Wadeye / Nauiyu Water Study

VOL. 1

Water Resources of Wadeye (Port Keats) & Nauiyu (Daly River), Main Report

March 2003

ATSIC

Natural Heritage Trust

Northern Territory Government
Department of Infrastructure, Planning and Environment

VOLUME 1

WATER RESOURCES OF WADEYE (PORT KEATS) AND NAUIYU (DALY RIVER) REGION, MAIN REPORT

Moyle River at Crossing near Peppimenarti and Nganmarriyang.

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DIPE, Darwin NT

Northern Territory Government

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COMMONLY USED ABBREVIATIONS

ADWG	Australian Drinking Water Guidelines
AHD	Australian Height Datum
BGL	Below Ground Level
$CaCO_3$	Calcium Carbonate
DLPE	Department of Lands, Planning and Environment
EC	Electrical conductivity
GIS	Geographical Information System
km	kilometres
L/s	litres per second
m	metres
m^3	cubic metres (1 m^3 = 1000 litres)
mg/L	milligrams per litre
mm	millimetres
NLC	Northern Land Council
NLP	National Landcare Program
CNR	Conservation and Natural Resources Group (Formerly Water Resources)
NT	Northern Territory
RN	Registered Number (referring to bore)
TDS	Total dissolved solids (in mg/l)
µS/cm	micro siemens per centimetre (units of Electrical Conductivity, EC)

NOTE:

Words in *italics* are defined in APPENDIX A: GLOSSARY OF TERMS.

EXECUTIVE SUMMARY

The water resources of the Daly River / Port Keats and Malak-Malak Aboriginal Land trusts were mapped, described and evaluated. The traditional knowledge that the Aboriginal people hold in regards to their water resources was incorporated into the technical study.

A set of decision-making tools comprised of reports, maps and an interactive CD-ROM was developed as a result of the study. An effort was made to compile and present the results in a manner that can be used by individuals who do not necessarily have a scientific or technical background. It is hoped that the information resulting from this study may be easily understood and effectively applied by the Aboriginal people and their community leaders.

A series of maps was prepared which show the distribution of hydrographic data, regional aquifers, Aboriginal place names and the sites which pertain to traditional knowledge about water. This map series, detailed below in Table 1 is also available in hard copy.

Table 1 Maps

Map Title	Scale	Description
Water Resource map of the Wadeye (Port Keats) and Nauiyu (Daly River) Region	1:250,000	Regional Aquifers, hydrographic stations and sources of recorded data
Satellite Image Poster of the Wadeye (Port Keats) and Nauiyu (Daly River) Region	1:200,000	Satellite image showing the main features of interest such as: communities, outstations, roads and Aboriginal place names.

The other products available from this study are three hardcopy reports. The reports have been subdivided into three volumes as follows:

Table 2 Reports

Volume 1. Water Resources of Wadeye (Port Keats) and Nauiyu (Daly River) Region; Main Report:	Regional geology, hydrogeology, aquifers and water resources.
Volume 2. Water Resources of Wadeye (Port Keats) and Nauiyu (Daly River) Region; Aboriginal Knowledge	Traditional knowledge, place names and stories about water.
Volume 3. Water Resources of Wadeye (Port Keats) and Nauiyu (Daly River) Region; Technical Report	A detailed listing of pre-existing and new technical data collected during the study.

The CD-ROM has been created to be interactive. It can be viewed on any computer with a *Microsoft Windows* operating system. The CD-ROM is comprehensive and includes regional Geographic Information System (GIS) data, regional base maps, hydrographic data, photos and the traditional knowledge map with Aboriginal place-names.

The Natural Systems Division of the Conservation and Natural Resources Group, (DIPE) holds the reports, maps and CD-ROM. Information regarding the availability of the results of this study is located inside the front cover of this report.

PART 1. INTRODUCTION

Prior to this investigation, it was identified that the existing information was inadequate to properly manage the land and water resources of the Wadeye and Nauiyu Regions. Funding was obtained through the Natural Heritage Trust (NHT) to carry out the three-year water resource investigation in this area. Additional funding was provided through the Northern Territory Government, ATSIC and local community councils. The project was managed through the Water Resources Assessment Branch, Natural Resources Division (NRD) of DIPE.

The partners in this study were the National Heritage Trust (NHT), the Department of Infrastructure, Planning and Environment (DIPE), the Aboriginal and Torres Strait Islander Commission NT (ATSIC), the local community councils and the outstation resource centres. The main recipients of the information and the primary clients during the study were the Aboriginal people of these areas.

The investigation began as a desktop study to collate and analyse the existing data, reports and maps that were currently available. The desktop study was followed by community consultation to further identify the regional information needs and water resource issues. The process involved community meetings to introduce the project objectives and to gain assistance from community leaders, elders and community managers. The preliminary consultation was followed by three years of data collection and fieldwork.

Standard water resource survey techniques were applied to assess both the surface water and *groundwater* resources. The *hydrographic* surveys involved the collection of stream flow data, rainfall data and water chemistry sampling. Further data on the resource was collected through *geophysical* surveys, assessment drilling and test pumping. The surveys made use of satellite imagery, topographic maps, geologic maps and draft base maps.

Base maps depicting existing hydrographic data were developed and presented to local community councils and the resource centres. The maps proved to be an effective tool in presenting the project objectives and outputs. The maps were presented during community consultations throughout the various stages of the investigation. Base maps were made available to traditional owners and to various government representatives working in the area.

During the collection of scientific data, traditional knowledge about the region and the water resources was also collected. The objective was to integrate the scientific knowledge with the traditional knowledge to produce a series of maps and reports for use by traditional owners. The process began with the identification of traditional landowners through council meetings and personal communication. During this time, contacts and friendships were made that helped the project staff in recording water stories and traditional place names.

Draft maps with tribal boundaries and place names in the local language were created and shown to traditional owners. The maps were effective in helping to collect information from the elders during trips in the bush. The use of *satellite images* was also found to be effective in the location of traditional places not visited for many years. During bush trips, water stories were also collected and have been included in the traditional knowledge report.

1.1 Location and Access

The project area is located 200 km south of the City of Darwin and 200 km west of the town of Katherine (Figure 1). The study covered the Malak Malak and the Daly River / Port Keats Aboriginal Land Trusts. The Land Trusts have a combined area of 14,500 Km2.

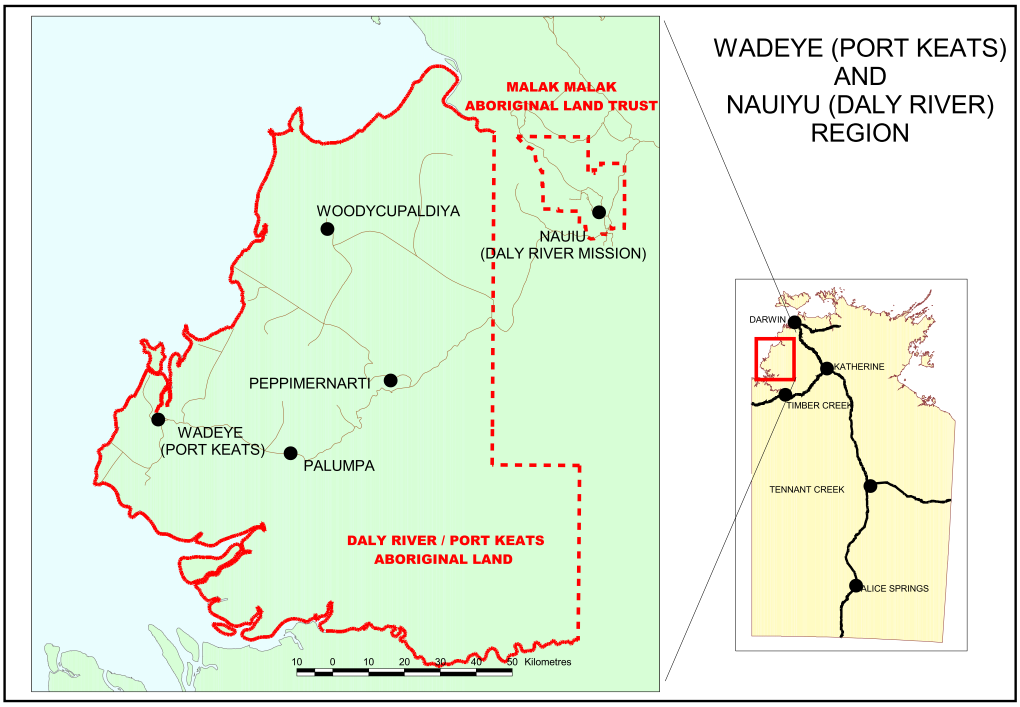

Figure 1 Location map

A small portion of the project area north of the Daly River is accessible by vehicle throughout the year. The majority of the study area located south of the Daly River can be accessed by vehicle during the dry season from about May to the end of December. Once the Daly River begins to rise at the end of December, access is restricted to boat or plane until the end of the wet season.

Murin Airways has two daily flights from Darwin to the largest community of Wadeye (Port Keats). Access to the other communities of Peppimenarti, Nganmarriyang (Palumpa) and Woodycupaldiya is by charter aircraft during the wet season. Freight is typically transported by barge to Wadeye (Port Keats) through the local barge services based in Darwin. Perkins Shipping operates on a weekly schedule throughout most of the year. The barges do not offer passenger services. Any visitors to the Wadeye and Malak Malak Aboriginal Lands must obtain a permit before arrival. The permits can be obtained from the Northern Land Council offices in Darwin or Palmerston.

Wadeye (Port Keats) is the largest community with a population of 2452, followed by Palumpa (457), Nauiyu (436), Peppimenarti (230), and Woodycupaldiya (25). Outside of the established communities there are about 37 permanent outstations which are home to about 200 people. The number of people in resident at the outstations ranges from 5 to 25, depending on the time of year.

1.2 Climate

The climate is tropical monsoonal with a dry season which extends from May to September. This is followed by a wet season that typically lasts until the end of April. The mean annual rainfall in the region is about 1,400 mm, with a majority of the precipitation occurring during the wet season. The average monthly rainfall and total annual rainfall data for Daly River Mission is shown in Figures 2 and 3, respectively. The peak monthly average rainfall ranges from about 350 mm in the wet season to a negligible amount in the dry season.

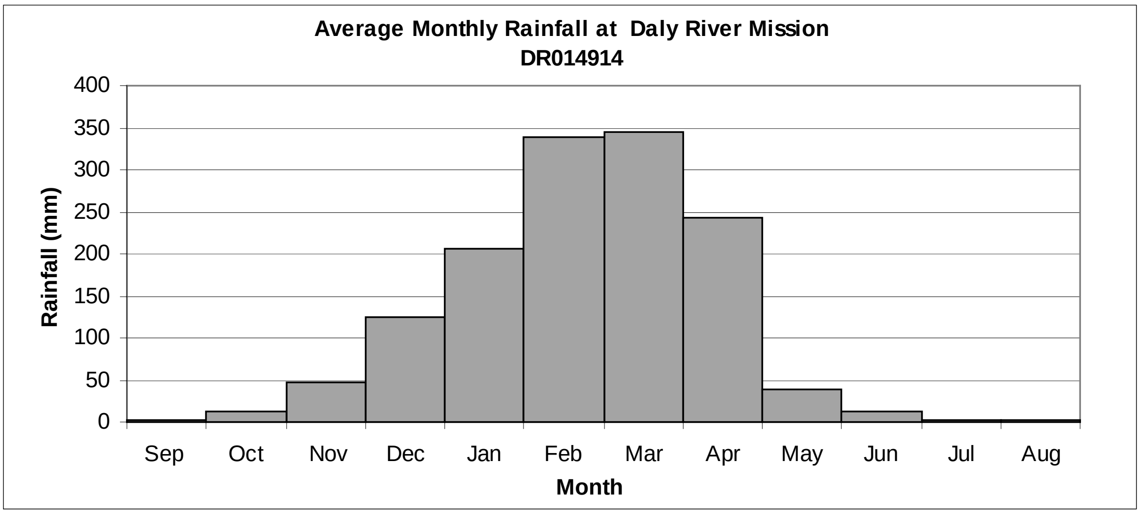

Figure 2 Average monthly rainfall – Daly River Mission

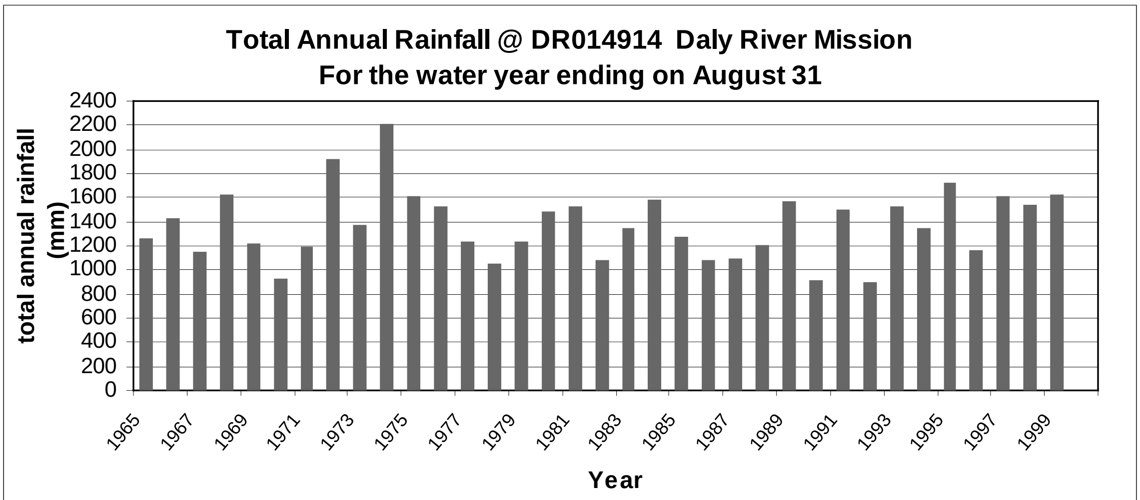

Figure 3 Total Annual rainfall - Daly River Mission

1.3 Geology

The geology of the study area has been mapped at a scale of 1:250,000 and partially at a scale of 1:100,000 by the Department of Mines and Energy, Northern Geological Survey. The extent of the geologic mapping at each scale is shown in Figure 4.

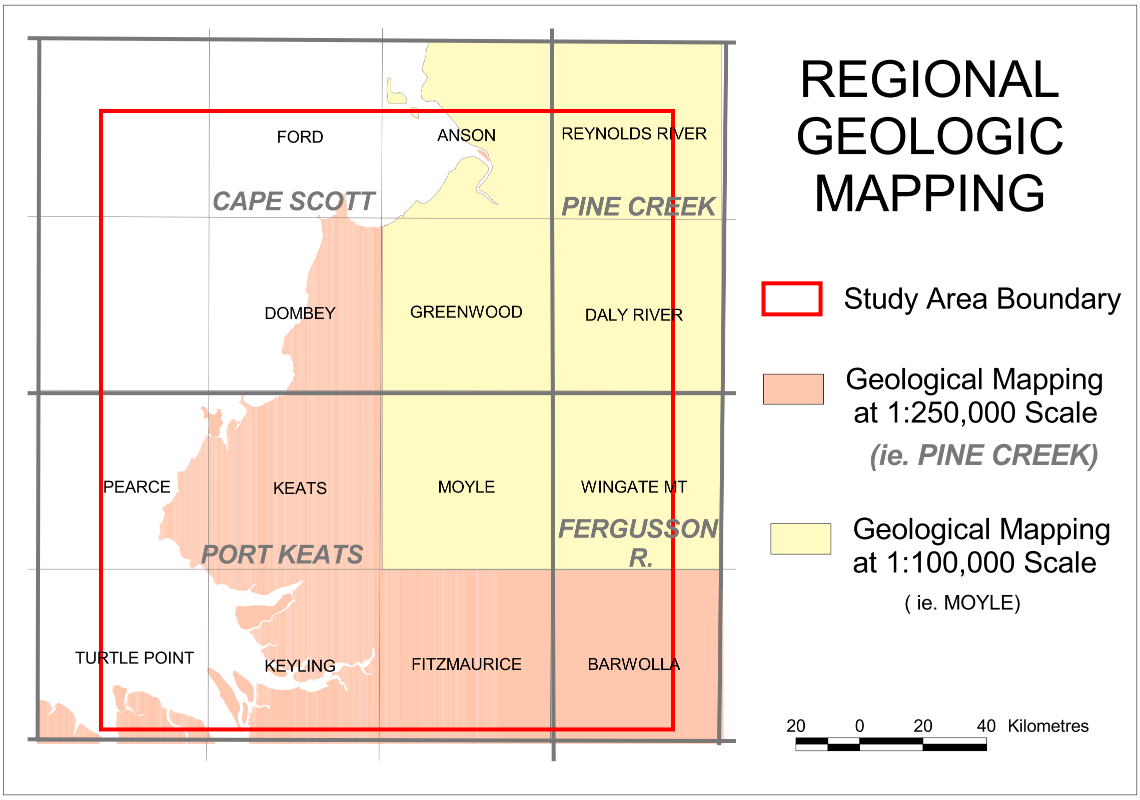

Figure 4 Geologic Mapping

The geology of the study area comprises 38 geologic formations that span a time frame from present alluvial deposition to Archaean age rocks that are more than 2,000 million years old. Due to the age of some of the rocks and the variety of changes through time, the geologic history of the region is highly complex. The regional geologic formations that can be found in the study area are shown in Figure 5.

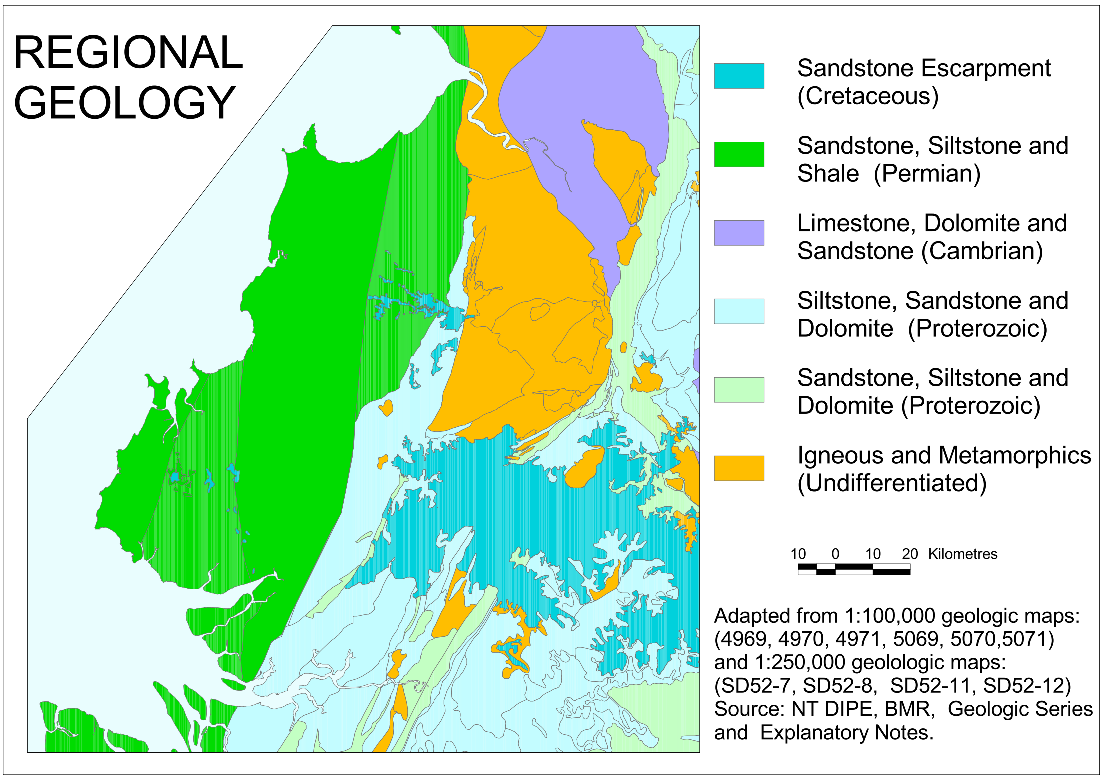

Figure 5 Regional Geologic Formations

A detailed description of the regional geology and geologic history is beyond the scope of this report. Instead, the lithologic descriptions and chronology of the formations shown in Figure 5 are summarised in Table 3.

Table 3 Regional Geology

Period/Group/Symbol		Formation.	Lithology
QUATERNARY			
	Q	Undifferentiated Alluvium	Silt, sand, gravel, laterite
CRETACEOUS			
	K	Undifferentiated	Sandstone, claystone and siltstone
		Unconformity	
PERMIAN			
Port Keats Group	P	Hyland Bay Fm (UPPER)	Sandstone,siltstone,claystone
	P	Undifferentiated (LOWER)	Sandstone, siltstone, shale, claystone,
		Unconformity	
CAMBRIAN			
Daly River Group	Cla	Antrim Plateau Volcanics	Basalt
	Coij	Jinduckin Formation	Dolomite, siltstone and sandstone
	Cmt	Tyndall Limestone	Limestone
	Cl	Cambrian Limestone	dolomite, limestone, siltstone
	C	Undifferentiated	Dolomite, limestone, siltstone
MID PROTEROZOIC			
	Pgi	Ti-Tree Granophyre	Altered and sheared granite
	Pdm	Murrenja Dolerite	Basalt and gabbro
Fitzmaurice Group	Pze	Legune Formation	Sandstone and Siltstone
	Pzg	Goobaieri Formation	Siltstone and sandstone
	Pzl	Laingang Formation	Sandstone
	Pzl	Laingang Formation	Sandstone
	Pzm	Moyle River Formation	Sandstone
	Pzm	Moyle River Formation	Sandstone
	Pzm	Moyle River Formation	Sandstone
MID PROTEROZOIC			
Auvergne Group	Pah	Shoal Beach Formation	Basalt, minor siltstone
	Paa	Angalarri Sandstone	Siltstone, dolomitic siltstone and shale
	Pap	Pinkerton Sandstone	Massive sandstone
	Pal	Lloyd Creek Formation	Dolomite, silty dolomite and siltstone
	Paj	Jasper Gorge Sandstone	Massive sandstone
	Pae	Spencer Sandstone	Sandstone, dolomitic sandstone
	Pad	Saddle Creek Formation	Cross bedded sandstone

Table 3 Regional Geology (continued)

Period/Group/Symbol		*Formation.*	*Lithology*
MID PROTEROZOIC			
Tolmer Group	Ptd	Depot Creek Sandstone	Massive sandstone
	Pts	Stray Creek Sandstone	Sandstone
	Pth	Hinde Dolomite	Dolomite
		Unconformity	
EARLY PROTEROZOIC			
	Pbb	Wangi Basics	Altered gabbro, pyroxenite and peridotite
	Pwt	Well Tree Metamorphics	Schist and gneiss
	Pgk	Koolendong Granite	Coarse grained granodiorite
	Pgs	Soldiers Creek Granite	Coarse grained to pegmatitic granite
	Pgml	Mount Litchfield Granite	Granodiorite
	Pgmk	Murra-Kamangee Granodiorite	Biotite Granite
	Pgfb	Fish Billabong Adamellite	Granite
	Pga	Allia Creek Granite	Biotite Granite
	Pgwa	Wagait Granite	Hornblende granodiorite
	Pgts	Two Sisters Granite	Biotite Granite
Finniss Group	Pfmm	Kulluk Mulluk Volcanics	Rhyolite
	Pla	Meeway Volcanics	Basalt and tuff
	Pfv	Warrs Volcanic Unit	Basalt and tuff
	Pfbv	Berinka Volcanics	Altered and metamorphosed tuff and andesite
	Pln	Noltenius Formation	Greywacke, siltstone, sandstone and conglomerate
	Pfb	Burrell Creek Formation	Phyllitic immature sandstone
	Pfh	Henschke Breccia	Massive brecciated conglomerate
	Pfc	Chilling Sandstone	Sandstone
		Unconformity	
ARCHEAN			
	Aw	Rum Jungle Complex	Undifferentiated granite and schist
	Ph	Hermit Creek Metamorphics	Schist and gneiss

1.4 Landforms and Physiography

Figure 6 shows the main physiographic features in the study area. One of the most striking features of the region are the vast, low lying areas that dominate the western half of the study area.

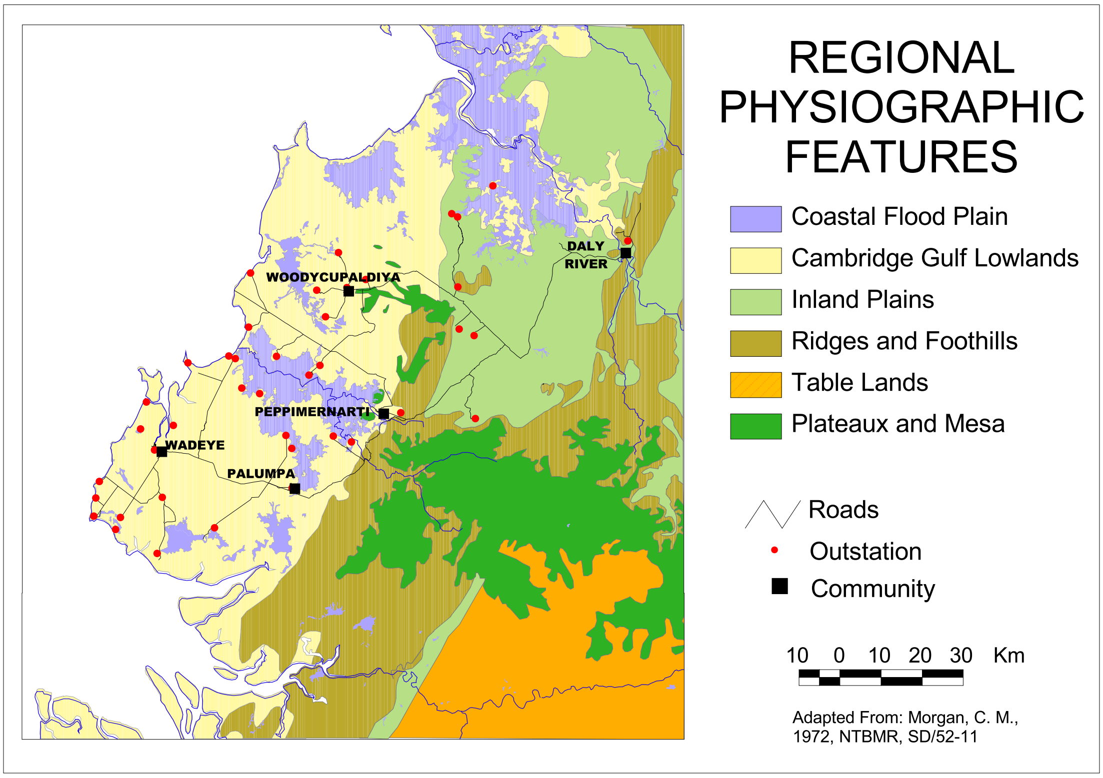

Figure 6 Regional Physiographic Units

The Cambridge Gulf Lowlands extend from the southern coastal area around Port Keats to the Daly River mouth in the north. They begin at the coast and end in the foothills near Peppimenarti and Nauiyu.

The inland portion of this physiographic unit is predominantly undulating, low hills and lowland which lead onto flat, low lying soil plains (Morgan, 1972). Nearer to the coast, much of the landscape turns to marshy alluvial plains and coastal river estuaries bordered by salt flats, sand dunes and flood plains. Much of this region is seasonally inundated, the largest extent of inundation being the Moyle River and the Daly River flood plains.

The second most striking physiographic feature is the Plateau and Mesa escarpment in the central and southeastern parts of the study area. This feature is formed by flat lying Cretaceous aged-sandstone sediments. The escarpment forms the Wingate lying Cretaceous aged-sandstone sediments. The escarpment forms the Wingate Plateau to the east of Palumpa and the Docherty Hills to the north of Peppimenarti. The plateaux and mesa country are heavily wooded, flat surfaces underlain by hard, resistant sandstone. The Wingate Plateau has maximum elevations of 320 metres above sea level. The ridges and mesas to the east of Port Keats and the Docherty Hills have maximum elevations of 170 and 210 metres, respectively. Cliffs and steep slopes dominate the edge of the plateaux. There are numerous water falls and springs that form around the edge of the escarpment.

The remainder of the area lies within the two extremes. To the south are tablelands where the Wingate plateau has been eroded to form gorges, terraces and undulating hills. Gently folded sandstones and siltstones of the Auvergne Group underlie this area.

The hilly area east of Palumpa and to the north and west of the Wingate Plateau is mostly rugged ridges and foothills. The zone extends from the south of the Fitzmaurice river, northward to the hilly country between Peppimenarti and Emu Point. Sandstones and siltstones of the Fitzmaurice Group underlie much of this area. Faulting and sparseness of vegetation have enhanced the ruggedness of the landscape.

The area that extends from Emu Point to the north of the Daly River Floodplain is predominantly inland plains. This physiographic unit consists of soil covered plains with minor outcropping of granite boulders and low lying, rolling hills. Granites and schists underlie the area.

1.5 Water Use

The communities of Wadeye, Peppimenarti, Palumpa, Nauiyu and Woodycupaldiya have designated borefields for their domestic water supply. The use of water from the reticulated water supply is reserved for drinking and the irrigation of lawns, community parks or football ovals. The community water supply is maintained by the Power Water Corporation through an essential services officer (ESO).

Monthly consumption records for Wadeye, Palumpa and Peppimenarti were obtained from the Power and Water Corporation, Rural Services Division, Darwin. The total consumption from January 1999 to December 2001 was calculated and divided by the total number of days to generate a production rate in terms of litres consumed per day for this three-year period. From this estimate, and the current population of each community, a rate of consumption for each community (litres/person/day) was calculated. The water consumption for each community is summarised in Table 4. The calculations shown in Table 4 do not include the irrigation of market gardens or industrial use.

Table 4 Water Use Estimates, 1999-2001

Community	Population	Water Consumption (Litre / Day)	Usage (L/person/day).
Wadeye	**2452**	**1,295,000**	**528**
Palumpa	**457**	**157,000**	**344**
Nauiyu	**436**	**261,000**	**599**
Peppimenarti	**230**	**247,000**	**1,073**

* Production figures for Woodycupaldiya are not available.

The discrepancies in the total consumption per capita for each community may indicate varying degrees of use efficiency in the home. Discrepancies may also reflect inaccuracies in the 2001 population Census.

Outside of the communities, there are 37 independent outstations, which depend on small domestic bores for drinking and/or limited irrigation. The traditional owners maintain the outstation supplies with the assistance of the regional resource centres. The outstations north of the Moyle River are supported through the Yantjarrwu Resource Centre based in Woodycupaldiya. The outstations to the south of the Moyle River receive assistance and support from the Murin Resource Centre based in Wadeye.

Surface water use south of the Daly River is limited to drinking supplies at dry season bush camps and recreation. There are numerous billabongs within the boundaries of the Moyle River and Daly River floodplains. The billabongs are popular camping areas for traditional owners.

The community of Nauiyu pumps water from the Daly River that is used exclusively for irrigation. Other than the community, there are a handful of users that pump water from the Daly River for purposes related to tourism and the irrigation of mangoes.

PART 2. THE WATER CYCLE

To understand the *groundwater* and surface water systems, it helps to have an understanding of the water cycle (see Figure 7). 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 and the intensity and duration of rainfall. Of the water that *infiltrates*, some will *evaporate* or be taken up from the soil and used by vegetation (e*vapotranspiration*) and the rest will move downwards until it reaches the *water table* 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*.

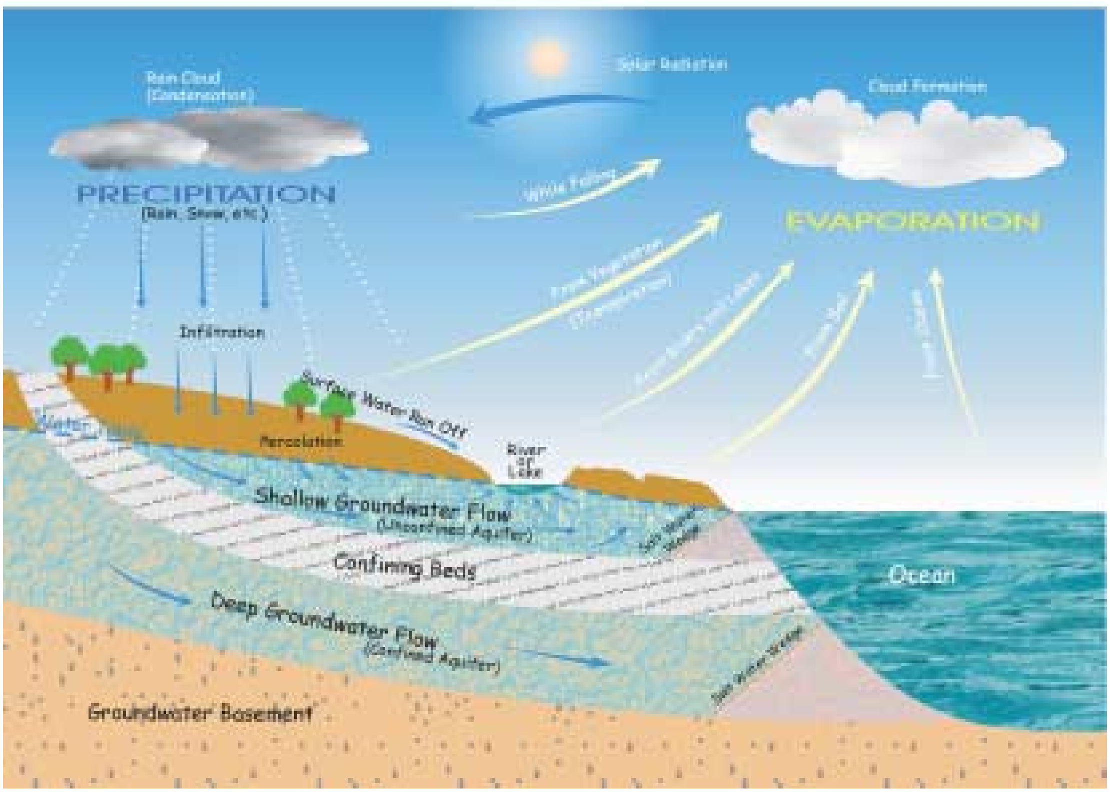

Figure 7 Components of the Water Cycle

Recharge occurs only in the wet season when rainfall intensity and duration is sufficient. During the wet season the *groundwater* levels rise, while in the dry season the levels fall. The amount and rate at which the *groundwater* levels rise and fall depends on the type, size and other physical properties of the *aquifer* as well as the amount of *recharge*. DIPE has monitored the change in *groundwater* levels in many *aquifers* throughout the NT over many years. *Groundwater* levels are collected by measuring the depth of the *water table* in the *observation bores*. Changes in the water table demonstrate the effects of recharge during the wet season and discharge during the dry season. Knowing how an *aquifer* responds to *recharge* and dry season water level changes can help us determine how much *groundwater* the bore will *yield* and how the *water table* levels will change in response to pumping

PART 3. GROUNDWATER

3.1 Groundwater Yields

Groundwater yields are typically expressed in terms of litres per second (L/s). A bore that is pumped at a rate of 1 L/s can fill a 10,000-litre storage tank in about 3 hours. In the study area, recorded bore yields range from 0.5 to 20 litres per second, depending on which regional aquifer the bore has been constructed in.

Typical bore yields are estimated by *airlifting* after the bore has been constructed. The process of airlifting forces compressed air into the bore to lift the head of water to the surface. The airlift yield is an approximation of the actual long-term yield of the bore, which is often less than the airlift yield. Most domestic bores in the region only have reported yields that were measured by the airlift method.

Most community production bores have had production yields measured with a constant rate pump test. In this case, a pump has been installed and the bore has been pumped at a constant rate for up to 24 hours. This is a more dependable method to determine the long-term production potential of each bore.

Community and domestic bores on outstations are usually not pumped at the maximum yield. The bores are pumped at rates that will meet community needs and storage restrictions.

The bores in the main community bore fields (Wadeye, Palumpa, Peppimenarti, Nauiyu) are pumped at between 2 and 7 litres per second, at different times of the year. Port Keats has one high yielding bore that can be pumped at rates as high as 18 L/s if necessary.

3.2 Regional Aquifers

Regional geologic formations (sandstone, siltstone, claystone, shale, granite, schist, etc.) were assessed for their ability to produce groundwater. Each formation was grouped into different *aquifers* of similar rock type and production capability. As a result, a map showing the regional aquifers and bore potential was developed. Figure 8 shows the main aquifer types resulting from this analysis.

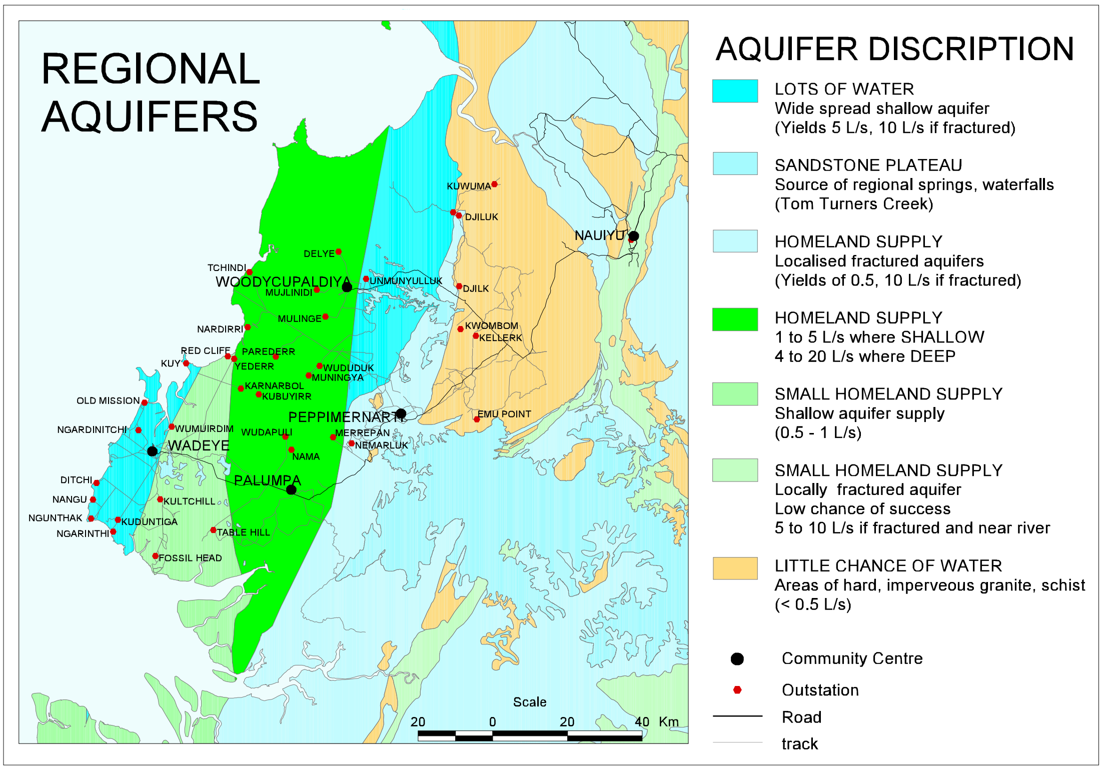

Figure 8 Regional Aquifers

Lots of Water / Large Supply (Yield)

The **dark blue** areas shown in Figure 8 represent aquifers where there is a good chance of drilling a bore that yields 5 L/s and a moderate chance of drilling a bore that yields 10 L/s. In general, bore yields are very inconsistent and vary between 0.5 and 22 L/s. Higher yielding bores are often associated with fracturing or a local source of recharge. The water quality from this regional aquifer is usually good.

The rock types in the Wadeye area consist of sandstone, siltstone and claystone sediments of the Upper Permian Hyland Bay Formation. Underlying Wadeye, an impervious claystone at a depth of 50 to 100 metres marks the base of the sandstone. This aquifer is the source of groundwater for the community of Wadeye and the outstations of Ditchi, Nangu, Kuduntiga, Ngardiniitchi, Old Mission, Kuy and Yedderr.

The aquifer area to the north, between Merrepan outstation and the mouth of the Daly River, is Lower Permian aged sandstone. A shallow bore at a depth of 41 metres has been successfully drilled at Unmunyulluk outstation near Woodycupaldiya. The bore is located next to a billabong, which is a significant source of recharge. The bore has been pump tested and may produce up to 16 litres per second. Other bores in this area, away from a direct source of recharge, may have significantly lower yields.

Sandstone Plateau

The **medium blue** area in Figure 8 is the regional sandstone escarpment that forms the Wingate Plateau and Docherty Hills. Although there are no bores on the escarpment, it is a significant hydrogeologic feature. There are many springs and waterfalls that form around the edge of the escarpment. The flow from the springs is caused by the drainage of groundwater from the sandstone escarpment. The large flows in Tom Turners Creek and the Moyle River are associated with faulting and the drainage of water from the sandstone escarpment and underlying Proterozoic aged sandstones.

Homeland Supply (Local Fractured Aquifers)

The **Light Blue** area represents local aquifers associated with faults or highly fractured rocks. Yields of 0.5 L/s may be possible in areas with only minor fracturing. Yields as high as 10 L/s are possible in areas of intense fracturing (faulting) and a nearby source of recharge.

Bores at Peppimenarti been completed in fractured Permian aged Sandstone. The fracturing is associated with the Chelanyi Creek fault. Pump testing of production bores show that yields of up to 10 L/s are possible. Bores in Peppimenarti are also within a kilometre of Tom Turners Creek, which acts as a significant source of recharge. Bores located away from the zone of fracturing and a source of recharge may have significantly lower yields. This is the case in Nemarluk, where bores completed in moderately fractured rocks yield only 0.7 L/s.

To the north, along the Daly River, the bores in the vicinity of Wooliana have been completed in fractured Cambrian aged sandstone. The bores in this area are less than a kilometre from the Daly River, which is a significant source of recharge. Yields between 1 and 6 L/s have been reported.

Homeland Supply (Southern shallow aquifer / Northern deep aquifer)

The dark **green** area has a shallow regional aquifer that extends from Table Hill in the south to the outstation of Tchindi in the north. Shallow bores have been successfully located that yield between 1 and 5 L/s. Underlying the Woodycupaldiya area is a deep aquifer with bore yields between 4 and 20 L/s. Higher yielding bores in the shallow and deep aquifers are not necessarily associated with fracturing or faulting.

South of the Moyle River, the shallow aquifer services the community of Nganmarriyang (Palumpa) and the outstations of Merrepan, Kubuyirr, Nardirri and Yedarr. The aquifer also extends to the north of the Moyle River to include the outstations of Mardingna, Parederr, Nardirri and Tchindi. The rock type consists of fractured, weathered, Lower Permian aged sandstone. The water quality from this aquifer is within acceptable drinking standards.

In the Northern portion of this area, the outstations of Woodycupaldiya, Mudjlindi , Mulinge and Deleye have water supplies from a deep, Permian aged sandstone aquifer. The aquifer is exposed at the surface near the western end of the Docherty hills and dips to the west beneath Woodycupaldiya and Mudjllindi. The sandstone aquifer is overlain by impermeable shale. The sandstone has been found below Woodycupaldiya at a depth of 40 metres and below Mudjlindi at a depth of 133 metres. Bore yields from the deeper aquifer range from 4 to 20 litres per second and is of good quality. The standing water level of these bores is close to the surface. The bores at Woodycupaldiya and Mulinge are known to be free flowing.

Small Homeland Supply

In the **medium Green** area, shallow water supplies may be found in sandstone and siltstone layers. Bores with limited yields of 0.5 to 1 L/s may be possible at selected sites. A low success rate is expected.

Small Homeland supplies have been found in this aquifer at Fossil Head, Table Hill, Kultchill and Redcliff. The bore yields for the outstations range from 0.2 to 1.2 L/s. The water has been found to be of good quality. Bores drilled near to black soil floodplains may tend to taste salty. Supply bores have typically been located away from the floodplains.

Small Homeland Supply (Locally fractured aquifers)

The **light green** represents locally developed aquifers in bedrock that is fractured and close to a source of recharge, such as a river. Bore yields of up to 5 L/s may be possible at selected sites. Unless fracturing and a source of recharge are near, a very low success rate is expected.

The main geologic unit that makes up this aquifer is the Burell Creek Sandstone, which extends as a narrow, north south trending strip between Litchfield National Park and the Wingate Plateau. The community of Nauiyu has production bores that are completed in this sandstone. The aquifer has been locally fractured and the bores are within a few hundred metres of the Daly River. Reported yields from the bores at Nauiyu range from 6 to 10 L/s and the water quality is good.

Little Chance of Water (Locally fractured aquifers)

Hard, impervious granite, schist and volcanic rocks underlie the area shown as light orange. Bore yields of up to 0.5 may be possible at selected sites. The sites are usually associated with a fracture or faulting. A very low success rate is expected.

This aquifer underlies the outstations of Emu Point, Kellerk, Kwombom, Djilk, Djiluk and Kuwama. In these cases, the bores were completed in fractured and weathered schist or granite. Reported bore yields at these locations range from 0.5 to 1.8 L/s. If fracturing is not present, it is unlikely that a successful bore can be drilled in this aquifer.

3.3 Groundwater Quality

Water quality standards for drinking water are defined by *the Water Quality and Monitoring Guidelines* as outlined by the *Australian and New Zealand (ANZECC, 2002); Guidelines for Fresh Water Quality*. A table of minimum allowable characteristics and inorganic chemicals is provided in APPENDIX B. Water sampling of all outstations and community bores indicate that water quality is generally within the guidelines. Water quality analyses from outstation and community bores have been summarised in Tables 5 and 6.

Water quality is very much affected by the interaction between groundwater and the aquifer material. As the rainwater percolates into the ground, it reacts with the aquifer material. Over time, this interaction may change the chemical composition of the water.

The quality of water can be described chemically by many constituents that are analysed in a laboratory. Some of the more basic properties of water that help to determine the quality of water are pH, alkalinity, electrical conductivity (EC), total dissolved solids (TDS) and hardness.

Water with a *pH* of less than 7 is usually corrosive to metal pipes and fittings, whereas a pH of greater than 7 is considered to be *alkaline*. Water which has a high alkalinity (>100 mg/l) may tend to cause scaling and deposits to form on water pipes, teakettles and other surfaces.

Water with an abundance of dissolved minerals is considered to be "hard". Hard water is usually associated with aquifers formed in dolomite or limestone. When water is considered to be hard, there will be difficulty in making suds from soap. Soft water has the opposite effect.

Salinity is a function of the amount of dissolved salts in solution. Salinity can be expressed in terms of *Electrical Conductivity* (EC) with units of µS/cm (microsiemens per centimetre). Another way to express salinity is by the concentration of Total Dissolved Solids (TDS). To determine this, a water sample is evaporated and the weight of the remaining solids is measured. The units for TDS are in mg/L (milligrams per litre). Salinity of water is often expressed as either total dissolved solids or electrical conductivity.

Table 5 Regional Groundwater Chemistry

Bore RN	Outstation or Community	Bore Yield (L/s)	pH	EC (µS/cm)	Total Dissolved Solids	Sodium, Na	Potassium, K	Calcium, Ca	Magnesium, Mg	Iron (Total), Fe	Total Hardness	Total Alkalinity	Silica, SiO_2	Chloride, Cl	Sulphate, SO_4	Nitrate, NO_3	Bicarbonate, HCO_3	Fluoride, F
					Mg/L													
RN025961	Ditchi	10.0	6.1	50	55	3	4	3	1	0.7	8	12	22	6	4	1	15	0.1
RN030785	Kuduntiga	2.0	6.1	74	79	9	5	1	2	1.9	8	13	45	13	2	1	16	0.1
RN026760	Kuy	10.0	5.3	50	60	7	1	1	1	0.1	7	7	25	11	2	1	7	0.1
RN025960	Nangu	0.5	6.1	245	155	35	2	4	3	12.6	22	5	21	69	7	1	5	0.1
RN024308	Ngardinitchi	5.0	6.5	75	70	5	4	5	1	1.1	17	17	22	10	5	1	20	0.1
RN030786	Old Mission	0.3	8	546	291	20	2	43	36	1.1	255	246	12	28	20	1	300	0.7
RN033302	Unmunyulluk	16	5.9	18	25	2	<1	<1	<1	<.1	---	4.1	18	3	3	<1	5	<.1
RN027211	Wadeye	22	4.8	28	27	3	1	1	1	0.1	4	2	16	6	1	1	2	0.1
RN027325	Nemarluk	0.7	5.5	35	30	2	1	4	1	0.7	10	10	10	5	1	1	12	0.1
RN023259	Peppimenarti	10.0	6.4	141	99	12	7	9	3	3.8	35	53	21	8	5	1	65	0.5
RN020225	Yederr	10.0	6.6	84	25	3	1	1	1	0.9	4	4	10	5	1	1	5	0.1
RN024305	Mardigna	5.0	6.1	20	25	1	2	1	1	0.1	3	6	19	1	1	1	7	0.1
RN032937	Merrepan	1.5	7.5	532	342	74	9	17	8	0.8	75	144	45	54	49	---	176	0.3
RN021026	Nardirri	3.0	5.1	45	42	6	1	1	1	1.2	7	5	13	12	3	1	6	0.1
RN030771	Palumpa	3.3	7.4	291	219	27	9	12	9	1.3	66	103	44	23	28	1	126	0.2
RN023283	Perederr	4.0	6.1	15	25	2	1	1	1	0.5	1	3	16	1	1	1	3	0.4

Table 6 Regional Groundwater Chemistry

Bore RN	Outstation or Community	Bore Yield (L/s)	pH	EC (µS/cm)	Total Dissolved Solids	Sodium, Na	Potassium, K	Calcium, Ca	Magnesium, Mg	Iron (Total), Fe	Total Hardness	Total Alkalinity	Silica, SiO_2	Chloride, Cl	Sulphate, SO_4	Nitrate, NO_3	Bicarbonate, HCO_3	Fluoride, F
					Mg/L													
RN032338	Tchindi	15.0	5.7	71	48	10	1	1	1	0.1	7	6	16	18	3	1	7	0.1
RN020226	Wudipulli	4.0	6.3	25	30	3	1	1	1	0.5	7	6	11	5	2	1	7	0.1
RN028358	Deleye	4.5	6.4	117	77	8	16	5	2	0.4	21	48	21	3	5	1	58	0.1
RN029300	Fossil Head	0.2	6.9	640	357	34	9	28	31	5.3	198	152	41	98	7	1	185	0.6
RN032936	Kulchill area	1.2	5.3	30	40	4.2	0.2	0.3	0.4	0.1	2.4	4.4	15	4	1	---	5.4	<.1
RN033301	Mudjlinidi	4.0	6.9	159	104	8	18	11	3	1.5	39.8	69.7	18	3	5	<1	85	0.2
RN031152	Mulingi	20.0	5.8	52	56	2	9	7	1	0.8	21	21	24	2	3	1	25	0.1
RN032935	Red Cliff	1.1	4.8	100	70	14	0.1	0.2	1	0.1	4.6	1.6	19	21	4	---	2	<.1
RN030745	Woodycupaldiya	5	9.6	65	44	10	14	4	1		14	24	23	6	2	1	0	0.1
RN029198	Wumardin	0.1	6.1	102	93	7	5	7	2	9.7	26	31	38	10	6	1	38	0.1
RN023385	Nauiyu	1.9	6.4	291	193	14	1	27	14	0.3	124	154	43	1	9	1	188	0.4
RN028354	Djiluk	2.0	6.9	292	202	12	4	15	22	0.1	128	153	75	4	7	1	186	0.2
RN032939	Emu Point	1.3	6.9	277	187	21	1	14	15	0.1	96.5	141	52	1	7	---	172	1.1
RN033300	Kellerk	0.5	7.1	238	162	26	2	2.3	14	0.3	63.2	118	44	3	7	---	144	1
RN028352	Kuwama	1.0	6.7	384	269	35	2	12	16	0.1	96	63	88	78	5	1	77	0.3
RN028357	Kwombom	1.5	6.8	247	150	12	1	1	26	0.1	110	128	32	5	5	1	156	0.3

3.4 Groundwater Monitoring

The measurement of water levels in designated monitoring bores helps to determine how the aquifer water table changes with time. Water levels in most bores have been measured and recorded immediately after the bore was constructed. Certain bores are constructed as designated monitoring bores and water levels are measured repeatedly. These measurements can be made either by hand or by using an automatic logger that gives continuous measurements of water level at specific periods of time or after a pre-determined change in level. Figure 9 shows the location of all bores in the project area. Bores used as monitoring bores have been highlighted.

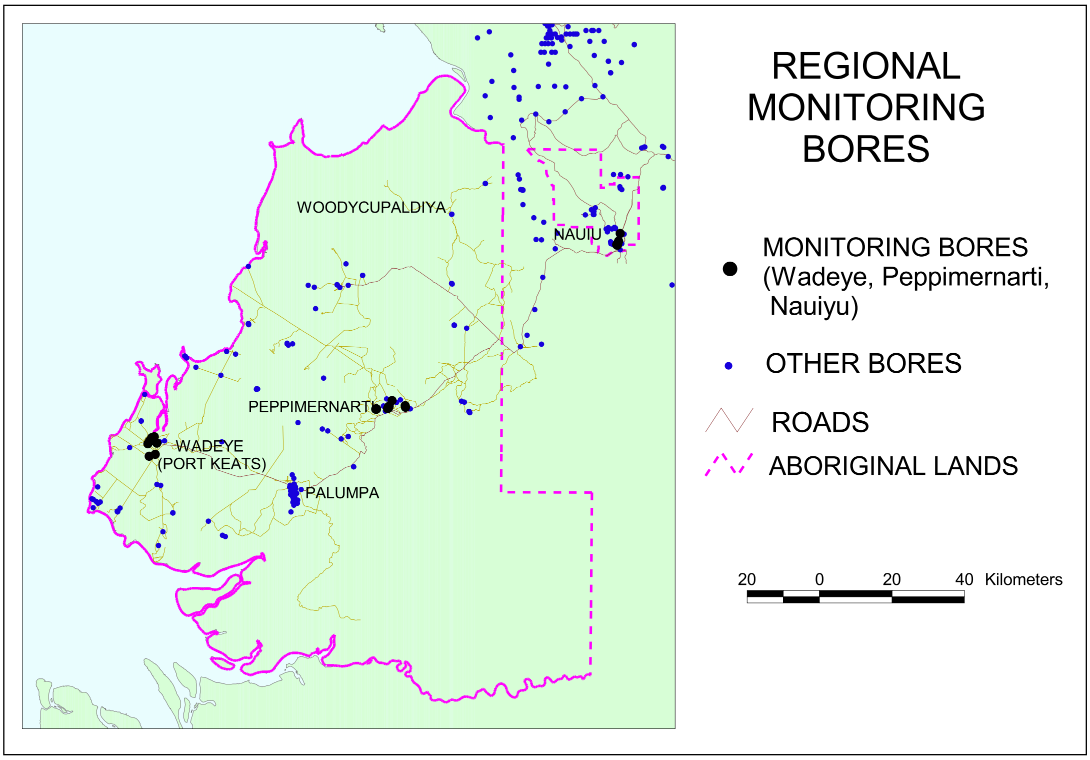

Figure 9 Monitoring Bores

The borefields in Port Keats, Peppimenarti and Daly River have monitoring bores where water levels have been measured periodically. Water level measurements have been made by DIPE staff or the community essential services officer.

Prior to this investigation, monitoring bores were measured either monthly or once a year between 1985 and 1997. Between 1997 and 2002, there were no water level measurements made in monitoring bores in any of the three main communities.

During the investigation, a single measurement was made in Peppimenarti and Port Keats in September 2003.

Figures 10, 11 and 12 are hydrographs showing the changing water levels in Port Keats, Peppimenarti and Nauiyu. Figure 13 is a hydrograph showing the total monthly rainfall at Nauiyu for the same period of time.

It is important that water level monitoring be done in the borefields on a regular basis. The information will help to assess the status of the local aquifer and water resource each year. The water level data has been stored in the HYDSYS database that is maintained by the Natural Systems Division of DIPE in Palmerston. All of the monitoring data from HYDSYS has been made available on the CD-ROM that accompanies this report.

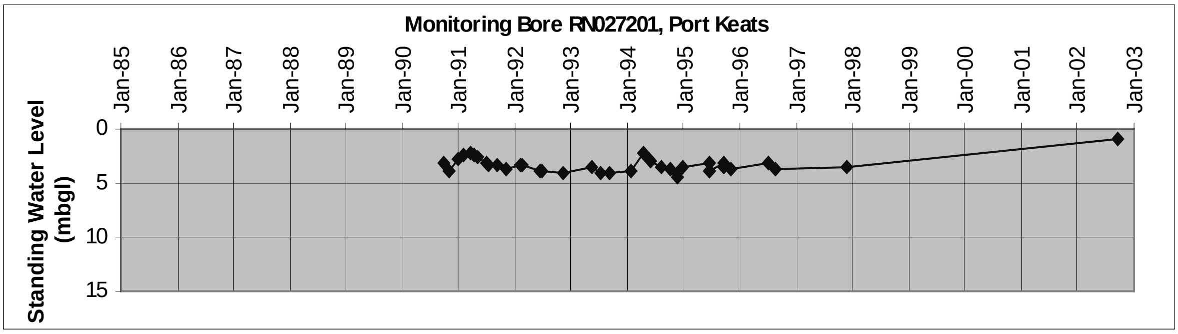

Figure 10 Monitoring Bore Data, Port Keats

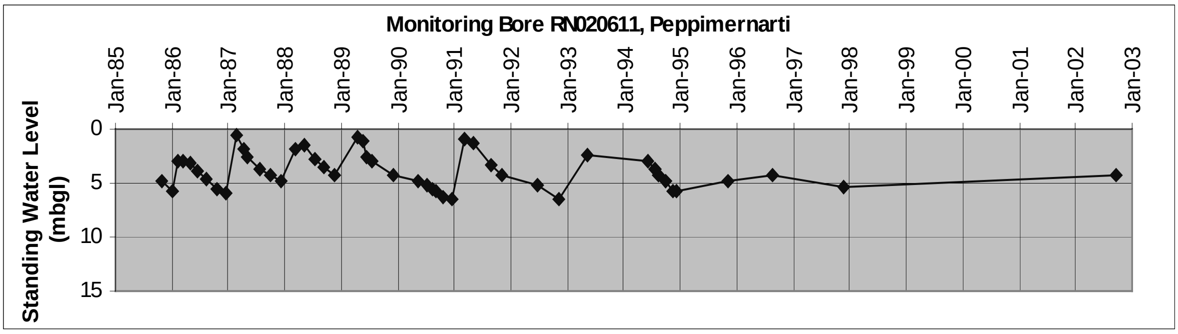

Figure 11 Monitoring Bore Data, Peppimenarti

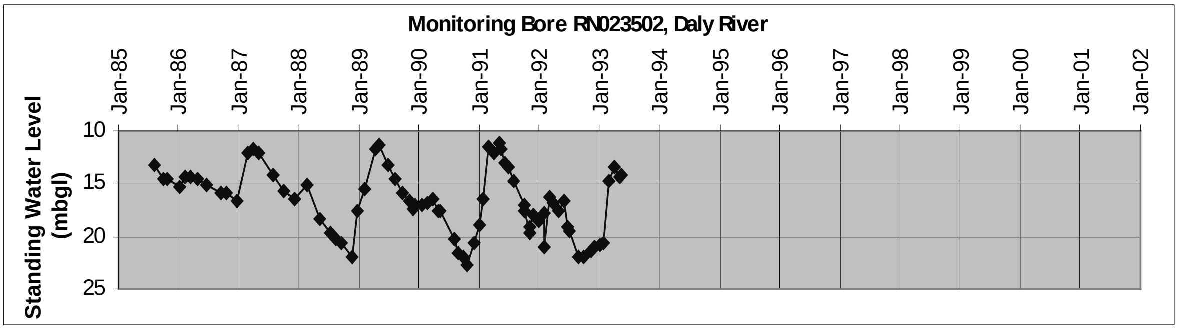

Figure 12 Monitoring Bore Data, Nauiyu

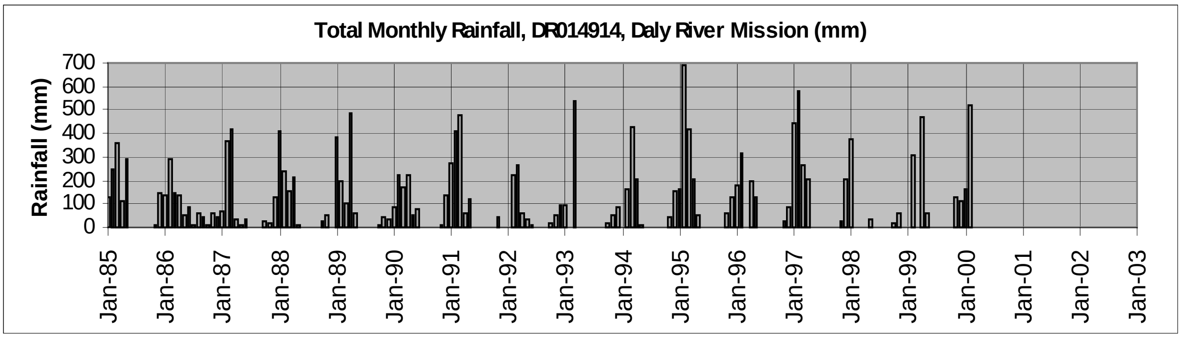

Figure 13 Total Monthly Rainfall, Daly River Mission (Nauiyu)

PART 4. SURFACE WATER

4.1 Surface Water Catchments

A surface water catchment describes a basin and stream system that includes all the upstream land and surface area that drains into a specific river or stream. A topographic divide defines the catchment area boundary. The divide is a line passing through the highest points between two neighbouring steam systems, or basins.

The Department of Infrastructure Planning and Environment has divided the Northern Territory into a series of regional surface water catchments. Catchments for the Wadeye-Nauiyu region are shown below in Figure 14.

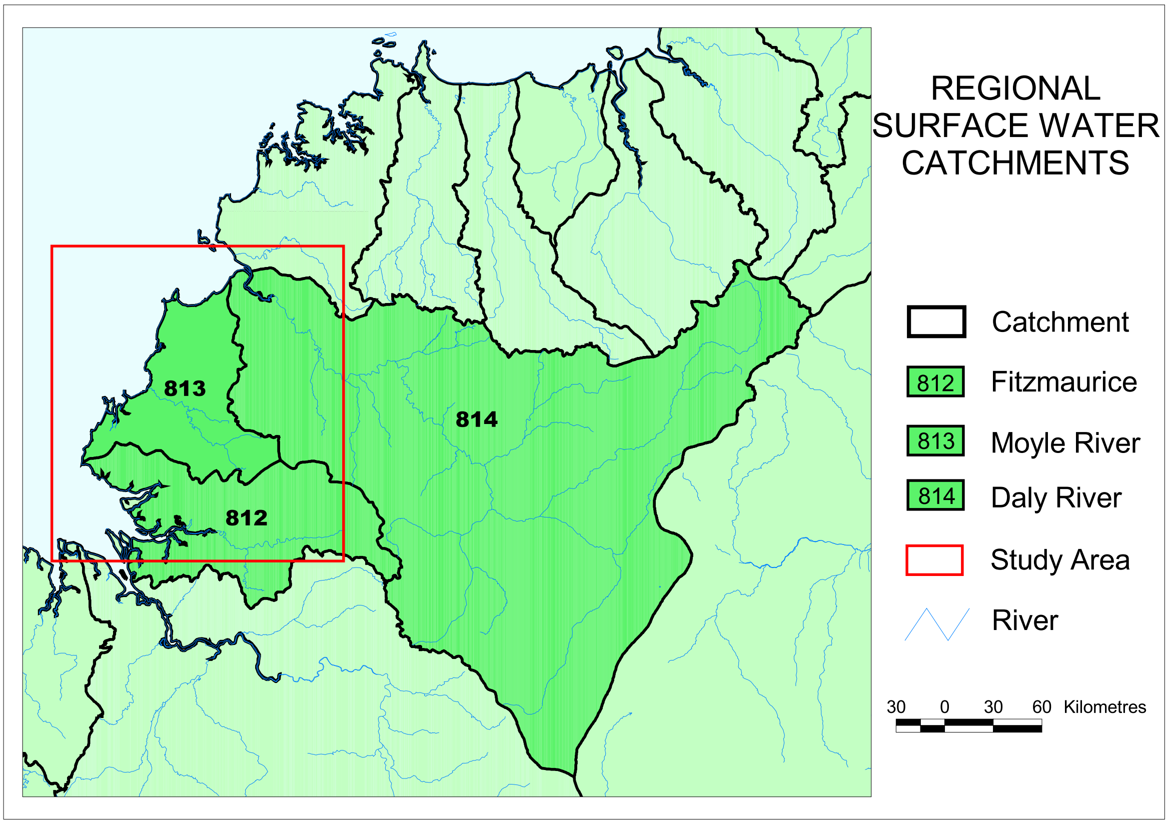

Figure 14 Catchment Boundaries

4.2 Stream Flow Monitoring

There are a total of 35 sites in the mapping area where stream flow measurements have been made (Figure 15). All sites have had at least one "spot" gauging, where stream flow was measured at an instant in time using hand held measuring equipment. Of the 35 sites, a total of 21 sites have time series records where flow measurements have been made continuously with the use of automatic data loggers. These stations have "gauging towers" that house the instruments that measure small changes in water level throughout the year. A survey of the shape of the streambed, or section, allows for the development of a rating curve. The curve equates a certain rise in the height of flow to the volume of flow and is a function of the cross-sectional area of the stream channel.

The gauging station at Mount Nancar (G8140040) is one of only two sites with automatic logging equipment installed and in operation. The gauging station at Daly River Police Station (G8140003) is also in operation, but only measures the river level at flood stages above 10 metres.

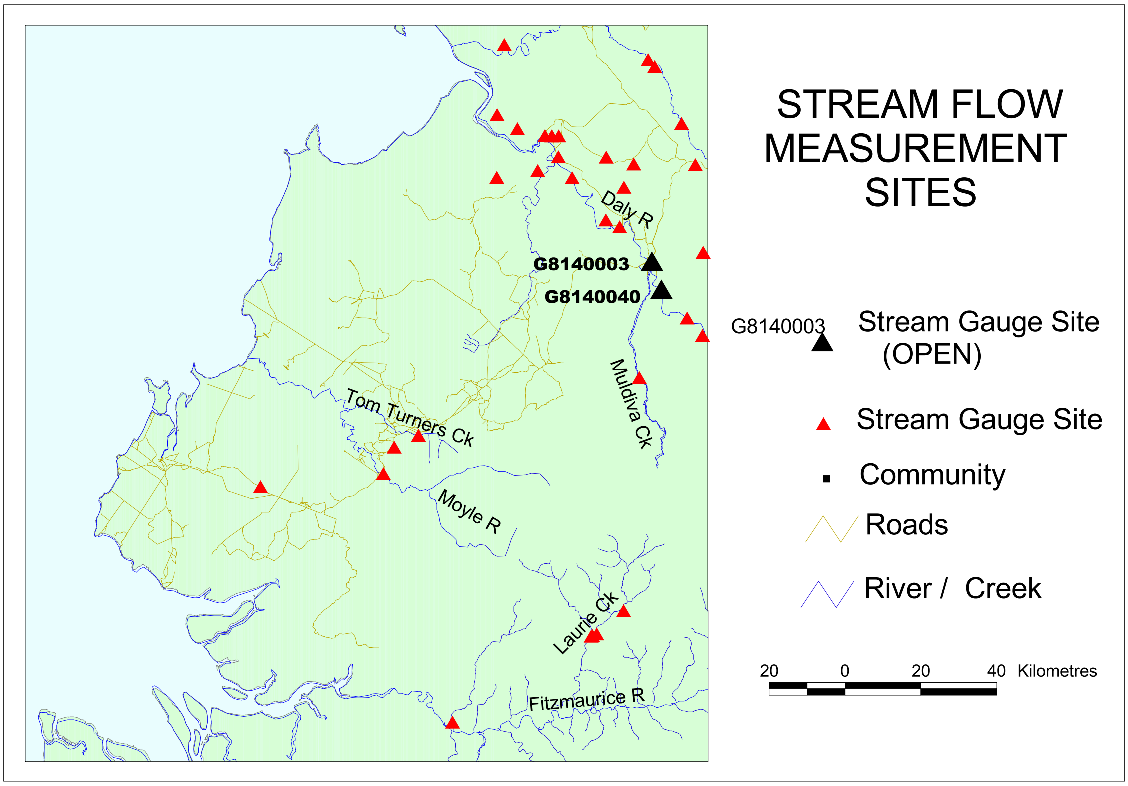

Figure 15 Stream Flow Measurement Sites

4.3 River and Stream Flow

There are a limited number of stream flow measurements in the region. Most of the sites where flow has been measured in the past are along the Daly River. It is important to understand that in the region between the Daly River and the Fitzmaurice River, many of the rivers and streams have very small flows at the end of the dry season. In most cases, the creeks dry up each year and do not flow again until the next wet season. Due to the rugged and inaccessible nature of the region, many creeks that could possibly have perennial flow have not been visited. The available data is limited to creeks that have the largest regional flows and reasonable access.

When driving along the road from Daly River to Woodycupaldiya or to Port Keats, there are numerous stream crossings that are flowing at the end of the wet season. By the end of the dry season, some of the few rivers and creeks that typically have measurable flow are the Daly River, Fitzmaurice River, Moyle River and Tom Turners Creek.

The Wingate Plateau and Docherty Hills are the source of water falls and springs, which form as a result of the draining of water from the sandstone. Laurie Creek to the south and Muldiva Creek to the north of the escarpment area have been gauged in the past. More information needs to be collected to determine if these creeks continue to flow all year.

4.4 River Flow Volumes; A Regional Comparison

Some of the largest flows in the region have been measured in the Daly River near Nauiyu, Tom Turners creek near Peppimenarti and the Moyle River between Peppimenarti and Nganmarriyang (Palumpa).

Figures 16, 17 and 18 are hydrographs of recorded flow volumes in the Daly River, Tom Turners Creek and the Moyle River. The data for the Daly River is from an automatic logger located near Mount Nancar. The data shown for Tom Turners Creek and the Moyle River are from hand measurements at different times of the year.

The flow volumes are expressed in cubic metres per second (cumecs), which is equivalent to 1,000 litres of flow per second. From this data, the maximum wet season and minimum end-of-dry season flows between June 1979 and July 1866 were extracted. These values are shown in Table 7.

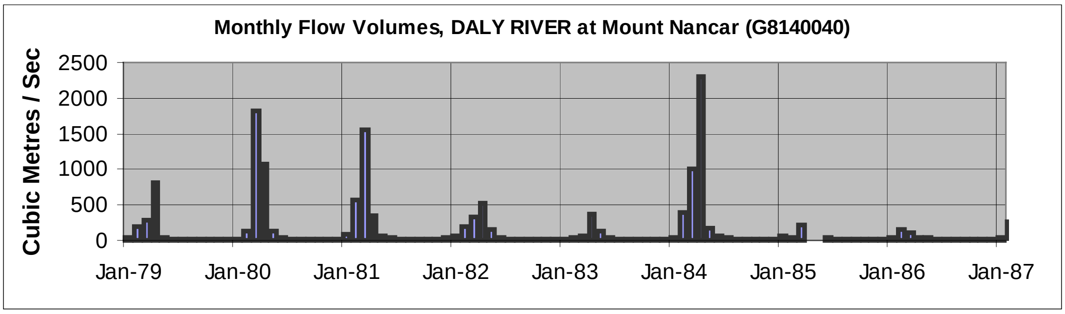

Figure 16 Stream Flow in the Daly River

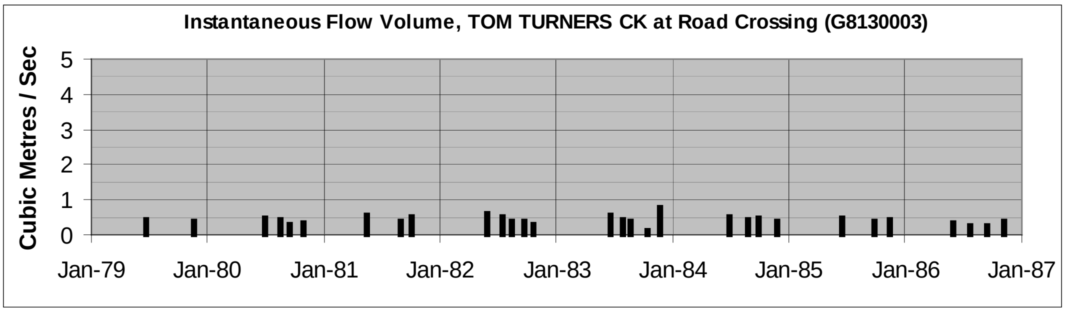

Figure 17 Stream Flow in Tom Turners Creek

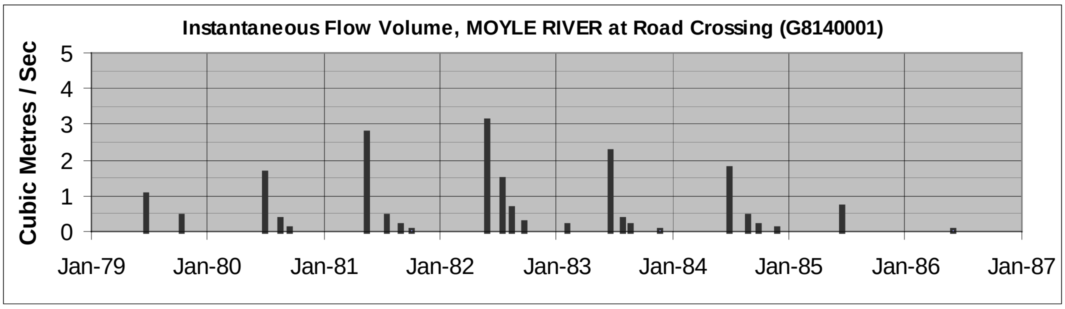

Figure 18 Stream Flow in the Moyle River

Table 7 Surface Water Flows (June 1979 to July 1986)

Station Name and Number	Up Stream Catchment Area (Km2)	Wet Season Maximum Flow (1000 litre/Sec)	Dry Season Minimum Flow (1,000 litre/Sec)
Daly River @ Nancar G8140040	48,000	2,294	13
Tom Turners @ Road G8130003	150	0.797	0.134
Moyle River @ Road, G8130001	1,000	3.090	0.005

The largest flows shown in Figures 16-18 are for the Daly River. This is to be expected due to the large area of the catchment above the gauging station. Maximum wet season flows have a high component of surface runoff by the time the river flow passes Mount Nancar. In comparison, the end of dry season flow is much lower (13 cumecs). In this case, there is no runoff component and the entire volume of flow measured at Mount Nancar is attributed to the drainage of the regional aquifers above the gauging station.

In comparison, the flows measured in Tom Turners Creek and the Moyle River are significantly less than those reported in the Daly River. This applies to both the wet season and end of dry season flows shown in Figures 17 and 18 and in Table 7. The main reason for the difference in flows is related to the difference in catchment size. The catchments for Tom Turners Creek and the Moyle River are about 1 to 2% of the Daly River catchment.

An interesting comparison can be made between the flows in the Moyle River and in Tom Turners Creek. The Moyle River catchment is much larger than the Tom Turner Catchment area. As can be expected, the recorded wet season runoff of the Moyle River is much higher. This is due to the significantly greater surface area and larger runoff component in the wet season flow.

Unexpectedly, the dry season flow for Tom Turners Creek (smaller catchment) is much larger than that of the Moyle River. In fact, the data implies that the Moyle River (at the gauging site) may stop flowing during times of drought. In comparison, the flows at Tom Turners creek is always maintained through the end of the dry season, This is due to the difference in the geology in the two catchments.

Figure 19 shows the size of the catchments of Tom Turner Creek and the Moyle River above the gauging stations. The main rock types in both catchments are Proterozoic aged sandstone overlain by Cretaceous aged Sandstone. The significant difference between catchments is that the upper catchment of Tom Turners Creek has been highly fractured by the north-south trending Tom Turners Fault and the east-west trending Hensche Fault. The secondary permeability caused by the two faults has greatly increased the ability of the rocks in this catchment to be recharged each wet season. Subsequently, the large volume of stored water is discharged thorough the same fracture system to sustain flow in Tom Turners Creek through the dry season.

In comparison, the upper Moyle River catchment does not have as high a degree of faulting and fracturing. Regardless, this catchment still supplies a significant amount of water to the Moyle River as a result of the draining of the Cretaceous sediments on the escarpment.

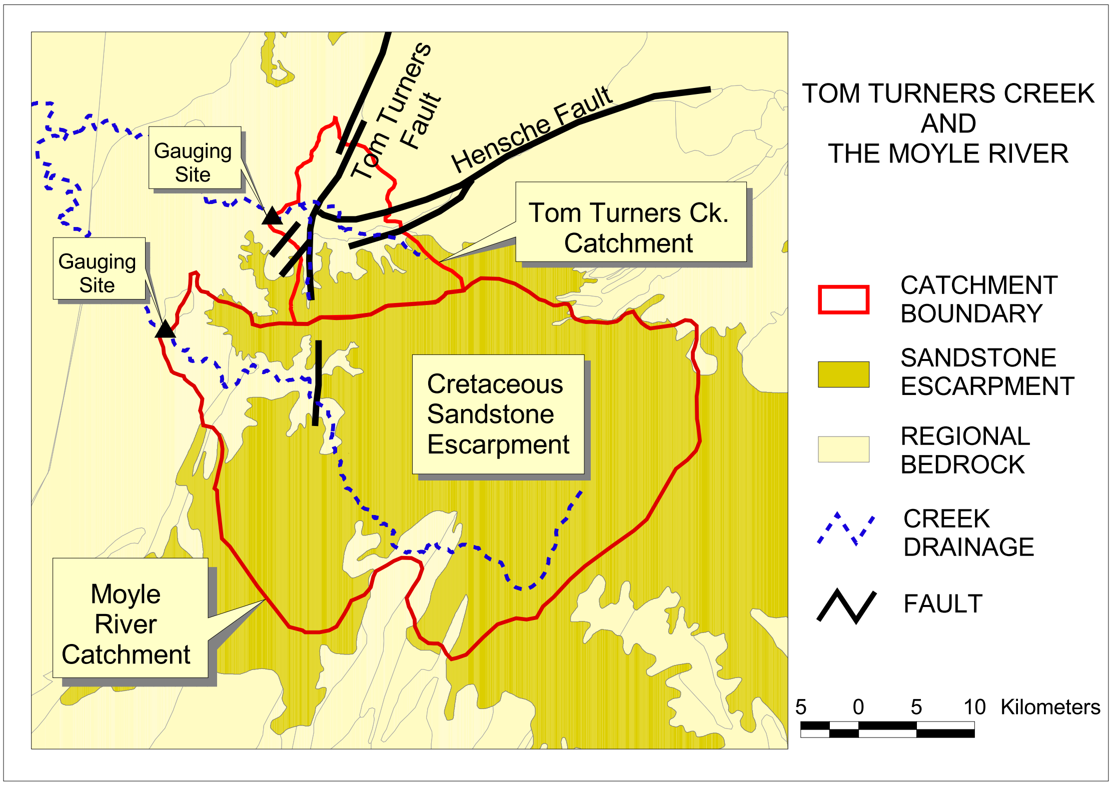

Figure 19 Catchments of Tom Turner Creek and the Moyle River

4.5 Surface Water Quality

A total of 108 surface water sites in the study were previously sampled for water quality. A majority of the sites are located on the Daly and Fitzmaurice Rivers. About 20 samples were collected from small creeks and rivers between the Daly and Fitzmaurice.

The surface water samples have had standard and bacteriological analysis, similar to the analysis for groundwater described in Tables 5 and 6. The surface water samples have had additional analysis for nutrients and trace metals. The data from the full set of analyses is available on the CD-ROM.

PART 5. ABORIGINAL KNOWLEDGE

An important aspect of this study was the integration of traditional knowledge about water with the technical understanding of the water resource. Throughout the investigation information was collected from traditional owners in the form of water stories, traditional place names and personal observations about the occurrence of water. The information has been presented in a traditional knowledge map and accompanying report. A full accounting of the methods used to collect traditional knowledge and the information collected are covered in detail in *Volume 2: Water Resources of the Wadeye (Port Keats) and Nauiyu (Daly River Region), Aboriginal Knowledge.*

The traditional owners and elders have given the project team permission to publish some of the place names on the final maps for public use. The map and report can be viewed and reproduced from the CD-ROM.

PART 6. WATER RESOURCE MANAGEMENT ISSUES

6.1 Sustainable Development

All State, Territory and Commonwealth governments recognise the importance of working in partnership with landcare groups, industry, traditional owners and other key stakeholders in the sustainable development and conservation of natural resources. This management principle seeks to ensure that the health of our land, water and vegetation are balanced with regional aspirations for long term productivity and prudent use of the resource for generations to come.

Thus far, the level of development on the study area has not caused any undue concern as to the health and sustainability of the water resources. The growth in the populations Wadeye, Palumpa, Peppimenarti and Woodycupaldiya may require the upgrading of and increase access to the water supply. These situations can be addressed when the time comes and the appropriate action should be taken.

6.2 Environmental protection

Threats to the municipal water supply have been addressed during the development of the borefields at Wadeye, Palumpa, Peppimenarti and Woodycupaldiya. Standard methods of bore construction were used to ensure that the possibility of contamination was minimal. The accepted practice of applying a minimum separation of supply bores from sources of contamination has been strictly adhered to.

Care should be taken in the placement of future rubbish tips; horticultural gardens, fuel storage and chemical supply depots near the current borefields. This principle has been applied in each community and the risk of contamination to municipal supply bores is minimal. It is recommended that a hydrogeologist be consulted in future when the placement of any facility on or near the present borefields (where contamination of the aquifer from surface pollution is an issue) is considered.

6.3 Groundwater Dependent Ecosystems

The importance of protecting the environment cannot be overstated and is a driving issue behind the water management strategies presently being developed nationally. It is recognised that certain plants, animals, and ecosystems rely on water from groundwater sources. This is certainly an issue in the study area as all of the freshwater springs are maintained by groundwater through the dry season. In areas of development, it is important that groundwater-dependant ecosystems be identified where current use may impact on either the quantity or quality of water.

Presently, the volume of use from the municipal borefields has not caused any noticeable impact on areas of environmental significance. It would be prudent, in the future, to address this issue when expanding or establishing new municipal bore fields.

Impacts to surface water drainage and freshwater aquatic life may arise in areas where sediment load into the creeks is increased during the wet season. This could arise from improperly managed land clearing.

6.4 Protection of the Moyle River and Daly River Flood Plains

The Moyle River and Daly River flood plains are a significant feature in the region. These areas should be protected and appropriately managed as resources of intrinsic natural beauty and of important cultural significance to the Aboriginal people.

6.5 Feral Animal and Introduced Weed Control

The digging of feral pigs around springs is impacting on the environment. Any disruption to the stream banks will cause an increase in turbidity and actively erode firm banks into muddy wallows.

Programs to map the extent of Mamosa have been initiated through the Northern Land Council. Feral animal and week control is an ongoing concern that needs to be managed by the traditional owners, resource centres and community councils.

6.6 Groundwater and Surface Water Monitoring

It is important that the regular monitoring of groundwater levels in and around the present borefields at Wadeye, Palumpa, Peppimenarti and Woodycupaldiya be continued. At the completion of this water resource investigation in December 2002, there will no longer be the resources available to continue the monitoring program. The traditional owners and local community governments could take on the responsibility of developing a monitoring program. The bores only need to be measured every month. A minimum of 5 bores in each of the fields would provide adequate coverage of the resource.

The first step in this process might be to write this responsibility into the contract of the essential services officer (ESO) in each community to guarantee that funds would be made available for this work. A second step could be to train local assistants in the monitoring procedures. This would continue the monitoring program beyond the extent of the ESO's contract and involve community members.

6.7 Water Use and Public Awareness

Efficient use of water should be a priority in all communities in the Top End. The first step to this process could be to raise the level of education and public awareness about the proper use of water. This may be as simple as developing an educational program for children in the local community schools about the importance of not letting taps run uncontrollably, and the sensible use of water.

PART 7. FURTHER WORK

It is hoped that the information presented to the Aboriginal people will assist them to better manage and use their land and water resources. The data from previous investigations and the data collected during this study have been merged to form a comprehensive and complete source of information in regards to regional water resources. It is important to continue the process of data collection, analysis and the further development of an understanding of the nature of the resource. With this in mind, the following work is recommended in the future:

7.1 Groundwater Monitoring

Continued regular monitoring of regional groundwater levels, specifically in the Nauiyu, Wadeye, Palumpa and Peppimenarti bore fields. It is recommended that the local community councils and community members take on this responsibility as part of caring for their country.

7.2 Surface Water Monitoring

Further investigation of stream flow and spring discharge around the Wingate Plateau, east of Palumpa, should be done. Future hydrologic studies could further define the perennial and or ephemeral nature of many of these springs.

7.3 Environmental Flow Studies (Moyle River and Daly River Floodplains)

Determination of environmental flows to many of the unique wetlands, specifically the Daly and Moyle River floodplains. This will allow for the better understanding of the water resources that maintain these areas.

7.4 Spring Flow Studies (Cretaceous Sandstone Escarpment)

Investigation of stream flow and spring discharge from the Cretaceous escarpment and other regional aquifers should continue. Future hydrologic studies could further define the perennial or ephemeral nature of many of these springs.

7.5 Further Investigation of the Permian Age Deep Regional Aquifer

The recharge mechanism and the production capabilities of the deep aquifer located under Woodycupaldiya and Mudjlindi outstations are poorly understood. It is recommended that further investigation be carried out to better define the hydrogeology of this considerable resource.

7.6 Traditional Knowledge

The traditional place names and the location of those sites have been recorded to as accurate an extent as time allowed. The map, which accompanies the report, should be regarded as a draft version. The Aboriginal people may wish to review and update the map as part of their traditional heritage.

PART 8. WATER RESOURCE DATA

The final products of this study are a series of hard copy maps, hard copy reports and an interactive CD-ROM. All of the hard copy maps and reports are available in digital format on the CD-ROM. The CD-ROM has instructions on how to print the maps and reports.

In addition to the maps and reports, the CD-ROM has a wealth of information in regards to hydrographic data and Geographical Information System (GIS) files. All of the data is in the Universal Transit Meridian (SUTM52) coordinate system and the datum is the Australian Geodesic Datum from 1966 (AGD 66). The following data categories are available on the CD-ROM:

Bore Details	Rainfall Measurements
Site Locations	Groundwater Chemistry
Water Level Data	Surface Water Chemistry
Stream Flow Measurements	Traditional Name Places

To obtain hard copy reports, maps and/or the CD-ROM, contact the Manager of the Spatial Data Mapping Secton, Department of Infrastructure, Planning and Environment, Fourth Floor, Goyder Building, PO Box 30, Palmerston, NT 0831, Phone: (08-89993603), Fax (08-89993666).

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APPENDIX A GLOSSARY OF TERMS

Alluvium: The sediments laid down by rivers, flood plains, estuaries and mountain slopes (clay, silt, sand and gravel).

Airlift Yield: Approximate measurement of aquifer / bore yield by forcing compressed air into a bore and lifting the static head of water to the surface.

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 stream flow. Baseflow often maintains the flow in a stream through the dry season.

Bacteriological Analysis: Water quality sampling to determine is water is impacted by septic systems. Coliform Bacteria is usually the biggest concern.

Basal Layer: Typically referring to the bottom part of a rock layer or geologic formation.

Brackish: The slightly salty quality of water that may result from the mixing of fresh water with seawater.

Carbonate (rock): A rock, which is made up of calcium carbonate ($CaCO^3$), such as limestone or dolomite.

Catchment: A basin and stream system that includes all the upstream land and surface area that drains into a specific river or stream.

Confined aquifer: An aquifer that occurs beneath an impermeable layer which confines the water and subjects it to a pressure higher than atmospheric.

Confining Layer: A rock unit typically made up of claystone or siltstone that confines or “caps” a water-bearing unit beneath.

Cretaceous: A geological time period from 65 to 144 million years ago.

Current meter: A device for measuring water velocity, consisting of a propeller that turns at a rate dependent on the water’s velocity. Tables are available to convert the number of turns over a period of time to water velocity.

Deposition: The lying down of loose material (clay, sand, silt or gravel) as a result of the breaking down (erosion) of other rocks.

Dissected Plateaux: A flat lying area of higher elevation that has been cut up and eroded by rivers and streams that drain off of the high ground.

Discharge: The draining of the shallow sandstone aquifer to specific springs and along the main stream course where the water table meets the land surface.

EC: Electrical conductivity, the ability of water to conduct electricity. It is directly related to the salt content of the water. EC is measured in micro siemens per centimetre, μS/cm.

Environmental Flow: The minimum flow required in a river or stream that is required to sustain the native flora and fauna.

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

Erosion: The break down of rocks by natural processes such as wind, water, heat and mechanical corrosion.

Erosional Remnants: Rocks of a particular type that once covered the area completely but have since been eroded away to leave only isolated hills and escarpments of the original material.

Estuary: That part of a river drainage that enters the sea within the limit of tidal action.

Evapotranspiration: That part of the rainfall that is returned to the atmosphere through direct evaporation and from the transpiration of plants.

Friable: A rock that crumbles easily, typically due to poor cementing of the grains.

Gamma Log: A borehole geophysical survey that measures the natural radiation in rocks. The survey typically identifies layers that may be rich in clay.

Gauging station: Site on a stream where direct observation of water velocities, heights and volumes are made and recorded to determine volume of stream flow.

Geology: The science, which studies the earth, the rocks of which it is composed and the changes, which it has undergone or is undergoing.

Geographical Information System (GIS): An organised collection of computer software, data and information designed to capture, store, manipulate and display all forms of geographically referenced information.

Geophysics: The use of specialised surveys that measure the physical characteristics of the earth, such as the resistivity, gravity, density (seismic) and magnetic properties to determine the underlying rock types.

Glaciation: A period during which global temperatures dropped and the ice sheets on the north and south poles spread toward the equator. The result was the locking up of ocean water in ice, causing an overall lowering of sea levels.

Groundwater: That part of subsurface water that is held within porous and permeable portions of the earth.

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. It is difficult to make soap suds in water that is considered to be "hard".

Hydrogeologist: A geologist who studies the properties of the earth to determine the relationship between geology, groundwater and surface water.

Hydrograph: A graph that shows water level or stream flow measurements over a period of time.

Hydrographic: The study and measurement of surface water flows, volumes and occurrence.

Impermeable: An impermeable rock or sediment forming a barrier that water cannot pass through.

Laterite: Reddish brown, rocky material that has formed as a result of excessive weathering and leaching in very wet conditions.

Lithologic Contact: The boundary between two different rock types, such as sandstone and claystone.

Matrix: The cementing material that often fills the spaces between sand or gravel grains in a rock.

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

Mudstone: A rock type which is a mixture of clay, silt and sand.

Nutrient Analysis: A water quality analysis that is suited for the measurement of chemical components typically associated with agriculture such as nitrogen, ammonia and phosphorous.

Perennial: A stream, lake or waterhole that does not dry up from year to year.

Permeability/Permeable: The characteristic of a rock or soil by which water can pass through.

pdf: "Portable Document File" a file format that allows reports and maps to be viewed using most popular software on a computer.

pH: A measure of the hydrogen ion concentration in water. A low pH is "acidic" and a high pH is "alkaline". A pH of 7 indicates neutrality - non-corrosive to metal.

Physiographic Unit: A landform with specific characteristics that reflect how the land formed, what it is made up of and what has happened to it after formation.

Potable: Drinking water that is fit for human consumption

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

Porous: A material (rock) with continuous pores that allow water and other fluids to be stored or pass through.

Quaternary (Period): The most recent geologic period that spans the time from 1.6 million years ago to present day.

Quartzose (Sandstone) sandstone that is made up primarily of clean well-rounded quartz grains.

Recession Curve: That part of a stream flow hydrograph that represents the component of flow that can be attributed to groundwater drainage.

Recharge: The process by which water is added to and absorbed onto a rock or soil.

Regression (Sea): The contraction of the seas and /or the rise of land that causes sea levels to lower with respect to the land.

Resistivity Log: A bore hole geophysical log that measures the rocks ability to conduct electricity. The log is helpful in determining between water bearing zones that are either fresh or salty.

Runoff: The component of rainwater that is not absorbed onto the ground and flows across the land surface.

Salinity: The measure of the total dissolved solids in water, ie. NaCl (salt).

Saltwater intrusion: movement of sea water into fresh water aquifers.

Satellite Imagery: Digital ‘photographs’ taken from satellites orbiting the Earth.

Saturated Aquifer: The portion of the aquifer that is water bearing.

Soak: An area where groundwater is close to the surface most of the year. A pit or shallow well can be dug to pump the shallow water.

Specific Yield: In an unconfined aquifer, it is the volume of water that can be drained from the rock due to gravity. Specific Yield is a unitless parameter.

Spring: Discharge points for groundwater where the watertable is close to the ground surface.

Standing Water Level: The depth (metres) to the top of the water table in a bore as measured from the ground surface.

Storage Coefficient: In a confined aquifer, it is the volume of water released from storage due to pumping. The Storage Coefficient is a unitless parameter.

Stratigraphy: The branch of geology that studies and describes the formation, composition, sequence and correlation of stratified rocks, such as: sandstone, siltstone, claystone and limestone.

Sustainable: To use a resource in such a way that the continued use is ensured and the other users of the resource are not adversely impacted.

Tertiary: A geological time period from 1.6 to 66.4 million years ago.

Trace Metal Analysis: Water Quality analysis test for the presence certain chemical components related to mining activity, such as; aluminium, copper, lead, nickel, zinc, chromium and arsenic.

Transgression (Sea): Expansion of the sea, which results in the eventual, rising of sea levels and the submergence of the land.

Transmissivity: The measurement of the ability of a material (aquifer) to allow water to pass through.

Turbidity: Relative measure of the clarity of the water, which is a function of the amount of suspended particles in the water. Muddy and murky water has a high turbidity.

Total dissolved solids (TDS): A measure of the dissolved solids in water expressed as milligrams per litre. High TDS implies that the water will be saline (salty).

Unconfined Aquifer: The upper portion of the aquifer is open to atmospheric pressure. Does not have an impermeable cap to "confine" the aquifer.

Unsaturated Aquifer: That portion of an aquifer that is not water bearing.

Water Cycle: The continuous cycle in nature by which rainfall is ultimately returned to the atmosphere as evaporation and transpiration.

Water Table: The level of water in an unconfined aquifer as measured from the ground surface.

Water Quality: The chemical and biological characteristics of water.

Water Year: In the NT, the water year extends from October to the following September so as to account for the total wet season rainfall.

Weathering: (See Erosion)

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

APPENDIX B ANZECC WATER QUALITY STANDARDS, 2002

Based on the Australian Drinking Water Guidelines, National Water Quality Management Strategy, 1996

Guidelines for Physical Characteristics

Characteristic	Health	Aesthetic
Hardness as CaCo3	**	200 mg/L
pH	**	6.5 to 8.5
Total Dissolved Solids	**	500 mg/L
Turbidity	*	5 NTU

Guidelines for Inorganic Chemicals (Values in mg/L)

Chemical	Symbol	Health	Aesthetic
Aluminium	Al	*	0.2
Ammonia (as NH3)	NH_3	*	0.5
Antimony	Sb	0.003	
Arsenic	As	0.007	
Barium	Ba	0.7	
Cadnium	Cn	0.002	
Chloride	NaCl	**	250
Chromium (as Cr(VI))	Cr(VI)	0.05	
Copper	Cu	2	1
Cyanide	CN	0.08	
Flouride	F	1.5	
Hydrogen Sulfide	H^2S	*	0.05
Iron	Fe	*	0.3
Lead	Pb	0.01	
Manganese	Mg	0.5	0.1
Mercury	Hg	0.001	
Molybenum	Mo	0.05	
Nickle	Ni	0.02	
Nitrate	NO_3	50	
Nitrite	NO2	3	
Sodium	Na	**	180
Sufate	SO_4	500	250
Zinc	Zn	*	3

* Insufficient data to set guideline based on health considerations

** No Health-based guideline is necessary