ngukurr Walter is a key elder people refer to. He travelled with the study team guiding them to waterholes and springs, naming the places and explaining cultural aspects. He spoke of the European and indigenous history of the sites.

Survival water supplies

Plate A17 & A18 Walter standing by a mature Kapok tree and holding a bark water carrier

As a young boy he lead a very traditional life. He relates how he travelled from Ngukurr to Borroloola when he was only 6 or 7 years old. The party travelled through the Limmen Bight River by canoe in the Dry season. As there were long distances between waterholes during their long walk they used to eat the sapling root of the Kapok tree (*Cochlospermum gregorii*) as a source of water. The Kapok tree is called Jiwurru in the Marra language. During the walk the guide was the man with the message stick. There was information on the stick to show the way. For short distances we used a bark water carrier to hold water.

Barnanda

Plate A19 Barnanda

Barnanda is goanna dreaming. The goanna came from Barryamirri. The goanna created the waterhole. This is a deep waterhole. The Turkey Lagoon community situated by the waterhole here doesn't get flooded. In the old days people used to stay here and fish and hunt. The water level will drop more as it gets drier. Back in the 1950's musterers trapped horses here. The posts in the water mark the trap-yard. They recently did a trapping as there are still many horses here.

Burrunju

Burrunju means catfish in the Wandarrang language. The Burrunju creek is part of the catfish dreaming. This creek can dry out. The catfish came all the way from the coast. Two hills near the creek mark the daughters of the catfish. The hills are called Manggurraja and Dulban. The ruined city is also called Burrunju as it is related to the catfish. At the ruined city some catfish stayed and some jumped to Katherine (Lake?). At the ruined city there are springs on top which seep all year round. There are no pools just seepage. The Wandarrang language runs from Wanmari to Burrunju.

Plate A20 Burrunju Creek

Plate A21 Burrunju – The Ruined City

Durrungutjbanganya

Durrungutjbanganya has permanent water. The quiet snake and flood water went through here, all the way to the coast to Port Roper. There is a song that is sung at circumcision which relates the journey of the quiet snake which came down from the Wilton River. This is sung with women but there is another song underneath this that is sacred and not sung by women. Connected to this site is a story of 5 young boys who travelled along the lagoon and were circumcised. They left their mark along the lagoon.

Plate A22 Durrungutjbanganya

Ganiyarrang

Ganiyarrang is the Ngandi name for the waterhole and outstation. The outstation uses a bore near the road. The name means freshwater crocodile which inhabit the waterhole. The waterhole can dry up. There is no-one at the outstation.

Plate A23 Ganiyarrang Waterhole

Gururrukal - Lake Katherine Community

The community is now deserted. Tourists used to camp here. The actual Lake Katherine is permanent but is located south of the community and is called Warawu. People used to stay at Gururrukul which is a waterhole to the north but it got flooded so they moved here. Now they call the waterhole at the Lake Katherine community Gururrukul. The Phelp river supplied the community.

Plate A24 Gururrukal Outstation

Jilliwirri waterhole and Costello Outstation.

Jilliwirri is the water supply to Costello. Costello is named after the stockman who lived here. He had his homestead here and stone footings of the homestead can still be seen in the ground. Costello bread horses for the army during WW1. There is a saying that Costello buried his money here somewhere as he didn't want to share it. The site relates to the quiet snake. There is a sacred site closeby.

Plate A25 & A26 Jilliwirri Waterhole and Costello

Malambuybuy

Malambuybuy is a permanent deep lagoon which always looks murky. Malambuybuy is a Ngandi word which means boomerang which the lagoon is named after as it is shaped like a boomerang. The English name is Boomerang Lagoon. The dreaming threw a boomerang which landed here at the site of the lake. There is no-one at Boomerang lagoon outstation but for buffalo shooters. People didn't stay here because there is a sacred site here, the hill, and they didn't want to build near it. Also this area gets flooded so they moved south of here. The water level drops over the dry season. There are fresh and saltwater crocs in the lagoon.

Plate A27 Malambuybuy Lagoon

Mitjingili

Plate A28 & A29 Mitjingili

This place is called Mitjingili and belongs to the Manbali clan. It is a permanent waterhole. It was an important camping area for hunting and fishing. There is a lot of fish and wallaby here. People used to come and have a big camp here. Over the other side are rock paintings. We like the rangers to go there because it is fading away. I used to come here a lot with my children when I had my vehicle. Further upstream from here there is not much in the way of springs. There are soaks. Water comes from underneath the bed of the creek. All along the creek you see some waterholes but not as big as this one. This is the main pool here. Some years ago the rangers walked from the Ruined City to here.

Namiliwirri

This permanent waterhole can get flooded and has saltwater crocodiles in it. It is related to the goanna dreaming. It came from Turkey Lagoon and went underground to come up at Namiliwirri. A fuel pump is used to pump water from the lagoon. There is no-one living here now. People used to live here a long time ago, they used to camp here, the Ngandi people.

Plate A30 Namiliwiri Waterhole

Nyawurlbarr (Mission Gorge)

Plate A31 Nyawurlbarr

The water level here will not drop any lower than this. This waterhole is reserved for drinking. There is a waterhole further upstream which is used for swimming and there is another waterhole further downstream which was used by the stockmen in the 1950's. Nyawurlbarr was an important source of water for Ngukurr community because back in the1950's the Roper River at Ngukurr became too salty to drink. As the river was the main water supply people had to look elsewhere for their drinking water. Women and children and teachers were taken here to live because this is permanent freshwater. No-one was allowed to swim here, it was used for drinking only. Water was carried away from the waterhole in drums for washing. Stockmen used the waterhole further downstream. Most of the missionaries and workers stayed at Ngukurr and obtained their water from Yalwarra lagoon. They drank the water after boiling it.

Warawu – Lake Katherine

This is sugarbag and wild bee dreaming. The sugarbag flew from here to nutwood (downs) and created the spring there at the homestead. That spring relates to the sugarbag. Warawu area floods in a big flood. The water level drops over the dry but it is permanent. Fresh and saltwater crocs live in the lagoon.

Plate A32 Warawu

Table A7 Indigenous place names and details supplied by Walter Rogers

Indigenous name	Site	Comment	Easting	Northing	Transcribed
Alirranya	Spring G9035151		538400 Location estimated	8391400	Ursula Zaar
Arrarurru	Soak G9035150	You may need to dig for water here.	548300 Location estimated	8383600	Ursula Zaar
Awunbunji	Soak G9035152	Permanent soak with clear water. When the Roper river became salty in the '50's stockmen came here and camped with their stock.	539300 Location estimated	8397000	Language Centre.
Balamu	Spring or soak		538400 Location estimated	8387750	Ursula Zaar
Banipani	Waterhole	Large waterhole on the Phelp River.	508200	8427000	Ngandi Language.
Barnanda	Turkey Lagoon G9035023	Permanent waterhole by the community	473100 Visited	8393700	Language Centre. Ngandi Language.
Barrabuga	Waterhole on Turkey Lagoon Creek	Permanent waterhole in gorge.	468700 Location estimated	8399000	Ursula Zaar
Barryamirri	Site	Relates to the dreaming story of the goanna. The goanna came from Barryamirri to Barnanda.			
Burrunju	Burunju creek. G9035430	Creek near the ruined city. It can dry out.	498118 Visited	8425867	Language Centre. Wandarrang language.
Burrunju	Ruined city	Rock formation	491500 Location estimated	8422500	Language Centre. Wandarrang language.
Durrungutjbanganya	Waterhole G9035428	Permanent.	492105 Visited	8388115	Language Centre. Ngandi language.
Gamanminymul	Towards Washaway creek.	This was a big camp in the old days. There are spear heads there. The name means King Brown snake. (Located just north of study area)	506200 Location estimated	8462800	Language Centre. Ngandi Language.
Ganiyarrang	Waterhole G9035429	Waterhole which can dry up and outstation.	502236 Visited	8399741	Language Centre. Ngandi Language.
Gularra	Small permanent spring or soak.	This is a permanent spring or soak but sometimes it needs to be dug to gain water, ie hand dug well.	479300 Location estimated	8378600	Language Centre.
Gururrukul	Billabong of the Phelp River.	This is the indigenous name for the (L. Katherine) community but the actual waterhole is located north of the community. The rainbow serpent came through here.	507200 Location estimated	8425000	Language Centre.
Jilliwirri (Mitjingili) this was corrected to Jilliwirri by Walter later.	Lagoon at Costello G9035022	Water level drops a lot more but it is a deep pool. A solar pump was running when we visited as this is the water supply to Costello.	487167 Visited	8390538	Ursula Zaar. Ngandi Language.

Indigenous name	Site	Comment	Easting	Northing	Transcribed
Malambuybuy	Boomerang lagoon G9035015	Permanent waterhole	509139 Visited	8407969	Language Centre. Ngandi Language.
Mambumambu	Waterhole and outstation.	The waterhole gets salty when the water level drops. Water is pumped from the waterhole. There are crocodiles in the waterhole.	535288 Visited	8409938	Language Centre.
Mangajarra	waterhole	Big permanent waterhole. This could be the same as Mungajirri waterhole as noted on 50K topographic map.	527200 Location estimated	8393000	Ursula Zaar
Manggurraja and Dulban	2 hills	The two hills are relate to the catfish which came from the sea. They mark the daughters from the catfish. Located near the ruined city.	491600 492300 Location estimated	8424300 8424500	Language Centre. Wandarrang language.
Marna	spring	Spring and sandy creek. Water runs about 100 m from the spring. There are big trees there in the valley.	478300 Location estimated	8420050	Ursula Zaar
Mayalurra	Waterhole	Permanent waterhole	522700 Location estimated	8404600	Language Centre. Wandarrang language.
Mirripi	Big waterhole	Located downstream of Burrunju crossing along Burrunju creek.			Language Centre.
Mitjingili	Waterhole on tributary to Turkey Lagoon creek.	Permanent waterhole in the gorge.	482550 Visited	8395501	Language Centre. Ngandi Language.
Nahwugunnya	well	The wells are in the sand along the coast. You have to dig for the water. The wells are located near the pandanus.	557500 Location estimated	8340000	Ursula Zaar
Najarrwayung	Waterhole G9035427	Permanent waterhole. Relates to the Goanna dreaming. Same goanna from Turkey Lagoon.	495729 Visited	8386675	Language Centre.
Namaja	Waterhole that dries	Waterhole that dries	501700 Location estimated	8369300	Language Centre. Wandarrang language.
Namiliwiri	Waterhole at community G9035033	Permanent waterhole. It gets flooded.	497515 Visited	8386848	Language Centre. Ngandi language.
Nanggabarra	Waterhole.	This is the only permanent water as the upstream waterholes dry. The water level will drop more as the Dry season progresses. This is where the quiet snake or silver snake was.	487995	8391646	Language Centre. Ngandi Language.
Napurr	Gorge	The kangaroo went through this gorge.	502300	8368500	Language Centre. Wandarrang language.
Ngunanyin	Waterhole	This waterhole will dry in a bad year	536400	8400000	Language Centre.

Indigenous name	Site	Comment	Easting	Northing	Transcribed
					Wandarrang language.
Nyajillajilla	Waterhole? On the Wilton.	This is at the top of the Wilton near Ferris crossing. The snake and floodwater are there. A song sung before initiation relates to this.			Ursula Zaar. Ngandi Language.
Nyawurlbarr	Permanent waterhole and spring G9035425	Mission gorge.	473223 Visited	8380296	Language Centre.
Nyanyalindi	Waterhole.	Waterholes at Lake Katherine community. Crocodiles lay their eggs here and women wash here.	507000 Location estimated	8422000	
Nyayawuldu	Waterhole	Permanent.	513300 Location estimated	8388300	Ursula Zaar
Walmaja	Waterhole	This waterhole can dry out.	480100	8370700	Language Centre.
Wanmari	Large waterhole on the Phelp River and outstation. G9035000	The catfish came from the sea to here and then went through to Burunju, the ruined city. The catfish created the waterhole here. The waterhole is permanent but in dry years the water level drops more and it gets brackish.	523873 Visited	8401985	Language centre. Wandarrang language.
Warawu	Waterhole. Lake Katherine. G9035432	Permanent.	506587 Visited	8418174	Language centre. Ngandi language.
Warrgujaja	Waterhole	Waterhole which is fresh now but as the water drops during the dry it will get salty. The mermaid that came from Numbulwar came through here and crossed to kangaroo island.	503600 Location estimated	8364600	Language Centre. Wandarrang language.
Wumulurru	Spring	This is a spring at the top of Naluwan. It flows all the time for a short distance. The goanna travelled there from Turkey lagoon.	493300 Location estimated	8374300	Language Centre.
Wunuwarriya	Waterhole.	This waterhole gets brackish. The waterhole dries out - it dried out last year.	534032 Visited	8408729	Language Centre.
Yawurrwarda	Yalwarra lagoon G9035433	Permanent lagoon close to Ngukurr.	469300 Visited	8372600	Language Centre.
Yilakal	Waterhole	This waterhole dries up.	506953 Visited	8421913	Language centre. Ngandi language.
Lake Katherine community.	Situated along the Phelp river.	The community is also called Gurrurrukul.	507313 Visited	8421991	
No name given	spring		550600 Location estimated	8392700	
No name given	spring.	This is a small permanent running spring.	487300 Location estimated	8373200	

Indigenous name	Site	Comment	Easting	Northing	Transcribed
Phelp river	River	The Phelp River stops flowing here in a very dry year.	510986	8411618	

Note: Transcriptions were undertaken at the language centre at Ngukurr with Walter Rogers in attendance. Transcribed by Greg Dickson, John Joshua and Aaron Joshua. The Language Centre was very generous in providing time to undertake these transcriptions.

Benny Tyson

Benny Tyson lives at Urapunga and is one of the older people who are referred to for knowledge on the Wilton River area. The table details what he had to say about water for the region. He said that pigs were a real problem in the area.

Table A8 Indigenous place names and details supplied by Benny Tyson

Indigenous name	Site	Comment	Easting	Northing	Transcribed
Goyupi	Spring/ waterhole	Big spring which runs into the Wilton River. It is a permanent waterhole. It stops flowing in December.			Ursula Zaar
Wallanji waterhole	waterhole	Located between Ngukurr and Urapunga. The bottom waterhole is permanent but the top one may dry.			Ursula Zaar
	5 mile spring	Located 5 miles from Urapunga. Situated north of the Roper, north of Baddawaka. It is a soak and when the water dries out you can always dig for water.			Ursula Zaar
	Clarey billabong	This billabong dries out in October.			Ursula Zaar
	Crocodile Hole	It is 3-4 mile east of the Wilton. There was a big stock camp there. It stops running in Sept/Oct. It is above Ah Cup waterhole.			Ursula Zaar
	Wilton river and Jalboi River	The Wilton stops running but has permanent waterholes all the way along. The Jalboi river stops running but there are permanent waterholes.			Ursula Zaar

Rex Wilfred

Plate A33 Rex Wilfred

The painting on the cover page of this report was undertaken by Rex and purchased for this project from the Ngukurr Arts centre at Ngukurr, where Rex resides. His explanation of the painting gives us an insight into Aboriginal views of water, how Aboriginal people have an intricate connection to water sites, and the cultural history of some of the water sites around Ngukurr. A transcription of his explanation is provided following. The sites he spoke of in his dialogue are listed in the table below.

Plate A34 Rex Wilfred with his painting

This is the dreaming bull which travelled from my homeland in North Arnhem Land, the Mitchell Ranges. The aboriginal name for that place is Munguritji. He travelled all the way from Arnhem Land this way south and made lots of country along the way. He travelled all along my country and came through the place Burrunju, the Ruined City. He is the *Dhuwa*. I am the *Jungkayi* for him. He came from my country and travelled down south, passed through Ngukurr area, and travelled along the other side of the river from St Vidgeon to Limmen Bight all along.

At Yawurrwarda (close to Ngukurr) you can see that billabong, it looks like this (the curves of the serpent in the picture), it looks like a snake. When you see it from the air you can see the shape of the billabong which looks like the snake. Well that's a shadow of this one, which we call *Motj.* A shadow of this rainbow. This is the rainbow serpent that created that waterhole.

From Yawurrwarda it travelled across the river and stopped off at a place called Yatalriya, this is the name in our language, Creole language, but in English we call it wreck. This is the place where that boat sunk, the Young Australian. At Yatalriya the serpent changed its name from *Motj*, and called himself blue tongue, Gapalan, and sank the boat. The boat touched the blue tongue. The blue tongue said 'my name is Gapalan, and I'm going to sink this one now' and sank that boat.

He stopped there, and remains there forever now, in that water where the Young Australian is. He is always looking after that country, the river. People dodge him all the time, when they are going in the boat, they go on the side. Before, he was like that (in the painting) with this body (of a snake) but when he came to Yatalriya he grew legs and arms.

Every dry season, the water level goes down at Yawurrwada, but he didn't want to stop there, so he went under the ground and came up at Yatalriya. The spring at Yawurrwada is related to him too because he made that country, that rainbow.

The *ralk* (cross hatching on the painting), that represents all the people. This *ralk* we draw on the body for sacred reason. The *Dhuwa* is the *Jungkayi* but this is the *Yirritja*, my *ralk* this one, all *Yirritja* this one. *Dhuwa* and *Yirritja* are the two moieties and *Dhuwa* is the *Jungkayi* for this one, *Jungkayi* for this *ralk*. This (*ralk*) represents me and my sister Cherry Daniels, it represents us. We are from Arnhem Land.

He came through a place called Walpanni, he made a lot of places, and then he came to this land. This land is my *darlnyin, darlnyin* means grandpa, and this river called Miluaparra, this place Miluaparra country, belong to the Prontos. He came to their country and made that billabong. All along here (the river) is his body, you know where that boat landing is here, there is that little area there on this side of the boat landing, there are rocks there, he stop there too, half of his body is there. And if you go down to one little island that they call Mission Island, his body is there too. He has been under the water for many years, he lives in the water and his body is still there and he is alive this animal. We call him Motj.

And this one (pointing to the horns) we call *konduroro*. This horn can sink anything, even steel, he is very, very strong. He also make him pretty colour, when he stands up he makes the colour of the rainbow, when its raining. Look at that rain and the rainbow, he makes that colour, this one.

In my law, my ceremony, he is my *Jungkayi.* He is both *Yirritja* and *Dhuwa,* both ways. My grandpa used to sing the song for this one, and I used to dance for him. But he's gone, finished, my grandpa, so we don't use that *bunggul* (ceremony) any more. He has got a son but he doesn't know how to do (this ceremony), it hasn't been passed on. That's a shame.

This one (serpent) travelled from the Mitchell ranges to here. It Stopped in Galnyin country, my *gadu* country, Miluaparra river. I handle him also Miluappara, I know the law of Miluappara.

Plate A35 Wreck of the Young Australian steamer at Yatalriya on the Roper River.

Table A9 Indigenous place names and details supplied by Rex Wilfred

Indigenous name	Site	Comment	Easting	Northing	Transcribed
Munguritji	Mitchell Ranges	Location from which the dreaming bull or Rainbow Serpent came from.			Ursula Zaar
Yatalriya	On the Roper River	Site where the wreck of the Young Australian is located.	0465692 Visited	8368880	Ursula Zaar
Miluaparra	Reach of the Roper River and country around Ngukurr				Ursula Zaar
Walpanni	Site	The Rainbow serpent travelled through this location before coming to the Ngukurr region.			Ursula Zaar

Table A10 Indigenous place names and details supplied by other Traditional Owners.

Indigenous name	Site	Comment	Easting	Northing	Transcribed
Yunduyi	Permanent spring	Provided by Winston Thompson	493300 Location estimated	8368200	Ursula Zaar
Badawaka	Outstation	Provided by Clara Hall and Noel Thompson This place is related to the Mimi spirit. The sugarbag dreaming also came through here			
Jawa	Permanent spring G9035424	Provided by Clara Hall and Noel Thompson The site is related to the quiet snake	0438719 Visited	8371197	
	Boomerang spring	Provided by Clara Hall and Noel Thompson This is mens story. The Mimi were arguing and one threw the boomerang. Where the boomerang hit the rock the water came up. Boomerang spring also feeds Jawa spring			
Goloto	Mt Mc Minn	Provided by Clara Hall and Noel Thompson There is an old story that there is water at the top. If women walk to the top then another hill will emerge. Only men can walk to the top.			
Yawurrwarda	Yalwarra Lagoon G9035433	Provided by David Daniels. The water turned yellow when it was low in 1952. People went to Mission Gorge. In this area the big gum trees represent the kangaroos that the dingoes chased. There is a sacred area next to the lagoon and it is marked by a sign. It is a ceremony place.	468548 Site visited	8372048	Ngalakgan name
Ngayagurri	Area name	Provided by David Daniels.	468510 Area visited	8374562	Ursula Zaar

Plate A36 Yawurrwarda, billabong of the Roper River

APPENDIX B: RECHARGE AND TRANSMISSIVITY

Detailed water resource investigations were undertaken at Minyerri, Ngukurr and Urapunga providing information on recharge and transmissivity. Pump testing provides one way of determining transmissivity, which is a measure of permeability. The results from pump tests, and other investigations at Minyerri and Ngukurr are summarised in Table B1 and B2. These are the only locations where extensive water resource investigations have been conducted in the mapped area.

Table B1 Transmissivity and recharge characteristics for aquifers at Ngukurr. (Adapted from Sumner, 2008)

Aquifer	Transmissivity (m^2/day)	Bore yields (L/s)	Comment on recharge
Yalwarra Volcanics	60 - 100	5 - 10	Directly recharged from rainfall. A maximum of 1 m increase in the water level is inferred from standing water level measurements.
Contact zone between the Yalwarra Volcanics and Knuckey Formation	100 - 150	5 - 10	In the current borefield water is being drawn from the Roper River into the aquifer. (Induced recharge from the river)
Mt Birch Sandstone	500 - 900	10 - 30	Aquifer is connected to the Roper River (providing recharge) so high pump rates are able to be maintained.

In his report, Sumner (2008) provides a coarse estimate of the sustainable yield for the Yalwarra Volcanics at 40 ML /yr based on the estimated 1 m change in water level over a wet season (due to recharge)

The high bore yields in the Mt Birch Sandstone are unusual. It is a result of localised conditions where the rock is particularly well fractured and connected to the Roper River.

Table B2 Transmissivity and recharge characteristics for aquifers at Minyerri. (Adapted from Matthews, 2008 and Jamieson, 1992)

Aquifer	**Transmissivity (m^2/day)**	**Bore Yields (L/s)**	**Comment on recharge**
Munyi/dolerite (Fractured, hard rock aquifer)	46 – 108 (RN35798, RN35876) (Matthews, 2008)	3	Recharged directly from rainfall with water stored in fractures. Annual safe yield not known and can only be determined through long term pumping and further investigation.
Bukalorkmi Sandstone	2.5 - 4.2 (RN35879, RN36300) (Matthews, 2008)	0.5 – 0.7	
Bessie Creek contact zone aquifers	1 – 4 (Jamieson, 1992)	0.7	Recharged through subcrop of the contact zones below sands and alluvium

The aquifers listed in the Table B2 have been classified and mapped under ‘Fractured and weathered rocks’ with the exception of the Munyi/dolerite aquifer which is classified under ‘Fractured and weathered rocks with minor groundwater resources’. This is because the rock types which host this aquifer do not usually provide such a high yield. The 3 L/s attained in the bores was highly unusual and due to better fracturing just at that particular location – it was an absolute strike of luck!

APPENDIX C: RECESSION FLOW MEASUREMENTS

Table C1 Recession flow gaugings in cumecs.

Date	Mataranka G9030176	Elsey G9030013	Moroak G9030123	Judy Crossing G9030010			Flying Fox Junction G9030011	Red Rock G9030250	Police Station G9030012			
10/09/1953		0.59										
04/09/1955		2.15										
07/06/1960			2.58									
18/08/1963	1.16	2.69	1.39						0.87			
10/09/1963	1.13	2.69	0.89						0.29			
24/10/1963	0.99	2.35	0.40									
28/02/1964			0.75									
21/05/1964		2.69	0.81									
03/09/1964	0.82	2.18	0.41									
14/08/1967	1.09	2.52	1.55					0.75				
24/06/1968	1.42		2.68					2.18				
22/08/1968	1.21	2.92	1.79					1.03				
04/11/1968	0.99	2.52	1.08									
27/06/1969	1.20	2.64	1.85	1.38			1.14	1.06				
30/11/1969	1.08	2.79	1.01	0.46			0.31	0.07				
23/03/1970				1.14			0.63	1.43				
18/05/1970	0.98	2.72	1.36	1.07			0.84	0.85				
18/07/1970	0.88	2.63	1.14	0.67			0.46	0.26				
30/08/1970	0.95	2.54	1.07	0.68			0.39	0.17				
17/10/1970	0.85	2.32		0.26			0.10					
25/11/1970	0.95	2.07						0.83				
17/12/1970			0.71									
18/06/1971	1.00	2.36	1.31					0.55				
12/08/1971	0.98	2.53	1.16	0.76			0.53	0.29				
30/07/1975	2.20							2.74				
01/10/1975	1.50	3.35	1.59					0.78				
12/10/1976								1.95				
26/10/1977								1.09				
07/08/1980				2.67				1.99				
30/06/1981	1.78			2.96								
21/08/1981	1.43	3.83		2.11				1.59				
21/09/1982		3.83		1.99				1.46				
29/10/1982	1.89	3.68	1.84	1.57				0.81				
19/07/1983	1.91	3.73	2.46	1.85				1.00				
14/08/1985		4.10	2.70	2.29				2.32				
01/10/1985	1.88							1.30				
27/05/1986	1.75	3.51	2.25	1.51				1.10				
22/07/1986	1.84	3.25	2.26	1.70				1.32				
10/09/1986	1.85	3.05	2.01	1.44				0.96				

20/09/1988	1.66	2.95	1.55	1.07				0.52				
02/11/1988								0.26				
14/07/1990	1.41		1.88									
17/07/1991	1.78	3.39	1.98	1.65				1.29				
03/10/1991	1.59	3.16	1.67	1.09				0.59				
16/09/1992	1.51	3.14		0.94				0.55				
04/10/2002	1.42	4.61	2.85					1.82				
13/08/2003	3.82	6.01	4.32									
	Mataranka G9035255	Elsey G9035294	Moroak	Judes Crossing G9035122	Lonesome Dove G9035068	Upstream Flying Fox junction	Downstream Flying Fox junction	Red Rock G9030250	Roper Bar G9030012	*Flying Fox River G9035287	*Maiwok G9035413	*Jalboi G9035414
19/09/2007	2.23	5.388	4.59	3.64	5.14	3.335	3.806	3.185	3.611	0.471		
17/11/2007	2.488	5.023	4.8	3.161	3.005	2.706	2.867	2.162	2.612	0.161	0	0
27/06/2008	4.53	7.19	6.77	6.01	6.405	5.722	7.122	6.75	7.32	1.4	0.045	0.063
08/09/2008	3.11	5.6	4.85	4.22	4.16	3.911	4.58	4.27	4.58	0.669	0	0
30/10/2008	2.21	3.95	3.44	2.79	2.92	2.488	2.856	2.62	2.696	0.368	0	0

- Gaugings were undertaken at sites within one week of date noted.
- For years 2007 – 2008:

  Moroak site = G9035408+G9035398+G9035076

  Upstream Flying Fox Junction site = G9035409+G9035410(sites on channels downstream from Flying Fox Creek)-G9035287(site at Flying Fox Creek)

  Flow has been listed upstream and downstream of Flying Fox junction because of the significant inflow from the creek.
- Flow measurements were undertaken at Lonesome Dove however the section was poor so the quality of the gauging is poor. The results are shown however.
- *These are tributary rivers.

APPENDIX D: FLOW LOSS ANALYSIS IN THE ROPER RIVER

Section A: Elsey to Moroak

Plate D1 Satellite image of the river between Elsey and Moroak. (Google Earth)

Between Elsey and Moroak lie extensive wetlands which include Red Lily Lagoon (part of the Roper River channel) and wetlands north and south of this lagoon. After the wetlands the river becomes braided.

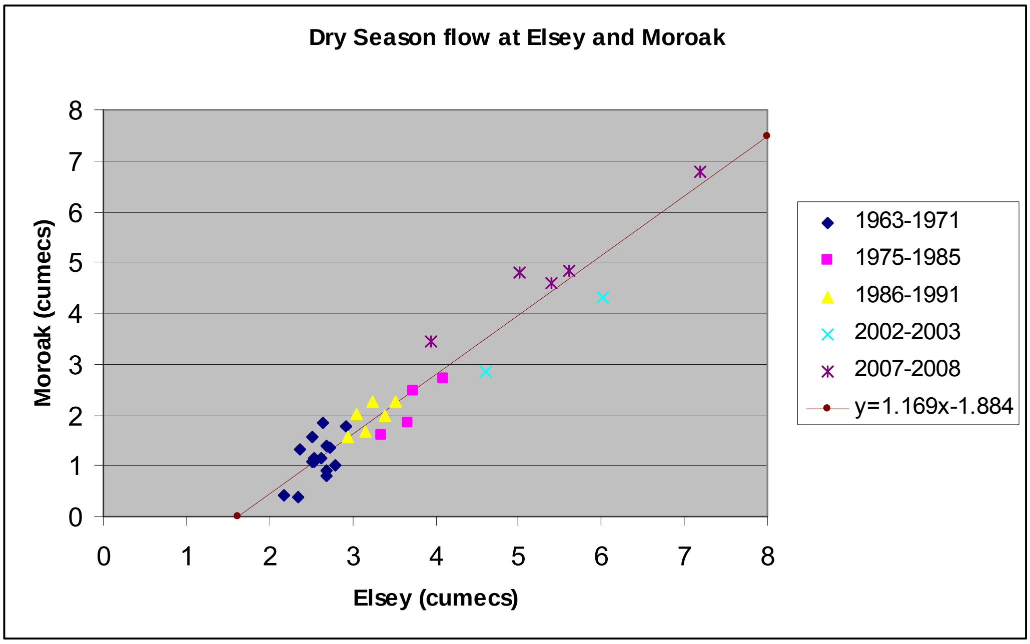

Figure D1 Correlation between gauged flow at Elsey and Moroak, grouped by rainfall period.
The line of best fit for all data points is shown. Data points from Table C1. **Elsey gauge site = G9030013** 1963 – 2003, **G9035294** 2007- 2008. **Moroak gauge site = G9030123** 1963 – 2003, **G9035408+G9035398+G9035076** 2007 – 2008 as discharge occurred in several channels.

In Figure D1 groupings are evident when flow gaugings for Elsey and Moroak are plotted according to wetter and dryer rainfall periods. The average rainfall for these periods is provided in Table D1. As expected in periods of higher rainfall, larger baseflows occurred. From 1962 to 1991 the dry and wet periods appear to plot along the same trend line. The average rainfall for this period (829 mm) is similar to the long term average (822 mm) (Table D1). 1962-1991 data has therefore been used in regression analysis to provide an indication of the average loss between the gauge sites. Although there are not many data points in the extremely wet period, the 2002-2003 flows show to plot differently to the 2007-2008 flows as they lie either side of the line of best fit.

Table D1 Rainfall periods and averages. For rainfall at Mataranka (See Appendix E).

Rainfall period	Average rainfall (mm)	Period type
1962/1963-1970/1971	760	Dry
1974/1975-1984/1985	952	Wet
1985/1986-1990/1991	656	Dry
1996/1997-2007/2008	1066	Extremely wet
Long term average 1916/1917-2007/2008 (91 years)	822	
1962/1963-1990/1991	829	

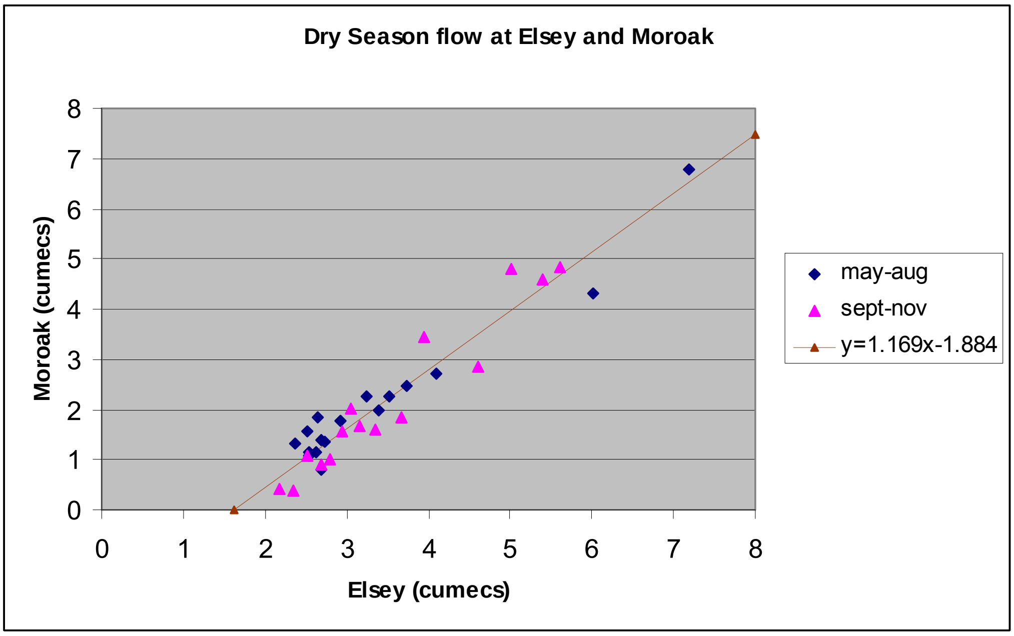

Figure D2 Correlation between gauged flow at Elsey and Moroak, grouped by month of gauging.

Viewing the data according to which month the gauging was undertaken results in a different trend emerging (Figure D2). Flow gaugings undertaken late in the Dry between September and November generally plot below the average line (line of best fit) with the exception of the data from 2002 onwards. This can largely be explained by changes in the evaporation rate. Evaporation is higher in the late Dry compared to the early Dry season; October evaporation (250 mm) is 30% higher than July evaporation (Table D2). The scatter in both of the plots can also be caused by changes in the channels. The number of flow channels can vary from year to year affecting evaporation losses. Also debris could build up or wash away in the outlet channels from the wetland reducing or enlarging the size of the wetland and the amount of water that discharges further downstream. This has also been accomplished by human intervention in the past through damming of channels and is documented by Merlan (1996) and Thonemann (1949).

Table D2 Evaporation rates
(From BOM website: www.bom.gov.au/jsp/ncc/climate_averages/evaporation)

Month	**Evaporation in Elsey-Moroak region**
July (early Dry season)	175 mm
October (late Dry season)	250-300 mm

To compare actual losses with expected losses from evaporation during the Dry season the following calculations were undertaken.

- Regression analysis on flow gaugings during the 1963-1991period
- Regression analysis on the 2007-2008 period as indicative of an extremely wet period (Table D3)
- Flow loss due to evaporation calculated between Elsey and Moroak gauge sites. (Table D4)

Regression analysis provides a line of best fit through a set of paired data points. The resulting line has the equation y=mx+c, where 'y' is the value on the y-axis (here the downstream flow at Moroak) and 'x' is the value along the x-axis (flow at Elsey) and 'm' is the gradient of the line and 'c' is where the line crosses the y-axis, the intercept. Results from the analyses are provided in Table D3.

Table D3 Data analysis for flow gaugings grouped in years noted. (Raw data Table C1)

	1963 – 1991 Average period	**2007 – 2008 Wet period**	**1963 – 2008 All years**
Intercept	-1.51	-0.56	-1.88
gradient	1.03	1.00	1.17
R squared	0.72	0.96	0.93
Calculated average loss m^3/s	-1.42	-0.54	-1.3

For each group of years the gradient in the regression analysis is close to one (Table D3) which suggests that there is a constant loss of flow between Elsey and Moroak for each era. That 'constant' is provided by the intercept or the calculated average loss (Table D3). These values vary significantly between the periods: -1.5 m^3/s in the representative 'average' rainfall period and -0.56 m^3/s in the wet period.

An estimate of the evaporation loss between the sites is provided in Table D4. It includes the estimated loss from a large wetland which exists along the river between Elsey and Moroak situated north and south of Red Lily Lagoon (Plate D1). Most of the evaporation loss can be attributed to the wetlands. Total evaporation loss may actually be higher as there are many braids downstream from the wetland and the evaporation loss from these has not been accounted for in the calculation. Also the extent of the wetlands are only estimated, they could be larger. The combined estimated evaporation loss of 1.2 m^3/s is close to the calculated 'average period' loss of 1.51 or 1.42 m^3/s (Table D3) and therefore provides confirmation that the large decrease in flow between the sites is primarily due to evaporation.

Table D4 Estimated evaporation losses along the Roper River between Elsey and Moroak
An average Dry season evaporation rate of 200 mm/month equivalent to about 7 mm/day was used. Flow loss due to Evaporation = 7 mm/day x length x width of open water area.

Open water area length	Open water area width	Evaporation rate	Evaporation over section	Equivalent loss in river flow
Distance between Elsey and Moroak 55 km	Average river width 60 m	7 mm/day	23100 m^3/day	≈ 0.3 m^3/s
Wetland length (Southern side) 4.75 km	Wetland width (Southern side) 1800 m	7 mm/day	59850 m^3/day	≈ 0.6 m^3/s
Wetland length (Northern side) 2.2 km	Wetland width (Northern side) 1800 m	7 mm/day	27720 m^3/day	≈ 0.3 m^3/s
		TOTAL		**1.2 m^3/s**

In 2007-2008 losses due to evaporation are expected to be higher because there would be a greater area of open water between the sites; the flow would spill into more river channels and wetlands would cover a larger area. But what is observed is that the flow is reduced by only 0.54 m^3/s between the gauge sites in the wet period compared to 1.42 m^3/s in the 'average period'. The discrepancy is attributed to extra groundwater inflow provided by the Tindall Limestone between the Elsey gauge site and Red Lily Lagoon. The Tindall Limestone extends as far as Red Lily Lagoon, approximately 10km further downstream of the Elsey gauge site (Figure D3). During the wet period, recharge to the Tindall Limestone aquifer would have been significant, resulting in high ground water levels. This in turn would provide higher spring discharges to the Roper River. Field investigations in 2009 provided evidence to this and an approximately 10% gain in flow was measured between the Elsey gauge site and Red Lily Lagoon in May 2009. This exercise should be repeated later in the Dry season to substantiate and better quantify this finding. Groundwater discharge in this area may also explain the difference between the 2002-2003 and 2007-2008 gaugings. After successive years of high rainfall the aquifer water levels probably reached their maximum in 2007-2008 resulting in larger groundwater discharges to the river in the latter years.

Recommended work:

- Gauge the flow along the river between the Elsey site and the wetland to ascertain how much groundwater inflows in this section during various months of the Dry Season.

- Gauge the flow just downstream from the wetland to find out how much water is used by the wetland.
- Refine length and width measurements of open water to better estimate evaporative loss.

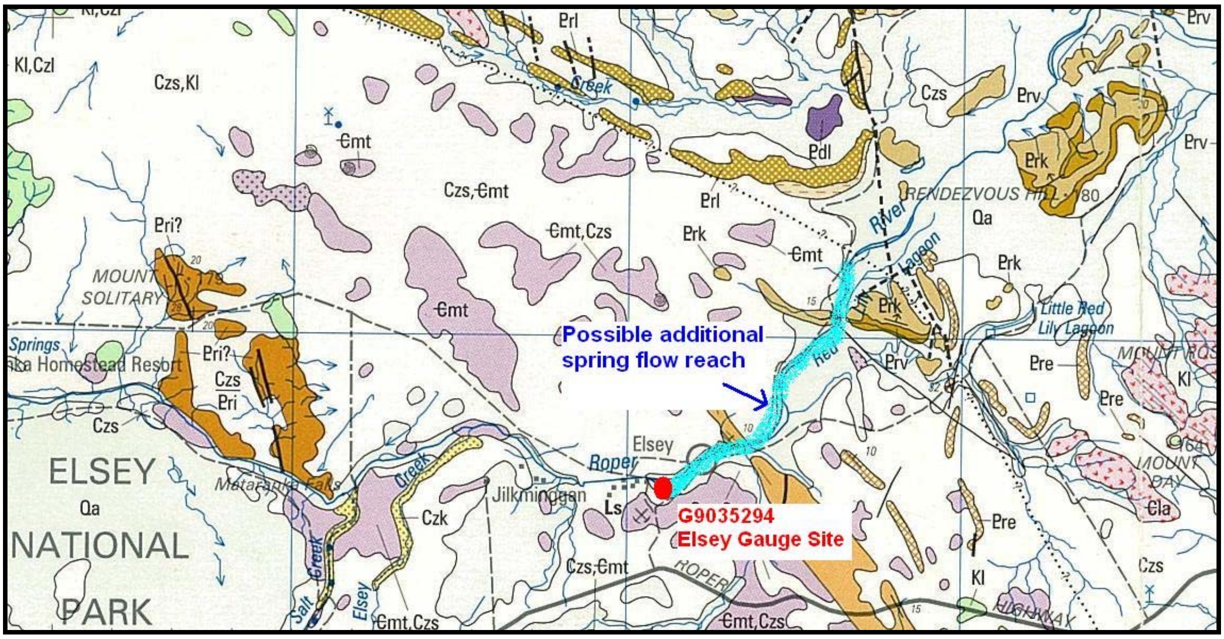

Figure D3 Excerpt from geology map showing extent of Tindall Limestone.
Tindall Limestone is denoted in pink and marked 'Emt'.

Plate D2 Rodney Metcalfe measuring the flow in one of the channels of the Roper River at Moroak Station

Section B: Moroak to Judy Crossing

Plate D3 Satellite image of the river between Moroak and Judy Crossing (Google Earth)

Here the river is extensively braided in the sector close to Judy Crossing.

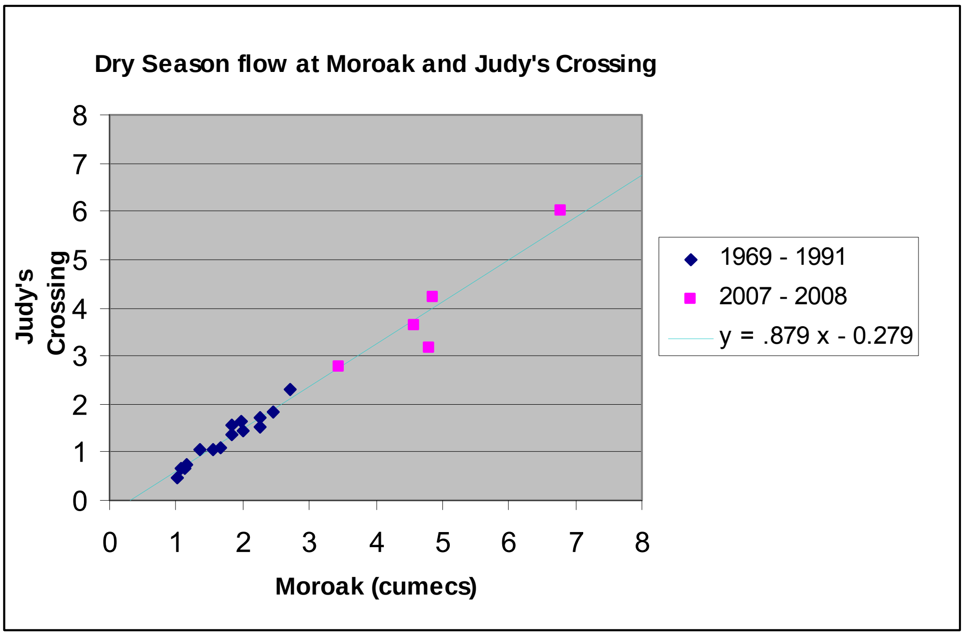

Figure D4 Correlation between gauged flow at Moroak and Judy Crossing.
Data points from Table C1. **Moroak** gauge site = **G9030123** 1963 – 2003, **G9035408+G9035398+G9035076** 2007 – 2008. **Judy Crossing** gauge site = **G9030010** 1969 – 1991, **G9035122** 2007 – 2008

There is less scatter in these points compared to Section A. This is because there are no extensive wetlands in this section and little to no input from groundwater is expected.

As was done in Section A, data was analysed to ascertain the measured average loss in this section of the river and comparisons made with the estimated loss due to evaporation.

Table D5 Data analysis for gaugings grouped in years noted. (Raw data from Table C1)

	1969 – 1991 Average period	**2007 – 2008 Wet period**	**1969 – 2008 All years**
Y-Intercept	-0.34	-0.89	-0.28
Gradient	0.93	0.99	0.88
R squared	0.94	0.89	0.97
Average loss	-0.47	-0.93	-0.59

Regression analysis suggests a constant loss of 0.34 m^3/s between the sites for the period 1969-1991 whereas the calculated average loss was 0.47 m^3/s. A much higher loss was calculated for the wet 2007-2008 period (around 0.9 m^3/s). This is in line with what may be expected, as in the wet period the higher flows would spill into more channels in the braided sections which would result in higher evaporation as there would be a greater area of open water.

Table D6 Estimated evaporation losses along the Roper River between Moroak and Judy Crossing for one channel.

Open water area length	**Open water area width**	**Evaporation rate**	**Evaporation over section**	**Equivalent loss in river flow**
Distance between Moroak and Judy Crossing 40 km	Average river width 60 m	7 mm/day	16,800 m^3/day	≈ 0.2 m^3/s

An estimate of the evaporation loss for a single channel between the sites is provided in Table D6. This value of 0.2 m^3/s is lower than the calculated losses (Table D5), however the river is well braided in about a third of this section and this could account for the difference. Given this, the analysis indicates that flow losses can be due primarily to evaporation.

Recommended work:

- Gauge the flow just upstream and downstream from the braided sections to determine the loss in these sections
- Refine length and width measurements of open water to better estimate evaporative loss.

Section C: Judy Crossing to Flying Fox Junction

Plate D4 Satellite image of the river between Judy Crossing and Flying Fox Junction (Google Earth)

In this section the river largely consists of a single channel but extensive braids exist in the lower third of the section.

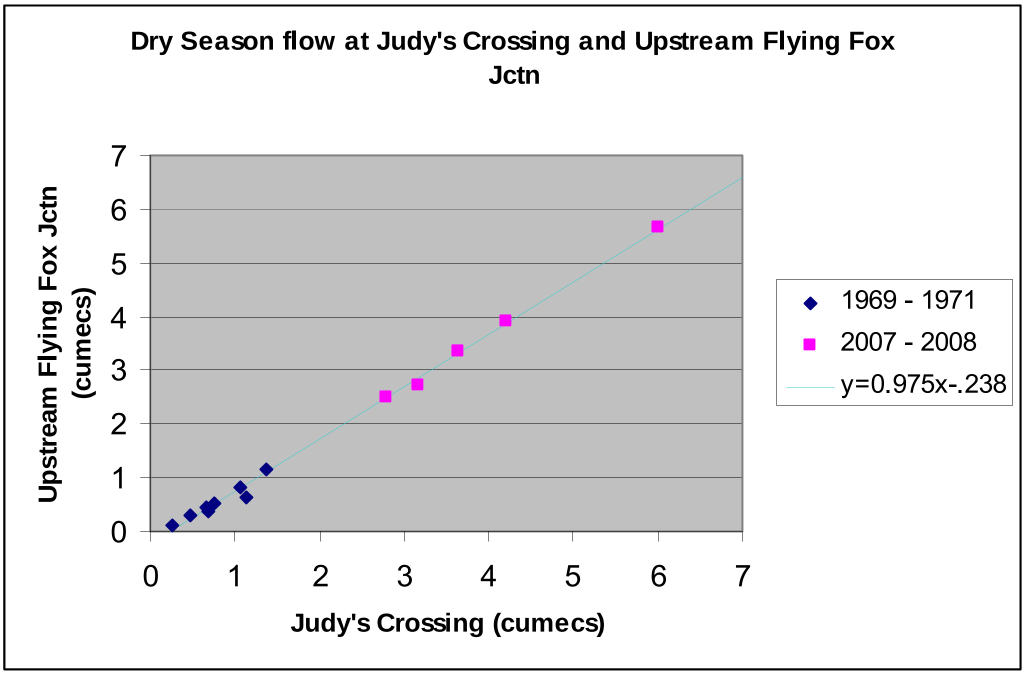

Figure D5 Correlation between gauged flow at Judy Crossing and Flying Fox Junction.

Data points from Table C1. **Judy Crossing** gauge site = **G9030010** 1969 – 1991, **G9035122** 2007 – 2008**.** **Flying Fox** gauge site = **G9030011** 1969 – 1991, **G9035409+G9035410** (sites on channels downstream from Flying Fox Creek)-**G9035287** (site at Flying Fox Creek) 2007-2008

As was done in Section A, data was analysed to ascertain the measured average loss in this section of the river and comparisons made with the estimated loss due to evaporation.

Table D7 Data analysis for gaugings grouped in years noted. (Raw data from Table C1)

	1969 – 1991 Average period	2007 – 2008 Wet period	1969 – 2008 All years
Y-Intercept	-0.12	-0.38	-0.24
Gradient	0.83	1.01	0.98
R squared	0.91	1.00	1.00
Average loss	-0.25	-0.33	-0.29

Regression analysis results have a similar trend to the analysis between Moroak and Judy Crossing however the amounts are all lower. This is somewhat unexpected as the river sections appear to have similar length and braiding characteristics.

Table D8 Estimated evaporation losses along the Roper River between Judy Crossing and Flying Fox Junction for one channel.

Open water area length	Open water area width	Evaporation rate	Evaporation over section	Equivalent loss in river flow
Distance between Judy Crossing and Flying Fox Jctn 41 km	Average river width 60 m	7 mm/day	17220 m^3/day	≈ 0.2 m^3/s

The estimated evaporation loss of 0.2 m^3/s (Table D8) is close to the loss values provided in Table D7. Evaporation losses due to braiding in the river has however not been accounted for in the evaporation estimate (0.2 m^3/s). The calculated loss for the 'average' period and the estimated evaporation loss are about the same which may indicate that usually in the Dry season river flow in the section is confined to one channel. In the wet period more than one channel contained flow (as confirmed by on site gaugings) which is reflected in the higher losses observed, Table D7. Overall the results show that flow loss in this section is primarily due to evaporation and there are no extra groundwater inflows.

Recommended work:

- Gauge the flow just upstream and downstream from the braided sections to determine the loss in these sections
- Refine length and width measurements of open water to better estimate evaporative loss.

Section D: **Flying Fox Junction to Red Rock**

Plate D5 **Satellite image of the river between Flying Fox Junction and Red Rock and Roper Bar** (Google Earth)

In this section of the river the flow is largely confined to one channel and two channels in the upper portion. Braiding continues for a few kilometres just after Flying Fox Junction.

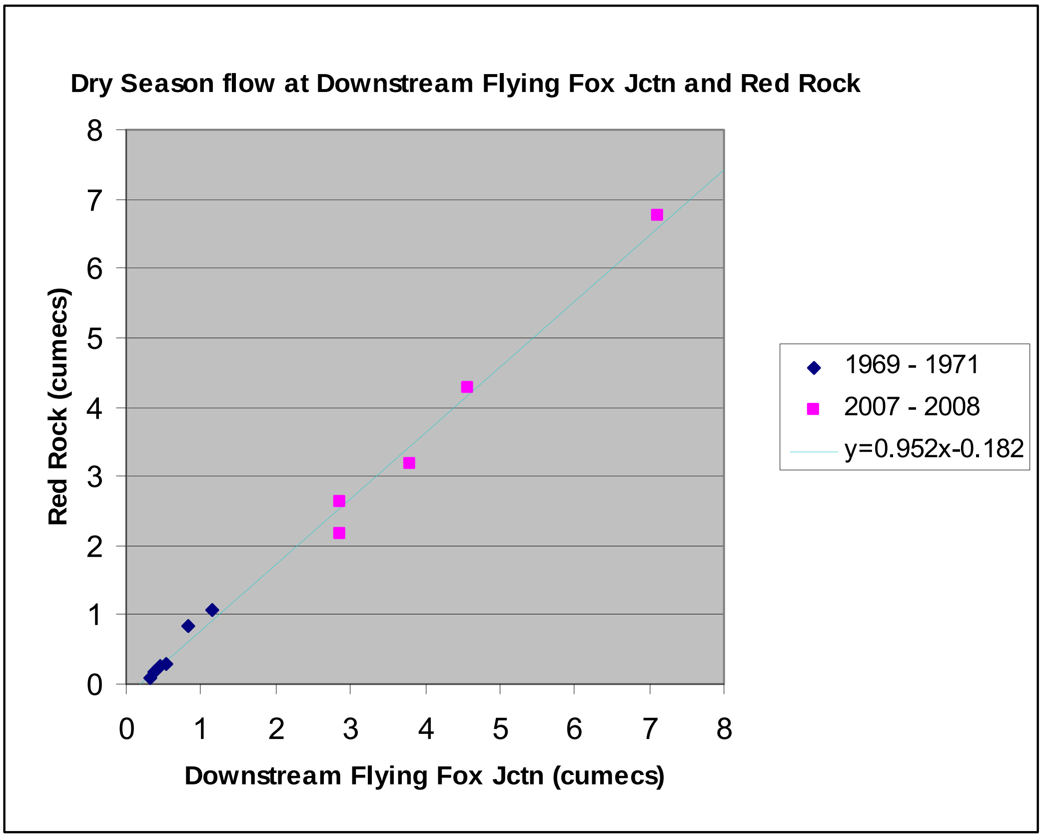

Figure D6 **Correlation between gauged flow at Flying Fox Junction and Red Rock.** Data points from Table C1. **Flying Fox** gauge site = **G9030011** 1969 – 1991, **G9035409+G9035410** (sites on channels downstream from Flying Fox Creek)-**G9035287** (site at Flying Fox Creek) 2007-2008 **Red Rock** = **G9030250** all years

Table D9 **Data analysis for gaugings grouped in years noted.** (Raw data from Appendix C)

	1969 – 1991 **Average period**	**2007 – 2008** **Wet period**	**1969 – 2008** **All years**
Y-Intercept	-0.31	-0.54	-0.18
Gradient	1.26	1.02	0.95
R squared	0.97	0.99	0.99
Average loss	-0.16	-0.46	-0.29

Regression analysis results are similar to previous sections in that the wet period shows higher losses than the average period. Again this may be attributed to braids with more channels containing flowing water in the wet period.

Table D10 **Estimated evaporation losses along the Roper River between Flying Fox Junction and Red Rock for one channel.**

Open water area length	**Open water area width**	**Evaporation rate**	**Evaporation over section**	**Equivalent loss in river flow**
Distance between Flying Fox Junction and Red Rock	Average river width			
35 km	60 m	7 mm/day	14,700 m^3/day	≈ 0.2 m^3/s

The estimated evaporation loss is very similar to the calculated average loss in the 'average' period. As explained for the adjacent upstream section such good correlation suggests that flow in the river was confined to one channel in the average rainfall period. In the wet period it was observed that more than one channel contained flow in this river section (confirmed by on site gaugings) and hence the higher losses. Overall the results show that flow loss in this section of the river is primarily due to evaporation and there are no extra groundwater inflows or outflows.

Recommended work:

- Gauge the flow just upstream and downstream from the braided sections to determine the loss in these sections
- Refine length and width measurements of open water to better estimate evaporative loss.

Section E: Red Rock to Roper Bar

There is a single channel between these two sites.

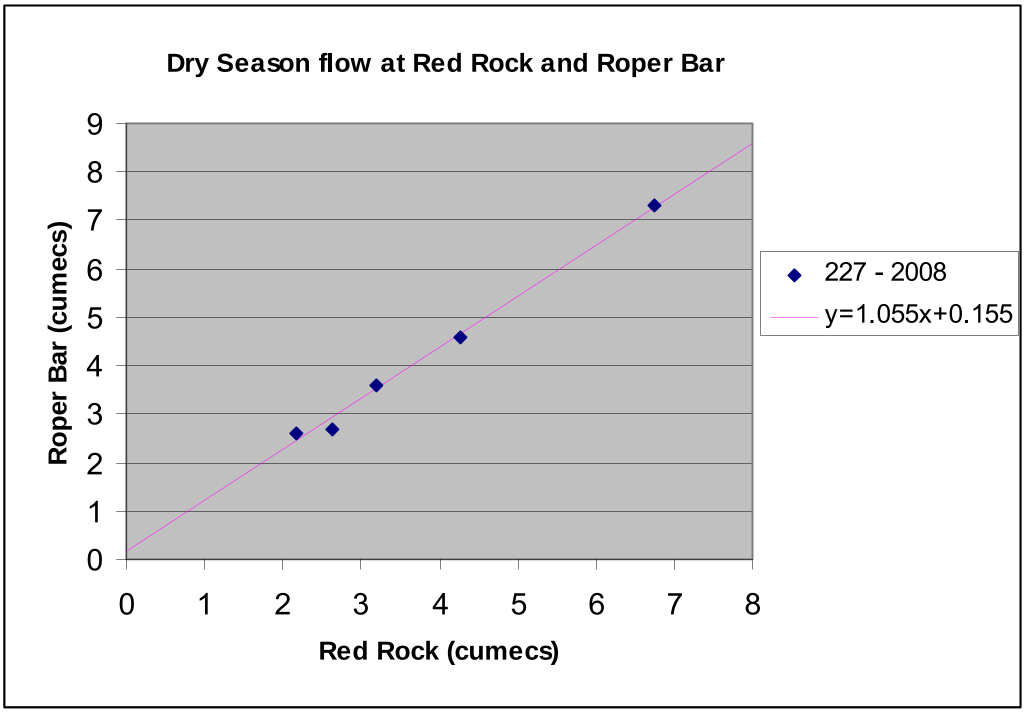

Figure D7 Correlation between gauged flow at Red Rock and Roper Bar.
Data points from Table C1. **Red Rock = G9030250**, **Roper Bar = G9030012**

Table D11 Data analysis for gaugings. (Raw data from Table C1)

	2007 – 2008 Wet period
Y-intercept	0.16
Gradient	1.06
R squared	0.99
Average gain	0.37

Between these two sites (Plate D5), gaugings were only undertaken during the wet era and the results show a gain in flow. The river has become a gaining stream. This result is a little unexpected but on further investigation there is some supporting evidence. Radon analysis was conducted in 2002 along the Roper River including the Red Rock site and Cook (2003) in his report writes that 'the data suggests that significant groundwater inflow occurs near the (Red Rock) gauging station'. The geology of this area also supports these results. The gauging station lies on outcrop of the Hodgson Sandstone which is host to numerous small springs (see section on springs) a number of which are located within a few kilometres of the gauging station. Aside from the Hodgson Sandstone lying adjacent to the river, the Arnold Sandstone also outcrops along the river about 1.5 km downstream from Red Rock. The Arnold Sandstone is similar to the Hodgson Sandstone and interestingly this is the only location where it intersects with the river. These two rock formations are likely to be providing groundwater discharge to the river although the amount of 0.37 cumecs is unexpected.

To test what contribution to flow these sandstone units provide it would be worthwhile to undertake flow gaugings along this section of the river coincident with the sandstone units with the one flow meter. The gaugings at the two sites were done by differing flow meters so the gain in flow may also be attributed to this.

Table D12 Estimated evaporation losses along the Roper River between Red Rock and Roper Bar

Open water area length	**Open water area width**	**Evaporation rate**	**Evaporation over section**	**Equivalent loss in river flow**
Distance between Red Rock and Roper Bar 11 km	Average river width 60 m	7 mm/day	4620 m^3/day	≈ 0.05 m^3/s

The evaporation loss between the sites would have been provided for by groundwater inflow. Hence the actual groundwater contribution to the river in this section can be approximated at 0.37 + 0.05 = 0.42 m^3/s

Recommended work:

- Gauge the flow at sites along the section coincident with the sandstone units to confirm the location and amount of gain in flow.

APPENDIX E: MATARANKA RAINFALL RECORD

Rainfall has been recorded at Mataranka since 1916 at DR14610, however many years have missing data. Interpolated long term rainfall data (SILO Data Drill) is however available through the Bureau of Meteorology for the Mataranka location since 1889 (SILO 1998). Figure E1 provides a plot of the recorded and interpolated data at Mataranka. Because the data drill record compares very well with the actual data and has a long and complete record starting in 1889, it has been used in this report as representative of Mataranka rainfall.

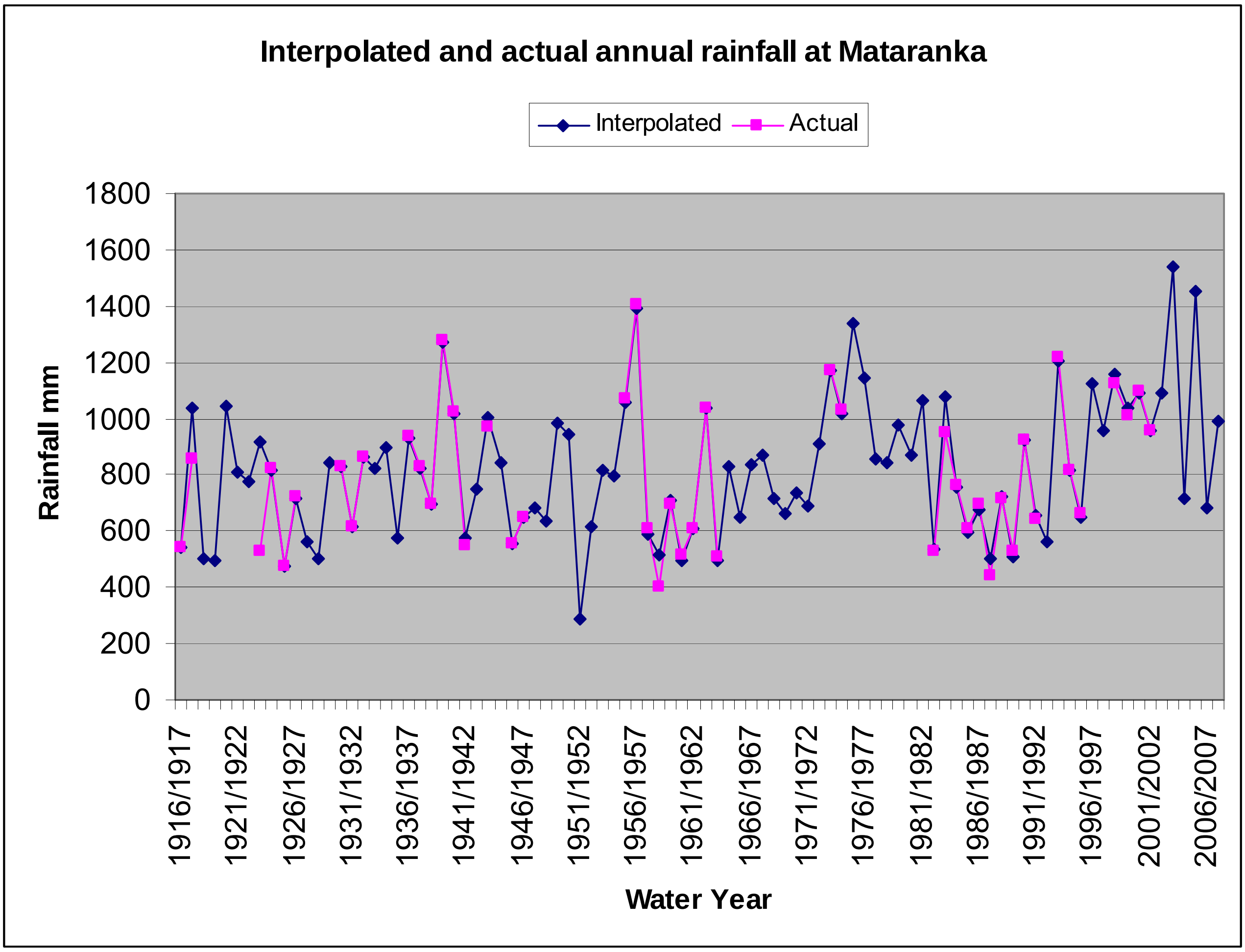

Figure E1 Actual Wet Season rainfall at Mataranka DR14610 compared with Data Drill interpolated data for the same location. DR14610 data is shown where the wet season record is complete or where there are minimal missing days.

Water Year refers to the total rain from September of one year to August of the following year so as to cover the complete wet season.

APPENDIX F: GROUNDWATER MONITORING DATA

There is scant groundwater monitoring data available for the area that the Water Resources map covers. At Minyerri 5 bores have up to 6 records each, for the period 1995 to 1999 (Zaar 2005).

In the Mataranka area monitoring in 7 bores was begun in 2004 (Zaar 2005) and at Elsey Station monitoring began on one bore in 2000.

To provide an indication of how groundwater levels have fluctuated in the longer term around Mataranka, data from one of the Mataranka monitoring bores (RN034031) and the Elsey bore (RN029012) are plotted alongside RN022006 which has a long period of record but is situated in the Venn area (Figure F1). RN022006 is also located in the Tindall aquifer north of Mataranka but drains to the Katherine River. It is situated near the groundwater divide that separates groundwater flow to the Katherine River from groundwater flow to the Roper River. Aside from the 2004 and 2005 years, where the bore shows to have had exceptional recharge due to local conditions, the groundwater levels appear consistent with the other bores shown.

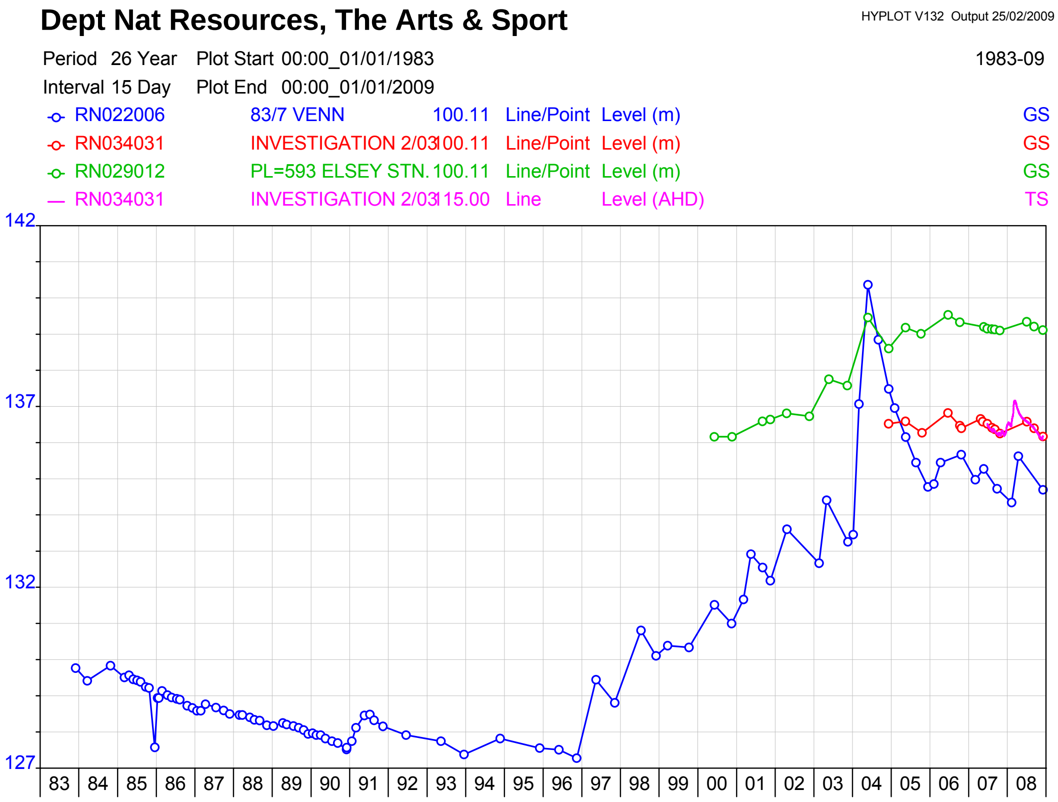

Figure F1 Groundwater levels as measured by bores in the Tindall aquifer.
(Levels denoted in AHD m)

APPENDIX G: WHEN THE ROPER RIVER STOPPED FLOWING

Table G1 Rainfall at Mataranka and minimum flow at Roper Bar, when available, for era where flow ceased. Actual (DR14610) rainfall shown in blue (when available), Mataranka Data Drill rainfall data in black.

Year	Rainfall	Minimum Flow (cumecs)	Month in which flow ceased	Data source
1944/1945	843			
1945/1946	554			
1946/1947	651			
1947/1948	683			
1948/1949	636			
1949/1950	987			
1950/1951	946			
1951/1952	290	0	N/A	Inferred by historical account (Cole 1968)
1952/1953	616	0	N/A	Inferred from very low flow at G9030013
1953/1954	814	0	June	G9030250 F34, G9030012 F42
1954/1955	797	0	July	G9030012 F6, F42
1955/1956	1073	0	June	G9030250 F34, G9030012 F42
1956/1957	1403	0	April	G9030250 F34, G9030012 F42
1957/1958	606	0	September	G9030250 F34, G9030012 F42
1958/1959	403	0	June	G9030250 F34, G9030012 F42
1959/1960	694	0	August	G9030250 F34, G9030012 F42
1960/1961	516	0	March	G9030250 F34, G9030012 F42
1961/1962	606	0	March	G9030250 F34, G9030012 F42
1962/1963	1038	0	N/A	G9030012 F32, F42
1963/1964	509	0	July	G9030250 F34
1964/1965	832	0	August	G9030250 F34
1965/1966	649	0	September	G9030250 F9, F34
1966/1967	834	0	September	G9030250 F19, Moretti 1992
1967/1968	873	0.133		G9030250 Gaugings and water level record
1968/1969	719	0.04		G9030250 Gaugings and water level record
1969/1970	665	0	September	G9030250 F58, 59. Moretti 1992.
1970/1971	739	0	October	G9030250 Gaugings and water level record
1971/1972	690	N/A		N/A
1972/1973	912	0	October	G9030250 Gaugings and water

				level record. Moretti 1992.
1973/1974	1173	0.09		G9030250 Gaugings and water level record
1974/1975	1014	0.57		G9030250 Gaugings and water level record
1975/1976	1336	1.3		G9030250 Gaugings and water level record

It is also noted on file G9030012 F39 that the river ceased to flow in 1939 and that there was a severe drought in that year.

APPENDIX H: DEPARTMENTAL WATER RESOURCES REPORTS

These reports are available from NRETAS. They pertain to this study region and are listed in order of area. Scanned reports are available in digital format. Reports can be viewed and downloaded at www.nt.gov.au/landwater/index.jsp. (GW = groundwater, SW = Surface water)

Scan No:	NRD No:	Title	Type	Area	Author
WRD84055	55/84D	Bore completion - Hodgson Downs outstation	GW	Miniyeri	Karp, D
WRD88047	47/88D	Bore Completion Report, RN 25383, Hodgson Downs Outstation.	GW	Miniyeri	Verma, M
	75/90D	Water Supply Investigation Hodgson Downs (Miniyeri) Community	GW	Minyerri	verma, M
	46/92D	Miniyeri Groundwater Resources Investigation 1991/92	GW	Minyerri	Jamieson M, Pidsley D,
WRD60011	11/60D	Roper River Mission: Water Resources Survey	GW	Ngukurr	Forbes, C. F
WRD60016	16/60D	Roper River Mission water resources investigation-field trip	GW	Ngukurr	Kneebone, D & Henderson, K
WRD60017	17/60D	Reconnaisance of the Roper River Mission area	GW	Ngukurr	Brooks, A & Kneebone, D
WRD62025	25/62D	Roper River mission water resources survey field trip	GW	Ngukurr	Friel, CM
WRD63021	21/63D	Surface Water Reconnaissance Of Roper and Wilton River Area	SW	Ngukurr	Brooks, B & Kneebone, D
WRD85020	20/85D	Barunga, Bulman, Lajamanu, Ngukurr Investigations for Water and Sewerage Services 1985	GW	Ngukurr	
WRD92041	41/92D	Ngukurr Water Supply Evaluation	GW	Ngukurr	Moretti, A et al.
	28/02D	Ngukurr Review of Water Supply Options	GW	Ngukurr	Jolly, P.
	56/02D	Preliminary Assessment of Water Supply source Options for Ngukurr	GW	Ngukurr	Yin Foo, D
	16/08D	Ngukurr Groundwater Investigation 2006 – 07	GW	Ngukurr	Sumner J
BMR00238	Bmr.bul 238	BMR Stratigraphic drilling the Roper Group Northern Territory	GW		
WRD87039	39/87D	Boomerang Lagoon Bore 24056	GW		Karp, D
WRD88076	76/88D	Bore Completion Report Bores 25319 & 25380 Numultja Oustation	GW		Verma, M
WRD88010	10/88D	Baseflow Water Quality Surveys in Rivers in the N.T. Vol.11. Roper, Wilton & Hodgson Rivers.	SW		
	36/01	Roper River Catchment. An Assessment of the Physical & Ecological Condition of the Roper River & its Major Tributaries			Faulks, J.
	18/05D	Bathymetric Survey of the Roper River Estuary 2002	SW		Knapton A, et al.
*WRD99003	03/99D	Water Resources of East Arnhem Land	SW & GW	East Arnhemland	Zaar, U, Prowse G & Matthews I.
*WRD01028	28/2001D	Water Resources of the Katherine Region and South West Arnhem Land	SW & GW	Katherine & Arnhem Land	George, D
*WRD00018	18/2000D	Water Resources of the Sturt Plateau region, overview report	GW	Sturt Plateau	Yin Foo, D

*These reports pertain to regions which abut this study region. They may be of interest.

APPENDIX I: SUMMARY OF BORE INFORMATION

There are no bores in this map region which are currently monitored by NRETAS.

Bores previously monitored are situated at Minyeri and are listed below:

Minyeri

Bore	Zone 53 Easting	Northing	Pipe	Commence	Cease	No. Records	AHD level
RN027815	398796	8310840	1	11/11/1996	02/11/1999	3	*64*
RN027816	399308	8312185	1	25/09/1995	02/11/1999	6	*59*
RN027901	401538	8317822	1	25/09/1995	02/11/1999	6	*54*
RN027906	397687	8318340	1	25/09/1995	02/11/1999	6	*62*
RN027908	398279	8318383	1	25/09/1995	02/11/1999	6	*58*

AHD = Australian Height Datum.

The following summary data is provided in alphabetical order of land parcel name.

Alawa 1 Aboriginal Land Trust (Hodgson Downs Station)

Site	Site Name	Zone	Easting	Northing	Start Date	Drill Depth	Casing Depth	Standing water level	Yield L/s
RN005027	NEW HOMESTEAD HODGSON DOWNS STN	53	402527	8322366	31/08/1965	153	17	11.6	0.5
RN007322	A=162/70 HODGSON DOWNS STN	53	401627	8317166	24/08/1970	91.4	3.65	10.7	0.2pumped
RN008145	A=21/73 HODGSON DOWNS STN	53	411377	8310416	18/07/1973	45.7	NA	NA	NA
RN008146	A=23/73 HODGSON DOWNS STN	53	415127	8335066	17/07/1973	76.2	NA	NA	0.3
RN008147	6 MILE A=22/73 HODGSON DOWNS STN	53	400027	8322666	16/07/1973	41.1	41.1	7	2.3
RN008436	GIBB 1/74 HODGSON DOWNS STN	53	401327	8315666	29/08/1974	100	Nil	NA	0
RN008502	GIBB 74/2 HODGSON DOWNS STN	53	401577	8317266	30/09/1974	38	NA	NA	NA
RN008503	GIBB 74/3 HODGSON DOWNS	53	402677	8317266	4/10/1974	77	28.4	7.5	1.3
RN008504	GIBB 74/4 HODGSON DOWNS STN	53	401627	8317216	22/10/1974	56	25.5	6.1	1.3
RN021093	HODGSON DOWNS 2/81 HODGSON DOWNS STN	53	400277	8315566	11/09/1981	215	6	NA	NA
RN021094	HODGSON DOWNS 1/81 HODGSON DOWNS STN	53	400927	8317166	9/09/1981	160	4	NA	0.2
RN022806	HODGSON DOWNS 1/84 HODGSON DOWNS STN	53	401727	8316866	10/08/1984	76.3	33	3	0.5
RN022807	HODGSON DOWNS 2/84 HODGSON DOWNS STN	53	402127	8316216	11/08/1984	88.5	NA	NA	0.9
RN022808	HODGDSON DOWNS 3/84 HODGSSON DOWNS STN	53	401727	8316666	12/08/1984	70.3	38	3	0.9
RN022809	HODGSON DOWNS 4/84 HOGDSON DOWNS STN	53	401547	8316566	14/08/1984	45.9	NA	2.5	0.3
RN023161	HODGSON DOWNS 5/84 HODGSON DOWNS STN	53	401727	8316766	14/08/1984	73.4	NA	2.6	0.6
RN023162	HODGSON DOWNS 6/84 HODGSON DOWNS STN	53	401727	8316616	16/08/1984	61.5	NA	1.7	0.6
RN023163	HODGSON DOWN 7/84 HODGSON DOWN STN	53	401777	8316466	18/08/1984	49.4	NA	4.5	0.5
RN025381	HODGSON DOWNS 1/87 HODGSON DOWNS STN	53	401627	8316566	12/10/1987	150	NA	9	0.4

Alawa 1 Aboriginal Land Trust (Hodgson Downs Station)

Site	Site Name	Zone	Easting	Northing	Start Date	Drill Depth	Casing Depth	Standing water level	Yield L/s
RN025382	HODGSON DOWNS 2/87 HODGSON DOWNS STN	53	401627	8316566	14/10/1987	50	NA	NA	0.2
RN025383	NO.1 MINIYERI 3/87 HODGSON DOWNS STN	53	401667	8317266	15/10/1987	92.2	92.7	6.5	0.7pumped
RN026145	BANIBI PTY LTD HODGSON DOWNS	53	415077	8335066	28/02/1989	101	101	14	0.3
RN027815	WR 91/1 MINIYERI HODGSON DOWNS	53	398797	8310841	11/10/1991	100.4	29	3	3 pumped
RN027816	WR 91/2 MINIYERI HODGSON DOWNS	53	399309	8312186	12/10/1991	130.5	5.9	1.9	2
RN027817	WR 91/3 MINIYERI HODGSON DOWNS	53	401887	8312206	15/10/1991	31.2	NA	NA	0
RN027818	WR 91/4 MINIYERI HODGSON DOWNS	53	399477	8313266	16/10/1991	92	NA	NA	0
RN027819	WR 91/5 MINIYERI HODGSON DOWNS	53	400217	8318866	17/10/1991	119	Nil	NA	0.1
RN027900	WR 91/6 MINIYERI HODGSON DOWNS	53	401627	8317866	18/10/1991	50.6	NA	NA	0
RN027901	WR 91/7 MINIYERI HODGSON DOWNS	53	401539	8317823	19/10/1991	100.8	96	5	0.5
RN027902	WR 91/8 MINIYERI HODGSON DOWNS	53	402627	8317836	23/10/1991	149.7	128	8.4	0.3
RN027903	WR 91/9 MINIYERI HODGSON DOWNS	53	400287	8315566	25/10/1991	259.2	NA	NA	NA
RN027904	WR 91/10 MINIYERI HODGSON DOWNS	53	399767	8318166	7/11/1991	102	Nil	NA	0.8
RN027905	WR 91/11 MINIYERI HODGSON DOWNS	53	399192	8318266	8/11/1991	127	NA	5	0.8
RN027906	WR 91/12 MINIYERI HODGSON DOWNS	53	397688	8318341	11/11/1991	68.9	68.9	5.6	2.6
RN027907	WR 91/13 P1 MINIYERI HODGSON DOWNS	53	397727	8318466	13/11/1991	64.4	40	6.1	0.7pumped
RN027908	WR 91/14 MINIYERI HODGSON DOWNS	53	398280	8318384	14/11/1991	106.9	65	1.8	0.5
RN027909	WR 91/15 P2 MINIYERI HODGSON DOWNS	53	398377	8318436	16/11/1991	119.1	67.3	2.5	0.7pumped
RN027960	NO.2 P3 MINIYERI=HODGSON DOWNS	53	401627	8317866	20/11/1991	95.8	50.7	4.3	0.7pumped
RN027961	NO.3 MINIYERI = HODGSON DOWNS	53	401227	8317966	22/11/1991	93	50.6	2.4	0.4pumped

Alawa 1 Aboriginal Land Trust (Hodgson Downs Station)

Site	Site Name	Zone	Easting	Northing	Start Date	Drill Depth	Casing Depth	Standing water level	Yield L/s
RN032155	SITE A	53	399027	8311016	26/05/1999	101	5.8	4.2	0.2
RN032156	SITE B	53	398827	8310766	27/05/1999	94	5.8	5.3	0.3
RN032157	NO 1/99	53	399127	8310666	28/05/1999	78	78	14.5	5.5
RN035797	PAWA (MINYERRI) ALAWA 1 ABORIGINAL LAND TRUST	53	399045	8310652	8/07/2008	91.5	42	19	2.3
RN035798	PAWA (MINYERRI) ALAWA 1 ABORIGINAL LAND TRUST	53	398998	8310615	8/07/2008	97.4	80	17.7	3 pumped
RN035799	PAWA (MINYERRI) ALAWA 1 ABORIGINAL LAND TRUST	53	399741	8312264	11/07/2008	139.2	5.7	4.95	1.3
RN035870	PAWA (MINYERRI) ALAWA 1 ABORIGINAL LAND TRUST	53	400722	8326429	12/07/2008	73.5	5.7	NA	0
RN035871	PAWA (MINYERRI) ALAWA 1 ABORIGINAL LAND TRUST	53	405659	8323343	14/07/2008	55.5	5.7	NA	0
RN035872	PAWA (MINYERRI) ALAWA 1 ABORIGINAL LAND TRUST	53	398888	8310348	15/07/2008	49.5	Nil	NA	0
RN035873	PAWA (MINYERRI) ALAWA 1 ABORIGINAL LAND TRUST	53	399043	8311093	16/07/2008	90.7	Nil	NA	0
RN035874	PAWA (MINYERRI)	53	398675	8311010	1/08/2008	61.5	Nil	NA	0
RN035875	PAWA (MINYERRI)	53	398791	8310933	4/08/2008	67.5	60	17.5	8.5
RN035876	PAWA (MINYERRI)	53	398850	8311030	7/08/2008	91.5	68.5	16	2 pumped
RN035877	PAWA (MINYERRI)	53	402982	8324515	9/08/2008	145.2	Nil	NA	0
RN035878	PAWA (MINYERRI)	53	403429	8324939	15/08/2008	115.5	115.5	Flowing	0.1
RN035879	PAWA (MINYERRI)	53	403417	8324975	15/08/2008	136	67.6	Flowing	0.7pumped
RN036300	PAWA (MINYERRI)	53	402745	8324958	4/09/2008	150.8	82.0	Flowing	0.5pumped
RN036301	PAWA (MINYERRI)	53	398910	8311247	6/09/2008	61.5	61.5	12.95	0.1

__ Bores drilled into the Bessie Creek contact zone aquifers

Arnhem Land Aboriginal Land Trust

Site	Site Name	Zone	Easting	Northing	Start Date	Drill Depth	Casing Depth	Standing water level	Yield L/s
RN002735	TEST NO. 1 NGUKURR	53	470626	8372265	23/09/1961	17.4	NA	NA	NA
RN002736	TEST NO. 2 NGUKURR	53	470826	8371565	25/09/1961	3.8	NA	NA	NA
RN002737	TEST NO. 3 NGUKURR	53	473036	8384065	26/09/1961	31.7	NA	8	0
RN002738	TEST NO. 4 NGUKURR	53	474326	8375965	29/09/1961	10.2	NA	NA	NA
RN002739	TEST NO. 5 NGUKURR	53	472926	8372165	30/09/1961	12.8	NA	NA	NA
RN002740	TEST NO. 6 NGUKURR	53	479726	8372155	2/10/1961	10.6	NA	NA	NA
RN002741	TEST NO. 7 NGUKURR	53	475926	8369166	3/10/1961	16.2	NA	NA	NA
RN002742	TEST NO. 8 NGUKURR	53	492626	8366866	5/10/1961	11.8	NA	NA	NA
RN002743	TEST NO. 9 NGUKURR	53	492626	8366866	6/10/1961	21.6	NA	9.15	0.2
RN004098	NO. 2 NGUKURR	53	470534	8370965	28/09/1963	85.4	5.8	24.36	1.3
RN004099	NO. 3 NGUKURR	53	473926	8371645	11/10/1963	38.1	NA	17.96	3.9
RN004100	NO. 4 NGUKURR	53	473924	8371640	17/10/1963	19.4	NA	10.98	0.5
RN004219	NO.1 NGUKURR	53	473925	8371646	25/09/1963	43.9	NA	18.51	0.2
RN005955	PROD. 1 NUGKURR	53	469836	8374300	8/11/1967	57.9	51.8	30.38	12pumped
RN006035	PROD. 2 NGUKURR	53	469826	8374100	20/11/1967	50.6	37.8	29	4 pumped
RN006160	N.M.R.R.1 ROPER RIVER	53	533126	8365466	8/07/1968	22.87	NA	2.43	2.5
RN006161	N.M.R.R.2 ROPER RIVER	53	529926	8365916	8/07/1968	45.75	none	9.14	0.5
RN006162	N.M.R.R.3 ROPER RIVER	53	527526	8365766	8/07/1968	30.48	none	12.9	0.2
RN006163	N.M.R.R.4 ROPER RIVER	53	503876	8359866	9/07/1968	91.46	none	6.09	0.7

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Site	Site Name	Zone	Easting	Northing	Start Date	Drill Depth	Casing Depth	Standing water level	Yield L/s
RN007868	NO.3 NGUKURR	53	476926	8393065	29/05/1972	106.75	22.875	NA	0
RN007869	NO.2 NGUKURR	53	469016	8384365	26/05/1972	122	3.05	NA	0
RN007870	NO.1 NGUKURR	53	477526	8373965	25/05/1972	48.8	45.5	14.03	1.4
RN009323	78/1 NGUKURR	53	478616	8386165	25/09/1978	15	NA	NA	0
RN009324	78/2 NGUKURR	53	469426	8380455	29/09/1978	35	NA	NA	0
RN009325	78/3 NGUKURR	53	473026	8379445	6/10/1978	31.5	NA	3.8	0.1
RN009669	79/1 WUYAGIBA	53	555826	8383666	24/10/1979	6	NA	NA	0
RN009871	79/3 WUYAGIBA	53	555806	8383646	26/10/1979	6	4	2.75	1
RN009872	79/2 WUYAGIBA	53	555816	8383626	25/10/1979	6	4	2.75	1.2
RN021481	PROD. NO.3 NGUKURR	53	469706	8374165	15/06/1982	49	49	27	5
RN021482	2/82 NAMALURI O/STN.	53	497826	8386665	10/06/1982	37	37	9	2.7
RN021483	1/82 NULLAWAN O/STN.	53	492326	8365516	4/06/1982	30	none	6	3.785
RN021484	2/82 NULLAWAN O/STN.	53	488526	8367566	7/06/1982	73	2	5	0.189
RN021485	3/82 NULLAWAN O/STN.	53	492226	8366366	16/06/1982	43	none	NA	0
RN021486	4/82 NULLAWAN O/STN	53	495126	8366566	17/06/1982	43	none	NA	0
RN021487	1/82 TURKEY LAGOON O/STN.	53	473126	8393665	8/06/1982	49	none	NA	0
RN021488	2/82 TURKEY LAGOON O/STN.	53	473126	8393765	9/06/1982	37	none	NA	0
RN021489	1/82 NAMALURI O/STN.	53	497926	8386635	9/06/1982	37	none	NA	0
RN021500	1/82 COSTELLO O/STN.	53	487126	8389665	11/06/1982	43	none	NA	0
RN021501	2/82 COSTELLO O/STN.	53	487126	8389365	11/06/1982	43	none	NA	0

Arnhem Land Aboriginal Land Trust

Site	Site Name	Zone	Easting	Northing	Start Date	Drill Depth	Casing Depth	Standing water level	Yield L/s
RN021502	3/82 COSTELLO O/STN.	53	487126	8389265	11/06/1982	30	none	NA	0
RN021503	1/82 NGUKURR	53	471626	8373645	12/06/1982	80	2	NA	0
RN021504	2/82 NGUKURR	53	472126	8373765	13/06/1982	27	none	NA	0
RN021505	3/82 NGUKURR	53	472326	8373615	14/06/1982	54	2	12	1.3
RN021506	4/82 NGUKURR	53	472526	8373265	14/06/1982	43	none	15	0.75
RN021507	5/82 NGUKURR	53	469526	8373765	16/06/1982	43	none	NA	0
RN024055	COMMUNITY DEVELOPMENT BOOMERANG LAGOON	53	504976	8402815	5/11/1985	60	none	NA	0
RN024056	COMMUNITY DEVELOPMENT BOOMERANG LAGOON	53	505026	8402165	7/11/1985	23	24	10.8	3
RN030383	WUYAGIBA COMMUNITY	53	556116	8383881	21/11/1995	4	3.95	2.25	1
RN030405	NGUKURR MISSION BORE	53	469926	8373965	11/10/1996	58.2	58	NA	10
RN030407	WUYAGIBA OUTSTATION BORE	53	555926	8383866	18/10/1996	11.5	NA	NA	NA
RN032802	IVAN BOND	53	469500	8374823	20/10/2000	45	41	NA	8
RN032965	SITE 1	53	502401	8399510	18/07/2001	50	6	NA	0
RN032966	SITE 2	53	502056	8394615	19/07/2001	60	60	7.9	3
RN031986	N.T. GOVT (NGUKURR)	53	466243	8372837	11/11/2006	48.8	43.7	16.15	5.8
RN031987	N.T. GOVT (NGUKURR)	53	466106	8372042	17/11/2006	129	0	15	0
RN031988	N.T. GOVT (NGUKURR)	53	468903	8371998	16/11/2006	73.6	0	7.2	7
RN031989	N.T. GOVT (NGUKURR)	53	471308	8375760	20/11/2006	122.4	0	21.65	4.4
RN034908	D.N.R.E.T.A. (NGUKURR)	53	469826	8371955	23/09/2006	19.6	0	NA	0
RN034909	D.N.R.E.T.A. (NGUKURR)	53	469295	8373352	26/09/2006	79.5	79.5	5.3	9

Arnhem Land Aboriginal Land Trust

Site	Site Name	Zone	Easting	Northing	Start Date	Drill Depth	Casing Depth	Standing water level	Yield L/s
RN035300	D.N.R.E.T.A. (NGUKURR)	53	469314	8373832	27/09/2006	55.5	0	NA	0
RN035301	D.N.R.E.T.A. (NGUKURR)	53	468076	8374867	7/10/2006	109.5	64.7	17.3	18
RN035302	D.N.R.E.T.A. (NGUKURR)	53	467499	8375164	6/10/2006	109.5	94.5	14.9	16
RN035315	DEPT.NATURAL RESOURCES ENVIRONMENT AND THE ARTS	53	466785	8375323	31/05/2007	70	69.8	39.15	6.3
RN035316	DEPT. NATURAL RESOUCRES ENVIRONMENT AND THE ARTS	53	467502	8375157	8/06/2007	109.4	33.5	7.2	10
RN035317	DEPT. NATURAL RESOURCES ENVIRONMENT AND THE ARTS	53	468093	8374892	14/06/2007	109.5	48.5	17.7	20
RN035318	DEPT. NATURAL RESOURCES ENVIRONMENT AND THE ARTS	53	465394	8369162	18/06/2007	42.5	0	NA	0
RN035319	DEPT N.R.E.T.A. (NGUKURR)	53	465860	8369522	2/07/2007	44	41.7	4.25	20
RN035510	N.T. GOVT (NGUKURR)	53	472257	8373429	22/11/2006	122.1	0	8.2	7.1
RN035511	N.T. GOVT (NGUKURR)	53	470937	8373966	23/11/2006	61.3	0	19.5	2.8
RN035512	N.T. GOVT (NGUKURR)	53	467631	8374911	25/11/2006	110	42	14.15	3.5
RN035513	N.T. GOVT (NGUKURR)	53	465320	8369175	28/11/2006	42.9	0	5.71	15
RN035514	N.T. GOVT (NGUKURR)	53	464847	8371534	30/11/2006	30.6	0	5.1	2.3
RN035515	N.T. GOVT (NGUKURR)	53	465276	8370390	30/11/2006	54.1	0	10.18	3
RN035720	DEPT N.R.E.T.A. (NGUKURR)	53	465963	8369469	7/07/2007	43.5	41.8	4	26
RN035721	DEPT N.R.E.T.A. (NGUKURR)	53	465957	8369473	13/07/2007	43.5	40.6	4.25	30

Outstation bores denoted by brown font.

Big River

Site	Site Name	Zone	Easting	Northing	Start Date	Drill Depth	Casing Depth	Standing water level	Yield L/s
RN003853	FLYING FOX NO.2 ROPER VALLEY STN.	53	412027	8383865	27/06/1963	106.75	NA	30.5	0.75
RN007088	69/70 MOUNTAIN VALLEY STN.	53	416056	8390065	14/06/1970	76.2	15.25	21.23	0.63

Flying Fox

Site	Site Name	Zone	Easting	Northing	Start Date	Drill Depth	Casing Depth	Standing water level	Yield L/s
RN008444	Gibb 74/3 Roper Valley	53	377826	8355065	18/09/1974	84	NA	NA	DUD
RN008443	Gibb 74/2 Roper Valley	53	389826	8355465	5/09/1974	120	NA	NA	DUD
RN008435	Gibb 74/1 Roper Valley	53	393626	8355365	22/08/1974	66	Nil	seepage	DUD

Goondooloo

Site	Site Name	Zone	Easting	Northing	Start Date	Drill Depth	Casing Depth	Standing water level	Yield L/s
RN006187	MUNGY BLUFF 1ST. ATT. MOROAK STN.	53	350127	8396465	22/08/1968	53.34	NA	NA	0
RN006719	47/61 MOROAK STN.	53	347927	8381915	1/10/1969	30.48	17.06	10.66	2.27
RN024886	A=86/148 GOONDALOO STN	53	337327	8369715	14/11/1986	80	6	NA	0
RN024887	A=149/86 GOONDALOO STN	53	340327	8369565	14/11/1986	102	6	NA	0
RN026301	A=84/121 GOONDOOLOO STN	53	337577	8369790	22/02/1989	120	none	11.65	0
RN026302	A=88/146 GOONDOOLOO STN	53	336877	8368565	23/02/1989	110	none	NA	0

Kewulyi Aboriginal Land Trust

Site	Site Name	Zone	Easting	Northing	Start Date	Drill Depth	Casing Depth	Standing water level	Yield L/s
RN003850	Garden Bore	53	393426	8349265	16.11.62	122	NA	NA	seepage
RN005037	Roper Valley No 6	53	393776	8349645	21.11.64	138.7	Nil	12.49	0.1
RN030908	Dry Hole	53	393776	8349645	25.10.96	69	Nil	NA	DUD
RN030909	House bore	53	393500	8349500	26.10.96	98	98	17	0.6

Limmen National Park (St Vidgeon Station)

Site	Site Name	Zone	Easting	Northing	Start Date	Drill Depth	Casing Depth	Standing water level	Yield L/s
RN001310	LION LAGOON HODGSON DOWNS STN	53	495026	8323066	NA	77.8	NA	NA	NA
RN006161	N.M.R.R.2 ROPER RIVER	53	529926	8365916	8/07/1968	45.75	none	9.14	0.5
RN006163	N.M.R.R.4 ROPER RIVER	53	503876	8359866	9/07/1968	91.5	none	6.09	0.12
RN025319	NUMULTJA 1/87 ST VIDGEON STN	53	547726	8308366	6/10/1987	120	none	8	20
RN025380	NUMULTJA 2/87 ST VIDGEON STN	53	547726	8308366	8/10/1987	37	none	10	10
RN026364	TOLLGATE CREEK 90/1 NGUKURR	53	475626	8367366	26/06/1989	46.3	46.8	9	1.5
RN035728	DEPT N.R.E.T.A. (LIMMEN N.P.)	53	466803	8369557	20/08/2007	31.5	31.5	5.55	9.5
RN035729	DEPT N.R.E.T.A. (LIMMEN N.P.)	53	466253	8368592	21/08/2007	49.5	0	9	0.25

Marra Aboriginal Land Trust

Site	Site Name	Zone	Easting	Northing	Start Date	Drill Depth	Casing Depth	Standing water level	Yield L/s
RN006160	N.M.R.R.1 ROPER RIVER	53	533126	8365466	8/07/1968	22.875	none	2.43	2.5

Moroak

Site	Site Name	Zone	Easting	Northing	Start Date	Drill Depth	Casing Depth	Standing water level	Yield L/s
RN005188	ADV. 53/65 PEAR TREE MOROAK STN.	53	372977	8367265	23/11/1965	152.5	18.3	9.75	0.05
RN005577	ADV. 55/65 RODMUIR MOROAK STN.	53	361107	8395165	3/08/1966	174.04	NA	16.47	0.37
RN005891	ADV. 109/66 FLAT TYRE MOROAK STN.	53	368627	8381965	22/07/1967	152.5	NA	NA	0.12
RN006185	SNAPPY GUM MOROAK STN	53	363427	8393845	15/08/1968	82.96	24.4	FLOWING	0.1
RN006186	BOB GUM 1ST ATT. MOROAK STN.	53	355227	8380265	19/08/1968	122	none	NA	0
RN006188	MUNGALO MOROAK STN.	53	360427	8390065	24/08/1968	45.72	NA	6	0.25
RN006189	BOB GUM 2ND ATT. MOROAK STN.	53	359727	8378115	25/08/1968	67.05	none	NA	0
RN006308	DI-GUM ADV. 37/58 MOROAK STN.	53	362327	8373165	27/08/1968	5.4	NA	NA	0
RN006720	48/69 MOROAK STN.	53	356627	8381065	19/09/1969	91.44	none	15.24	0.25
RN007324	GUMHOLE MOROAK STN.	53	363227	8406865	28/08/1970	68.58	10.66	6.09	0.88
RN007325	165/70 MOROAK STN.	53	370977	8392005	3/09/1970	106.68	none	7.62	0.18
RN007326	166/70 MOROAK STN.	53	357127	8366765	5/09/1970	45.72	none	7.67	1.26
RN007327	167/70 MOROAK STN.	53	367527	8369155	8/09/1970	76.2	11.58	9.14	1.76
RN007328	168/70 MOROAK STN.	53	374827	8362865	11/09/1970	137.16	none	9.14	0.25
RN007329	192/70 MOROAK STN.	53	357127	8364065	16/09/1970	45.72	none	NA	0
RN007330	193/70 MOROAK STN	53	378127	8364565	14/09/1970	45.72	none	NA	0
RN007331	197/70 MOROAK STN.	53	361947	8373865	19/09/1970	61	none	NA	0
RN024249	MC FARLANE T A=88/85 MOROAK STN	53	361427	8372065	11/11/1985	85	none	NA	0
RN024250	MC FARLANE T A=85/86 MOROAK STN	53	357727	8367465	11/11/1985	72	none	NA	0.75

Moroak

Site	Site Name	Zone	Easting	Northing	Start Date	Drill Depth	Casing Depth	Standing water level	Yield L/s
RN024741	YUMA PTY LTD A=89/85 MOROAK STN	53	365927	8402465	30/08/1986	75	3	10	0.2
RN024742	YUMA PTY LTD A=90/85 MOROAK STN	53	363627	8393265	28/08/1986	77	none	NA	0.21
RN024746	YUMA PTY LTD MOROAK	53	357727	8367465	1/09/1986	43	none	NA	0
RN027333	ADV. 104/80 MOROAK	53	362927	8399215	31/10/1990	60	none	NA	0
RN027334	A=90/103 MOROAK	53	362227	8393465	1/11/1990	50	none	NA	0
RN027335	A=90/110 MOROAK	53	371927	8407565	1/11/1990	50	none	NA	0
RN028624	34 KL.DUD MOROAK	53	361527	8388665	23/08/1992	90	none	NA	0
RN028625	LUCKY BORE MOROAK	53	365377	8397415	25/08/1992	37	37	22	1
RN029239	MOROAK STN BORE PL=751	53	370127	8369165	29/07/1993	97	none	NA	0.3

Mt Mc Minn

Site	Site Name	Zone	Easting	Northing	Start Date	Drill Depth	Casing Depth	Standing water level	Yield L/s
RN008769	SITE B/75 ADV.37/75 ROPER VALLEY STN.	53	440046	8360966	4/09/1975	99	99	4.5	1.26

Namul Namul

Site	Site Name	Zone	Easting	Northing	Start Date	Drill Depth	Casing Depth	Standing water level	Yield L/s
RN003851	AIRSTRIP NO. 5 1ST ATT. ROPER VALLEY STN.	53	397377	8350616	14/06/1963	94.55	none	6.1	0.625
RN003852	AIRSTRIP NO.5 2ND ATT. ROPER VALLEY STN.	53	397377	8350612	19/06/1963	89.97	none	NA	0
RN004119	AIRSTRIP NO.5 3RD ATT. ROPER VALLEY STN.	53	397377	8350616	24/10/1963	97.57	6	7.991	0.378
RN004568	HOLE NO.6 (DUD) ROPER VALLEY STN	53	399827	8351866	14/10/1964	152.4	none	NA	0
RN004603	6 MILE BORE ROPER VALLEY STN.	53	403777	8351646	14/10/1964	152.4	none	NA	0
RN006704	66/69 ROPER VALLEY STN.	53	400927	8349166	27/09/1969	98.4	none	NA	0.1
RN006705	67/69 ROPER VALLEY STN.	53	400897	8344966	24/09/1969	152.5	none	NA	0.042
RN006707	68/69 ROPER VALLEY STN.	53	394817	8348616	23/09/1969	70.5	14.7	31.16	4.5
RN007083	65/70 MOUNTAIN VALLEY STN.	53	403117	8354765	6/07/1970	76.25	none	NA	0.06
RN007084	67/70 MOUNTAIN VALLEY STN.	53	407577	8354366	4/06/1970	106.68	none	NA	0
RN007085	63/70 MOUNTAIN VALLEY STN.	53	395577	8354765	8/06/1970	137.16	none	NA	0
RN007086	66/70 MOUNTAIN VALLEY STN.	53	413077	8364065	11/06/1970	53.34	15.24	9.14	2.84
RN007087	68/70 MOUNTAIN VALLEY STN.	53	413627	8362157	12/06/1970	76.2	none	NA	NA
RN008435	GIBB 74/1 ROPER VALLEY STN.	53	393627	8355365	22/08/1974	66	none	NA	0
RN008768	MT. COOK SITE ADV. 40/75 ROPER VALLEY STN.	53	415377	8364585	9/09/1975	122	NA	NA	NA
RN008770	SITE D/75 ADV.39/75 ROPER VALLEY STN	53	413627	8362865	8/09/1975	107	NA	NA	NA
RN008771	DEEPENING ADV.36/75 ROPER VALLEY STN.	53	410527	8359017	12/09/1975	200	NA	NA	NA
RN026300	A=89/4 ROPER VALLEY STN	53	404027	8347366	17/02/1989	120	4	20.4	0.2
RN030954	B. TAPP AIRSTRIP BORE NO.2 CHATTAHOOCHIE STATION	53	398227	8349466	27/10/1996	120	120	23	0.4

Namul Namul

Site	Site Name	Zone	Easting	Northing	Start Date	Drill Depth	Casing Depth	Standing water level	Yield L/s
RN033141	NAMUL NAMUL STATION (M. O'BRIAN)	53	403170	8358256	6/11/2002	40	NA	NA	0.3
RN033142	NAMUL NAMUL STATION (M. O'BRIAN)	53	406993	8355317	7/11/2002	46	NA	NA	NA
RN033143	NAMUL NAMUL STATION (M. O'BRIAN)	53	408689	8356099	7/11/2002	103	NA	NA	NA
RN034127	NAMUL-NAMUL ABORIGINAL CORPORATION (M. O'BRIAN)	53	395435	8345331	31/07/2004	85	19	61	1

NT Portion 9472 (Lonesome Dove)

Site	Site Name	Zone	Easting	Northing	Start Date	Drill Depth	Casing Depth	Standing water level	Yield L/s
RN003853	FLYING FOX NO.2 ROPER VALLEY STN.	53	412027	8383865	27/06/1963	106.75	NA	30.5	0.75
RN007088	69/70 MOUNTAIN VALLEY STN.	53	416056	8390065	14/06/1970	76.2	15.25	21.23	0.63

Urapunga Aboriginal Land Trust

Site	Site Name	Zone	Easting	Northing	Start Date	Drill Depth	Casing Depth	Standing water level	Yield L/s
RN009125	NO.1 URAPUNGA STN	53	453226	8374365	17/09/1977	38.4	39	18.3	3
RN009126	NO.2 URAPUNGA STN	53	453226	8373965	18/09/1977	36	36.5	18	3
RN028126	DUPLICATE HOMESTEAD URAPUNGA	53	452676	8373865	13/05/1992	46.5	46.5	28	3.2
RN030406	WUYAGIBA OUTSTATION	53	454726	8383665	17/10/1996	40	NA	NA	0
RN035722	DEPT N.R.E.T.A. (URAPUNGA ABORIGINAL LAND TRUST)	53	453878	8374226	17/07/2007	49.5	0	9.4	1.7
RN035723	DEPT N.R.E.T.A. (URAPUNGA ABORIGINAL LAND TRUST)	53	453740	8373113	19/07/2007	50.9	50.4	9.28	10
RN035724	DEPT N.R.E.T.A. (URAPUNGA ABORIGINAL LAND TRUST)	53	451679	8373777	8/08/2007	91.2	91.2	9.9	8
RN035725	DEPT N.R.E.T.A. (URAPUNGA ABORIGINAL LAND TRUST)	53	452505	8373212	10/08/2007	34.7	24	7.9	7
RN035726	DEPT N.R.E.T.A. (URAPUNGA ABORIGINAL LAND TRUST)	53	453393	8372993	14/08/2007	55.5	55.1	7.7	20
RN035727	DEPT N.R.E.T.A. (URAPUNGA ABORIGINAL LAND TRUST)	53	453496	8372973	17/08/2007	57.5	57.3	7.95	15

Wongalara

Site	Site Name	Zone	Easting	Northing	Start Date	Drill Depth	Casing Depth	Standing water level	Yield L/s
RN008218	80/72 (DUD) MAINORU STN.	53	402677	8432155	30/07/1973	45.75	none	NA	0.06

Yutpundji-Djindiwirritj Aboriginal Land Trust

Site	Site Name	Zone	Easting	Northing	Start Date	Drill Depth	Casing Depth	Standing water level	Yield L/s
RN008208	ROPER BAR STORE (DUD) ROPER RIVER	53	448626	8371765	21/09/1973	91.5	none	NA	0
RN009320	78/1 ROPER BAR POLICE STN.	53	447926	8373245	15/08/1978	35	35	NA	0
RN009321	ROPERBAR POLICE STN. 2/78 ROPERBAR POLICE STATION	53	446776	8373265	1/09/1978	21	21	11.2	0
RN009322	78/3 ROPER BAR POLICE STN.	53	447926	8373246	7/09/1978	24	24	NA	0
RN022070	BADUWARRKA O/STN.	53	440506	8375165	18/05/1983	72	72	16	1
RN024332	DIETER ROPER BAR STORE	53	447226	8373165	5/11/1985	50	none	NA	0
RN026365	JARWA 90/1 NGUKURR(JOYAR)	53	437626	8372015	26/06/1989	46.3	46.3	9	1.5

APPENDIX J: BORE WATER CHEMISTRY

All groundwater contains various kinds of dissolved salts (minerals). Small quantities of many of these salts are essential to good health. Excessive concentrations however, can limit the uses of the water. Following is some information to help you interpret the water quality represented on the following pages. The information has been summarised from NRETAS technical fact sheet @ www.nt.gov.au/nreta/publications/natres/waterfactsheets.html. More information is available from this site.

Source of dissolves salts:

Salts in the water originate from minute quantities dissolved in rain water and from the chemical breakdown of rocks. Nitrate is also produced in the soil by natural biological activity. Over long periods of time evaporation concentrates them to varying degrees.

Guideline Values:

The maximum recommended values listed beside each salt are guidelines rather than strict limits. The reason for this is because there are often many factors governing how a particular salt affects the user. These can include a person's age and the total volume of water consumed. The guidelines given below are conservatively chosen in order to cover most situations. (Guideline values for stock noted in brown)

Fluoride 1.5 mg/L **(Stock 2 mg/L)**	This limit is based on health considerations. Excess fluoride can be removed by water treatment.
Hardness 200 mg/L	Hardness is a measure of the amount of calcium and magnesium in the water. Hard waters can cause the build up of scale in hot water pipes and fittings. They also require more soap to obtain a lather.
Iron 0.3 mg/L	Above this limit, taste may be unacceptable but it does not pose a health problem. High iron concentrations give water a rust brown appearance resulting in staining of laundry, pipe encrustation and odour problems. A common way to remove iron is to aerate the water by cascading it into a tank and allowing the iron to floc or settle.
Nitrate 50 mg/L **(Stock 400 mg/L)**	Based on health considerations a limit of 50mg/L is recommended for babies less than three months old and 100mg/L for older children and adults. Nitrate levels can be reduced if necessary by water treatment.
pH 6.5 - 8.5 **(Stock 5.5 – 9.0)**	This is a measure of the acidity or alkalinity. Values less than 6.5 indicate acidic water and can results in corrosion of pipes and fittings. When pH is more than 7.5, the water is alkaline and encrustation of pipes with calcium carbonate can occur. pH can be treated.
Total Dissolved Solids (TDS) 500 mg/L **(Stock 10000 mg/L)** **Chloride 250 mg/L** **Sulphate 250 mg/L** **(Stock 2000 mg/L)** **Sodium 180 mg/L**	Above these limits for TDS, chloride, sulphate and sodium, taste may be unacceptable but it does not pose a health problem. (Aesthetic guideline only) TDS is approximately equal to 0.6 x EC

The following bore water chemistry data is provided in alphabetical order of land parcel name.

Alawa 1 Aboriginal Land Trust (Hodgson Downs Station)

BoreRN	Sample Date	Sample No:	EC (uS/cm)	pH	Total Alkalinity	Bicarb-onate	Total Hardness	TDS	Calcium	Chloride	NaCl	Magn-esium	Nitrate	Potass-ium	Sodium	Sulp-hate	Flou-ride	Iron	Silica	Other Analysis
RN005027	14/10/1968	8671	69	7	26	16	24	50	5	8		3	1	3	5	2	0.2	0.5	11	
RN005027	14/10/1968	8672	530	7.7	276	168	256	320	53	16		28	5	2	20	2	0.6	0.2	42	
RN007322	27/08/1970	13667	170	6.5	32	39	17	75	5	15		1	7	5	11	7	0.1	37	12	
RN007322	22/01/1971	13668	60	5.5	18	22	11	50	1	8		1	1	2	4	2	0.1	1.8	14	
RN007322	23/01/1971	13669	72	5.4	20	24	12	44	1	8		1	1	2	4	2	0.1	1.6	13	
RN007322	15/11/1971	13670	90	6.1	32	39	25	60	6	9		1	2	2	6	2	0.1	9.5	13	
RN007322	15/11/1971	13671	66	5.9	22	27	19	48	3	9		1	1	1	4	2	0.1	5.9	12	
RN007322	13/12/1991	13672	80	6.3	22	27	9	55	2	7	11	1	2	2	7	4	0.1	14.6	14	
RN008146	1/08/1973	15749	780	8.6	267	327	35	440	6	41		5	2	3	163	45	2		14	
RN008147	16/07/1973	15750	69	7.4	23	28	23	52	1	1		5	1	1	4	2	0.4	47	22	
RN008503	8/10/1974	17024	110	6.3	30	36	13	73	2	8		2	1	3	13	4	0.2	40	6	
RN008503	15/10/1974	17025	100	6.3	33	40	13	79	2	12		34	1	3	13	4	0.2	34	5	
RN008503	18/11/1974	17026	77	6.2	29	35	26			13										
RN008503	18/11/1974	17027	69	6.1	22	27	13	46	2	10	16	2	1	2	6	8	0.1	17	11	
RN008503	29/06/1982	17028	66	6	20	24	12	47	3	4	6	1	1	3	4	2	0.1	6.5	11	
RN008503	30/06/1982	17029	64	6.1	17	21	11			8	12									
RN008503	12/06/1985	17030	70	6	20	24	7	45	1	6	10	1	1	2	6	1	0.1	10	15	
RN008504	16/11/1974	17031	82	6.1	29	35	16	53	3	6	10	2	1	3	7	9	0.1	58	9	
RN022806	11/08/1984	42532	260	6.5	56	68	47	170	14	18	30	3	64	29	8	1	0.2		15	
RN022806	11/08/1984	42533	85	6.7	5	6	13	85	2	14	21	2	14	10	7	6	0.1		13	

Alawa 1 Aboriginal Land Trust (Hodgson Downs Station)

BoreRN	Sample Date	Sample No:	EC (uS/cm)	pH	Total Alkalinity	Bicarb-onate	Total Hardness	TDS	Calcium	Chloride	NaCl	Magn-esium	Nitrate	Potass-ium	Sodium	Sulp-hate	Flou-ride	Iron	Silica	Other Analysis
RN022806	27/11/1984	42534	55	5.5	9	11	7	50	1	8	12	1	4	2	6	2	0.1	4.8	17	Copper, Lead, Manganese
RN022806	15/05/1992	42535	50	5.8	10	9	8	45	1	8	13	1	5	2	5	4	0.1	0.5	17	
RN022807	12/08/1984	42536	150	7	102	125	13	140	2	14	23	2	1	3	28	3	0.2	9.9	14	
RN022807	12/08/1984	42537	150	7.6	51	62	11	90	1	16	25	2	5	4	26	5	0.2	6.8	13	
RN022808	13/08/1984	42538	45	6.1	13	15	7	45	1	6	10	1	2	2	5	1	0.1	2.5	17	
RN022808	13/08/1984	42539	55	6.6	7	9	7	50	1	10	16	1	3	2	6	1	0.1	2.4	15	
RN022808	12/09/1984	42540																		
RN022808	13/09/1984	42541	100	6.1	43	53	7	70	1	4	7	1	1	1	6	1	0.1		16	
RN022808	27/11/1984	42542	110	5.9	38	47	7	55	1	10	16	1	1	4	9	1	0.1	10	13	Manganese
RN022808	27/11/1984	42543																		Copper, Lead, Manganese
RN022808	12/06/1985	42544	130	5.9	25	31	4	70	1	20	33	1	1	3	19	1	0.1		11	
RN022808	12/06/1985	42545	125	5.9	25	31	4	65	1	16	25	1	1	3	15	1	0.1		13	
RN022808	18/03/1990	42546	45	5	4	5	7	35	1	11	17	1	2	1	5	2	0.1	2	16	
RN022808	18/03/1990	42547																		Bacto
RN022808	26/09/1990	42548																		Bacto
RN022808	10/10/1990	42549	45	4.9	3	4	4	40	1	8	13	1	3	1	6	1	0.1	1.1	16	
RN022808	12/12/1991	42550	55	5.9	9	11	7	50	1	11	18	1	3	1	6	2	0.1	0.4	16	
RN022808	18/09/1992	42551	45	5.3	6	8	4	38	1	8	13	1	2	1	5	1	0.1	6	17	
RN022808	26/03/1993	42552	48	5.2	7	8	4	40	1	9	15	1	2	1	6	1	0.1	0.5	16	

Alawa 1 Aboriginal Land Trust (Hodgson Downs Station)

BoreRN	Sample Date	Sample No:	EC (uS/cm)	pH	Total Alkalinity	Bicarb-onate	Total Hardness	TDS	Calcium	Chloride	NaCl	Magn-esium	Nitrate	Potass-ium	Sodium	Sulp-hate	Flou-ride	Iron	Silica	Other Analysis
RN022808	4/10/1996	158302	48	5.47	6.6	8	6.6	42	1	7	11.54	1	2	1	6	1	1	8.8	14	
RN022808	4/10/1996	154890	48	5.5	7	8	7	42	1	7	12	1	2	1	6	1	0.1	8.8	14	
RN022808	27/10/1997	158303	47	5.3	5.7	7	4.1	41	1	10	16.48	1	3	1	6	1	0.1	0.3	39	
RN022809	14/08/1984	42553	120	6.6	26	32	28		1	12	20	6	4	8	13	21	0.1		13	
RN023161	15/08/1984	45123	60	6.4	26	32	19	60	1	6	10	4	6	4	8	2	0.1		16	
RN023162	18/08/1984	45124	50	6.2	18	22	7	45	1	8	13	1	1	4	7	1	0.1	2.9	16	
RN023162	18/08/1984	45125	55	6.6	7	9	7	45	1	14	21	1	1	3	7	2	0.1	2.5	15	
RN023163	18/08/1984	45126	60	6.3	19	23	7	50	1	9	15	1	2	4	8	1	0.1	3.7	17	
RN025383	13/11/1987	49037	60	5.6	13	15	9	40	1	2	4	1	1	2	5	4	0.1	5.6	13	
RN025383	18/03/1990	49038																		Bacto
RN025383	18/03/1990	49039	60	5.7	17	21	7	40	1	7	12	1	1	2	5	3	0.1	17.2	13	
RN025383	21/11/1991	49040	45	6	7	9	6	35	1	6	10	1	1	1	5	3	0.1	7.7	13	
RN025383	19/05/1992	49041																7.4		
RN025383	19/05/1992	49042																7.1		
RN025383	20/05/1992	49043																6.9		Copper, Lead, Manganese
RN025383	21/05/1992	49044																5.7		Copper, Lead, Manganese
RN025383	18/09/1992	49045	46	5.8	3	10	7	67	1	6	10	1	1	2	5	3	0.1	5.9	14	
RN025383	26/03/1993	49046	63	5.9	18	22	7	49	1	5	8	1	1	2	5	7	0.1	7.7	14	
RN025383	30/10/1995	146356	47	5.5	8	10	7	21	1	4	7	1	1	2	5	6	0.1	2.9	13	

Alawa 1 Aboriginal Land Trust (Hodgson Downs Station)

BoreRN	Sample Date	Sample No:	EC (uS/cm)	pH	Total Alkalinity	Bicarb-onate	Total Hardness	TDS	Calcium	Chloride	NaCl	Magn-esium	Nitrate	Potass-ium	Sodium	Sulp-hate	Flou-ride	Iron	Silica	Other Analysis
RN025383	1/11/1995	146357	58	5.7	12	15	7	14	1	8	13	1	1	2	7	9	0.1	9.3	13	
RN025383	1/11/1995	148																		Bacto
RN025383	16/08/1996	158346	550	3.08		0	19.8	200	3	1	1	3	2	2	5	1	0.1	46	14	
RN025383	16/08/1996	154895	550	3.1	1	0	20	200	3	1	1	3	2	2	5	1	0.1	46	14	
RN025383	4/10/1996	157401	49	5.43	16.4	20	19.1	49	6	7	11.54	1	1	2	5	5	0.1	5.2	14	
RN025383	4/10/1996	154896	49	5.4	16	20	19	49	6	7	12	1	1	2	5	5	0.1	5.2	14	
RN025383	11/11/1996	158347	58	6	14.8	18	11.6	38	3	6	10	1	1	1	4	6	0.1	13.5	13	
RN025383	27/10/1997	158348	41	5.3	7.4	9	6.6	36	1	8	13.18	1	1	1	5	1	0.1	48	18	
RN026145	1/03/1989	49735	550	7.7	250	304	120	320	25	18	30	14	6	24	68	23	0.7		10	
RN027815	12/10/1991	51039	355	7.3	150	183	121	220	24	18	30	15	1	7	32	18	0.3		36	
RN027815	20/05/1992	51040	330	6.8	121	147	100	205	22	16	26	11	1	6	24	16	0.3	1	28	
RN027815	20/05/1992	51041	320	6.8	117	143	98	200	21	15	24	11	1	6	23	15	0.3	1.2	33	
RN027815	13/06/2000	368	337	6.8	150.1	183	114	178	21	7	11.5	15	1	6	23	20	0.3	0.1	22	
RN027815	20/06/2000	369																2.8		
RN027816	15/10/1991	51042	820	7.8	207	253	176	450	39	114	188	19	1	12	102	33	0.3		15	
RN027901	23/10/1991	51103	75	6.8	11	13	8	55	2	8	13	1	1	2	10	12	0.1	2.6	17	
RN027902	24/10/1991	51104	625	8	193	235	118	375	21	35	58	15	1	21	89	80	0.4		10	
RN027905	9/11/1991	51105	8140	7.7	150	183	1452	5250	108	1988	3276	281	1	35	1249	1109	0.3		12	
RN027906	12/11/1991	51106	30	6.3	4	5	4	35	1	6	10	1	1	3	5	3	0.1	2.5	19	
RN027907	14/11/1991	51107	25	6.4	4	5	1	35	1	5	8	1	1	1	4	2	0.1	0.7	19	
RN027907	12/05/1992	51108	30	5.2	5	6	4	35	1	7	11	1	1	1	3	3	0.1	1.3	19	

Alawa 1 Aboriginal Land Trust (Hodgson Downs Station)

BoreRN	Sample Date	Sample No:	EC (uS/cm)	pH	Total Alkalinity	Bicarb-onate	Total Hardness	TDS	Calcium	Chloride	NaCl	Magn-esium	Nitrate	Potass-ium	Sodium	Sulp-hate	Flou-ride	Iron	Silica	Other Analysis
RN027908	15/11/1991	51109	395	8.2	143	174	63	235	17	37	60	5	1	17	52	5	0.3	4.7	15	
RN027908	16/11/1991	51110	385	7.3	137	167	52	220	12	34	55	5	1	13	52	11	0.3		14	
RN027909	20/11/1991	51111	345	8	126	154	49	195	13	32	52	4	1	8	44	7	0.2	3.1	13	
RN027909	8/05/1992	51112	360	7.4	114	139	76	190	24	33	55	4	1	7	42	9	0.1	0.1	15	
RN027960	22/11/1991	51149	60	6.8	15	18	8	45	2	6	10	1	1	3	7	5	0.1	4.7	13	
RN027960	10/12/1991	51150	60	6.1	13	16	6	40	1	6	10	1	1	2	7	4	0.1	4.1	12	
RN027960	1/11/1995	146358	71	5.9	19	23	7	13	1	10	16	1	1	2	9	6	0.1	5	13	
RN027960	1/11/1995	25																		Bacto
RN027960	4/10/1996	158402	55	5.8	14	17	19.1	42	6	6	10	1	1	2	6	6	0.1	2.6	12	
RN027960	4/10/1996	154900	55	5.8	14	17	19	42	6	6	10	1	1	2	6	6	0.1	2.6	12	
RN027960	11/11/1996	158403	65	6.2	19.7	24	11.6	45	3	4	6.6	1	1	1	6	5	0.1	2.6	10	
RN027960	27/10/1997	158404	124	6.1	51	62	39.1	85	14	6	10	1	1	2	7	4	0.1	2.6	28	
RN027961	25/11/1991	51151	60	6.9	19	24	12	45	3	6	10	1	1	2	6	3	0.1	1.6	13	
RN027961	14/05/1992	51152																3.9		
RN027961	15/05/1992	51153	55	5.8	15	18	7	45	1	6	10	1	1	2	5	2	0.1	2.6	14	
RN027961	15/05/1992	51154																2.6		Copper, Lead, Manganese
RN027961	1/11/1995	146359	51	5.8	14	17	7	9	1	8	13	1	1	2	6	7	0.1	2.6	13	
RN027961	1/11/1995	24																		Bacto
RN027961	4/10/1996	158405	42	7.23	13	16	6.6	40	1	4	6.6	1	1	2	5	3	0.1	2.4	12	
RN027961	4/10/1996	154901	42	7.2	13	16	7	40	1	4	7	1	1	2	5	3	0.1	2.4	12	

Alawa 1 Aboriginal Land Trust (Hodgson Downs Station)

BoreRN	Sample Date	Sample No:	EC (uS/cm)	pH	Total Alkalinity	Bicarb-onate	Total Hardness	TDS	Calcium	Chloride	NaCl	Magn-esium	Nitrate	Potass-ium	Sodium	Sulp-hate	Flou-ride	Iron	Silica	Other Analysis
RN027961	11/11/1996	158406	41	5.7	11.5	14	6.6	36	1	5	8.24	1	1	1	4	2	0.1	1	13	
RN027961	27/10/1997	158407	44	5.6	13	16	6.6	38	1	6	10	1	1	2	5	2	0.1	0.8	28	
RN032155	27/05/1999	163631	393	8.4	177	204	117	229	19	19	31	17	1	8	35	21	0.3	1.9	29	
RN032157	29/05/1999	163632	259	7.92	112	136	84	160	17	8	13	10	1	6	17	15	0.3	4.8	28	
RN032157	13/06/2000	410	269	6.7	119	145	90.1	192	18	6	9.9	11	1	5	16	17	0.3	0.1	34	
RN032157	20/06/2000	411																1.9		

Arnhem Land Aboriginal Land Trust

BoreRN	Sample Date	Sample No:	EC (uS/cm)	pH	Total Alkalinity	Bicarb-onate	Total Hardness	TDS	Calcium	Chloride	NaCl	Magn-esium	Nitrate	Potass-ium	Sodium	Sulp-hate	Flou-ride	Iron	Silica	Other Analysis
RN004098	10/10/1963	6982		7.3	310		2200			4950										
RN004098	1/11/1963	6983	9342	6.65	330		2500			6500										
RN004099	1/11/1963	6984	4898	7.55	410		1900			3000										
RN004100	17/10/1963	6985	21042	7.35	350		5100			16000										
RN004219	27/09/1963	7119	564	7.8	335		315			40										
RN005955	17/09/1968	10775	1400	7.5	288	176	524	849	27	310		80	1	7	100	24	0.6	0.1	13	
RN005955	9/10/1968	10776	1500	7.7	332	203	560	840	66	300		78	1	7	103	19	0.9	0.2	26	
RN005955	23/07/1982	10777	1610	7.1	340	415	626	920	106	320	530	88	1	9	88	35	0.3	1.4	24	
RN005955	6/06/1985	10778	1330	7.6	367	448	538	710	94	220	370	74	1	5	66	22	0.3	0.1	29	
RN006035	12/12/1967	10806	1159	7.9	338	206	455	707	13	55		101	1.5	14	82		0.2	0.1		
RN006035	12/12/1967	10807	1008	7.7	304	185	450	700	7	40		104	0.4	11	70		0.2	2.6		
RN006035	23/07/1982	10808	1230	7	384	468	515	690	91	166	274	70	1	8	58	29	0.1	0.3	24	
RN006035	3/10/1996	156754	1493	7.17	354.3	432	622	793	111	279	460	84	1	6	60	37	0.2	0.7	24	
RN006035	3/10/1996	154843	1490	7.2	354	432	622	793	111	279	460	84	1	6	60	37	0.2	0.7	24	
RN006160	29/07/1968	10998	27100	6.4	26	15.9	6100			13000									28	
RN006160	29/07/1968	10999	30500	6.3	26	15.9	6200			12900										
RN006160	29/07/1968	11000	28500	6.45	56	16	5800			12200									36	
RN006163	29/07/1968	11001	10580	3.68			1760			3520									13	
RN007870	26/05/1972	14813	26490	7.5	88	107	8000			1010	1684									
RN007870	26/05/1972	14814	27000	7.3	75	92	8000			1030	1697									

Arnhem Land Aboriginal Land Trust

BoreRN	Sample Date	Sample No:	EC (uS/cm)	pH	Total Alkalinity	Bicarb-onate	Total Hardness	TDS	Calcium	Chloride	NaCl	Magn-esium	Nitrate	Potass-ium	Sodium	Sulp-hate	Flou-ride	Iron	Silica	Other Analysis
RN007870	26/06/1972	14815	26490	7.2	85	104	8000			1020	1681									
RN007870	16/01/1976	14816	1200	8	294	359	435			189	311									
RN007870	12/03/1976	14817	1220	8	361	440	495			181	298									
RN007870	26/03/1976	14818	1290	7.4	379	462	530			191	315									
RN009325	7/02/1979	20273	870	8.2			478	520	60	14	24	80	1	13	23	22	0.7	0.1	52	
RN009669	29/10/1979	21769	540	7.3	219	267	226	340	74	25	41	10	1	1	26	19	1.1	0.1	63	
RN009871	26/10/1979	23160	560	7.7	225	274	220		70	25	41	11	1	1	26	17	0.6	3.2	20	
RN009871	17/11/1994	136894	766	7.2	228	278	272	430	81	86	142	17	1	3	62	48	0.6	0.6	24	
RN009872	23/10/1979	23161	570	7.6	221	221	216	320	70	27	44	10	1	2	30	18	0.6	0.1	21	
RN009872	6/10/1988	23162	530	7.8	216	263	228	320	73	34	56	11	2	1	29	21	0.6	0.1	15	
RN021481	15/06/1982	39246	1200	7.3	281	343	433	670	81	200	330	56	9	12	75	34	0.6		24	
RN021481	2/07/1982	39247	1360	7	370	451	543	720	96	230	370	74	1	8	70	24	0.3	1.3	25	
RN021481	10/10/1990	39248	1415	6.8	365	445	565	780	98	241	397	78	2	6	70	37	0.3	0.1	25	
RN021481	28/08/1992	39249	1405	7.1	370	453	596	765	107	238	392	80	1	6	58	29	0.2	0.1	29	
RN021481	18/03/1993	39250	1630	7.1	356	434	645	902	118	309	509	85	1	6	78	36	0.3	0.1	27	
RN021481	3/10/1996	157300	1788	7.14	349.4	426	712	948	124	369	608	98	1	6	89	45	0.2	0.1	24	
RN021481	3/10/1996	154886	1790	7.1	349	426	712	948	124	369	608	98	1	6	89	45	0.2	0.1	24	
RN021481	24/04/1997	158274	1775	7.7	353.5	431	634	1096	101	382	630	93	1	6	90	51	0.3	0.1	23	
RN021481	1/07/1997	157302	1746	6.65	354.3	432	664	1013	113	379	625	93	2	6	86	38	0.3	0.1	24	
RN021482	10/06/1982	39251	2900	7.9	587	716	187	1620	24	530	880	31	2	28	542	95	1.2		13	
RN021482	6/07/1982	39252	3400	7.5	600	732	310			710	1160									

Arnhem Land Aboriginal Land Trust

BoreRN	Sample Date	Sample No:	EC (uS/cm)	pH	Total Alkalinity	Bicarb-onate	Total Hardness	TDS	Calcium	Chloride	NaCl	Magn-esium	Nitrate	Potass-ium	Sodium	Sulp-hate	Flou-ride	Iron	Silica	Other Analysis
RN021482	7/07/1982	39253	4300	7.4	595	725	463	2370	64	970	1600	74	1	15	730	180	0.8	0.6	16	
RN021483	4/06/1982	39254	35500	7.3	317	387	6000			12200	20110									
RN021483	4/06/1982	39255	780	7.7	395	482	391	410	53	26	44	63	1	8	16	13	0.8	0.6	25	
RN021484	8/06/1982	39256	1710	5.9	10	12	174	920	17	450	740	32	1	30	245	98	0.2		29	
RN021503	12/06/1982	39291	1090	7.7	372	543	427	610	38	140	230	81	2	39	50	28	0.3	0.9	20	
RN021503	12/06/1982	39292	1150	7.5	343	418	482	630	60	175	290	81	1	9	53	24	0.2	0.3	19	
RN021505	14/06/1982	39293	760	7.4	290	354	328	430	59	70	112	44	4	10	25	14	0.3		27	
RN021506	14/06/1982	39294	1330	7.4	352	429	539	790	86	224	368	79	2	10	78	42	2	4	24	
RN024056	8/11/1985	46818	1400	7.7	316	385	525	800	74	240	400	83	1	2	69	31	0.3	3.3	78	
RN024056	19/11/1986	46819	1365	7	398	400	532	790	80	230	376	81	1	2	68	37	0.4	0.3	78	
RN030383	22/11/1995	146672	617	7.7	221	270	172	346	49	49	81	12	7	2	65	35	0.8	0.1	21	
RN030405	7/11/1996	157563	1788	7	356	434	709	1017	123	382	630	98	1	6	91	51	0.3	0.9	23	
RN030405	7/11/1996	155263	1790	7	356	434	709	1020	123	382	630	98	1	6	91	51	0.3	0.9	23	
RN030405	1/07/1997	157564	1810	6.79	358.4	437	660	1041	105	400	659	97	1	7	94	38	0.2	0.1	25	
RN031986	10/11/2006	6825	675	8	333	333	328	370	36	30.6		57.7	0.26	6.1	22.8	4	0.4	4.55	23	Heavy metals
RN031987	13/11/2006	6825	744	8.2	210	210	267	430	17.6	104		54.2	0.035	10.8	54.2	27	0.3	0.74	13	Heavy metals
RN031988	18/11/2006	6825	1240	7.8	282	282	468	700	57.6	224		78.8	<0.005	7.3	75.3	34.2	0.4	4.26	28.6	Heavy metals
RN031988	18/11/2006	6825	2410	7.6	259	259	783	1450	100	652		129	0.035	9.7	188	94.4	0.4	3.28	26.2	Heavy metals
RN031989	20/11/2006	6825	552	8.1	289	289	290	300	20.2	14.3		58.2	0.235	6.5	8.7	1	0.6	4.2	25.2	Heavy metals

Arnhem Land Aboriginal Land Trust

BoreRN	Sample Date	Sample No:	EC (uS/cm)	pH	Total Alkalinity	Bicarb-onate	Total Hardness	TDS	Calcium	Chloride	NaCl	Magn-esium	Nitrate	Potass-ium	Sodium	Sulp-hate	Flou-ride	Iron	Silica	Other Analysis
RN032802	22/11/2006	6825	1660	7.3	259	259	579	910	95	373		82.9	0.26	7.8	108	27.6	0.3	2.04	22.8	Heavy metals
RN034909	26/09/2006	6825	1030	7.4	341	341	431	570	69.7	126		62.4	0.075	5.4	56.2	17.5	0.3	0.66	27.4	Heavy metals
RN035301	29/09/2006	6825	922	7.4	438	438	497	520	53.9	44.4		88	0.565	9.9	19.6	2.5	0.7	0.36	20.8	Heavy metals
RN035302	30/09/2006	6825	830	7.4	412	412	465	460	78.9	26.8		65.1	0.17	6.5	14.5	1.4	0.3	0.62	20.4	Heavy metals
RN035315	17/08/2007	8039	655	8	333	333	338	360	42.1	16		56.4	0.415	5.6	10.9	1.8	0.5		19.4	Heavy metals
RN035316	14/09/2007	8365	815	7.5	404	404	421	470	73.7	26.3		57.4	0.16	6.3	11.7	0.7	0.5		19.2	Heavy metals
RN035317	17/08/2007	8039	804	8	246	246	337	440	56.7	105		47.4	0.26	5.5	30	22.3	0.1		26.4	Heavy metals
RN035317	17/09/2007	8365	1050	7.6	413	413	477	590	71.3	98.9		72.7	0.25	8.8	34.3	12.4	0.6		20.6	Heavy metals
RN035318	17/08/2007	8039	1520	8.1	267	267	350	870	47.6	262		56.2	0.26	3.4	194	139	0.6	0.26	25	Heavy metals
RN035319	17/08/2007	8039	2300	7.9	261	261	692	1280	100	504		107	0.255	6.7	213	165	0.4	0.44	29.2	Heavy metals
RN035319	17/08/2007	8039	2660	8	258	258	748	1540	108	584		116	0.25	5.6	276	222	0.5	3.64	26.8	Heavy metals
RN035319	17/08/2007	8039	602	8.1	246	246	276	340	48	45.6		37.9	0.255	5.4	17.8	7.5	0.1	0.44	25.6	Heavy metals
RN035510	22/11/2006	6825	789	8	387	387	413	450	34.9	33.6		79.2	0.005	8.3	25.9	3.9	0.4	1.35	23.8	Heavy metals
RN035511	23/11/2006	6825	620	8.1	259	259	277	350	40	43		43.1	0.295	3.8	24.7	1.5	0.8	1.75	19	Heavy metals
RN035512	25/11/2006	6825	672	8	323	323	329	370	34.4	24.9		59	0.04	6.2	20.4	2.1	0.5	0.6	18.2	Heavy metals

Arnhem Land Aboriginal Land Trust

BoreRN	Sample Date	Sample No:	EC (uS/cm)	pH	Total Alkalinity	Bicarb-onate	Total Hardness	TDS	Calcium	Chloride	NaCl	Magn-esium	Nitrate	Potass-ium	Sodium	Sulp-hate	Flou-ride	Iron	Silica	Other Analysis
RN035513	28/11/2006	6825	855	7.8	296	296	384	530	60.9	87.2		56.2	<0.005	6.8	40.9	18.9	0.2	18.6	26.2	Heavy metals
RN035515	30/11/2006	6825	994	8	400	400	421	570	50.4	138		71.6	0.27	5.8	56.9	12.6	0.2	7.2	32.8	Heavy metals
RN035721	17/08/2007	8039	570	8.1	261	261	264	320	48.1	23.8		35	0.265	5.3	14	3.2	0.1	0.06	25.4	Heavy metals
RN035721	19/09/2007	8365	613	7.7	280	280	287	350	55.7	28.5		35.8	0.23	6	12.8	3.6	0.2		26.2	Heavy metals

Big River

BoreRN	Sample Date	Sample No:	EC (uS/cm)	pH	Total Alkalinity	Bicarb-onate	Total Hardness	TDS	Calcium	Chloride	NaCl	Magn-esium	Nitrate	Potass-ium	Sodium	Sulp-hate	Flou-ride	Iron	Silica	Other Analysis
RN007088	28/09/1971	13309	470	8.1	249	303	237	320	37	4		33	1	3	13	12	1.7	27	62	

Goondooloo

BoreRN	Sample Date	Sample No:	EC (uS/cm)	pH	Total Alkalinity	Bicarb-onate	Total Hardness	TDS	Calcium	Chloride	NaCl	Magn-esium	Nitrate	Potass-ium	Sodium	Sulp-hate	Flou-ride	Iron	Silica	Other Analysis
RN006719	1/11/1969	12194	355	7.7	202	246	178	240	38	8		21	1	2	15	8	0.3	0.1	36	
RN006719	3/01/1970	12195	2000	8	449	547	540	1380	54	175		102	2	36	258	442	2.2	0.7	12	
RN026301	23/02/1989	49906	6270	6.2	138	168	3370	5475	577	392	646	470	1	50	468	3610	1.5		18	
RN026302	24/02/1989	49907	26300	6.3	222	271	6700			6174	10175									

Limmen National Park (St Vidgeon Station)

BoreRN	Sample Date	Sample No:	EC (uS/cm)	pH	Total Alkalinity	Bicarb-onate	Total Hardness	TDS	Calcium	Chloride	NaCl	Magn-esium	Nitrate	Potass-ium	Sodium	Sulp-hate	Flou-ride	Iron	Silica	Other Analysis
RN006163	29/07/1968	11001	10580	3.68			1760			3520									13	

Moroak

BoreRN	Sample Date	Sample No:	EC (uS/cm)	pH	Total Alkalinity	Bicarb-onate	Total Hardness	TDS	Calcium	Chloride	NaCl	Magn-esium	Nitrate	Potass-ium	Sodium	Sulp-hate	Flou-ride	Iron	Silica	Other Analysis
RN005188	23/11/1965	8781	680	7.6	342	209	112	480	23	42		13						0.5		
RN006185	27/08/1968	11019	100	6.6	34	21	56	77	10	14		3	1	4	10	37	0.6	1.2	13	
RN006189	23/09/1968	11020	800	7.6	320	195	312	500	15	58		52	1	10	42	67	0.7	0.1	39	
RN007324	9/09/1989	13674	750	7.3	418	510	385	460	72	12	20	50	1	1	22	16	0.5	0.1	60	
RN006720	13/01/1970	53	2000	8	449	547	570	1380	54	175		102	2	36	258	442	2.2	0.7	12	
RN007326	10/09/1970	13675	19400	7.5	366	366	8100			8050										
RN007327	11/09/1970	13676	1180	8	406	495	114	750	16	152		18	25	7	230	13	1.9	11	34	
RN024250	12/11/1985	47032	7510	7	79	96	2209	4940	280	1980	3263	368	1	18	760	859	0.2	1.1	14	
RN024741	31/08/1986	47600	1201	3.8	1	1	340	820	70	30	60	40	3	20	85	510	0.8		65	
RN024742	29/08/1986	47601	21800	7.5	220	270	6300			6500	10710									

Namul Namul

BoreRN	Sample Date	Sample No:	EC (uS/cm)	pH	Total Alkalinity	Bicarb-onate	Total Hardness	TDS	Calcium	Chloride	NaCl	Magn-esium	Nitrate	Potass-ium	Sodium	Sulp-hate	Flou-ride	Iron	Silica	Other Analysis
RN003852	27/11/1963	6582	538	8.15	270		205			70										
RN003852	28/11/1963	6583	557	7.95	300		210			50										
RN003852	14/10/1968	6584	570	7.7	244	149	248	400	53	28		27	28	1	31	12	1.2	0.2	92	
RN006704	16/10/1969	12180	14000	7.1	200	244	5800	11710	740	5280		920		65	1550			1.1	7	
RN006707	29/10/1963	12181	526	7.1	310		225			40										
RN006707	16/10/1969	12182	1320	7	324	395	374	920	42	110		70	1	19	175	291	1.5	1.2	13	
RN007086	12/06/1970	13308	4240	8.1	650	793	713	3060	18	860		163	1	5	844	765	1.3	2.7	33	
RN008770	9/09/1975	17426	180	7.1	25	31	21	110	2	24	35	4	2	10	28	21	0.3		14	
RN008771	7/09/1975	17427	190	6.9	29	35	17	110	2	27	44	3	1	7	29	23	0.4		13	
RN030954	28/10/1996	158680	475	7.26	228.016	278	169.3	265	30	22	36	23	1	7	33	9	0.2	0.1	18	

NT Portion 9472 (Lonesome Dove)

BoreRN	Sample Date	Sample No:	EC (uS/cm)	pH	Total Alkalinity	Bicarb-onate	Total Hardness	TDS	Calcium	Chloride	NaCl	Magn-esium	Nitrate	Potass-ium	Sodium	Sulp-hate	Flou-ride	Iron	Silica	Other Analysis
RN007088	28/09/1971	13309	470	8.1	249	303	237	320	37	4		33	1	3	13	12	1.7	27	62	

Urapunga Aboriginal Land Trust

BoreRN	Sample Date	Sample No:	EC (uS/cm)	pH	Total Alkalinity	Bicarb-onate	Total Hardness	TDS	Calcium	Chloride	NaCl	Magn-esium	Nitrate	Potass-ium	Sodium	Sulp-hate	Flou-ride	Iron	Silica	Other Analysis
RN009125	18/09/1977	19142	550	7.7	260	317	267	320	51	27	44	34	1	3	14	10	0.5	0.5	22	
RN009125	18/09/1977	19143	570	7.8	255	311	268	320	48	28	48	36	1	5	17	13	0.5		22	
RN009125	2/08/1978	19144	550	7.2	255	311	269	300	50	24	40	35	1	2	14	10	0.2	3.4	23	
RN009125	2/08/1978	19145	563	7.3	267	326	280			24	40									
RN009125	3/10/1996	156812	573	7.85	277	338	272.6	320	50	28	46	36	2	3	13	13	0.2	0.1	22	
RN009125	3/10/1996	154852	573	7.9	277	338	273	320	50	28	46	36	2	3	13	13	0.2	0.1	22	
RN009126	19/09/1977	19146	570	7.8	265	323	263	330	46	31	51	36	2	4	20	9	0.5	0.7	23	
RN009126	19/09/1977	19147	550	7.6	260	317	257	310	45	29	48	35	2	5	18	9	0.4	35	23	
RN009126	12/07/1978	19148	550	7.3	260	317	263	300	51	23	38	33	1	2	13	11	0.2	3	24	
RN009126	2/08/1978	19149	550	7.4	255	311	260	300	50	22	36	33	1	2	13	10	0.1	2.7	24	
RN009126	10/10/1990	19150	580	7.5	273	333	285	305	53	28	46	37	1	3	14	13	0.2	1.1	19	
RN009126	3/10/1996	156813	579	7.19	278	339	284.2	321	53	27	44.5	37	1	3	13	13	0.1	0.1	23	
RN009126	3/10/1996	154853	579	7.2	278	339	284	321	53	27	44	37	1	3	13	13	0.1	0.1	23	
RN009320	8/09/1978	20270	930	7.1	260	317	355	510	106	84	138	22	8	1	35	52	0.3	13	40	
RN009321	5/09/1978	20271	1210	7.5	260	317	381	690	108	122	201	27	1	4	88	142	0.4	7	34	
RN009322	11/09/1978	20272	710	7.7	226	275	283	400	82	54	89	19	7	1	26	36	0.2	0.1	45	
RN028126	13/05/1992	51229	1220	7.2	258	314	367	621	66	185	305	49	2	5	131	28	0.1		21	

Yutpundji-Djindiwirritj Aboriginal Land Trust

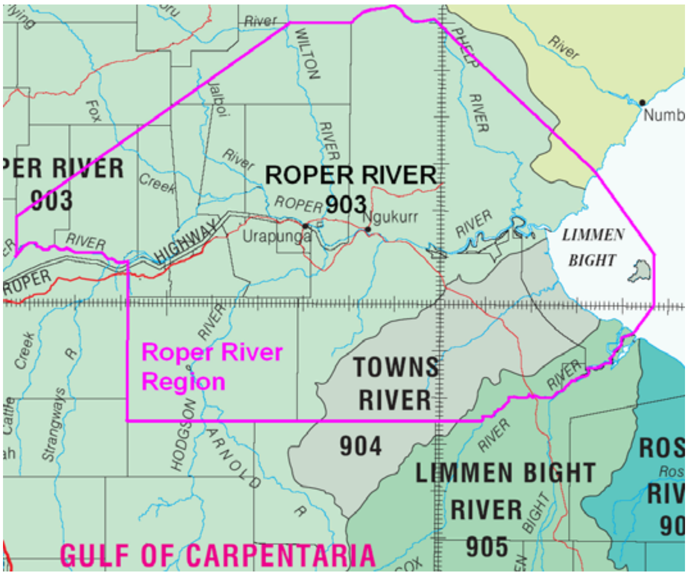
BoreRN	Sample Date	Sample No:	EC (uS/cm)	pH	Total Alkalinity	Bicarb-onate	Total Hardness	TDS	Calcium	Chloride	NaCl	Magn-esium	Nitrate	Potass-ium	Sodium	Sulp-hate	Flou-ride	Iron	Silica	Other Analysis
RN009320	8/09/1978	20270	930	7.1	260	317	355	510	106	84	138	22	8	1	35	52	0.3	13	40	
RN009321	5/09/1978	20271	1210	7.5	260	317	381	690	108	122	201	27	1	4	88	142	0.4	7	34	
RN009322	11/09/1978	20272	710	7.7	226	275	283	400	82	54	89	19	7	1	26	36	0.2	0.1	45	
RN022070	20/05/1983	40776	6000	7.5	153	186	573	3540	144	1900	3133	52	1	65	976	8	0.7	8.2	11	
RN022070	1/12/1983	40777	4430	7.1	115	140	423	2360	105	1350	2226	39	1	34	753	4	0.6	0.2	6	
RN022070	1/12/1983	40778	3620	7.6	178	217	545	3110	136	1760	2904	50	1	42	992	5	0.8	0.1	9	
RN026365	24/06/1989	49943	610	7.9	282	344	300	355	56	32	53	39	1	5	12	10	0.5	0.1	20	
RN026365	19/10/1989	49944	620	7	296	361	326	340	63	28	46	41	1	5	11	14	0.3		20	Cadmium, Manganese, Lead, Copper, Zinc

APPENDIX K: SURFACE WATER SITES

Surface water sites include:

- Sites along a river
- Waterholes
- Springs

All NRETAS surface water sites have a unique 'gauge site', 'G' number and name eg. G9030250 Roper River at Red Rock. Sites are numbered according to which basin (catchment) they lie within. The first 3 digits of the 'G' number refer to the basin number and the following digits identify the site. The following surface water site listings are provided in numerical order of basin (catchment) number.



River basins across the Roper River map region

Basins represented in the Roper River Region are shown in the figure to the left. These are:

- 903 Roper River Basin
- 904 Towns River Basin
- 905 Limmen Bight River Basin

Only those sites within the map sheet are listed.

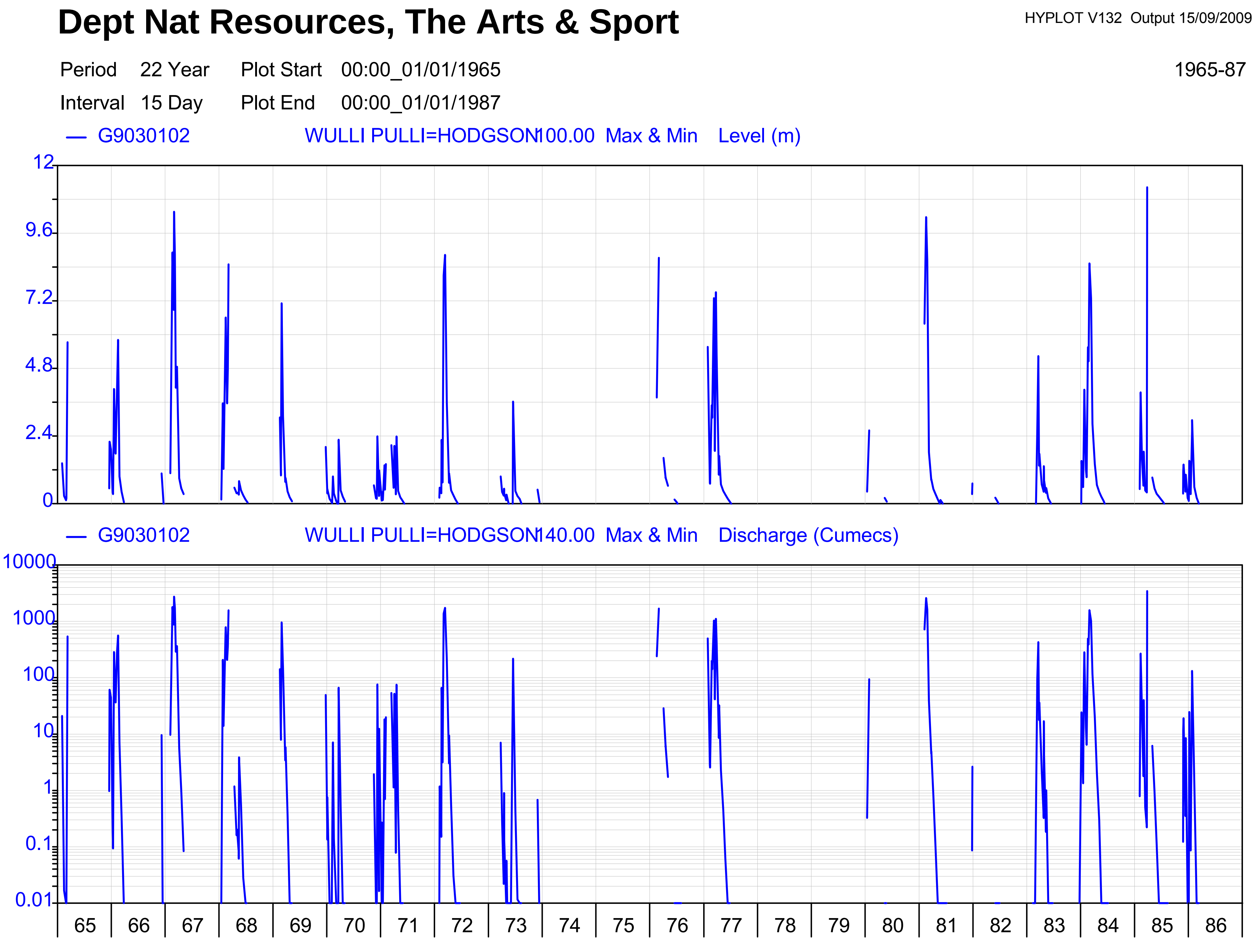
For each of these basins data is listed in order of:

- River gauging stations with a continuous height record (and flow measurements)
- River gauging sites (Sites where flow has been measured)
- Water quality sites (Some of these sites have river flow measured)

For the river gauging sites that have a continuous height record and flow measurements, plots of river height and discharge for the period of record are provided. These are:

- G9030102
- G9030146
- G9030250

The only site that is currently recording river level is G9030250 Roper River at Red Rock.



Dept Nat Resources, The Arts & Sport
HYPLOT V132 Output 15/09/2009
Period 22 Year
Plot Start 00:00_01/01/1965
Interval 15 Day
Plot End 00:00_01/01/1987
1965-87
G9030102
WULLI PULLI=HODGSON100.00 Max & Min
Level (m)
12
9.6
7.2
4.8
2.4
0
G9030102
WULLI PULLI=HODGSON140.00 Max & Min
Discharge (Cumecs)
10000
1000
100
10
1
0.1
0.01
65
66
67
68
69
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86

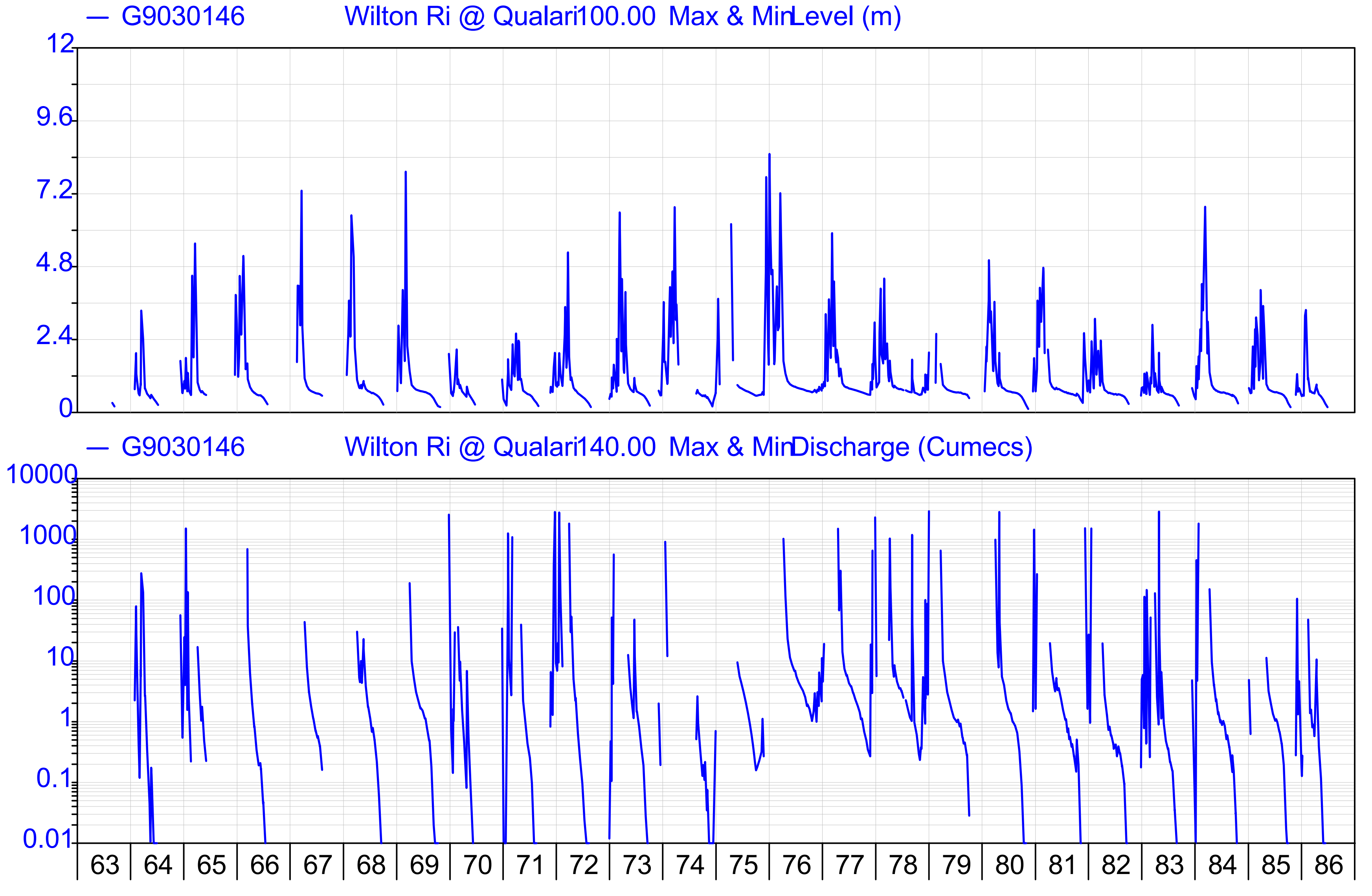
Dept Nat Resources, The Arts & Sport

HYPLOT V132 Output 15/09/2009

Period 24 Year Plot Start 00:00_01/01/1963

Interval 15 Day Plot End 00:00_01/01/1987

1963-87

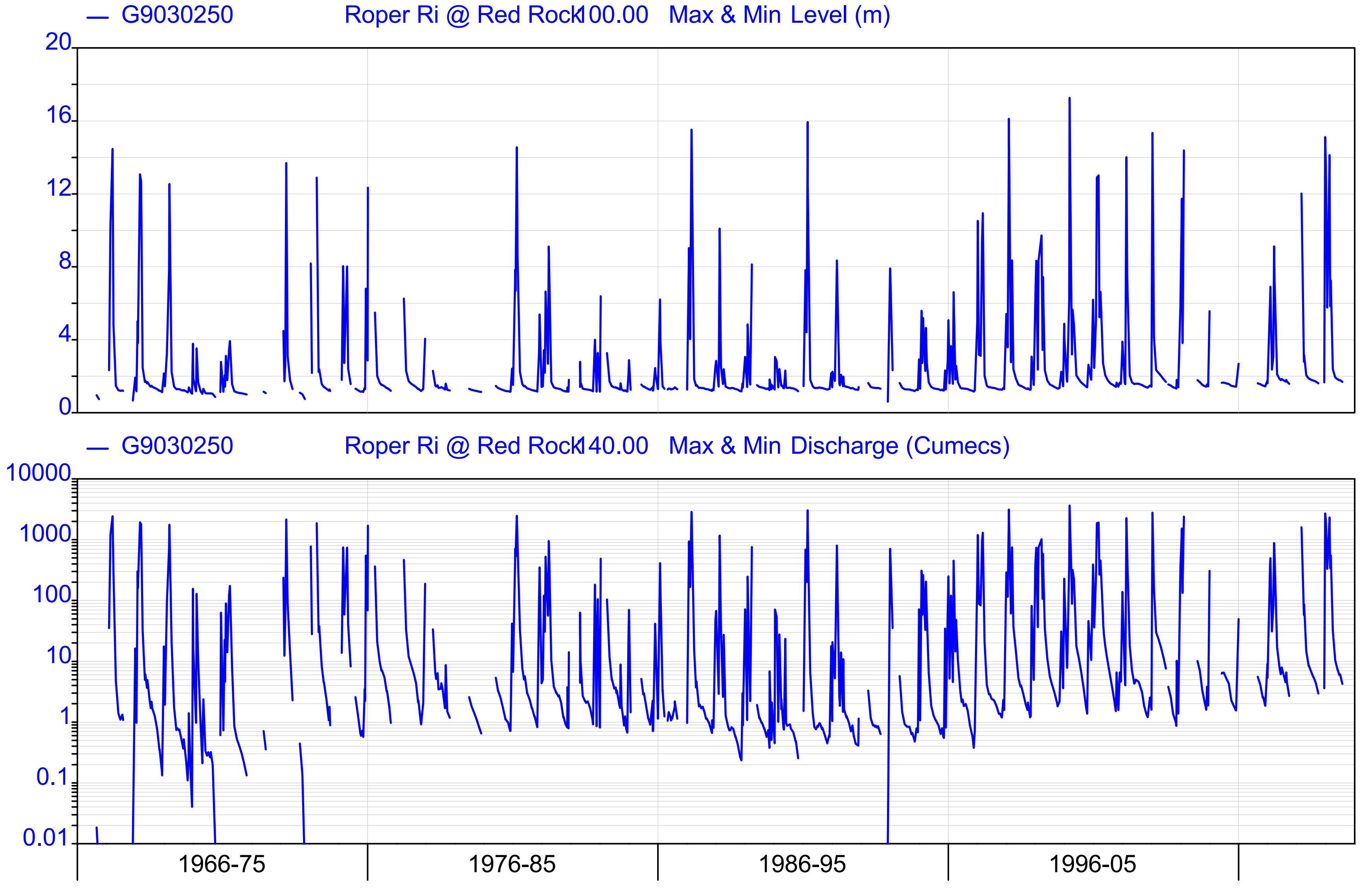


Dept Nat Resources, The Arts & Sport

HYPLOT V132 Output 15/09/2009

Period 44 Year Plot Start 00:00_01/01/1966 1966-10

Interval 1 Month Plot End 00:00_01/01/2010



903 ROPER RIVER

STATION	STATION NAME	EASTING	NORTHING	COMMENCE	CEASE	NUMBER OF FLOW RECORDS
Gauging stations with a continuous height record and flow measurements						
G9030012	Roper River At Police Station	445301	8373111	1/01/1954	31/08/1987	3
G9030102	Hodgson River At Wulli Pulli	446342	8354677	15/01/1965	29/10/1986	16
G9030123	Roper River At Downstream Moraok Homestead	358444	8361694	18/06/1963	23/02/1972	33
G9030146	Wilton River At Qualari Waterhole	457043	8386036	10/09/1963	30/10/1986	36
G9030250	Roper River At Red Rock	437326	8374934	11/08/1966	open	149
G9030310	@apx right bank opp wreck of young australian	464239	8368293	29/09/2002	4/10/2002	No, tidal
G9030311	@ left bank opp kangaroo island	498764	8364840	28/09/2002	5/10/2002	No, tidal
Gauging Sites						
G9030010	Roper River At Judy Crossing	396563	8360966	11/07/1969	13/08/1971	23
G9030011	Roper River At Flying Fox Junction	415766	8382549	11/07/1969	12/08/1971	8
G9035068	Roper River At Pt Ag	397727	8370665			6
G9035076	Roper River At Pt Ao	357927	8360965			6
G9035122	Roper River At Aa 86	395967	8361445			6
G9035283	Wilton River Xing, Ngukurr Road	453998	8376760	1/11/2006		6
G9035286	Flying Fox Creek @ Flying Fox station (Nth of Maiwok)	389355	8398000	6/12/2006		6
G9035287	Flying Fox Creek @ 150m U/S Roper River Confluence	414735	8382884	8/12/2006		6
G9035288	Flying Fox Creek xing on Lonesome Dove stn north yard	403628	8385473	7/12/2006		4
G9035300	Roper River 2meters U/S Roper Highway crossing	446986	8373373	2/11/2006		6
G9035398	Roper River @ U/S 2nd Tributary crossing to Moroak Stn	354211	8359149	8/06/2000		6
G9035408	Roper River South Braid @ Moroak Station Road crossing	354009	8358910	6/12/2006		6
G9035409	Roper River North Braid 40m U/S Flying Fox Ck confluenc	414851	8382870	8/12/2006		6
G9035410	Roper River Mid Braid @ Big River Station yards track	415120	8382713	29/06/2007		6
G9035412	Toll Gate Creek @ Nathan River Road crossing	464548	8366461	28/06/2007		5
G9035413	Maiwok Creek crossing @ Flying Fox Station	387874	8375749	3/07/2007		5
G9035414	Jalboi Creek crossing @ Flying Fox Station	394823	8362641	3/07/2007		5

STATION	STATION NAME	EASTING	NORTHING	DATE OF FLOW RECORD	FLOW L/s	SITE TYPE	COMMENT
Water quality sites, some have river flow measured							
G9030002	Bright Creek At Yannapira	462375	8421377		N/A	River	
G9030006	Mountain Creek At Old St. Vidgeons Homestead	467526	8337166		N/A	River	
G9030007	Strangeways River At Roper Highway	365678	8351287		N/A	River	
G9030009	Phelp River At Panipanin Waterhole	507768	8426626		N/A	River	
G9030016	Maria Island Tide Gauge At Gulf Of Carpentaria	577125	8357166		N/A	Tidal	
G9030147	Wilton River At 1km D/s Mainaru Confluence	439526	8446565	17/06/1986	103	River	
G9030148	Wilton River At Sth. Wongalara Waterhole	443726	8433565	17/06/1986	42	River	
G9030178	Roper River At Roper Mission (Ngukurr)	470709	8370827		N/A	River, tidal	
G9030253	Bella Glen Creek At 1.5km Sw Cork Hole Yard	402227	8299566		N/A	River	
G9030266	Turkey Lagoon At North Of Roper Mission	473176	8393865		N/A	Waterhole	Permanent
G9030509	Outlet At Billabong At Ngukurr Sewage	469826	8371665		N/A	Dam	
G9030510	Outlet Evap Pond At Ngukurr Sewage	469826	8371665		N/A	Dam	
G9030511	Outlet Pond 4 At Ngukurr Sewage	469826	8371665		N/A	Dam	
G9030512	Billabong Away From Inlet At Ngukurr Sewage	469826	8371665		N/A	Waterhole	
G9035000	Wonmurri Water Hole	523726	8401965		N/A	Waterhole	Located on Phelp River
G9035005	Moroak Station At Moroak Spring	353527	8358665		N/A	Spring	
G9035007	L.d. Creek At Picannie Yard Spring	379827	8321066		N/A	River	
G9035008	Duck Spring At Duck Creek Crossing	494726	8359166		N/A	Spring	
G9035009	Roper River At Pump Intake Dieter's Landing	452526	8370465		N/A	River	
G9035010	Roper River d/s Fizzer Creek	416926	8383565		N/A	River	
G9035011	Bella Glen Creek At Spring	402227	8299565		N/A	Spring	
G9035012	Roper Valley Station At Homestead Spring	393327	8349466	808/09/2007	0.25 est	Spring	
G9035013	Hodgson River At Grassmere Billabong	320927	8345565		N/A	River	Permanent Waterhole
G9035014	Kaniyarrang Creek At Billabong	502026	8397865		N/A	River	
G9035015	Boomarang Lagoon	509226	8408065		N/A	Waterhole	Permanent
G9035017	Badawarrka Waterhole At Pump Intake	440126	8375465		N/A	River	
G9035020	Goondooloo Station At Goondooloo Lagoon	338427	8365165		N/A	River	Waterhole on Roper River
G9035022	Costello Lagoon At 7km North Numbulwar Road	487126	8390665		N/A	Waterhole	Permanent
G9035023	Turkey Lagoon At Trib. Of Turkey Lagoon Creek	473126	8393665		N/A	Waterhole	Permanent
G9035024	Hodgson Downs Station At Bloodwood Yard Spring	419227	8308666		N/A	Spring	
G9035025	Hodgson Downs Stn. H/std Minyerri B/bong	401727	8317466		N/A	River	Permanent Waterhole

STATION	STATION NAME	EASTING	NORTHING	DATE OF FLOW RECORD	FLOW L/s	SITE TYPE	COMMENT
<u>Water quality sites, some have river flow measured</u>							
G9035026	Roper Valley Station At Spring	392327	8342666		N/A	Spring	
G9035028	St Vidgeons Station At Spring	467426	8336566		N/A	Spring	
G9035029	St. Vidgeons Station At Billabong	467626	8336466		N/A	River	
G9035031	Nullowan Lagoon	491326	8365766		N/A	Waterhole	
G9035032	Yellow Waterhole	474526	8394165		N/A	Waterhole	
G9035033	Namaluri Waterhole	497726	8386965		N/A	Waterhole	Permanent
G9035034	Hodgson River At Pt A	454426	8364466		N/A	River	
G9035035	Mountain Creek At Pt A	478826	8366866		N/A	River	
G9035036	Roper River At Pt A	511426	8367466		N/A	River, tidal	
G9035037	Roper River At Pt B	511026	8365566		N/A	River, tidal	
G9035038	Roper River At Pt C	509726	8363666		N/A	River, tidal	
G9035039	Roper River At Pt D	508026	8362666		N/A	River, tidal	
G9035040	Roper River At Pt E	506126	8362166		N/A	River, tidal	
G9035041	Roper River At Pt F	504026	8361666		N/A	River, tidal	
G9035042	Roper River At Pt. G	502226	8362566		N/A	River, tidal	
G9035043	Roper River At Pt H	500426	8363866		N/A	River, tidal	
G9035044	Roper River At Pt I	497926	8364866		N/A	River, tidal	
G9035045	Roper River At Pt J	496026	8366166		N/A	River, tidal	
G9035046	Roper River At Pt K	495726	8364766		N/A	River, tidal	
G9035047	Roper River At Pt L	494326	8364266		N/A	River, tidal	
G9035048	Roper River At Pt M	492326	8364666		N/A	River, tidal	
G9035049	Roper River At Pt N	490326	8365566		N/A	River, tidal	
G9035050	Roper River At Pt O	488726	8366566		N/A	River, tidal	
G9035051	Roper River At Pt P	485826	8367866		N/A	River, tidal	
G9035052	Roper River At Pt Q	482826	8367866		N/A	River, tidal	
G9035053	Roper River At Pt R	479126	8367066		N/A	River, tidal	
G9035054	Roper River At Pt S	474426	8369865		N/A	River, tidal	
G9035055	Roper River At Pt T	447426	8373465		N/A	River, tidal	
G9035056	Roper River At Pt U	448326	8373065		N/A	River, tidal	
G9035057	Roper River At Pt V	451726	8371765		N/A	River, tidal	
G9035058	Roper River At Pt W	452726	8369465		N/A	River, tidal	
G9035059	Roper River At Pt X	453926	8367165		N/A	River, tidal	
G9035060	Roper River At Pt Y	455626	8365166		N/A	River, tidal	

STATION	STATION NAME	EASTING	NORTHING	DATE OF FLOW RECORD	FLOW L/s	SITE TYPE	COMMENT
<u>Water quality sites, some have river flow measured</u>							
G9035061	Roper River At Pt Z	459426	8366465		N/A	River, tidal	
G9035062	Roper River At Pt Aa	463626	8368165		N/A	River, tidal	
G9035063	Roper River At Pt Ab	467126	8370565		N/A	River, tidal	
G9035064	Roper River At Pt Ac	432826	8376165		N/A	River	
G9035065	Roper River At Pt Ad	431126	8379565		N/A	River	
G9035066	Roper River At Pt Ae	432326	8380765		N/A	River	
G9035067	Roper River At Pt Af	429226	8381965		N/A	River	
G9035069	Roper River At Pt Ah	395627	8365865		N/A	River	
G9035070	BRINGUNG.PTAI ROPER RIVER	394627	8359465		N/A	River	
G9035071	Roper River At Pt Aj	387927	8357765		N/A	River	
G9035072	Roper River At Pt Ak	382427	8359365		N/A	River	
G9035073	Roper River At Pt Al	374527	8356765		N/A	River	
G9035074	Roper River At Pt Am	369727	8357765		N/A	River	
G9035075	Roper River At Pt An	367627	8359965		N/A	River	
G9035076	Roper River At Pt Ao	357926	8360965		N/A	River	
G9035077	Roper River At Pt Ap	354327	8359165		N/A	River	
G9035078	Roper River At Pt Aq	346327	8357565		N/A	River	
G9035098	Hodgson River At A 86	453426	8355366		N/A	River	
G9035099	HODGSON R. ROCKY BAR XING	451576	8353366		N/A	River	
G9035100	Hodgson River At C 86	453926	8363866		N/A	River	
G9035101	Hodgson River At D 86	454826	8358466		N/A	River	
G9035102	Hodgson River At E 86	455526	8361866		N/A	River	
G9035103	Arnold River At F 86	414427	8297866		N/A	River	
G9035105	Wilton River At H 86	439396	8446565		N/A	River	
G9035106	Wilton River At I 86	443726	8433565		N/A	River	
G9035107	Wilton River At J 86	453426	8398965		N/A	River	
G9035108	Wilton River At K 86	456126	8392865		N/A	River	
G9035109	Wilton River At L 86	457126	8382755		N/A	River	
G9035110	Wilton River At M 86	453926	8372645		N/A	River	
G9035111	Wilton River At N 86	453576	8374985	30/09/2002	207	River	
G9035112	Sherwin Creek At P 86	429126	8378540		N/A	River	
G9035115	Mainoru River At 30km East Of Homestead	432426	8450015	20/06/2006	163	River	
G9035116	Roper River At U 86	472916	8369395		N/A	River, tidal	

STATION	STATION NAME	EASTING	NORTHING	DATE OF FLOW RECORD	FLOW L/s	SITE TYPE	COMMENT
<u>Water quality sites, some have river flow measured</u>							
G9035117	Roper River At V 86	465916	8369065		N/A	River, tidal	
G9035118	Roper River At W 86	495726	8364016		N/A	River, tidal	
G9035119	Roper River At X 86	456936	8364866		N/A	River, tidal	
G9035120	Roper River At Y 86	453376	8367865		N/A	River, tidal	
G9035121	Mainoru River At 5 Km U/s Wilton Confluence	436326	8450065	17/06/1986	122	River	
G9035125	Roper River At Mole Hill	374027	8355665		N/A	River	
G9035126	Tollgate Ck	465856	8367366	30/09/2002	36	River	
G9035127	Spring At Hodgson Downs Stn	402227	8310366		N/A	Spring	
G9035129	Billabong At Roper Valley Stn.	393127	8349716		N/A	Waterhole	
G9035131	Lagoon At Wadjali Lagoon (Roper)	472126	8370065		N/A	Waterhole	
G9035133	Minimere Lagoon Arnold River	412737	8295496		N/A	River	Permanent Waterhole
G9035134	Tank yard Ngukurr	471416	8371305		N/A	Tank	
G9035140	Hodgson Downs = O/H Tank	401727	8317466		N/A	Tank	
G9035143	Hodgson R. Sth Roper Bar	446311	8355660		N/A	River	
G9035144	Roper River (Rocky Bar Xing) Roper Valley Stn	397838	8370405		N/A	River	
G9035150	Arraruru Waterhole	547451	8383894		N/A	Waterhole	Permanent
G9035151	Alirranya Spring	538586	8391512	28/10/1998	0.3	Spring	
G9035152	Allunbunji	538592	8397499		N/A	Soak	Permanent
G9035295	Bella Glen Gorge @ pool 24km Sth of Minyerri community	397523	8296323	8/09/2007	0.25 est	Spring	
G9035301	Roper River @ 5km U/S Ngukurr community	466558	8369691		N/A	River, tidal	
G9035302	Roper River @ 7km D/S Ngukurr Community	475922	8369655		N/A	River, tidal	
G9035303	Roper River @ 5km D/S Ngukurr Community	473786	8369701		N/A	River, tidal	
G9035304	Roper River @ 2.3km D/S Ngukurr Community	471983	8369117		N/A	River, tidal	
G9035305	Roper River @ 1.9km U/S Ngukurr Community	469011	8371221		N/A	River, tidal	
G9035306	Roper River @ 1.5km U/S Wilton River Confluence	450445	8372409		N/A	River, tidal	
G9035307	Wilton River @ 0.7km U/S Roper River confluence	452429	8372056		N/A	River, tidal	
G9035308	Roper River @ 2km D/S Wilton River confluence	452624	8369974		N/A	River, tidal	
G9035309	Roper River @ 1km U/S Hodgson River confluence	454727	8365500		N/A	River, tidal	
G9035310	Roper River @ 2km D/S Hodgson River confluence	457670	8365254		N/A	River, tidal	
G9035311	Roper River @ 6km D/S Ngukurr Community	480891	8366650		N/A	River, tidal	
G9035312	Roper River @ 5.4km U/S Ngukurr Community	466558	8369691		N/A	River, tidal	
G9035313	Roper River @ 7.3km D/S Hodgson River confluence	462051	8367327		N/A	River, tidal	
G9035314	Hodgson River @ 5.7km U/S Roper River cinfluence	455687	8361014		N/A	River	

STATION	STATION NAME	EASTING	NORTHING	DATE OF FLOW RECORD	FLOW L/s	SITE TYPE	COMMENT
Water quality sites, some have river flow measured							
G9035315	Roper River @ 1.2km D/S Roper Bar crossing	448127	8373628		N/A	River, tidal	
G9035317	Phelps River @ Numbulwar road crossing	513130	8406175		N/A	River	
G9035417	Toll Gate Creek 100m D/S Spring	465549	8365709	5/09/2007	121	Spring	
G9035418	Phelp River 5km U/S Numbulwar Xing	510986	8411618	11/09/2007	89	River	
G9035419	Wurdawawa swamp	453116	8356977		N/A	Waterhole	Permanent
G9035420	Namarlil Waterhole	469610	8370780		N/A	Waterhole	Permanent
G9035421	Wadangarda Lagoon near Ngukurr	467826	8370399		N/A	Waterhole	Permanent
G9035423	Balubalumani spring / waterhole near Roper Valley Stn	393486	8351859		N/A	Spring	
G9035424	Jowar (Jawa) spring discharge	438719	8371197	8/09/2007	1 est	Spring	
G9035425	Mission Gorge, Nyawurlbarr, Walmudga Creek	473223	8380296	10/09/2007	CTF	River	Permanent spring fed waterhole
G9035426	Nanggabarra waterhole north of Costello	487995	8391646		N/A	Waterhole	Permanent
G9035427	Najarrwayung waterhole 2km west of Nummerloori cmty	495729	8386675		N/A	Waterhole	Permanent
G9035428	Durrungutjbanganya waterhole 5km east of Costello cmty	492105	8388115		N/A	Waterhole	Permanent
G9035429	Ganiyarrang waterhole north of Nummerloori	502236	8399741		N/A	Waterhole	Intermittent
G9035430	Burrunju Creek near track, west of Phelp River	498118	8425867	11/09/2007	CTF	River	
G9035431	Phelp River at Gurrurrukul (L. Katherine) Community	507400	8422000	11/09/2007	20 est	River	
G9035432	Warawu Lagoon (Lake Katherine) west of Phelp River	506587	8418174	11/09/2007	N/A	Waterhole	Permanent
G9035433	Yawurrwada lagoon near Ngukurr	469071	8372490		N/A	Waterhole	Permanent

904 TOWNS RIVER

STATION	STATION NAME	EASTING	NORTHING	DATE OF FLOW RECORD	FLOW L/s	SITE TYPE	COMMENT
Surface Water sites, some have river flow measured							
G9040001	Towns River At St Vidgeons	522676	8336866		N/A	River, tidal	
G9045001	Nawarlbur Swamp/ Waterhole	530400	8324400		N/A	Waterhole	
G9045002	Little Towns River at hwy crossing	518950	8337600	29/11/2007	10 est	River	

905 LIMMEN BIGHT RIVER

STATION	STATION NAME	EASTING	NORTHING	DATE OF FLOW RECORD	FLOW L/s	SITE TYPE	COMMENT

Water quality sites, some have river flow measured

G9055022	Cox River 18km U/S Highway	523526	8300266		N/A	River	
G9055023	Limmen Bight River U/S Maria Lagoon	552826	8312166		N/A	River, tidal	
G9055024	Limmen Bight River near Maria Lagoon	547626	8307566		N/A	River, tidal	
G9055025	Cox River at Limmen Bight Confluence	544626	8305366		N/A	River	
G9055029	Cox River At Crossing	537026	8305966	21/07/2007	0.5 est	River	
G9055031	Beatrice Island At Point Q	583825	8331066		N/A	River, tidal	
G9055032	Limmen Bight River At Mouth Point R	576125	8330666		N/A	River, tidal	
G9055033	Limmen Bight River At Point S	570426	8325366		N/A	River, tidal	
G9055034	Limmen Bight River At Point T	567926	8319966		N/A	River, tidal	
G9055035	Limmen Bight River At West Is Point U	561926	8317566		N/A	River, tidal	
G9055046	Maria Lagoon At Namultja	547826	8308356		N/A	Waterhole	

APPENDIX L: CHEMISTRY OF SURFACE WATER SITES

All water contains various kinds of dissolved salts (minerals). Small quantities of many of these salts are essential to good health. Excessive concentrations however, can limit the uses of the water.
Following is some information to help you interpret the water quality represented on the following pages.
The information has been summarised from NRETAS technical fact sheet @ www.nt.gov.au/nreta/publications/natres/waterfactsheets.html. More information is available from this site.

Guideline Values:

The maximum recommended values listed beside each salt are guidelines rather than strict limits. The reason for this is because there are often many factors governing how a particular salt affects the user. These can include a person's age and the total volume of water consumed. The guidelines given below are conservatively chosen in order to cover most situations. (Guideline values for stock noted in brown)

Fluoride 1.5 mg/L **(Stock 2 mg/L)**	This limit is based on health considerations. Excess fluoride can be removed by water treatment.
Hardness 200 mg/L	Hardness is a measure of the amount of calcium and magnesium in the water. Hard waters can cause the build up of scale in hot water pipes and fittings. They also require more soap to obtain a lather.
Iron 0.3 mg/L	Above this limit, taste may be unacceptable but it does not pose a health problem. High iron concentrations give water a rust brown appearance resulting in staining of laundry, pipe encrustation and odour problems. A common way to remove iron is to aerate the water by cascading it into a tank and allowing the iron to floc or settle.
Nitrate 50 mg/L **(Stock 400 mg/L)**	Based on health considerations a limit of 50mg/L is recommended for babies less than three months old and 100mg/L for older children and adults. Nitrate levels can be reduced if necessary by water treatment.
pH 6.5 - 8.5 **(Stock 5.5 – 9.0)**	This is a measure of the acidity or alkalinity. Values less than 6.5 indicate acidic water and can results in corrosion of pipes and fittings. When pH is more than 7.5, the water is alkaline and encrustation of pipes with calcium carbonate can occur. pH can be treated.
Total Dissolved Solids (TDS) 500 mg/L **(Stock 10000 mg/L)** **Chloride 250 mg/L** **Sulphate 250 mg/L** **(Stock 2000 mg/L)** **Sodium 180 mg/L**	Above these limits for TDS, chloride, sulphate and sodium, taste may be unacceptable but it does not pose a health problem. (Aesthetic guideline only) TDS is approximately equal to 0.6 x EC

The sites are listed in numerical order according to 'G' number.

Surface Water Site	Sample Date	Sample No:	Specific Conduct (uS/cm)	pH	Total Alkalinity (mg/L)	Bicarb-onate (mg/L)	Total Hardness (mg/L)	TDS (mg/L)	Calcium (mg/L)	Chloride (mg/L)	NaCl (mg/L)	Magn-esium (mg/L)	Nitrate (mg/L)	Potass-ium (mg/L)	Sodium (mg/L)	Sulp-hate (mg/L)	Flou-ride (mg/L)	Iron (mg/L)	Silica (mg/L)	Other Analysis
G9030010	3/12/1969	115206																		Turbidity
G9030012	20/08/1959	115207	249	7			80			25	40									
G9030012	11/08/1963	115208	685	7.7	200		252			85	136									
G9030012	11/08/1963	115209		8.3	360		280			170	275									
G9030012	11/08/1963	115210		8.3	360		285			170	275									
G9030012	11/08/1963	115211		7.9	300		850			155	250									
G9030012	28/02/1964	115212	609	8	130		170			65	107									
G9030012	28/02/1964	115213	609	8		130	170	454	28	65	107	24				10				
G9030012	16/01/1967	115214	505	7.45	140	85	166			54	86									
G9030012	17/05/1967	115215	446	8	136		154			48										
G9030012	15/08/1967	115216	832	7.75	296	126	296	515	45	108	168	44	0.5	8	70	50		0.2		
G9030012	4/12/1969	115217																		Turbidity
G9030012	11/12/1970	115218	490	7.7	96	117	130	260	20	64	105	19	2	7	48	60	0.2	3.4	8	
G9030012	15/11/1977	115219	1570	7.8	250	305	415			250	412									
G9030012	9/10/1980	115220	1637	8.5	249	304			58	117	193	63	1	16	157	180	0.4	0.1	18	
G9030012	21/06/1986	115221	1540	8.4	305	364	425	955	63	225	372	65	1	17	165	189	0.3	0.3	28	
G9030013	18/08/1967	115222	1760	7.6	438	267	630		90	240		97	1	20	190	24	0.1	0.2		
G9030013	15/10/1968	115223	1700	7.7	348	212	500	1010	52	255		71	1	23	190	187	0.7	0.2	42	
G9030013	4/12/1969	115224																		Turbidity
G9030013	3/10/1975	115225	1920	7.7	455	555	620			250	412									
G9030013	13/10/1980	115226	2180	7.4	415	506			105	252	416	69	1	23	183	235	0.4	0.1	38	

Surface Water Site	Sample Date	Sample No:	Specific Conduct (uS/cm)	pH	Total Alkalinity (mg/L)	Bicarb-onate (mg/L)	Total Hardness (mg/L)	TDS (mg/L)	Calcium (mg/L)	Chloride (mg/L)	NaCl (mg/L)	Magn-esium (mg/L)	Nitrate (mg/L)	Potass-ium (mg/L)	Sodium (mg/L)	Sulp-hate (mg/L)	Flou-ride (mg/L)	Iron (mg/L)	Silica (mg/L)	Other Analysis
G9030013	22/03/1981	115227	1920	7.9	417	508	595			260	428									
G9030013	27/06/1986	115228	1760	8.1	448	546	553	1090	111	218	359	67	1	20	170	208	0.4	0.1	41	
G9030102	14/01/1965	115246																		TSS
G9030102	11/02/1970	115247																		TSS
G9030102	22/03/1970	115248																		TSS
G9030102	22/03/1970	115249																		TSS
G9030102	23/03/1970	115250																		TSS
G9030102	24/03/1970	115251																		TSS
G9030102	21/05/1975	115252	520	7.5																
G9030102	9/02/1976	115253	58	6.5	19	23	16	60	3	5	8	2	3	3	4	2	0.1	14	13	
G9030102	15/03/1976	115254	30	6.7																
G9030102	25/01/1977	115255	130	6.3																
G9030102	14/03/1977	115256	49	6.2	17	21	16	43	3	7	112	2	3	3	4	7	0.1	5	13	
G9030102	3/05/1977	115257	170	6.9																
G9030102	14/04/1978	115258	180	7																
G9030102	16/06/1986	115259	75	7.5	29	35	34	60	5	6	8	5	4	4	4	9	0.2	0.2	13	
G9030108	6/07/1966	115260	496	8.23		139	254	285	29	14		43	1.4	1.4	9					
G9030123	12/08/1963	115265	1498	8.4	500		463			425										
G9030123	14/08/1967	115266	3200	7.95	32	20	580	1072	60	52		130		17	200	270	0.1	0.1		
G9030123	26/06/1968	115267	1300	8	54	33	400		35	190		58	1	15	175	1.2	0.4	0.1	25	
G9030123	4/12/1969	115268																		Turbidity
G9030123	10/09/1975	115269	1950	8.4	320	339	513	1110	84	286	471	74	2	19	207	252	0.6	0.1	13	

Surface Water Site	Sample Date	Sample No:	Specific Conduct (uS/cm)	pH	Total Alkalinity (mg/L)	Bicarb-onate (mg/L)	Total Hardness (mg/L)	TDS (mg/L)	Calcium (mg/L)	Chloride (mg/L)	NaCl (mg/L)	Magn-esium (mg/L)	Nitrate (mg/L)	Potass-ium (mg/L)	Sodium (mg/L)	Sulp-hate (mg/L)	Flou-ride (mg/L)	Iron (mg/L)	Silica (mg/L)	Other Analysis
G9030123	1/10/1975	115270	1820	8	326	397	503	1090	80	284	468	74	1	25	196	234	0.4	0.1	27	
G9030123	22/07/1976	115271	1620	7.6	316	385	480			56	93									
G9030123	12/10/1980	115272	2239	8.3																
G9030123	13/12/1994	140493	1410	8.2	280	350							0.004							
G9030123	21/08/1995	148104	1615	8.2	351	428							0.012							
G9030123	21/08/1995	152928	1615	8.2	351	428							0.012							
G9030123	20/11/1995	153112	1320	8.2	318	388							0.155							
G9030146	25/09/1974	115282	380	7.7	179	218	173	210	30	14	23	24	1	2	9	4	0.4	0.1	16	
G9030146	4/11/1974	115283	380	7.6	180	219														
G9030146	22/05/1975	115284	240	7.3	130	159	100	130		12	20		1					0.2		
G9030146	6/06/1975	115285	280	7.6																
G9030146	2/08/1975	115286	350	8.2																
G9030146	3/10/1975	115287	380	8.4																
G9030146	9/02/1976	115288	140	7.4	53	65	50	90	10	9	15	6	1	2	6	2	0.1	9.1	15	
G9030146	15/03/1976	115289	46	6.8																
G9030146	27/04/1976	115290	290	7.4																
G9030146	9/06/1976	115291	390	7.4																
G9030146	13/10/1976	115292	470	8.2																
G9030146	25/01/1977	115293	84	6.7																
G9030146	14/03/1977	115294	92	6.3																
G9030146	3/05/1977	115295	220	7	75	92	87	120	15	14	23	12	5	3	11	3	0.2	1.4	17	
G9030146	20/01/1978	115296	210	7.7																

Surface Water Site	Sample Date	Sample No:	Specific Conduct (uS/cm)	pH	Total Alkalinity (mg/L)	Bicarb-onate (mg/L)	Total Hardness (mg/L)	TDS (mg/L)	Calcium (mg/L)	Chloride (mg/L)	NaCl (mg/L)	Magn-esium (mg/L)	Nitrate (mg/L)	Potass-ium (mg/L)	Sodium (mg/L)	Sulp-hate (mg/L)	Flou-ride (mg/L)	Iron (mg/L)	Silica (mg/L)	Other Analysis
G9030146	14/04/1978	115297	130	7.5																
G9030146	8/08/1980	115298	420	8.4	181	214	176	200	31	8	13	24	1	3	6	6	0.1	0.1	14	
G9030176	5/02/1964	115299																		TSS
G9030176	6/12/1964	115300																		TSS
G9030176	8/02/1966	115301																		Turbidity
G9030176	9/02/1966	115302																		Turbidity
G9030176	9/02/1966	115303																		Turbidity
G9030176	10/02/1966	115304	36	6.8	26		21													
G9030176	10/02/1966	115305																		Turbidity
G9030176	11/02/1966	115306																		Turbidity
G9030176	12/02/1966	115307																		Turbidity
G9030176	7/07/1966	115308	1565	7.98	376	229	380	960	37	195		70	0.7	19	355	150				
G9030176	21/01/1967	115309	502	7.7	148	90	162	303		52										
G9030176	12/08/1967	115310	1660	7.55	380	232	590			245										
G9030176	4/12/1969	115311																		Turbidity
G9030176	6/11/1974	115312	1670	7.5	390	476	516	1060	98	247	407	66	1	22	172	196	0.4	0.2	40	
G9030176	7/05/1975	115313	910	7.7																Turbidity
G9030176	20/05/1975	115314	760	7.6																Turbidity
G9030176	4/06/1975	115315	950	7.8																Turbidity
G9030176	29/07/1975	115316	1460	7.7																Turbidity
G9030176	1/10/1975	115317	1750	7.6																Turbidity
G9030176	7/05/1976	115318	910	7.7																Turbidity

Surface Water Site	Sample Date	Sample No:	Specific Conduct (uS/cm)	pH	Total Alkalinity (mg/L)	Bicarb-onate (mg/L)	Total Hardness (mg/L)	TDS (mg/L)	Calcium (mg/L)	Chloride (mg/L)	NaCl (mg/L)	Magn-esium (mg/L)	Nitrate (mg/L)	Potass-ium (mg/L)	Sodium (mg/L)	Sulp-hate (mg/L)	Flou-ride (mg/L)	Iron (mg/L)	Silica (mg/L)	Other Analysis
G9030176	5/08/1976	115319	1540	7.7																Turbidity
G9030176	13/01/1977	115320	720	7.2	175	214	225	470	47	83	137	26	2	10	60	68	0.4	2.3	10	
G9030176	14/03/1977	115321	180	7.2																
G9030176	20/01/1978	115322	580	7.7																
G9030176	14/04/1978	115323	1010	7.9																
G9030176	3/08/1995	143155	1613	7.8	403	491	477	1003	87	213	351	63	1	7	163	202	0.3	0.1	40	
G9030178	25/05/1960	115324		7		35	34			15										
G9030178	25/05/1960	115325		7		35	34			15										
G9030178	27/07/1960	115326		7.5		32	43			16										
G9030178	16/08/1960	115327		7		44	44			22										
G9030178	17/08/1960	115328		7		42	44			22										
G9030178	7/09/1960	115329		7		45	46			25										
G9030178	7/09/1960	115330		7		45	47			25										
G9030178	14/09/1960	115331		7		48	49			30										
G9030178	14/09/1960	115332		7.5		44	46			25										
G9030178	25/09/1960	115333	161	7.5		45	48			30										
G9030178	28/09/1960	115334	162	7.5		45	48			30										
G9030178	12/10/1960	115335	183	7		45	49			50										
G9030178	12/10/1960	115336	175	7		45	49			35										
G9030178	19/10/1960	115337	178	7		45	51			40										
G9030178	19/10/1960	115338	179	7		45	51			40										
G9030178	2/11/1960	115339	210	7.5		49	57			50										

Surface Water Site	Sample Date	Sample No:	Specific Conduct (uS/cm)	pH	Total Alkalinity (mg/L)	Bicarb-onate (mg/L)	Total Hardness (mg/L)	TDS (mg/L)	Calcium (mg/L)	Chloride (mg/L)	NaCl (mg/L)	Magn-esium (mg/L)	Nitrate (mg/L)	Potass-ium (mg/L)	Sodium (mg/L)	Sulp-hate (mg/L)	Flou-ride (mg/L)	Iron (mg/L)	Silica (mg/L)	Other Analysis
G9030178	3/11/1960	115340	225	7.5		48	56			50										
G9030178	9/11/1960	115341	250	7		47	59			60										
G9030178	9/11/1960	115342	207	7		50	56			35										
G9030178	23/11/1960	115343	215	7.5		48	58			50										
G9030178	23/11/1960	115344	201	7.5		50	59			45										
G9030178	30/11/1960	115345	197	7.5		51	59			37										
G9030178	3/12/1960	115346	203	7.5		51	63			48										
G9030178	14/12/1960	115347	215	7.5		54	61			45										
G9030178	14/12/1960	115348	220	7.5		55	62			53										
G9030178	20/12/1960	115349	265	7.5		49	66			71										
G9030178	20/12/1960	115350	213	7.5		50	63			50										
G9030178	28/12/1960	115351	315			68	56			61										
G9030178	28/12/1960	115352	253			61	76			63										
G9030178	3/01/1961	115353	113	7		33	35			26										
G9030178	11/01/1961	115354	163	7.5		37	49			30										
G9030178	11/01/1961	115355	165	7.5		38	50			30										
G9030178	17/01/1961	115356	154	7		36	21			30										
G9030178	17/01/1961	115357	222	7.5		46	31			48										
G9030178	25/01/1961	115358	247	7.5		50	70			45										
G9030178	25/01/1961	115359	206	7.5		42	58			38										
G9030178	31/01/1961	115360	287	7.5		54	80			60										
G9030178	31/01/1961	115361	265	7.5		50	72			50										

Surface Water Site	Sample Date	Sample No:	Specific Conduct (uS/cm)	pH	Total Alkalinity (mg/L)	Bicarb-onate (mg/L)	Total Hardness (mg/L)	TDS (mg/L)	Calcium (mg/L)	Chloride (mg/L)	NaCl (mg/L)	Magn-esium (mg/L)	Nitrate (mg/L)	Potass-ium (mg/L)	Sodium (mg/L)	Sulp-hate (mg/L)	Flou-ride (mg/L)	Iron (mg/L)	Silica (mg/L)	Other Analysis
G9030178	1/02/1961	115362	305	7.5		56	85			61										
G9030178	1/02/1961	115363	267	7.5		52	74			51										
G9030178	8/02/1961	115364	283	7.5		60	78			62										
G9030178	8/02/1961	115365	357	8.5		70	100			78										
G9030178	15/02/1961	115366	393	7		78	112			88										
G9030178	15/02/1961	115367	548	7.5		105	168			124										
G9030178	22/02/1961	115368	487	7.5		101	135			96										
G9030178	22/02/1961	115369	491	7.5		104	135			104										
G9030178	1/03/1961	115370	493	7.5		105	136			102										
G9030178	1/03/1961	115371	489	7.5		105	132			92										
G9030178	8/03/1961	115372	435	7.5		100	125			90										
G9030178	8/03/1961	115373	419	7.5		100	119			84										
G9030178	15/03/1961	115374	420	7.5		99	120			84										
G9030178	15/03/1961	115375	430	7.5		99	122			88										
G9030178	22/03/1961	115376	470	8.5		100	126			90										
G9030178	22/03/1961	115377	469	8.5		100	124			90										
G9030178	29/03/1961	115378	471	7.5		103	126			89										
G9030178	29/03/1961	115379	472	7.5		102	127			90										
G9030178	14/04/1961	115380	484	7.5		105	131			90										
G9030178	14/04/1961	115381	501	7.5		100	130			98										
G9030178	19/04/1961	115382	501	7.5		105	125			98										
G9030178	19/04/1961	115383	501	7.5		105	140			98										

Surface Water Site	Sample Date	Sample No:	Specific Conduct (uS/cm)	pH	Total Alkalinity (mg/L)	Bicarb-onate (mg/L)	Total Hardness (mg/L)	TDS (mg/L)	Calcium (mg/L)	Chloride (mg/L)	NaCl (mg/L)	Magn-esium (mg/L)	Nitrate (mg/L)	Potass-ium (mg/L)	Sodium (mg/L)	Sulp-hate (mg/L)	Flou-ride (mg/L)	Iron (mg/L)	Silica (mg/L)	Other Analysis
G9030178	26/04/1961	115384	492	7.5		109	125			94										
G9030178	26/04/1961	115385	494	7.5		105	130			96										
G9030178	5/05/1961	115386	499	7.5		112	142			92										
G9030178	5/05/1961	115387	516	7.5		108	145			98										
G9030178	10/05/1961	115388	532	7.5		106	140			94										
G9030178	10/05/1961	115389	541	7.5		106	142			98										
G9030178	24/05/1961	115390	529	7.5		107	140			84										
G9030178	24/05/1961	115391	543	8		105	122			102										
G9030178	2/06/1961	115392	537	7.5		110	155			94										
G9030178	2/06/1961	115393	537	7.5		108	150			96										
G9030178	2/06/1961	115394	537	7.5		109	150			96										
G9030178	2/06/1961	115395	550	7		111	150			96										
G9030178	2/06/1961	115396	551	7		110	149			95										
G9030178	2/06/1961	115397	559	7.5		109	143			95										
G9030178	2/06/1961	115398	536	7.5		114	145			94										
G9030178	7/06/1961	115399	549	7		131	140			92										
G9030178	7/06/1961	115400	537	7		115	138			100										
G9030178	23/11/1961	115401	215	7.5		48	58			50										
G9030178	23/11/1961	115402	201	7.5		50	59			45										
G9030178	17/04/1962	115403	94	7.4	20		20			33										
G9030178	17/04/1962	115404	180	6	5		20			82										
G9030178	24/04/1962	115405	120	7	35		33			32										

Surface Water Site	Sample Date	Sample No:	Specific Conduct (uS/cm)	pH	Total Alkalinity (mg/L)	Bicarb-onate (mg/L)	Total Hardness (mg/L)	TDS (mg/L)	Calcium (mg/L)	Chloride (mg/L)	NaCl (mg/L)	Magn-esium (mg/L)	Nitrate (mg/L)	Potass-ium (mg/L)	Sodium (mg/L)	Sulp-hate (mg/L)	Flou-ride (mg/L)	Iron (mg/L)	Silica (mg/L)	Other Analysis
G9030178	7/05/1962	115406	135	7.3	30		30			30										
G9030178	8/05/1962	115407	138	7.5	35		35			30										
G9030178	20/05/1962	115408	113	7.4		35	36			36										
G9030178	20/05/1962	115409	133	7.4	35		36			36										
G9030178	21/05/1962	115410	140	7.4		35	38			38										
G9030178	21/05/1962	115411	140	7.4	35		38			38										
G9030178	29/05/1962	115412	260	5.8	10		38			112										
G9030178	2/06/1962	115413	168	7.8		40	34			34										
G9030178	2/06/1962	115414	89	7.6		45	31			35										
G9030178	23/07/1963	115415	250	7.6		83	92			52						20				
G9030178	23/07/1963	115416	263	7.6		87	86			54						20				
G9030178	10/08/1963	115417	289	7		100	98			58										
G9030178	23/09/1963	115418	1780	7.25	88		215			600										
G9030178	23/09/1963	115419	1273	7.5	83		155			500										
G9030178	24/09/1963	115420	1958	7.4	95		240			950										
G9030178	24/09/1963	115421	1762	7.6	80		140			550										
G9030178	25/09/1963	115422	2331	7.6	85		265			1150										
G9030178	25/09/1963	115423	2422	7.25	83		280			1120										
G9030178	26/09/1963	115424	1043	7.25	80		150			550										
G9030178	26/09/1963	115425	450	7	100		88			155										
G9030178	8/06/1964	115426	256	7.6	74		78	208		36										
G9030178	5/08/1964	115427	336	7.61	75		78	257		33										

Surface Water Site	Sample Date	Sample No:	Specific Conduct (uS/cm)	pH	Total Alkalinity (mg/L)	Bicarb-onate (mg/L)	Total Hardness (mg/L)	TDS (mg/L)	Calcium (mg/L)	Chloride (mg/L)	NaCl (mg/L)	Magn-esium (mg/L)	Nitrate (mg/L)	Potass-ium (mg/L)	Sodium (mg/L)	Sulp-hate (mg/L)	Flou-ride (mg/L)	Iron (mg/L)	Silica (mg/L)	Other Analysis
G9030178	5/08/1964	115428	368	7.57	85		86	274		33										
G9030178	6/08/1964	115429	348	7.77	76		76	251		30										
G9030178	6/08/1964	115430	253	3.5	76		78			36										
G9030178	6/08/1964	115431	326	7.8	74		78	268		36										
G9030178	7/08/1964	115432	348	7.68	76		78	200		36										
G9030178	8/08/1964	115433	320	7.64	74		80	253		30										
G9030178	8/08/1964	115434	308	7.68	70		78	264		36										
G9030178	10/08/1964	115435	364	7.76	76		78	250		30										
G9030178	10/08/1964	115436	356	7.32	76		80	283		42										
G9030178	11/08/1964	115437	320	7.94	80		80	256		36										
G9030178	11/08/1964	115438	334	7.72	74		82	266		36										
G9030178	12/08/1964	115439	266	7.73	76		78			33										
G9030178	12/08/1964	115440	312	7.77	74		78	264		33										
G9030178	12/08/1964	115441	308	7.42	76		78	262		33										
G9030178	13/08/1964	115442	340	7.54	78		82	259		36										
G9030178	15/11/1964	115443	1100	7.8	94	57	174			262										
G9030178	16/11/1964	115444	755	7.8	96	59	146			164										
G9030178	16/11/1964	115445	1470	7.8	116	71	226			374										
G9030178	16/11/1964	115446	1490	8.06	94	94	224			424										
G9030178	17/11/1964	115447	1040	8.1	92	94	170			282										
G9030178	17/11/1964	115448	850	8.2	88	94	150			218										
G9030178	18/11/1964	115449	1405	8.1	90	94	204			376										

Surface Water Site	Sample Date	Sample No:	Specific Conduct (uS/cm)	pH	Total Alkalinity (mg/L)	Bicarb-onate (mg/L)	Total Hardness (mg/L)	TDS (mg/L)	Calcium (mg/L)	Chloride (mg/L)	NaCl (mg/L)	Magn-esium (mg/L)	Nitrate (mg/L)	Potass-ium (mg/L)	Sodium (mg/L)	Sulp-hate (mg/L)	Flou-ride (mg/L)	Iron (mg/L)	Silica (mg/L)	Other Analysis
G9030178	18/11/1964	115450	910	8.09	90	94	156			224										
G9030178	19/11/1964	115451	1560	8.1	92	94	230			424										
G9030178	20/11/1964	115452	1080	8.2	88	94	170			268										
G9030178	20/11/1964	115453	1675	8.06	88	94	238			442										
G9030178	16/11/1966	115454	655	7.23	100	61	130			126										
G9030178	16/11/1966	115455	1155	7.74	100	61	184			268										
G9030178	18/11/1966	115456	908	7.86	98	60	150			204										
G9030178	18/11/1966	115457	850	8.1	92	56	148			186										
G9030178	18/11/1966	115458	1135	7.6	92	56	210			392										
G9030178	18/11/1966	115459	1415	7.7	98	60	202			364										
G9030178	18/11/1966	115460	723	7.3	96	59	146			152										
G9030178	18/11/1966	115461	672	7.9	96	59	136			134										
G9030178	18/11/1966	115462	1110	7.6	94	57	170			270										
G9030178	19/11/1966	115463	1122	7.8	92	56	182			278										
G9030178	19/11/1966	115464	875	7.9	92	56	154			204										
G9030178	19/11/1966	115465	1320	7.7	94	57	190			342										
G9030178	19/11/1966	115466	761	7.1	100	61	142			164										
G9030178	21/11/1966	115467	1155	7.86	88	54	178			292										
G9030178	21/11/1966	115468	913	7.95	92	60	166			216										
G9030178	21/11/1966	115469	1295	8	92	59	198			320										
G9030178	21/11/1966	115470	826			56				180										
G9030178	21/11/1966	115471	806			56				172										

Surface Water Site	Sample Date	Sample No:	Specific Conduct (uS/cm)	pH	Total Alkalinity (mg/L)	Bicarb-onate (mg/L)	Total Hardness (mg/L)	TDS (mg/L)	Calcium (mg/L)	Chloride (mg/L)	NaCl (mg/L)	Magn-esium (mg/L)	Nitrate (mg/L)	Potass-ium (mg/L)	Sodium (mg/L)	Sulp-hate (mg/L)	Flou-ride (mg/L)	Iron (mg/L)	Silica (mg/L)	Other Analysis
G9030178	21/11/1966	115472	762			57				162										
G9030178	21/11/1966	115473	714	7.66	94	61	148			148										
G9030178	21/11/1966	115474	632							148										
G9030178	29/11/1966	115475	1965	8.06	98		850	1175		60								0.04		
G9030178	21/12/1966	115476	2600	7.9	96	59	310	1519		710										
G9030178	28/12/1966	115477	3800	7.86	100		450	2359		61										
G9030178	2/01/1967	115478	4950	8	100	61	530	2967		1380								0.19		
G9030178	3/01/1967	115479	4330	7.99	102	62	505	2749		1270								0.03		
G9030178	4/01/1967	115480	4440	7.78	98	59	620	2760		1300								0.95		
G9030178	10/01/1967	115481	2790	8.07	102	62	370	1537		730								0.25		
G9030178	11/01/1967	115482	5530	7.88	102	62	690	3582		1700								0.1		
G9030178	17/01/1967	115483	3035	7.58	106	64	410			910										
G9030178	17/01/1967	115484	5590	7.65	102	62	750			1800										
G9030178	24/01/1967	115485	872	7.75	106	64	164			198										
G9030178	24/01/1967	115486	1290	7.75	104	63	208			328										
G9030178	24/01/1967	115487	1552	7.68	106	64	230			298										
G9030178	12/05/1969	115488	240	6.8	94	115	94	160	22	16		11	1	3	14	11	0.2	0.6	14	
G9030178	14/08/1969	115489	315	8.1	123	150	126	200	26	24		15	1	3	18	10	0.1	0.5	8	
G9030178	4/09/1969	115490	300	7.5	122	149	130	170	26	24		15	1	3	18	14	0.1	0.8	5	
G9030178	23/09/1969	115491	320	8.2	126	154	133	180	27	26		15	1	3	20	17	0.1	0.5	6	
G9030178	21/05/1970	115492	245	8	70	85	78	110	16	26		10	2	3	17	23	0.2		4	
G9030178	27/07/1970	115493		7.5		40	46			18										

Surface Water Site	Sample Date	Sample No:	Specific Conduct (uS/cm)	pH	Total Alkalinity (mg/L)	Bicarb-onate (mg/L)	Total Hardness (mg/L)	TDS (mg/L)	Calcium (mg/L)	Chloride (mg/L)	NaCl (mg/L)	Magn-esium (mg/L)	Nitrate (mg/L)	Potass-ium (mg/L)	Sodium (mg/L)	Sulp-hate (mg/L)	Flou-ride (mg/L)	Iron (mg/L)	Silica (mg/L)	Other Analysis
G9030178	8/09/1970	115494	400	7.2	82	100	107	240	20	60		14	2	5	37	36	0.2	1.4	2	
G9030178	3/11/1970	115495	1620							427										
G9030178	4/10/1973	115496	240	8	75	92	86	140	18	23	38	10	1	4	17	20	0.2	2.2	1	
G9030178	19/09/1974	115497	700	8.1	177	216	221	480	44	77	127	27	1	6	47	55	0.3	1	7	
G9030178	26/09/1974	115498																		Turbidity
G9030178	10/10/1974	115499																		Turbidity
G9030178	24/10/1974	115500																		Turbidity
G9030178	1/11/1974	115501	1070	8.1	226	275	330	778	58	155	255	45	1	10	100	124	0.2	0.4	10	
G9030178	1/11/1974	115502	1070	8.1	226	275	330	777	58	155	255	45	1	10	100	123	0.3	0.5	10	
G9030178	5/11/1974	115503	1180	8.2	231	282	343	824	60	170	280	47	1	11	110	138	0.3	1.1	5	
G9030178	5/11/1974	115504	1140	8.1	233	284	333	789	59	160	264	45	1	10	100	126	0.3	0.9	4	
G9030178	7/11/1974	115505																		Turbidity
G9030178	12/11/1974	115506	1200	7.5	228	278	343	833	60	175	288	47	1	11	109	142	0.4	0.1	10	
G9030178	14/11/1974	115507																		Turbidity
G9030178	19/11/1974	115508																		Turbidity
G9030178	21/11/1974	115509																		Turbidity
G9030178	25/11/1974	115510																		Turbidity
G9030178	25/11/1974	115511	1240	8.1	232	283	343	859	60	171	282	47	1	12	119	156	0.4	0.5	10	
G9030178	5/12/1974	115512																		Turbidity
G9030178	6/12/1974	115513	1180	8	224	273	341	819	59	165	272	47	1	11	107	142	0.1	1.2	9	
G9030178	10/12/1974	115514	1250	8.1	226	275	353	853	59	184	303	50	1	11	120	148	0.3	0.6	10	
G9030178	19/12/1974	115515	1170	8.3	215	262	353	826	64	174	287	47	1	11	112	146	0.3	0.5	9	

Surface Water Site	Sample Date	Sample No:	Specific Conduct (uS/cm)	pH	Total Alkalinity (mg/L)	Bicarb-onate (mg/L)	Total Hardness (mg/L)	TDS (mg/L)	Calcium (mg/L)	Chloride (mg/L)	NaCl (mg/L)	Magn-esium (mg/L)	Nitrate (mg/L)	Potass-ium (mg/L)	Sodium (mg/L)	Sulp-hate (mg/L)	Flou-ride (mg/L)	Iron (mg/L)	Silica (mg/L)	Other Analysis
G9030178	9/02/1975	115516																		Turbidity
G9030178	4/03/1975	115517																		Turbidity
G9030178	13/03/1975	115518																		Turbidity
G9030178	26/03/1975	115519																		Turbidity
G9030178	24/04/1975	115520																		Turbidity
G9030178	8/05/1975	115521	210							20	33									
G9030178	22/05/1975	115522	290							25	41									
G9030178	12/06/1975	115523	360	7.1	110	134	120	264	26	31	51	14	1	3	20	21	0.2	0.4	14	
G9030178	19/06/1975	115524	380							35	57									
G9030178	3/07/1975	115525	430							39	64									
G9030178	24/07/1975	115526	450							42	69									
G9030178	14/08/1975	115527	510							48	79									
G9030178	9/10/1975	115528	570							59	97									
G9030178	9/10/1975	115529	590							59	97									
G9030178	23/10/1975	115530	630							67	110									
G9030178	6/11/1975	115531	600							63	104									
G9030178	21/11/1975	115532	650							69	114									
G9030178	5/12/1975	115533	720							73										
G9030178	12/12/1975	115534	52	6.9	21	26	21	32	5	2	3	2	1	2	2	2	0.2	9	8	
G9030178	20/01/1976	115535	150							12										
G9030178	13/02/1976	115536	100							9										
G9030178	27/02/1976	115537	73							7										

Surface Water Site	Sample Date	Sample No:	Specific Conduct (uS/cm)	pH	Total Alkalinity (mg/L)	Bicarb-onate (mg/L)	Total Hardness (mg/L)	TDS (mg/L)	Calcium (mg/L)	Chloride (mg/L)	NaCl (mg/L)	Magn-esium (mg/L)	Nitrate (mg/L)	Potass-ium (mg/L)	Sodium (mg/L)	Sulp-hate (mg/L)	Flou-ride (mg/L)	Iron (mg/L)	Silica (mg/L)	Other Analysis
G9030178	23/04/1976	115538	360	7.7						29	48									
G9030178	6/05/1976	115539	410	7.7						33	54									
G9030178	20/05/1976	115540	490	7.9						43	71									
G9030178	3/06/1976	115541	550	7.9						49	81									
G9030178	1/07/1976	115542	700							72	119									
G9030178	29/07/1976	115543	790							95	157									
G9030178	15/11/1977	115544	1570	7.8	255	311	415			250	412									
G9030178	15/08/1979	115545	530	8.1	165	201	189	300	38	49	81	23	1	5	36	36	0.2	0.5	10	
G9030178	14/02/1980	115546																		Turbidity
G9030178	4/03/1980	115547																		Turbidity
G9030178	4/03/1980	115548																		Turbidity
G9030178	30/06/1980	115549	455	8.4	118	138	136	200	28	37	61	16	1	3	25	26	0.2	0.5	6	
G9030178	9/10/1980	115550	708		174	212			40	75	124	28	1	5	46	50	0.2	0.4	6	
G9030178	9/02/1983	115551																		Faecal
G9030178	15/11/1983	115552																		Faecal
G9030178	27/01/1984	115553																		Faecal
G9030178	21/02/1984	115554																		Faecal
G9030178	6/06/1985	115555	280	7	84	102	86	150	18	24	40	10	1	3	19	17	0.1	0.7	18	
G9030178	29/04/1986	115556																		Faecal
G9030178	21/07/1987	115557																		Faecal
G9030178	14/08/1992	115558	280	8.2	89	109	100	165	22	25	41	11	2	4	18	17	0.1	1.1	3	
G9030178	23/09/1993	115559	44	7.4	21	25	11	37	1	7	12	2	1	2	4	2	0.1	0.3	11	

Surface Water Site	Sample Date	Sample No:	Specific Conduct (uS/cm)	pH	Total Alkalinity (mg/L)	Bicarb-onate (mg/L)	Total Hardness (mg/L)	TDS (mg/L)	Calcium (mg/L)	Chloride (mg/L)	NaCl (mg/L)	Magn-esium (mg/L)	Nitrate (mg/L)	Potass-ium (mg/L)	Sodium (mg/L)	Sulp-hate (mg/L)	Flou-ride (mg/L)	Iron (mg/L)	Silica (mg/L)	Other Analysis
G9030250	15/08/1967	115560	832	7.75	206	126	296	515	45	108		44	0.5	8	70	50		0.2		
G9030250	8/02/1970	115561																		Turbidity
G9030250	8/02/1970	115562																		Turbidity
G9030250	8/02/1970	115563																		Turbidity
G9030250	9/02/1970	115564																		Turbidity
G9030250	9/02/1970	115565																		Turbidity
G9030250	15/03/1973	115566																		TSS
G9030250	16/03/1973	115567																		TSS
G9030250	16/03/1973	115568																		TSS
G9030250	17/03/1973	115569																		TSS
G9030250	17/03/1973	115570																		TSS
G9030250	18/03/1973	115571																		TSS
G9030250	19/03/1973	115572																		TSS
G9030250	19/03/1973	115573																		TSS
G9030250	20/03/1973	115574																		TSS
G9030250	21/03/1973	115575																		TSS
G9030250	22/03/1973	115576																		TSS
G9030250	23/03/1973	115577																		TSS
G9030250	24/03/1973	115578																		TSS
G9030250	24/03/1973	115579																		TSS
G9030250	25/03/1973	115580																		TSS
G9030250	25/03/1973	115581																		TSS

Surface Water Site	Sample Date	Sample No:	Specific Conduct (uS/cm)	pH	Total Alkalinity (mg/L)	Bicarb-onate (mg/L)	Total Hardness (mg/L)	TDS (mg/L)	Calcium (mg/L)	Chloride (mg/L)	NaCl (mg/L)	Magn-esium (mg/L)	Nitrate (mg/L)	Potass-ium (mg/L)	Sodium (mg/L)	Sulp-hate (mg/L)	Flou-ride (mg/L)	Iron (mg/L)	Silica (mg/L)	Other Analysis
G9030250	26/09/1974	115582	1600	7.8	265	323	434	990	72	252	415	62	1	16	170	210	0.8	0.1	18	
G9030250	5/11/1974	115583	530	6.7	108	132														
G9030250	6/12/1974	115584	740	7.7																
G9030250	6/04/1975	115585	140	6.8																
G9030250	4/06/1975	115586	650	7.7																
G9030250	30/08/1975	115587	1100	7.8	237	289	328	640	67	147	247	39	1	11	96	120	0.3	0.1	18	
G9030250	2/10/1975	115588	1400	8.1																
G9030250	9/02/1976	115589	260	7.3	76	93	78	150	18	22	36	8	2	3	16	11	0.1	3.7	18	
G9030250	15/03/1976	115590	37	6.7																
G9030250	28/04/1976	115591	550	7.6																
G9030250	8/06/1976	115592	990	7.3																
G9030250	2/07/1976	115593	1310	7.8																
G9030250	12/10/1976	115594	1600	7.9																
G9030250	14/03/1977	115595	120	6.7	43	52	41	70	10	4	7	4	2	3	6	12	0.2	4	14	
G9030250	3/05/1977	115596	580	7.9																
G9030250	12/01/1978	115597	140	7.4																
G9030250	20/01/1978	115598	380	7.4																
G9030250	15/02/1978	115599	210	7.2																
G9030250	14/04/1978	115600	550	7.6																
G9030250	10/10/1980	115601	1907	7.5	261	318			70	261	430	57	1	18	171	212	0.5	0.1	21	
G9030250	8/09/1984	115602	1710	8.2	289	352	468	1040	64	270	440	75	1	16	184	229	0.2	0.2	25	
G9030250	13/11/1984	115603	1910	8	291	355	477	1150	61	310	517	79	1	22	216	251	0.3	0.4	26	

Surface Water Site	Sample Date	Sample No:	Specific Conduct (uS/cm)	pH	Total Alkalinity (mg/L)	Bicarb-onate (mg/L)	Total Hardness (mg/L)	TDS (mg/L)	Calcium (mg/L)	Chloride (mg/L)	NaCl (mg/L)	Magn-esium (mg/L)	Nitrate (mg/L)	Potass-ium (mg/L)	Sodium (mg/L)	Sulp-hate (mg/L)	Flou-ride (mg/L)	Iron (mg/L)	Silica (mg/L)	Other Analysis
G9030250	20/06/1986	115604	825	8.4	210	250	254	480	44	110	175	35	2	9	78	63	0.2	0.3	18	
G9030250	31/08/1994	135205	1418	8.3	263	321	402	830	72	201	331	54	1	15	134	194	0.2	2.1	19	
G9030250	9/12/1994	140495	1880	8.3	190	230							0.005							
G9030250	9/12/1994	151647	1880	8.3	190	230							0.005							
G9030250	3/08/1995	143156	788	8.4	202	240	228	469	45	95	157	28	1	3	71	82	0.2	0.1	15	
G9030250	22/08/1995	152929	833	8.4	215	250							0.008							
G9030250	22/11/1995	153115	252	6.4	58	70							0.177							
G9030250	9/09/1998	160314	1514	8.3	286.2498	349	406.7	891	61	230	379.04	62	1	15	146	173	0.2	0.2	22	
G9030509	18/02/1992	115631	1160	8.2				732												
G9030509	18/02/1992	115632																		Faecal
G9030509	11/03/1992	115633		8.1																
G9030509	11/03/1992	115634																		Faecal
G9030509	13/07/1993	115635	1580	8.4				997												
G9030509	13/07/1993	115636																		Faecal
G9030509	9/08/1993	115637																		Faecal
G9030509	6/09/1993	115638																		Faecal
G9030509	1/11/1993	115639																		Faecal
G9030509	12/01/1994	115640																		Faecal
G9030509	7/02/1994	115641																		Faecal
G9030509	16/05/1994	115642																		Faecal
G9030509	16/05/1994	1354																		Faecal
G9030509	8/06/1994	120011																		Faecal

Surface Water Site	Sample Date	Sample No:	Specific Conduct (uS/cm)	pH	Total Alkalinity (mg/L)	Bicarb-onate (mg/L)	Total Hardness (mg/L)	TDS (mg/L)	Calcium (mg/L)	Chloride (mg/L)	NaCl (mg/L)	Magn-esium (mg/L)	Nitrate (mg/L)	Potass-ium (mg/L)	Sodium (mg/L)	Sulp-hate (mg/L)	Flou-ride (mg/L)	Iron (mg/L)	Silica (mg/L)	Other Analysis
G9030509	8/06/1994	1353																		Faecal
G9030509	13/07/1994	130356																		Faecal
G9030509	13/07/1994	1352																		Faecal
G9030510	27/06/1987	115643	1260	8.4	286		347	795		187										
G9030510	21/07/1987	115644																		Faecal
G9030510	18/02/1992	115645	1200	8.1				757												
G9030510	18/02/1992	115646																		Faecal
G9030510	11/03/1992	115647		8.8																
G9030510	11/03/1992	115648																		Faecal
G9030511	21/07/1987	115649																		Faecal
G9030511	27/06/1989	115650	1235	8.8	264		336	780		190										
G9030511	18/02/1992	115651	990	8.3				625												
G9030511	18/02/1992	115652																		Faecal
G9030511	11/03/1992	115653		9.9																
G9030511	11/03/1992	115654																		Faecal
G9030511	24/11/1992	115655																		Faecal
G9030511	12/01/1993	115656																		Faecal
G9030511	13/07/1993	115657	1570	8.4				991												
G9030511	13/07/1993	115658																		Faecal
G9030511	9/08/1993	115659																		Faecal
G9030511	6/09/1993	115660																		Faecal
G9030511	1/11/1993	115661																		Faecal

Surface Water Site	Sample Date	Sample No:	Specific Conduct (uS/cm)	pH	Total Alkalinity (mg/L)	Bicarb-onate (mg/L)	Total Hardness (mg/L)	TDS (mg/L)	Calcium (mg/L)	Chloride (mg/L)	NaCl (mg/L)	Magn-esium (mg/L)	Nitrate (mg/L)	Potass-ium (mg/L)	Sodium (mg/L)	Sulp-hate (mg/L)	Flou-ride (mg/L)	Iron (mg/L)	Silica (mg/L)	Other Analysis
G9030511	12/01/1994	115662																		Faecal
G9030511	7/02/1994	115663																		Faecal
G9030511	16/05/1994	115664																		Faecal
G9030511	16/05/1994	1351																		Faecal
G9030511	8/06/1994	120012																		Faecal
G9030511	8/06/1994	1350																		Faecal
G9030511	13/07/1994	130357																		Faecal
G9030511	13/07/1994	1349																		Faecal
G9030512	25/02/1992	115665	82	7				52												
G9030512	25/02/1992	115666																		Faecal
G9030512	11/03/1992	115667		8.1																
G9030512	11/03/1992	115668																		Faecal
G9035000	23/09/1963	115682	287	7.6	85		78				45									
G9035000	23/09/1963	115683	210	8	97		155				45									
G9035000	11/09/2007		544																	
G9035005	27/06/1986	115838	35	6.2	7	9	4	40	1	8	12	1	1	2	4	2	0.1	0.8	17	
G9035007	24/06/1986	115840	55	6.5	13	16	16	55	3	8	13	2	3	4	3	5	0.1	2.2	14	
G9035008	2/12/1974	115841																		Faecal
G9035008	27/06/1986	115842	1645	7.2	522	637	573	1025	137	180	295	56	1	20	143	179	0.6	0.1	43	
G9035009	7/06/1978	115843	1102	8.3	239	290	344	670	62	144	237	46	1	9	103	104	0.3	0.7	20	
G9035009	10/10/1980	115844	1510	7.9	245	299	371	830	53	206	339	58	1	15	144	170	0.3	0.1	19	
G9035009	26/06/1986	115845	685	8.3	189	231	217	400	46	80	133	29	2	7	55	49	0.2	0.2	16	

Surface Water Site	Sample Date	Sample No:	Specific Conduct (uS/cm)	pH	Total Alkalinity (mg/L)	Bicarb-onate (mg/L)	Total Hardness (mg/L)	TDS (mg/L)	Calcium (mg/L)	Chloride (mg/L)	NaCl (mg/L)	Magn-esium (mg/L)	Nitrate (mg/L)	Potass-ium (mg/L)	Sodium (mg/L)	Sulp-hate (mg/L)	Flou-ride (mg/L)	Iron (mg/L)	Silica (mg/L)	Other Analysis
G9035010	20/06/1986	115846	1210	8.3	253	308	363	720	60	166	269	52	1	13	122	137	0.2	0.1	22	
G9035011	16/06/1986	115847	20	6.1	4	5	7	35	1	6	10	1	1	1	3	1	0.1	0.5	14	
G9035011	12/12/1994	151648	142	6.9	50	61														
G9035011	23/08/1995	152930	117	6.6	44.5	54.3														
G9035011	21/11/1995	153114	137	6.4	56	68														
G9035012	14/10/1968	115848	47	6.6	8	5	10	40	1	12		1	1	1	6	2	0.2	0.8	14	
G9035012	22/09/1970	115849	47	5.7	10	12	5	48	1	10		1	1	1	4	2	0.1	6.8	18	
G9035012	2/06/1973	115850	54	6.1	10	12	7	47	1	9	15	1	1	1	7	2	0.1	2	20	
G9035012	11/07/1979	115851	40	5.6	3	4	7	43	1	12	20	1	1	2	4	1	0.1	1.8	18	
G9035012	24/06/1986	115852	40	6	5	6	4	40	1	10	15	1	1	1	5	1	0.1	1	19	
G9035012	14/09/1993	115853	73	6.6	16	19	11	55	1	13	21	2	1	3	8	1	0.1	6	20	
G9035012	14/09/1993	115854																		Faecal
G9035012	14/09/1993	115855																		Faecal
G9035012	14/09/1993	115856	56	6.4	11	13	8	44	1	12	20	2	1	2	7	1	0.1	4.8	18	
G9035012	14/09/1993	115857																		Faecal
G9035012	14/09/1993	115858																		Faecal
G9035012	8/09/2007		50																	
G9035013	16/06/1986	115859	95	7	38	46	31	65	6	8	12	4	2	3	6	3	0.1	10	12	
G9035013	16/06/1986	115860																		Turbidity
G9035014	4/09/1985	115861	140	6.9	40	49	38	70	5	19	32	6	1	1	12	1	0.1	0.6	1	
G9035015	4/09/1985	115862	40	6.2	1	1	11	80	1	4	8	2	4	3	4	4	0.1	4.5	11	
G9035015	11/09/2007		56																	

Surface Water Site	Sample Date	Sample No:	Specific Conduct (uS/cm)	pH	Total Alkalinity (mg/L)	Bicarb-onate (mg/L)	Total Hardness (mg/L)	TDS (mg/L)	Calcium (mg/L)	Chloride (mg/L)	NaCl (mg/L)	Magn-esium (mg/L)	Nitrate (mg/L)	Potass-ium (mg/L)	Sodium (mg/L)	Sulp-hate (mg/L)	Flou-ride (mg/L)	Iron (mg/L)	Silica (mg/L)	Other Analysis
G9035017	8/09/1984	115867	1690	8.2	290	353	462	1010	65	240	392	73	1	16	173	221	0.2	0.1	25	
G9035017	8/09/1984	115868	1690	8.2	290	354	451	1040	67	240	392	69	1	17	171	225	0.2	0.1	25	
G9035017	13/11/1984	115869	1900	8.2	295	360	458	1160	60	320	522	75	2	22	208	256	0.3	0.2	25	
G9035017	12/12/1984	115870	1780	8.1	285	348	455	1040	57	280	465	76	1	20	192	224	0.3	0.1	24	
G9035017	12/12/1984	115871	1780	8	286	349	453	1010	58	280	460	75	2	16	186	218	0.2	0.2	23	
G9035017	12/12/1984	115872	1750	7.9	331	403	475	990	72	270	445	72	3	17	182	192	0.2	0.4	28	
G9035020	16/08/1986	115883	1730	8.2	355	433	474	1045	70	240	396	73	1	21	172	210	0.3	0.1	34	
G9035020	16/08/1986	115884	1765	8.1	388	473	500	1070	82	240	392	72	1	20	171	208	0.4	0.1	34	
G9035022	9/11/1982	115894	43	5.9	8	10	3	36	1	6	10	1	3	6	3	3	0.1	4	3	
G9035022	9/11/1982	115895	28	5.9	7	8	7	16	1	6	8	1	2	1	3	2	0.1	0.8	1	
G9035022	15/09/1983	115896																		Faecal
G9035022	14/06/1984	115897																		Faecal
G9035022	10/09/2007		39																	
G9035023	10/11/1982	115898	34	6.1	10	12	7	26	1	6	8	1	2	2	3	1	0.2	2.9	2	
G9035023	10/11/1982	115899	29	6	10	12	7	29	1	4	8	1	1	2	3	1	0.1	1.4	2	
G9035023	13/06/1985	115900	30	6.1	6	7	7	20	1	2	3	1	2	2	2	1	0.1	1.1	3	
G9035023	14/06/1985	115901	45	6.2	12	15	13	30	2	2	3	2	1	1	3	2	0.1	1.5	6	
G9035023	10/09/2007		70																	
G9035024	23/06/1986	115902	80	7.1	30	37	30	60	2	6	10	6	1	1	5	3	0.1	0.5	19	
G9035025	14/09/1977	115903	69	6.7	22	27	22		4	5	8	3		3	5					
G9035025	6/07/1979	115904	70	6.6	25	30	22			8	13									
G9035025	27/11/1984	115905	70	6.4	25	30	20	60	3	6	10	3	2	3	4	1	0.1	2.9	12	

Surface Water Site	Sample Date	Sample No:	Specific Conduct (uS/cm)	pH	Total Alkalinity (mg/L)	Bicarb-onate (mg/L)	Total Hardness (mg/L)	TDS (mg/L)	Calcium (mg/L)	Chloride (mg/L)	NaCl (mg/L)	Magn-esium (mg/L)	Nitrate (mg/L)	Potass-ium (mg/L)	Sodium (mg/L)	Sulp-hate (mg/L)	Flou-ride (mg/L)	Iron (mg/L)	Silica (mg/L)	Other Analysis
G9035025	12/06/1985	115906	50	6.8	15	18	16	55	3	6	10	2	2	1	3	5	0.1	2.9	13	
G9035025	24/06/1986	115907	70	6.6	28	34	20	55	3	6	8	3	2	3	5	3	0.2	3	11	
G9035025	22/03/1988	115908																		Faecal
G9035025	18/03/1990	115909																		Faecal
G9035025	18/03/1990	115910	65	6.8	28	34	26	65	4	4	6	4	2	4	4	9	0.1	11.3	13	
G9035025	26/09/1990	115911																		Faecal
G9035025	10/10/1990	115912	85	6.9	33	40	33	85	7	6	10	4	3	4	6	4	0.2	19.5	16	
G9035025	11/12/1994	151649	77.4	6.1	29	35														
G9035025	23/08/1995	152936	78	6.6	27.3	33.3														
G9035025	21/11/1995	153737	96	6.5	35	43														
G9035026	24/06/1986	115913	40	6.3	7	9	4	55	1	8	13	1	1	3	4	1	0.1	4.3	26	
G9035028	13/08/1966	115918	170	8	58	33	46	96	1	10		10		3	17	2	0.2	2.7		
G9035029	12/10/1965	115919	90	6.3	30	18	9	113	4	18		2		3	16			1		
G9035029	12/12/1970	115920	140	7.1	36	44	42	100	6	18		7	11	8	13	21	0.2	7.4		
G9035031	22/06/1961	115924	1260	7.5		108	205													
G9035031	10/11/1982	115925	500	4.3	1	1	47	250	7	120	200	7	1	10	62	20	0.1	1.8	22	
G9035031	13/06/1984	115926	360	7.7		130	120	200	25	38	63	14	1	3	27	26	0.1			
G9035032	26/05/1960	115927		6.5		25	26								15					
G9035032	27/07/1960	115928		6.5		20	16								7					
G9035032	17/08/1960	115929		6.5		20	18								10		0.1			
G9035032	7/09/1960	115930		6.5		15	16								15					
G9035032	14/09/1960	115931		6.5		23	17								11					

Surface Water Site	Sample Date	Sample No:	Specific Conduct (uS/cm)	pH	Total Alkalinity (mg/L)	Bicarb-onate (mg/L)	Total Hardness (mg/L)	TDS (mg/L)	Calcium (mg/L)	Chloride (mg/L)	NaCl (mg/L)	Magn-esium (mg/L)	Nitrate (mg/L)	Potass-ium (mg/L)	Sodium (mg/L)	Sulp-hate (mg/L)	Flou-ride (mg/L)	Iron (mg/L)	Silica (mg/L)	Other Analysis
G9035032	25/09/1960	115932	60	7		25	19								10					
G9035032	13/10/1960	115933	49	6.5		30	5								16					
G9035032	20/10/1960	115934	73	6.5		35	21								20					
G9035032	2/11/1960	115935	75	7		28	19								11					
G9035032	9/11/1960	115936	70	6.5		27	9								11					
G9035032	23/11/1960	115937	71	6.5		26	19								12					
G9035032	1/12/1960	115938	78	6.5		25	19								12					
G9035032	14/12/1960	115939	79	6.5		26	19								18					
G9035032	20/12/1960	115940	76	7		28	18								17					
G9035032	28/12/1960	115941	79	7		24	19								15					
G9035032	4/01/1961	115942	73	6.5		26	18								20					
G9035032	12/01/1961	115943	77	7		24	18								18					
G9035032	18/01/1961	115944	77	7		25	17								18					
G9035032	25/01/1961	115945	77	7		25	16								18					
G9035032	30/01/1961	115946	76	7		26	16								18					
G9035032	1/02/1961	115947	77	7		26	17								20					
G9035032	8/02/1961	115948	78	7		25	15								20					
G9035032	15/02/1961	115949	74	6		22	16								24					
G9035032	22/02/1961	115950	71	6.5		22	12.5								24					
G9035032	1/03/1961	115951	70	6.5		25	12.5								24					
G9035032	9/03/1961	115952	70	6.5		23	12								22					
G9035032	15/03/1961	115953	73	6.5		15	13								21					

Surface Water Site	Sample Date	Sample No:	Specific Conduct (uS/cm)	pH	Total Alkalinity (mg/L)	Bicarb-onate (mg/L)	Total Hardness (mg/L)	TDS (mg/L)	Calcium (mg/L)	Chloride (mg/L)	NaCl (mg/L)	Magn-esium (mg/L)	Nitrate (mg/L)	Potass-ium (mg/L)	Sodium (mg/L)	Sulp-hate (mg/L)	Flou-ride (mg/L)	Iron (mg/L)	Silica (mg/L)	Other Analysis
G9035032	22/03/1961	115954	78	6.5		22	12								25					
G9035032	29/03/1961	115955	79	7		22	11								19					
G9035032	13/04/1961	115956	74	6.5		20	8								20					
G9035032	19/04/1961	115957	74	6.5		20	10								28					
G9035032	26/04/1961	115958	72	6		15	8								24					
G9035032	4/05/1961	115959	72	6		17	8.6								26					
G9035032	10/05/1961	115960	72	6.5		13	8								24					
G9035032	24/05/1961	115961	72	6		10	7								30					
G9035032	31/05/1961	115962	67	6		10	7								26					
G9035032	6/06/1961	115963	68	6.5		10	8								24					
G9035033	9/11/1982	115964	61	6.3	20	24	18	37	4	8	12	2	1	2	4	1	0.1	0.3	3	
G9035033	10/09/2007		37																	
G9035034	9/10/1980	115965	967	8.4	208	253			48	109	180	36	1	8	70	81	0.2	0.2	14	
G9035035	8/10/1980	115966	573	7.9	148	180			36	58	96	22	1	4	36	37	0.2	0.2	4	
G9035036	8/10/1980	115967	11970	8	115	500			88	3570	5890	247	2	77	1897	500	0.7	17	5	
G9035036	8/10/1980	115968	12010	8.1																
G9035036	8/10/1980	115969	11130	8.2																
G9035036	25/06/1986	115970	15380	7.9	98	119	1820			5100	8403									
G9035037	8/10/1980	115971	8540	8	120	146			70	2356	3883	179	1	56	1336	360	0.5	10	5	
G9035038	8/10/1980	115972	4500	8.2																
G9035039	8/10/1980	115973	3588	8.4																
G9035040	8/10/1980	115974	2700	8.4																

Surface Water Site	Sample Date	Sample No:	Specific Conduct (uS/cm)	pH	Total Alkalinity (mg/L)	Bicarb-onate (mg/L)	Total Hardness (mg/L)	TDS (mg/L)	Calcium (mg/L)	Chloride (mg/L)	NaCl (mg/L)	Magn-esium (mg/L)	Nitrate (mg/L)	Potass-ium (mg/L)	Sodium (mg/L)	Sulp-hate (mg/L)	Flou-ride (mg/L)	Iron (mg/L)	Silica (mg/L)	Other Analysis
G9035041	8/10/1980	115975	2250	8.4																
G9035041	25/06/1986	115976	3940	8.2	93	113	447	2220	39	1100	1811	85	2	24	592	176	0.2	1.4	9	
G9035041	25/06/1986	115977																		TSS
G9035042	8/10/1980	115978	1600	8.2																
G9035043	8/10/1980	115979	1422	8.3	119	145			28	298	491	35	1	10	175	56	0.3	9.4	3	
G9035044	8/10/1980	115980	1422	8.3																
G9035045	8/10/1980	115981	694	8.3																
G9035046	8/10/1980	115982	573	8.4																
G9035047	8/10/1980	115983	541	8.4																
G9035048	8/10/1980	115984	513	8.4	116	142			26	61	101	19	1	4	37	29	0.1	1.5	2	
G9035049	8/10/1980	115985	515	8.4																
G9035050	8/10/1980	115986	510	8.4																
G9035051	8/10/1980	115987	515	8.4																
G9035052	8/10/1980	115988	518	8.5																
G9035052	25/06/1986	115989	280	8.3	75	92	87	155	15	34	54	12	1	5	22	15	0.1	5.7	6	
G9035053	8/10/1980	115990	566	8.5	145	177			34	54	89	22	1	4	35	38	0.2	0.4	1	
G9035054	8/10/1980	115991	654	8.5																
G9035056	9/10/1980	115992	1472	8.4																
G9035057	9/10/1980	115993	1247	8.4	230	281			52	159	262	48	1	11	101	120	0.3	0.1	17	
G9035057	15/06/1986	115994	515	8.3	157	192	166	305	32	55	89	21	1	5	40	32	0.1	0.9	13	
G9035058	9/10/1980	115995	1143	8.5																
G9035059	9/10/1980	115996	1070	8.4	219	267			50	122	201	43	1	9	82	96	0.3	0.2	15	

Surface Water Site	Sample Date	Sample No:	Specific Conduct (uS/cm)	pH	Total Alkalinity (mg/L)	Bicarb-onate (mg/L)	Total Hardness (mg/L)	TDS (mg/L)	Calcium (mg/L)	Chloride (mg/L)	NaCl (mg/L)	Magn-esium (mg/L)	Nitrate (mg/L)	Potass-ium (mg/L)	Sodium (mg/L)	Sulp-hate (mg/L)	Flou-ride (mg/L)	Iron (mg/L)	Silica (mg/L)	Other Analysis
G9035060	9/10/1980	115997	1009	8.5																
G9035061	9/10/1980	115998	932	8.5																
G9035062	9/10/1980	115999	793	8.5	187	228			43	82	135	29	1	6	52	60	0.2	0.6	8	
G9035063	9/10/1980	116000	776	8.6																
G9035064	10/10/1980	116001	1907	8.5	272	332			74	273	450	60	1	19	186	221	0.4	0.1	15	
G9035066	10/10/1980	116002	2050	8.3	278	339			75	284	468	63	2	19	183	215	0.5	0.1	22	
G9035067	11/10/1980	116003	1956	8.4	281	342			76	279	460	63	1	19	195	224	0.4	0.1	21	
G9035068	11/10/1980	116004	2140	8.4	310	378			81	284	468	68	1	21	196	220	0.5	0.1	26	
G9035069	11/10/1980	116005	2131	8.3																
G9035070	11/10/1980	116006	2140	8.4	309	377			81	282	465	64	1	22	202	223	0.4	0.2	26	
G9035070	11/10/1980	143017	2140	8.4	309	377			81	282	465	64		22	202	223	0.4	0.2	26	
G9035071	11/10/1980	116007	2170	8.2	320	390			82	284	468	73	1	21	184	245	0.5	0.1	27	
G9035072	11/10/1980	116008	2219	8.4																
G9035073	12/10/1980	116009	2180	8.3	321	391			86	283	466	68	1	21	199	240	0.3	0.1	30	
G9035073	12/10/1980	116010	2190	8.3	331	403			83	285	470	69	1	21	206	240	0.5	0.1	29	
G9035073	12/10/1980	116011	2040	7.7	330	402			75	261	430	78	1	19	180	208	0.5	0.6	28	
G9035074	12/10/1980	116012	2161	8.3																
G9035075	12/10/1980	116013	2220	8	336	410			83	270	445	70	1	21	205	235	0.5	0.1	30	
G9035076	12/10/1980	116014	2250	8.3	352	429			84	297	489	76	1	22	208	230	0.5	0.2	30	
G9035077	12/10/1980	116015	2200	8.5	333	406			69	280	460	81	1	23	205	270	0.4	0.1	29	
G9035077	27/06/1986	116016	1640	8.3	334	407	490	990	68	230	379	78	1	19	166	216	0.3	0.2	35	
G9035078	12/10/1980	116017	2153	8.2																

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G9035095	11/10/1968	116048	200	7.4	88	54	88	130	21	10	16	5	1	3	7	3	0.3	0.2	7	
G9035098	18/06/1986	116058	70	7	22	27	34		5	6	10	5		3	9		0.2	20	18	
G9035099	18/06/1986	116059	50	6.6	15	18	24	50	3	5	8	4	3	3	4	9	0.1	15	13	
G9035099	13/12/1994	140492	1810	8.2	300	360														
G9035100	13/06/1986	116060	345	8.1	117	143	122	215	24	30	48	15	1	4	22	18	0.1	1.1	9	
G9035101	13/06/1986	116061	235	7.4	81	99	83	150	15	22	35	11	1	3	15	11	0.1	4.7	13	
G9035102	13/06/1986	116062	290	7.9	100	122	106	165	21	25	41	13	1	4	18	15	0.1	2	12	
G9035103	24/06/1986	116063	35	6.3	7	9	9	30	2	6	10	1	1	2	4	2	0.1	0.3	8	
G9035105	17/06/1986	116065	485	8.5	268	314	275	290	38	10	16	44	1	3	6	9	0.1	0.2	16	
G9035106	17/06/1986	116066	290	8.2	145	177	141	170	25	10	16	19	1	4	6	3	0.1	0.1	14	
G9035107	17/06/1986	116067	315	8	160	195	156	185	28	8	13	21	1	4	6	3	0.1	0.8	12	
G9035108	19/06/1986	116068	295	8.3	148	180	147	170	26	10	16	20	1	3	6	5	0.1	0.1	11	
G9035109	19/06/1986	116069	270	8.1	133	162	132	160	23	8	13	18	1	3	5	5	0.1	0.2	10	
G9035110	15/06/1986	116070	430	8.1	146	178	151	265	29	40	64	19	1	4	29	22	0.1	0.3	15	
G9035111	15/06/1986	116071	320	7.9	134	163	133	195	25	18	28	17	1	3	14	10	0.1	0.1	11	
G9035111	25/05/1995	151652	218	8.2	108	131														
G9035111	27/09/1995	152934	420	8.3	221	265														
G9035112	20/06/1986	116072	925	8.5	222	259	280	545	48	120	198	39	1	10	89	82	0.2	0.1	19	
G9035115	20/06/1986	116075	485	8.4	262	304	262	295	39	14	21	40	1	4	6	9	0.1	0.2	16	
G9035116	25/06/1986	116076	245	8.2	83	101	85	130	16	20	35	11	1	4	15	12	0.1	2.2	3	
G9035117	25/06/1986	116077	265	8.2	90	110	94	150	18	22	36	12	1	4	16	13	0.1	1.7	4	
G9035118	25/06/1986	116078	770	8.2	83	101	131	410	18	165	275	21	1	8	96	36	0.1	6.5	9	

Surface Water Site	Sample Date	Sample No:	Specific Conduct (uS/cm)	pH	Total Alkalinity (mg/L)	Bicarb-onate (mg/L)	Total Hardness (mg/L)	TDS (mg/L)	Calcium (mg/L)	Chloride (mg/L)	NaCl (mg/L)	Magn-esium (mg/L)	Nitrate (mg/L)	Potass-ium (mg/L)	Sodium (mg/L)	Sulp-hate (mg/L)	Flou-ride (mg/L)	Iron (mg/L)	Silica (mg/L)	Other Analysis
G9035119	13/06/1986	116079	310	8.3	107	131	111	185	23	25	41	13	1	4	19	16	0.1	1.6	6	
G9035120	13/06/1986	116080	390	8.2	130	159	138	245	27	35	58	17	1	4	27	22	0.1	0.9	10	
G9035121	17/06/1986	116081	480	8.5	265	311	275	275	38	10	16	44	1	3	6	8	0.1	0.2	16	
G9035122	26/06/1986	116082	1650	8.4	318	375	463	1000	64	250	415	74	1	21	179	212	0.3	0.2	30	
G9035125	18/10/1989	116085	1730	8	331	404	447	1060	59	257	424	73	1	21	189	218	0.3	0.1	30	
G9035125	18/10/1989	116086	180	6.5	67	82	57	115	8	10	16	9	7	10	10	4	0.3		8	
G9035126	2/06/1989	116087	435	8.4	228	278	220	225	24	15	25	39	1	2	9	7	0.2	0.2	2	
G9035127	4/11/1977	116088	420	7.5	176	214	170			22	36									
G9035127	20/08/1991	116089	15	5.3	2	2	2	20	1	3	5	1	1	1	1	3	0.1	0.1	13	
G9035129	24/09/1974	116091	1770	7.9	277	338	478	1080	68	281	463	75	2	192	20	244	0.4	0.5	22	
G9035129	14/09/1993	116092	35	5.8	6	7	4	31	1	9	15	1	1	1	4	1	0.1	1.8	19	
G9035129	14/09/1993	116093																		Faecal
G9035129	14/09/1993	116094																		Faecal
G9035131	26/05/1960	116101		6.5		25	22			10	16									
G9035131	27/07/1960	116102		6.5		19	14			5	8									
G9035131	17/08/1960	116103		6.5		16	12			6	10						0.1			
G9035131	7/09/1960	116104		6.5		13	9			15	24									
G9035131	14/09/1960	116105		6.5		13	9			10	16									
G9035131	28/09/1960	116106	48	7		20	11			10	16									
G9035131	20/10/1960	116107	48	6.5		15	8			10	16									
G9035131	30/10/1960	116108	70	6.5		30	19			20	32									
G9035131	2/11/1960	116109	47	7		17	8			11	17									

Surface Water Site	Sample Date	Sample No:	Specific Conduct (uS/cm)	pH	Total Alkalinity (mg/L)	Bicarb-onate (mg/L)	Total Hardness (mg/L)	TDS (mg/L)	Calcium (mg/L)	Chloride (mg/L)	NaCl (mg/L)	Magn-esium (mg/L)	Nitrate (mg/L)	Potass-ium (mg/L)	Sodium (mg/L)	Sulp-hate (mg/L)	Flou-ride (mg/L)	Iron (mg/L)	Silica (mg/L)	Other Analysis
G9035131	9/11/1960	116110	44	6.5		18	6			8	13									
G9035131	23/11/1960	116111	47	6.5			7			10	16									
G9035131	30/11/1960	116112	54	6.5		17	5			9	15									
G9035131	14/12/1960	116113	55	6.5		19	10			10	16									
G9035131	19/12/1960	116114	51	6.5		17	9			8	13									
G9035131	28/12/1960	116115	48	7		12	7			10	16									
G9035131	4/01/1961	116116	38	6.5		14	6			16	26									
G9035131	12/01/1961	116117	43	6.5		13	7			10	16									
G9035131	18/01/1961	116118	39	6.5		12	6			14	22									
G9035131	25/01/1961	116119	40	6.5		9	6			8	13									
G9035131	30/01/1961	116120	40	6.5		10	6			10	16									
G9035131	1/02/1961	116121	40	6.5		7	7			10	16									
G9035131	8/02/1961	116122	40	6.5		10	6			14	22									
G9035131	15/02/1961	116123	40	6.5		10	7			8	14									
G9035131	22/02/1961	116124	39	6		15	7			12	20									
G9035131	1/03/1961	116125	39	6		17	7			20	32									
G9035131	9/03/1961	116126	39	6		10	7			20	32									
G9035131	15/03/1961	116127	40	6		9	7			15	25									
G9035131	22/03/1961	116128	47	6		7	10			30	48									
G9035131	29/03/1961	116129	43	6		8	10			12	20									
G9035131	13/04/1961	116130	45	6		5	9			20	32									
G9035131	19/04/1961	116131	47	6		10	11			22	36									

Surface Water Site	Sample Date	Sample No:	Specific Conduct (uS/cm)	pH	Total Alkalinity (mg/L)	Bicarb-onate (mg/L)	Total Hardness (mg/L)	TDS (mg/L)	Calcium (mg/L)	Chloride (mg/L)	NaCl (mg/L)	Magn-esium (mg/L)	Nitrate (mg/L)	Potass-ium (mg/L)	Sodium (mg/L)	Sulp-hate (mg/L)	Flou-ride (mg/L)	Iron (mg/L)	Silica (mg/L)	Other Analysis
G9035131	26/04/1961	116132	56	5.5		5	12			20	34									
G9035131	4/05/1961	116133	54	5.5		10	9			18	28									
G9035131	10/05/1961	116134	55	5.5		6	13			22	34									
G9035131	24/05/1961	116135	58	6		5	6			20	32									
G9035131	31/05/1961	116136	58	5.5		8	11			22	34									
G9035131	7/06/1961	116137	61	6		10	12			22	34									
G9035133	12/12/1994	140487	47.7	6.7	11	13														
G9035133	12/12/1994	151655	47.7	6.7	11	13														
G9035133	23/08/1995	152938	34	6.3	7.4	9														
G9035133	21/11/1995	153113	40	6.8	11	13														
G9035134	1/09/1972	145411	220	7.4	83	101	78	120	18	16	26	8		3	12	9	0.2	0.1	1	
G9035134	9/04/1976	145412	250	7.2	83	101	82	196	18	18	30	9		3	15	14	0.1	0.1	17	
G9035134	22/04/1991	145415																		Faecal
G9035134	14/05/1991	145416																		Faecal
G9035134	6/06/1991	145417																		Faecal
G9035134	4/07/1991	145418																		Faecal
G9035134	16/08/1991	145419																		Faecal
G9035134	28/09/1991	145420																		Faecal
G9035134	3/10/1991	145421																		Faecal
G9035134	7/11/1991	145422																		Faecal
G9035134	7/01/1992	145423																		Faecal
G9035134	18/02/1992	145424																		Faecal

Surface Water Site	Sample Date	Sample No:	Specific Conduct (uS/cm)	pH	Total Alkalinity (mg/L)	Bicarb-onate (mg/L)	Total Hardness (mg/L)	TDS (mg/L)	Calcium (mg/L)	Chloride (mg/L)	NaCl (mg/L)	Magn-esium (mg/L)	Nitrate (mg/L)	Potass-ium (mg/L)	Sodium (mg/L)	Sulp-hate (mg/L)	Flou-ride (mg/L)	Iron (mg/L)	Silica (mg/L)	Other Analysis
G9035134	11/03/1992	145425																		Faecal
G9035134	5/05/1992	145426																		Faecal
G9035134	9/06/1992	145427																		Faecal
G9035134	11/08/1992	145428																		Faecal
G9035134	24/11/1992	145429																		Faecal
G9035134	6/12/1992	145413		7.5	342	417														
G9035134	8/12/1992	145430																		Faecal
G9035134	9/02/1993	145431																		Faecal
G9035134	2/03/1993	145432																		Faecal
G9035134	18/03/1993	145414	1460	7.1	337	411	580	803	112	265	437	73		6	65	31	0.2	0.1	25	
G9035134	18/05/1993	145433																		Faecal
G9035134	15/06/1993	145434																		Faecal
G9035134	11/10/1993	145435																		Faecal
G9035134	29/03/1994	145436																		Faecal
G9035134	8/08/1994	145437																		Faecal
G9035134	8/08/1994	1312																		Faecal
G9035134	26/09/1994	1311																		Faecal
G9035134	10/10/1994	1310																		Faecal
G9035134	21/11/1994	1309																		Faecal
G9035134	5/12/1994	1308																		Faecal
G9035134	3/05/1995	1307																		Faecal
G9035134	5/06/1995	1306																		Faecal

Surface Water Site	Sample Date	Sample No:	Specific Conduct (uS/cm)	pH	Total Alkalinity (mg/L)	Bicarb-onate (mg/L)	Total Hardness (mg/L)	TDS (mg/L)	Calcium (mg/L)	Chloride (mg/L)	NaCl (mg/L)	Magn-esium (mg/L)	Nitrate (mg/L)	Potass-ium (mg/L)	Sodium (mg/L)	Sulp-hate (mg/L)	Flou-ride (mg/L)	Iron (mg/L)	Silica (mg/L)	Other Analysis
G9035134	17/07/1995	1305																		Faecal
G9035134	1/11/1995	1304																		Faecal
G9035134	3/01/1996	1303																		Faecal
G9035134	31/01/1996	1302																		Faecal
G9035134	18/03/1996	1301																		Faecal
G9035134	3/04/1996	1300																		Faecal
G9035134	8/05/1996	1299																		Faecal
G9035134	5/06/1996	1298																		Faecal
G9035134	3/07/1996	1297																		Faecal
G9035134	21/08/1996	1296																		Faecal
G9035134	9/09/1996	1295																		Faecal
G9035134	7/10/1996	1294																		Faecal
G9035134	6/11/1996	1293																		Faecal
G9035134	13/01/1997	1292																		Faecal
G9035134	10/02/1997	1291																		Faecal
G9035134	10/03/1997	1290																		Faecal
G9035134	26/03/1997	1289																		Faecal
G9035134	12/05/1997	1288																		Faecal
G9035134	18/06/1997	1287																		Faecal
G9035134	7/07/1997	1286																		Faecal
G9035134	25/08/1997	1285																		Faecal
G9035134	6/10/1997	1284																		Faecal

Surface Water Site	Sample Date	Sample No:	Specific Conduct (uS/cm)	pH	Total Alkalinity (mg/L)	Bicarb-onate (mg/L)	Total Hardness (mg/L)	TDS (mg/L)	Calcium (mg/L)	Chloride (mg/L)	NaCl (mg/L)	Magn-esium (mg/L)	Nitrate (mg/L)	Potass-ium (mg/L)	Sodium (mg/L)	Sulp-hate (mg/L)	Flou-ride (mg/L)	Iron (mg/L)	Silica (mg/L)	Other Analysis
G9035134	20/10/1997	1283																		Faecal
G9035134	12/01/1998	1282																		Faecal
G9035143	10/12/1994	151658	56.8	7.6	27	33														
G9035143	24/08/1995	152941	54	6.6	22	27														
G9035143	22/11/1995	153736	96	6.9	26	32														
G9035144	13/12/1994	151659	1810	8.2	300	360														
G9035144	22/08/1995	148105	1310	8.3	58.7	70.5														
G9035144	22/08/1995	152942	1310	8.3	58.7	70.5														
G9035144	23/11/1995	153738	1760	8.5	336	386														
G9035295	8/09/2007		79																	
G9035417	5/09/2007		649																	
G9035418	11/09/2007		537																	
G9035419	5/09/2007		216																	
G9035420	6/09/2007		86																	
G9035421	6/09/2007		86																	
G9035423	8/09/2007		46																	
G9035424	8/09/2007		34																	
G9035425	10/09/2007		144																	
G9035426	10/09/2007		137																	
G9035427	10/09/2007		29																	
G9035428	10/09/2007		35																	
G9035429	11/09/2007		157																	

Surface Water Site	Sample Date	Sample No:	Specific Conduct (uS/cm)	pH	Total Alkalinity (mg/L)	Bicarb-onate (mg/L)	Total Hardness (mg/L)	TDS (mg/L)	Calcium (mg/L)	Chloride (mg/L)	NaCl (mg/L)	Magn-esium (mg/L)	Nitrate (mg/L)	Potass-ium (mg/L)	Sodium (mg/L)	Sulp-hate (mg/L)	Flou-ride (mg/L)	Iron (mg/L)	Silica (mg/L)	Other Analysis
G9035430	11/09/2007		377																	
G9035431	11/09/2007		526																	
G9035432	11/09/2007		48	6.6																
G9035433	13/09/2006		70	7.2																
G9040001	21.07.2007		903																	
G9045001	29.07.2007		51																	
G9045002	29.11.2007		912																	
G9055022	17/09/1983	116163	75	6.5	17	20	20	80	3	10	15	3	3	4	6	3	0.1	4.5	14	
G9055023	24/09/1983	116164	39900	7.6	105	128	4900			14820	24410									
G9055025	24/09/1983	116166	29900	7.6	95	116	2580			11020	18164									
G9055029	26/09/1983	116170	2790	7.5	75	91	385	1560	44	868	1430	67	1	30	430	102	0.1	0.5	16	
G9055029	21/07/2007		353																	
G9055031	23/09/1983	116171	58400	7.7	117	142	7240			22840	37640									
G9055032	24/09/1983	116172	57700	7.9	120	146	7360			22420	36951									
G9055033	24/09/1983	116173	56300	7.8	125	153	7300			22560	37179									
G9055034	24/09/1983	116174	53300	7.8	121	148	6800			20720	34132									
G9055035	24/09/1983	116175	46900	7.7	114	139	6120			17600	29020									
G9055046	17/07/1989	116184	30	6.2	11	14	9	20	2	2	3	1	1	2	2	1	0.1	0.3	2	

APPENDIX M: RAINFALL RECORDER SITES

Station Number	Site	Easting	Northing	Commence	Cease	Recommence	Status
DE014609	Ngukurr	470704	8371648	1/08/1971	31/08/1971		closed
DE014633	Roper Bar Store	449894	8371276	1/07/1993	31/12/1993		closed
DR014602	Wongalara	443005	8436417	31/12/1998	28/02/2003		open
DR014604	Roper Bar	424674	8404393	31/05/1957	30/06/1958		closed
DR014605	Moroak Stn	360249	8359861	30/11/1967	31/12/1975	30/04/2001	closed
DR014608	St Vidgeon Stn	487571	8365795	31/10/1967	31/12/1976		closed
DR014609	Ngukurr Roper R	471422	8371311	31/12/1909	31/03/2003		open
DR014614	Hodgson Downs	401674	8317663	31/12/1900	31/05/1991		closed
DR014616	Urapunga	453478	8373126	31/12/1962	31/10/1988	29/02/1996	closed
DR014617	Roper Valley Stn	392581	8348966	31/12/1962	31/03/1988	31/01/1997	closed
DR014620	Roper R Police Stn	446301	8373111	31/12/1893	31/12/1976		closed
DR014630	Port Roper	536003	8369459	31/10/1971	30/09/1972		closed
DR014633	Roper Bar Store	449897	8369432	30/04/1976	28/02/1995		closed
DR014643	Roper Aquafarm	521405	8360597	31/07/1993	31/12/1993		closed
DR014645	Limmen River	553751	8312092	31/05/1995	31/03/2003		open
DR014646	Flying Fox	396191	8357643	31/10/1996	31/03/2003		closed
G9030250	Roper Ri @ Red Rock	437326	8374934	11/08/1966	10/04/2006		open

Sites are all located in zone 53, Datum MGA94.

Back Cover: Indigenous wooden food and water carrier – Coolamon or *Lujuluju* -purchased from Waralungku Arts, Borroloola

Daphne Mawson

Daphne Mawson, a Garrwa woman, related the following story about a coolamon of water. She lives in Borroloola and works at the Borroloola primary school teaching indigenous culture in Garrwa.

Story about the frog and the Pee Wee

Every night when I was little, my grandmother told me a story about the frog and the Pee Wee. It is a story of how the rivers came to be and not to be greedy. She said that a long, long time ago in the dreamtime there was a Pee Wee and a frog. The Pee Wee was the owner of a coolamon of water. He used to carry it around.

One day the Pee Wee camped under a tree and hid the Coolamon of water. The frog came to the Pee Wee to ask where he got water from. The Pee Wee said go north and the frog went north. In the evening he came back tired and weary and said there was no water there. 'Where did you get the water from' he asked? The Pee Wee replied 'ah I forgot, I got the water from the east'. So the frog went to the east and as he traveled he was getting very tired but he made it back to the Pee Wee. Once again he asked 'where did you get the water from'? The Pee Wee said 'Oh silly me, that's right I got it from the south'. Off he slowly went, he was getting very tired and very thirsty. But the frog still didn't find the water and went back to the Pee Wee. He asked the Pee Wee again, his lips were dry and parched, his voice was croaky 'Where did you get the water from'? The Pee Wee said 'I'm getting old, I keep forgetting, that's right, I got it from the west'. So off went the frog, he was very tired and dehydrated. By this time the Pee Wee was getting tired because he hadn't slept for days as he was guarding his coolamon from the frog. He fell asleep. Poor old frog slowly dragged himself back after not finding any water. He saw the Pee Wee had fallen asleep and grabbed a rock and smashed the coolamon. Water gushed everywhere and that's how the rivers were created. The Pee Wee woke up with a start and found his water gushing everywhere, he ran and grabbed the stick and bashed himself over the head crying for his water. Blood streamed all over his body and that's why today the black marks you see on the Pee Wee are the blood stains for when he cried for his water. Today when you hear the first storms you hear the frogs in the lagoons, that's the frogs teasing the greedy Pee Wee who wouldn't share his water.

This was the story my grandmother told to teach us to share everything, especially water which is needed for everyone's survival.