1. BACKGROUND ON N.T. WATER RESOURCES
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Report No: 67/520
WHAT DO WE KNOW?

Introduction

This report looks to the future development and conservation of water resources in the Northern Territory.

Our views of the future, need to be firmly based on the lessons learned and knowledge gained in the past.

Managers of water resources must tackle these three basic questions: how much water do we have?, how have we used it to date?, how can we best use it in the future?

What Resources Do We Have?

The Northern Territory can be broken into two broad regions of differing landscape, climate and water resources. These regions are the northern humid zone and inland arid zone. The boundary between them marks the divide between the rivers flowing northwards to the coast and those which drain to the inland. The humid zone occupies the northern-most one-third of the Northern Territory and is known as "The Top End". Presenting a landscape of low, flat coastal lands backed by a belt of hills and rugged, broken country which rises to an inland plateau 350 metres above sea-level, this zone extends up to 300 kilometres inland from the coast.

The inland arid zone extends over 1,000 kilometres southwards to encompass the remaining two-thirds of the Territory. This region is locally called "The Centre". The patterns of rainfall, runoff and drainage are different in each of these broad regions, with the Top End better watered than the Centre. Taken overall, though, there is no part of the Northern Territory which receives year around rain, and only one or two areas in the north which can boast of major permanent Territory but it is generally found that
underground supplies in the Top End are better than those found in the Centre.
How Have They Affected Us?

The traditional lifestyles of Aborigines were influenced by the water resources available to them. As a result, small clan groups followed a highly mobile nomadic lifestyle in the arid zone, making efficient use of the few waterholes and soaks and their associated natural food resources. In the humid zone there was more permanent water available, with a greater abundance of food resources to draw upon. Accordingly, the capability of the environment to support larger communities reduced the need for wide-ranging mobility. While lifestyles were characteristically different and reflected the different environments between humid and arid zones, Aborigines throughout the Northern Territory attach spiritual significance to surface water features. Such strong cultural links are only to be expected in the driest settled continent.

Early European exploration and settlement of the Northern Territory was constrained by the availability of water. With permanent surface waters and reliable seasonal rainfall, it is not surprising that initial settlement occurred in the Top End. The relative ease of access by sea, compared to the arduous overland trek required for travel to and from the arid Centre, resulted in a concentration of settlements along the coast. Until the success rate and economics of water-well sinking improved, the development options of the Northern Territory were linked to the better watered parts of the Top End and those scattered sites in the arid zone where surface water supplies were available.

The strong influence of water resources upon development is seen in the Territory’s "spine": the Stuart Highway. This crucial road-link follows a chain of springs which were the earliest water supplies for exploration and settlement.
Other interests and pressures have ultimately led to expanded settlement throughout the Northern Territory but the influence of the broad division into humid and arid zones persists to the present and can be seen in the current population distribution. A little under two-thirds of the total population, and number of towns, occurs in the humid zone. In other words, the humid zone supports almost four times the density of settlement that is found in the arid zone.
How Much Do We Have?

Introduction

All the elements of the water resource base belong within the hydrologic cycle. This is the flow of water bringing rainfall and ultimately returning water vapour to the atmosphere by evaporation. Between rainfall and evaporation there are two other possible flows; these are direct runoff in streamflow, and infiltration to underground water storage. The breakdown of the initial rainfall into fractions going to streamflow, groundwater and evaporation is important in deciding the potential uses which can be made of water resources. Considerations of typical hydrological cycles will also emphasise the different constraints to development which water resources present in the humid zone as compared with the arid zone.

It must be stressed that it is impossible to accurately describe the hydrologic cycle for either of the two zones. There is a great variety of conditions within each zone which act to cause wide differences in the breakdown of rainfall into the two basic landflows of runoff and percolation to deep groundwaters. Different soils, vegetation, slopes and the presence of urban areas will alter runoff and infiltration. Weather patterns, such as the length of dry season and intensity of rainfall, will also have important effects. Wide ranging effort over a long time is required to investigate and describe all of these factors.

The hydrologic cycles presented for each zone do, however, show clearly their major differences, although it is unlikely that any single area is accurately represented. The key features for comparison of humid and arid zones are the greater levels of runoff and recharge to groundwaters in
the humid zone, with very little runoff occurring in the arid zone.
Rainfall

The main influence on rainfall in the Top End is the monsoon which can usually be relied upon to regularly bring summer rains over most of the humid zone. Thunderstorms herald the start of the wet season and may bring rain throughout the summer months. Occasionally very high intensity, but often localised, rain occurs when cyclones pass close to, or over, the coastline. When a cyclone travels inland the winds quickly dissipate and the intense storm may become a more general rain depression which can affect wide areas, even extending into the arid zone. Very little rain is received in the humid zone during the dry season winter months, but sometimes the weather systems typical of southern Australia's winters reach far enough north to bring winter rains to the Centre. Annual rainfall averages more than 1,200mm at the northern coast, falling to less than 200mm in the southern arid zone. At the transition from humid zone to arid zone the annual total is about 600mm. In addition to receiving less rainfall, the reliability of rain in the arid zone is less than for the humid zone.
MEDIAN RAINFALL (mm) EXPECTED 5 YEARS OUT OF 10

LOW RAINFALL (mm) EXPECTED EVERY 10 YEARS OR MORE

HIGH RAINFALL (mm) EXPECTED EVERY 10 YEARS OR MORE

ANNUAL RAINFALL
Evaporation

Although high throughout the whole Northern Territory, evaporation is lowest along the coast and highest at the Centre of the arid zone.
Runoff

Comparing runoff across the Northern Territory will give a broad scale guide to the options for development of water resources. Runoff is one of the elements in the hydrologic and represents that fraction of rainfall which drains away by overland flow in rivers and streams. Being a fraction of rain, we describe runoff in terms of depth in mm, just as we do for rainfall. By looking at the different depths of runoff between regions we can compare the development potential for surface water projects, such as water supply reservoirs. From a simple viewpoint, where runoff is higher each square kilometre of land delivers a greater quantity of water to the rivers. This means that more water is available for use in high runoff areas, either directly from rivers or potentially from reservoirs which can be formed by damming. Differences in runoff will also be reflected in different ecologies for streams, and the effects of altering runoff with large scale land and water developments is a basic environmental consideration for planners.

Runoff is estimated from the measurements of flow in rivers. All of the land area which drains to a river is its catchment. By measuring the total volume of water which flows in the river, and then dividing that volume by the area of the catchment we are able to calculate the depth of runoff. If several points are chosen along each of the main rivers to measure streamflow, and the catchment areas above each point measured using maps, the runoff calculated at all of these places may be used to give Territory wide maps of runoff.

Since it is really a fraction of rainfall the amount of runoff will depend firstly on how much rain is received. This can be seen clearly for the Territory, where the humid zone has much higher runoff than the arid zone. Runoff
within the arid zone increases as we move northwards, as also does the rainfall. Other factors which affect runoff are the type of soil, extent of rocky areas, density and type of trees and grasses and land slopes. The effects of these factors can be seen in the arid zone where the steep, rocky slopes of the McDonnell Ranges cause increased runoff in the area around Alice Springs. For the rest of the arid zone runoff is consistently low.
MEAN RUNOFF (mm) EXPECTED 5 YEARS OUT OF 10

HIGH RUNOFF (mm) EXPECTED EVERY 10 YEARS OR MORE

LOW RUNOFF (mm) EXPECTED EVERY 10 YEARS OR MORE

VARIABILITY OF RUNOFF
Surface Waters

Natural surface waters are probably the most familiar of our water resources. They can be divided into three broad groups: permanent waters and ephemeral waters and man-made.

1. As the name suggests, permanent surface waters persist throughout the year. They can be found as streams which flow for the full year, but more usually they are contained in waterholes, lagoons, springs and swamps. Since there is little or no rain over the dry season the waters which flow in permanent streams must be supplied from some source other than rainfall. Similarly, most of the lagoons; waterholes and swamps have an average depth which is less than the losses to be expected from evaporation and yet water is retained throughout the year. These, too, are fed from a source of water additional to rainfall. In both cases the source is groundwater; part of the rainfall which soaks into the ground eventually drains into these permanent streams and waterbodies.

2. The other broad group of surface waters are ephemeral, which is to say that they hold water for only part of the year. This group is also made up of streams, waterholes, lagoons and swamps but they receive insufficient groundwater drainage to sustain them for the whole year.

3. Man-made reservoirs range from comparatively simple stock-water tanks to the large lakes formed by the damming of rivers. The majority of these artificial water-bodies are, of course, intended to provide permanent water.
All streamflow is ephemeral throughout the arid zone. With low rainfall and long dry periods, rivers cannot be relied upon to flow even once every year. Scattered across the arid zone, however, are permanent waterholes and small soaks. These formed the nomadic paths of the desert Aborigines for thousands of years and were vital to the European settlement of the inland.

Compared to the arid zone the humid zone carries many more rivers. Most of these can be expected to flow for at least part of each year, but permanent streamflow occurs in only a small number. There are also many more waterholes along the rivers of the humid zone, and a great number of lagoons are scattered throughout the coastal plains. A large proportion of these carry permanent water and all are important for supporting a wide array of wildlife.

Two major centres in the humid zone take their water supplies from surface waters. Katherine draws water from a long waterhole in the Katherine River, and Darwin River Dam. Permanent waterholes in some of the larger rivers are used to irrigate market gardens in the northern part of the Top End. Many waterhole and lagoons are enjoyed for recreation in the Top End, and two man-made lakes have been built for boating.
Groundwaters

The portion of rainfall which soaks into the ground surface to drain down through the soils and enter into the rock systems of the underlying geology forms that important part of our water resource base called groundwater. The soil layer between the surface and deeper solid rock also stores water. Depending on such things as the sandiness of the soil, its depth, slope and the type of vegetation it carries, and of course the seasonal rainfall patterns, the level of saturation may vary throughout the year and from year to year. Over many, many thousands of years large areas of rock deep below the surface have taken up, and now store, large stable reserves of groundwater. These apparently solid rock masses can store water in two ways. In the first place all rock is naturally porous to some degree, and will hold water within its mass irrespective of cracking, holes or cavities. This is called primary porosity. Most rock masses have been subjected to twisting, buckling and pressure as the land surface formed. The result is that many structural features such as fault lines, shear zones, joint patterns and fractures are also able to hold and carry water. This is called secondary porosity. The action of groundwater itself can actually increase secondary porosity in some rock by dissolving and eroding holes, cavities and pipes, and so increase the capacity to store groundwater. Where rock systems are inclined it is possible for the groundwater to move downslope through the rock. This can bring groundwater over long distances, even to places where rainfall is negligible. The slope also acts to pressurise the groundwaters in the lower rocks so that springs or artesian wells are possible. The many ways in which water can move into and through the ground are complicated, beyond the simple description outlined here. In fact, this is an area of continuing investigation and research. Better understanding of recharge to and movement
of groundwaters will be vital to our use and conservation of this important resource. As a starting point, however, we should recognise the importance of geology in controlling the occurrence of groundwater.

Different processes produce different land surfaces and geological conditions below the surface. Those areas over which generally similar processes of land and rock formation have acted are called geological units. The Northern Territory can be described in terms of two types of geological unit: these are "basins" and "blocks". Basins form the majority of units across the Territory.

These are the areas where rock has been formed from sediments deposited on the floors of ancient seas and large lakes. They are called Sedimentary Basins and typical rock groups found are sandstones, siltstones, mudstones and limestones for example. It was erosion of the early landscape which supplied the sediments which were deposited to form the Sedimentary Basins. In fact remnants of that early landscape still exist and form the second type of geological unit, the Blocks. The geology of the Blocks is often complex as a result of the many, often violent, processes of deformation and heating over their long lifetimes. Their different geological histories are reflected in the different groundwater prospects which can be expected between Blocks and Sedimentary Basins. In Sedimentary Basins groundwater occurs most usually in the primary porosity, but in limestone, for example, large cavities can mean that secondary porosity gives the major storage of groundwater. In a very general sense, the potential for water supplies in Sedimentary Basins depends on the primary porosity and total depth of rock forming the Basin. Blocks on the other hand generally offer only slight primary porosity and groundwater occurs most usually in the fault and fracture zones which make up secondary porosity.
Generally speaking the Sedimentary Basins offer better prospects for water from groundwater than do the Blocks.
GEOLOGY

EROMANGA BASIN;
GENERAL SUITABLE FOR ALL USES BUT IN SOME AREAS QUALITY RESTRICTS IRRIGATION AND IN OTHERS YIELDS ARE NOT ADEQUATE FOR TOWN, INDUSTRY OR IRRIGATION.

QUALITY GENERALLY RESTRICTS USE BUT MAY BE SUITABLE FOR STOCK-WATER SUPPLIES.

QUALITY UNSUITABLE EVEN FOR STOCK-WATER.

UNDERGROUND WATERS
APPENDIX IB

Important Rivers

Victoria

This is the longest river in the Northern Territory, draining the second largest catchment area of the humid zone. With a large portion of its catchment in the drier southern part of the humid zone the Victoria River does not flow permanently and there may be wide variation in flow from one year to the next. The catchment is sparsely populated with large cattle properties throughout.

Daly

Possessing the third largest catchment in the humid zone the Daly River is the most important permanent stream in the Northern Territory. The Flora and Katherine rivers are its two main tributaries. Permanent flow is carried in the lower reaches of the Flora and the Katherine has many large permanent waterholes. Cattle properties operate throughout the catchment and dry land cropping is also being tried in a major project area. A few market gardens are successfully irrigated from the Katherine River.

Finniss

This is the name chosen for a collection of catchments near Darwin. Their importance may be measured by the fact that two reservoirs in the area, at Manton Dam and Darwin River Dam, supply water to approximately half of the Territory's population. In addition to the aspect of water supply to a population of this size the impacts of urban, industrial and recreational developments will be important.
Adelaide

At present there is only minor development in the Adelaide River catchment; mainly beef and buffalo production and several successful market gardens which irrigate from the river. There is potential for large scale irrigation in the catchment but the major importance lies in the possible future need to dam the Adelaide to supply water to Darwin.

East Alligator

This river has a most spectacular catchment with large tracts of rugged sandstone escarpment country and extensive coastal wetlands. The unique combination of landscapes and wildlife were decisive in the declaration of Kakadu National Park and its listing in the World Heritage Register. Great care is taken to ensure that minimal environmental impact occurs due to uranium mining in the area.

Buckingham

This is the name chosen for the group of catchments which includes the mining centre of Nhulunbuy on the Gove Peninsula. Care is taken here to minimise the impacts of bauxite mining and alumina refining. Apart from the Gove Peninsula the rest of the area is undeveloped and carries only a handful of settlements.

Walker

This is also a collection of catchments, including Groote Eyelandt. There is no development on the mainland but large scale manganese mining is carried out at Alyangula on Groote Eyelandt. The concern here is with controlling environmental impacts.
Roper

This is the largest catchment in the humid zone, and the issue of concern is our lack of knowledge about the river. There is little development in the area apart from pastoral activity, but the development potential of this large river and its lands are yet to be evaluated.

Todd

This is the most important stream in the arid zone. The Todd River has a catchment almost as large as the Victoria River, but its flow is only one hundredth that of its sister river in the north. High evaporation and unreliability of flows make the Todd unsuitable for water supply reservoirs, but the construction of a recreation lake at Alice Springs is under serious consideration.
APPENDIX IC

Important Groundwaters

Amadeus Basin, Wiso Basin

Both basins are formed by deep sandstones with high primary porosity. High yielding bores provide water for Alice Springs and Tennant Creek.

Daly Basin

This basin receives regular recharge from monsoon rains, and with deep sandstones and limestones provides the highest yielding bores in the Territory.

Pine Creek Geosyncline

This geological unit was originally a sedimentary basin, but many processes have greatly altered its structure and rock types. As a consequence there is great variability of groundwater. Nevertheless, several towns and mining operations rely upon groundwater from this unit.
<table>
<thead>
<tr>
<th>GEOLOGY</th>
<th>SUCCESSFUL RANGE OF TYPICAL YIELDS m³/day</th>
<th>BORES RANGE OF TYPICAL DEPTHS m</th>
<th>REMARKS/COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Victoria River</td>
<td>10-500</td>
<td>60-100</td>
<td>Faulting, variable sediments, Basin basalt cap make general comments misleading.</td>
</tr>
<tr>
<td>Bonaparte Gulf Basin</td>
<td>50-400</td>
<td>15-40</td>
<td>Shallow bores have yielded good quality, sometimes acidic water. Supplies OK for stock and homestead.</td>
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<tr>
<td>Litchfield Block</td>
<td>10-200</td>
<td>40-60</td>
<td></td>
</tr>
<tr>
<td>Melville Cretaceous Platform</td>
<td>1-250</td>
<td>5-90</td>
<td>Reliable yearly recharge, good quality, sometimes acidic water.</td>
</tr>
<tr>
<td>Pine Creek</td>
<td>5-5000</td>
<td>30-80</td>
<td>Variable geology, variable water supplies.</td>
</tr>
<tr>
<td>Geosyncline</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Daly River Basin</td>
<td>50-8000</td>
<td>20-120</td>
<td>Reliable high recharge, sandstone/limestone yield large supplies, some hard.</td>
</tr>
<tr>
<td>Arafura Basin</td>
<td>1-1000</td>
<td>5-90</td>
<td>Scattered data, good quality, sometimes acidic water.</td>
</tr>
<tr>
<td>Arnhem Block</td>
<td>1000-2000</td>
<td>70-150</td>
<td>Good quality water from sediment layers.</td>
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<tr>
<td>Basin</td>
<td>Range</td>
<td>Range</td>
<td>Additional Notes</td>
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<tr>
<td>McArthur Basin</td>
<td>50-1000</td>
<td>50-100</td>
<td>Little data, variable supplies, general comments misleading.</td>
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<tr>
<td>Wiso Basin</td>
<td>40-400</td>
<td>20-80</td>
<td>Reliable data for south-east corner only, salinity problems.</td>
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<tr>
<td>Georgina Basin</td>
<td>150-4000</td>
<td>80-120</td>
<td>Reliable data for only small area, salinity and nitrate problems.</td>
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<tr>
<td>Arunta Block</td>
<td>50-400</td>
<td>50-60</td>
<td>Most data from stock bores, much unsuccessful drilling, variable quality, fluoride, nitrate problems.</td>
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<tr>
<td>Amadeus Basin</td>
<td>40-5000</td>
<td>50-300</td>
<td>Data for north-east only, quality good.</td>
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<tr>
<td>Ord Basin,</td>
<td></td>
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<td>Insufficient or nil data.</td>
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<tr>
<td>Birrindudu Basin,</td>
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<tr>
<td>Granites-Tanami Block,</td>
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