Northern Territory Government

DEPARTMENT OF
NATURAL RESOURCES, ENVIRONMENT AND THE ARTS

Alice Springs

Water Resource Strategy

2006 - 2015

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Department of Natural Resources, Environment and the Arts

Natural Resource Management Division

Water Management Branch

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This Strategy reflects combined input from the community and government agencies and has been endorsed by the Minister for Natural Resources, Environment and the Arts. The Strategy is due for review in five years and interested persons and groups are invited to comment on this Strategy. Any comments received will be considered in the review and may be made publicly available.

The Alice Springs Water Resource Strategy is also available on CD ROM from the Water Management Branch. Further information on the Strategy is available at www.alicewaterplan.nt.gov.au.

Important Disclaimer

Delia Lawrie
Minister for Natural Resources, Environment and Heritage

MESSAGE FROM THE MINISTER

Water is a natural resource valued by all Territorians. Whether it is used for drinking, showering or washing our clothes, it is something we all need. The Northern Territory Government recognises the importance of water and is keen to avoid the extreme challenges facing our southern counterparts. One way of protecting and preserving water is to implement strategies benefiting us all. One such strategy is the Alice Springs Water Resource Strategy.

The Alice Springs Water Resource Strategy is a Water Allocation Plan, made under the Northern Territory's *Water Act 1992*. One of the catalysts for this Strategy was the National Competition Policy reforms endorsed by the Council of Australian Governments several years ago, aimed at enhanced use of daily necessities such as water.

This Strategy is vital to the sustainable development of central Australia and the Northern Territory. The importance of water in desert communities has been recognised by the Northern Territory Government, which will continue to work closely with regional communities to manage their water resources more efficiently and effectively.

The Alice Springs region is recognised as having potential for further development but there are limits to which the region's water resources can be used to support economic growth, improve social systems and maintain environmental integrity. This Strategy aims for the best long-term use of water by balancing economic, social and environmental needs and assigns limits within an expanded Water Control District in the Alice Springs region.

The Strategy is the starting point for a shared understanding of the region's water resources. It explains the behaviour and interaction of rivers and groundwater and describes the range of regional water needs and how they will be met. It sets a direction for future water resource assessment, planning, development and use within sustainable limits.

The Strategy is an invaluable reference for those who need, use and manage the region's water resources. I am pleased this Strategy has been developed through a successful regional partnership with landholders, industry representatives, community groups and Northern Territory Government agencies, working together as part of the Alice Springs Water Resource Strategy Steering Committee.

I acknowledge the efforts of those individuals appointed to the Steering Committee and thank them for their contribution to the sustainable management of water resources in the Alice Springs region. I look forward to appointing a similar group of dedicated individuals to form a Water Advisory Committee to guide the implementation of this Strategy.

In accordance with the *Water Act*, I have determined that the Water Allocation Plan for Alice Springs will have a lifetime of ten years (2006-2015) and will be subject to a review within five years, led by the Alice Springs Water Advisory Committee. I hope this regional partnership will continue for many years and become an example to other communities across the Territory.

September 2007

EXECUTIVE SUMMARY

The Alice Springs Water Resource Strategy has been motivated by local community concerns about the sustainability of water resources in the region and informed by the national water reform agenda. The mechanism for implementation of the Strategy is provided by NT legislation. In declaring beneficial uses and a Water Allocation Plan for the expanded Alice Springs Water Control District, the Strategy reflects the principles of equity, efficacy and efficiency in respect of water rights and entitlements.

A community-based, Ministerially-endorsed, Alice Springs Water Resource Strategy Steering Committee oversaw the development of this Strategy. Public participation was an important part of the process. Community information, education and opinion, have been crucial in creating acceptability and accountability in the search for the triple bottom line – protecting environmental and cultural values while providing for existing and emerging industries.

In addition to providing the Alice Springs community with improved certainty regarding water allocations, the Strategy also sets the framework for a shared understanding of the resource, identifying opportunities and debating what may or may not be acceptable in the longer term. It provides an adaptive framework to amend allocations in light of new findings and improved understanding. Adaptive management is based on accumulated experience, reflective learning and improved knowledge.

The Strategy adopts a conservative approach to water allocation because of inherent limitations in the available science, based as it is, on averages, extrapolations and some qualified assumptions about known water resources. The Strategy attempts to quantify a complex set of natural systems, known collectively, as the water cycle. With significant variability in rainfall, surface water runoff and recharge to groundwater, there remain a number of areas under investigation.

The Strategy includes three broad policy zones; surface water (rivers), groundwater (Alluvial Aquifers); and groundwater (Amadeus Basin Aquifers). These zones are separate in a policy sense although their natural interconnectivity has been recognised. Contingent allocations were developed to guide the approach in each of the policy zones, so that at least 95% of flow at any time in any part of a river is allocated to the environment with no deleterious change in groundwater discharges to dependent ecosystems.

Consumptive and non-consumptive demands have been determined and beneficial uses have been declared for each of the eight management zones; Upper Catchment; Lower Catchment; Town Basin; Inner Farm Basin; Outer Farm Basin; Wanngardi Basin, Roe Creek; and Rocky Hill / Ooraminna.

Allocations to each of the beneficial use categories are based on a working definition of 'sustainable yield' known as 'maximum allowable yield' which protects environmental systems and preserves an acceptable amount of water for future generations, so that no more than 5% of flow shall be diverted at any time in any part of a river; total extraction from Alluvial Aquifers shall be based on estimated average annual recharge; and total extraction from Amadeus Basin Aquifers over a period of no less than 320 years shall not exceed 80% of the total aquifer storage at the start of extraction or not more than 25% of the total aquifer storage extracted every 100 years.

The allocation of a majority of the groundwater in the Amadeus Basin Aquifers to public water supply allows for increasing demand for potable water. Using the demand scenario adopted in the Strategy, extraction for public water supply will need to be capped at 10 731 ML/yr, which is the rate of demand expected to be reached in 2017. Existing entitlements will necessarily be curtailed to maintain consistency with the Strategy in the future. Other factors influencing the amount available for extraction in the future include additional hydrogeological evidence which may influence the estimate of available storage, improved extraction methods, water reuse and blending techniques or reallocation of the amount of water available for horticulture at Rocky Hill.

Importantly the Strategy does not account for any demand management programs that may be considered by the NT Government, or individual licensees, in response to the prospect of having a finite and dwindling resource. A water efficiency program would go some way towards reducing per capita water consumption in Alice Springs, which is among the highest in Australia.

Groundwater extraction licences and trade in water licences will need to be approved by the Controller of Water Resources or the Minister, in accordance with the declared Water Allocation Plan. New applications will be considered depending on the economic and social benefits to the Northern Territory, consistent with existing environmental and cultural values. Applications for new groundwater extraction licences or water trading licence entitlements shall be subject to review by the Water Advisory Committee. Records of all licences and water trades will be contained in a publicly-accessible water register.

A review of the Strategy is scheduled to take place every five years. A series of priority issues will be addressed in current and future work programs to guide the Water Advisory Committee's advice on the implementation of the Strategy. The first review will address areas such as rainfall and recharge, surface water and groundwater interactions, Indigenous water rights and values, groundwater dependent ecosystems, protection from contamination, salinity and groundwater quality, water recycling and reuse and demand management measures.

This document (Volume 1) should be viewed in combination with its companion document (Volume 2) which contains annotated maps of the Strategy region. Both documents have been made available on compact disc.

CONTENTS

VOLUME 1 – REPORT

CONTENTS

LIST OF FIGURES

LIST OF TABLES

CONTENTS

VOLUME 2 – MAPS AND SUPPORTING MATERIAL

PART 1 BACKGROUND

1.1 The Purpose

The Alice Springs Water Resource Strategy summarises the present understanding of water resources and water demand, defines water allocations, establishes mechanisms for community involvement and sets a strategic work plan to manage the water resources of Alice Springs over the next 10 years.

This strategy has been prepared to provide for the best long term use of Alice Springs water resources balancing social and environmental protection while allowing for economic growth. It aims to avoid economic costs and environmental losses due to over-extraction, salinity and poor water quality, and to better coordinate the management of Alice Springs water resources. It seeks to present a common understanding and means to manage potentially conflicting interests toward the best public and environmental good.

The development of this Strategy also reflects the Northern Territory Government’s commitment to national water reforms. It sets a framework for management and allocation decisions involving judgements informed by the best available science, socio-economic analysis and community input.

The Alice Springs Water Resource Strategy should be considered a living document. It establishes a clear, transparent and adaptive process to improve understanding and management of this important resource. The Strategy will be reviewed every 5 years, under the supervision of the Alice Springs Water Advisory Committee.

1.2 The Region

Alice Springs lies in the heart of Australia’s arid zone, in the southern part of the Northern Territory approximately halfway between Darwin (1 508 kilometres north) and Adelaide (1 526 kilometres south). The water resources of Alice Springs have supported the Arrernte peoples of Central Australia for many thousands of years. The town’s location was chosen for European settlement in 1871 due to the availability of water in the sandy bed of the Todd River.

Map 1 shows the regional setting of the Alice Springs Water Control District and the area covered by this Strategy (called the ‘Strategy region’ in this document). The Water Control District currently has an area of 8 200 km^2. The Strategy region encompasses the catchments of the Todd River and a portion of the groundwater aquifers in the northern part of the Amadeus Basin in the immediate vicinity of the township of Alice Springs, where there is greatest current and projected demand. The remaining portion of the Water Control District to the south of the Strategy region is identified for future consideration as the region develops.

Alice Springs is a regional centre with a residential population of 26 058 (ABS 2005). Most of the population live within the Alice Springs Municipal Area. A small number of communities and cattle stations are situated in the Strategy region, outside the existing boundary of the Alice Springs Municipal Area.

Almost all of the water supplies in the Strategy region are drawn from groundwater, either from alluvial sediments or from rock aquifers in the northern part of the Amadeus Basin, with the exception of some surface water retention in small dams for stock use. Map 2 shows the extent of Alluvial Aquifers and Amadeus Basin Aquifers in the Strategy region.

A considerable area of land suitable for irrigated horticulture overlies these significant groundwater resources. Broad scale mapping of soils has been completed for a large portion of the Alice Springs region and more definitive information is available in some localities.

In addition to supporting the area’s unique environment and areas of traditional significance, the water resources of the Alice Springs region support all major economic activities of Alice Springs including residential development, tertiary industries (including tourism and regional support functions), defence, pastoral production and horticulture. Maps 3 and 4 show the land tenure and land use in the Strategy region. Presently irrigated horticulture within the Strategy region totals 48.5 hectares (ha) for table grapes at Rocky Hill; but there are other small areas of horticultural development, and potential exists for future expansion.

PART 2 WATER MANAGEMENT POLICIES

2.1 The Council of Australian Governments water reforms

In 1994 the Council of Australian Governments (COAG) agreed to take a number of actions to stop the degradation of water resources and to achieve efficient and sustainable water use. These actions relate to pricing reform, research into environmental water needs and allocation of water to meet these needs, trading of water entitlements, administrative arrangements and other matters. COAG agreed that environmental water requirements would be determined on the best scientific information available, but contingency environmental allocations could be made as an interim measure. Contingency allocations should be reviewed after five years.

2.2 The Intergovernmental Agreement on a National Water Initiative

In June 2004 an intergovernmental agreement on a National Water Initiative set out a number of actions to put into place the reforms intended by COAG in 1994. The parties to this agreement are the Commonwealth of Australia and the Governments of New South Wales, Victoria, Queensland, South Australia, the Australian Capital Territory and the Northern Territory. The parties agreed to a timetable of actions to be carried out under implementation plans to be developed by each party within 12 months of signing the agreement. This draft Strategy is part of the NT's implementation plan. The Strategy has been written according to the guidelines for water plans set out in the Intergovernmental Agreement, as far as is allowed by the scope of the NT *Water Act*.

2.3 The Water Act 1992

The NT *Water Act* 1992 guides all aspects of water use and management, including how water resources are investigated, allocated and protected in the Northern Territory. The Minister for Natural Resources, Environment and Heritage administers the Act through the Controller of Water Resources. The Strategy takes formal effect when it is declared as a Water Allocation Plan under Section 22B of the NT *Water Act*.

2.4 Defining Sustainable Yield

Although there is general agreement on the desirability of sustainable water use, there are many interpretations of what sustainability is in practice. Determination of a sustainable extraction regime from a groundwater basin requires an understanding of basin hydrogeology that is, an assessment of how much water the basin contains and the rate of water flow into and through the basin. If extraction is concentrated at one point of a groundwater basin, the effects of this extraction combined with low rates of replacement inflow may result in a local area of declining water levels, even if extraction is within the limits of sustainability for the basin as a whole.

The National Groundwater Committee (2004a) defines sustainable groundwater yield as:

"The groundwater extraction regime, measured over a specified planning timeframe that allows acceptable levels of stress and protects dependent economic, social, and environmental values."

The term 'extraction regime' is used rather than extraction volume, because specifying an extraction volume in itself is unlikely to be an adequate measure to achieve sustainability. Management of extraction to achieve sustainability may involve varying the rate of extraction in response to triggers such as changes in standing water level or water quality.

The concept of 'acceptable levels of stress' recognises the need for a trade-off between environmental, social and economic needs. This approach acknowledges that groundwater extraction may result in some depletion of groundwater storage. The community may consider this resource depletion acceptable relative to the economic and social benefits, provided the resource is used efficiently and is well managed.

Community consultation, which was important in the preparation of this Strategy, revealed a common understanding and acceptance that a portion of the water resources of Alice Springs is essentially being 'mined'. However the community did not consider the term 'sustainable groundwater yield' to be appropriate in the context of an unsustainable use. The term 'maximum allowable yield' was preferred by the community to describe the acceptable rate of depletion of the groundwater resource.

2.5 Policy Approach to Water Allocation

The framework below specifies the policy approach for planning and managing water resources within the Alice Springs Water Resource Strategy region.

ALICE SPRINGS WATER RESOURCE STRATEGY FRAMEWORK

All available scientific research directly related to environmental and other public benefit requirements for the water resource will be applied in setting environmental and other public benefit water provisions as the first priority, with allocations for consumptive use made subsequently within the remaining available water resource (termed the consumptive pool).

In the absence of scientific research directly related to environmental and other public benefit water requirements, the following contingent allocations are made for environmental and other public benefit water provisions and consumptive use:

Surface Water (Rivers)	**Groundwater (Alluvial Aquifers)**	**Groundwater (Amadeus Basin Aquifers)**
at least 95% of flow at any time in any part of a river is allocated to the environment; <u>and</u> no more than 5% of flow may be diverted at any time in any part of a river.	there will be no deleterious change in groundwater discharges to dependent ecosystems; <u>and</u> total extraction will be based on estimated average recharge, including urban and rural activities, less evapotranspiration and outflow.	there will be no deleterious change in groundwater discharges to dependent ecosystems; <u>and</u> total extraction over a period of no less than 320 years will not exceed 80% of the total aquifer storage of the combined volume of the Amadeus Basin Aquifers at the start of extraction.

In the event that current and/or projected consumptive use exceeds threshold levels or discharges to dependent ecosystems are impacted, then:

New Surface Water Licences will not be granted unless supported by directly related scientific research into environmental water requirements.	**New Groundwater Licences** will not be granted unless supported by directly related scientific research into the requirements of groundwater dependent ecosystems

The planning policy for groundwater extraction from the Amadeus Basin Aquifers, as detailed above, is derived from the default NT-wide policy which states that total extraction over a period no less than 100 years will not exceed 80% of the total aquifer storage at the start of extraction.

As a result of intensive consultation used to develop this strategy (*Community Consultation Report*, 2005), a more conservative approach than the default position is considered appropriate for Alice Springs. Therefore within the Alice Springs Water Resource Strategy region, current and future water extraction from the combined volume of Amadeus Basin Aquifers must not exceed 80% depletion of total available aquifer storage over a period no less than 320 years. This rate is equivalent to the maximum allowable yield and is used as the initial planning tool in developing this first strategy for Alice Springs. Alternatively, the maximum allowable yield can also be described as the rate of extraction that will not exceed 25% depletion of the total aquifer storage within 100 years.

The maximum allowable yield for the Alice Springs Water Resource Strategy region reflects the acceptable level of depletion of storage from the principal aquifers that support Alice Springs relative to economic and social benefit. The maximum allowable yield for the Strategy region was determined through a comprehensive process of community engagement which included several community forums, surveys, public submissions and the participation of a ministerially appointed Steering Committee of community stakeholders.

2.6 Beneficial Use Definitions

The various uses of rivers and groundwater are defined by the *Water Act* as 'beneficial uses'. The declaration of beneficial uses is one of the key factors determining how the community and government will protect, manage, and use the water resources of a particular region. Beneficial uses can be applied to an overall water resource or individual water management zones. This Strategy will be used to declare beneficial uses for Surface Water (upper and lower catchments), Alluvial Aquifers (Town Basin, Inner Farm Basin, Outer Farm Basin and Wanngardi Basin) and Amadeus Basin Aquifers (Mereenie Aquifer System, Pacoota Sandstone, Shannon and Goyder Formation).

The term 'environmental values' is often used to describe beneficial uses in other States and Territories. The two terms can be used interchangeably however, to be consistent with the NT *Water Act*, only the term 'beneficial uses' will be used in this Strategy (see Table 1).

Table 1. Beneficial use categories and definitions as defined under the NT *Water Act*

BENEFICIAL USE CATEGORY	THIS CATEGORY PROVIDES WATER FOR:
Non-Consumptive Uses:	
Environment	maintain the health of aquatic ecosystems (e.g. groundwater-dependent ecosystems)
Cultural	aesthetic, recreational and cultural needs
Consumptive Uses:	
Public Water Supply	source water for drinking purposes delivered through community water supply systems (e.g. general residential/commercial use)
Agriculture	irrigation for primary production including related research (e.g. horticulture)
Rural Stock and Domestic	homestead with an attached garden up to 0.5 ha and grazing stock
Aquaculture	commercial production of aquatic animals including related research
Industry	industry, including secondary industry and a mining or petroleum related activity, and for any other industry uses not referred to elsewhere in this subsection (e.g. irrigation of parks and ovals)

2.7 Principles for Planning and Management

The NT *Water Act* states the purpose of the Water Allocation Plan is to ensure:

- Water is allocated within the estimated sustainable yield to beneficial uses;
- Water is allocated to the environment;
- The total water use for all beneficial uses is less than the sum of the allocations to each beneficial use;
- The right to take water under licence is able to be traded;

The NT *Water Act* also makes provision for a Water Advisory Committee to advise on the effectiveness of the Water Allocation Plan in maximising economic and social benefits within ecological restraints.

Further to the role of a declared Water Allocation Plan, as defined under the NT *Water Act*, the following seven key principles were developed by the community-based Alice Springs Water Resource Strategy Steering Committee which assisted in the preparation of this Strategy, to guide the long term development and implementation of the Alice Springs Water Resource Strategy:

- The Strategy should consider the needs of future generations reflected through a conservative approach to water allocation
- The Strategy should encourage the advancement of best practice in water efficiency and the development of high value, creative and innovative uses for water
- The Strategy should deliver solutions to water management issues that are developed through a triple bottom line approach to balance economic, social and environmental needs
- The Strategy should be developed and managed through equitable, representative community participation that maximises local determination
- The Strategy should be adaptive, encouraging reflective learning, improved knowledge and utilising accumulated experience
- The Strategy should maximise economic and social benefits of water extraction for the Alice Springs region and the Northern Territory.
- The Strategy should be administered through efficient processes

PART 3 KNOWN WATER RESOURCES

3.1 Overview

A scientific approach to understanding complex and interrelated natural processes underpins the Government's ability to forecast, plan and manage the water resource.

Alice Springs is situated in the Central Australian arid zone. Rainfall patterns are unpredictable, in that rainfall can occur at any time of the year, and is extremely variable between years. Average rainfall data (see Figure 1) has limited application as a predictive tool for water resource assessment, however, in some cases, it remains a good indicator of groundwater recharge, especially where the relationship between rainfall, surface water flow and groundwater recharge can be determined. These relationships are highly variable in time and space.

There is virtually no permanent surface water in the region. Consequently, Alice Springs depends almost entirely on underground water for all current and future development needs, except for the provision of some stock watering points around dams. The region overlies a series of underground aquifers that are recharged by the movement of groundwater, which is derived from both recent and ancient rainfall travelling through rock and sediment over time, and from seepage (infiltration) from ephemeral rivers and floodout areas.

The main sources of groundwater supporting the region are shown in Figure 2 and are identified in this Strategy as the Alluvial Aquifers (which include; Alice Springs Town Basin, Alice Springs Inner Farm Basin and Alice Springs Outer Farm Basin) and Amadeus Basin Aquifers (which include; Mereenie Aquifer System, Pacoota Sandstones as well as the Shannon and Goyder Formations).

The surface catchments and groundwater systems of the Strategy region are interconnected; flows in the Todd River consecutively provide recharge to the Alice Springs Town Basin, Inner Farm Basin and Outer Farm Basin before finally connecting with the underlying permeable rock layers in the northern section of the Amadeus Basin. Groundwater flows in the sediments of the catchment and floodout areas continue long after high surface water flow has subsided and provide an unseen connection between the various parts of the system.

Groundwaters of the Alice Springs Town Basin move in an overall southerly direction, both in the bed sediments of the Todd River and along buried river channels (called palaeo-channels). Town Basin groundwaters then move south, through Heavitree Gap, to the Inner Farm Basin before passing Mount Blatherskite on their way to the Outer Farm Basin. This happens over long periods of time while natural discharge from the aquifers is balanced by recharge from rainfall in the catchment and intermittent surface water flow in the Todd River.

The relationship between groundwater recharge, throughflow and natural discharge may be altered by rural and urban development which increases the extraction of groundwater and has been known to cause dewatering of the aquifer or, as in the case of the Town Basin recently, may increase artificial recharge to the underlying aquifer.

Groundwater in the Alice Springs region contains naturally occurring dissolved salts. The concentration of dissolved salts is used as a general indicator of water quality. In the shallow alluvial aquifers, evaporation close to the surface works to increase the residual concentration of salt, especially in areas where irrigation has taken place. The concentration of salt in the deeper Amadeus Basin Aquifers is fairly constant although it does vary spatially. Water quality is also affected by urban development.

The older rocks, in the northern section of the Amadeus Basin, immediately south of Alice Springs, underlie the much younger sediments of the Outer Farm Basin and extend westward beyond the Western Australian border. Both the current town water supply borefield located at Roe Creek and the proposed future town water supply borefield at Rocky Hill tap into the north-eastern corner of this large aquifer system.

Central Australia contains unique examples of plant and animal communities that depend partly or completely on groundwater. River red gums (*Eucalyptus camaldulensis*) are an iconic example of species growing along watercourses and in areas where groundwater is close to the surface. The ancestors of Central Australia's modern Indigenous inhabitants experienced a close association with the landscape over the millennia. Arrernte peoples retain a spiritual association with the country and value its water resources for traditional and other purposes.

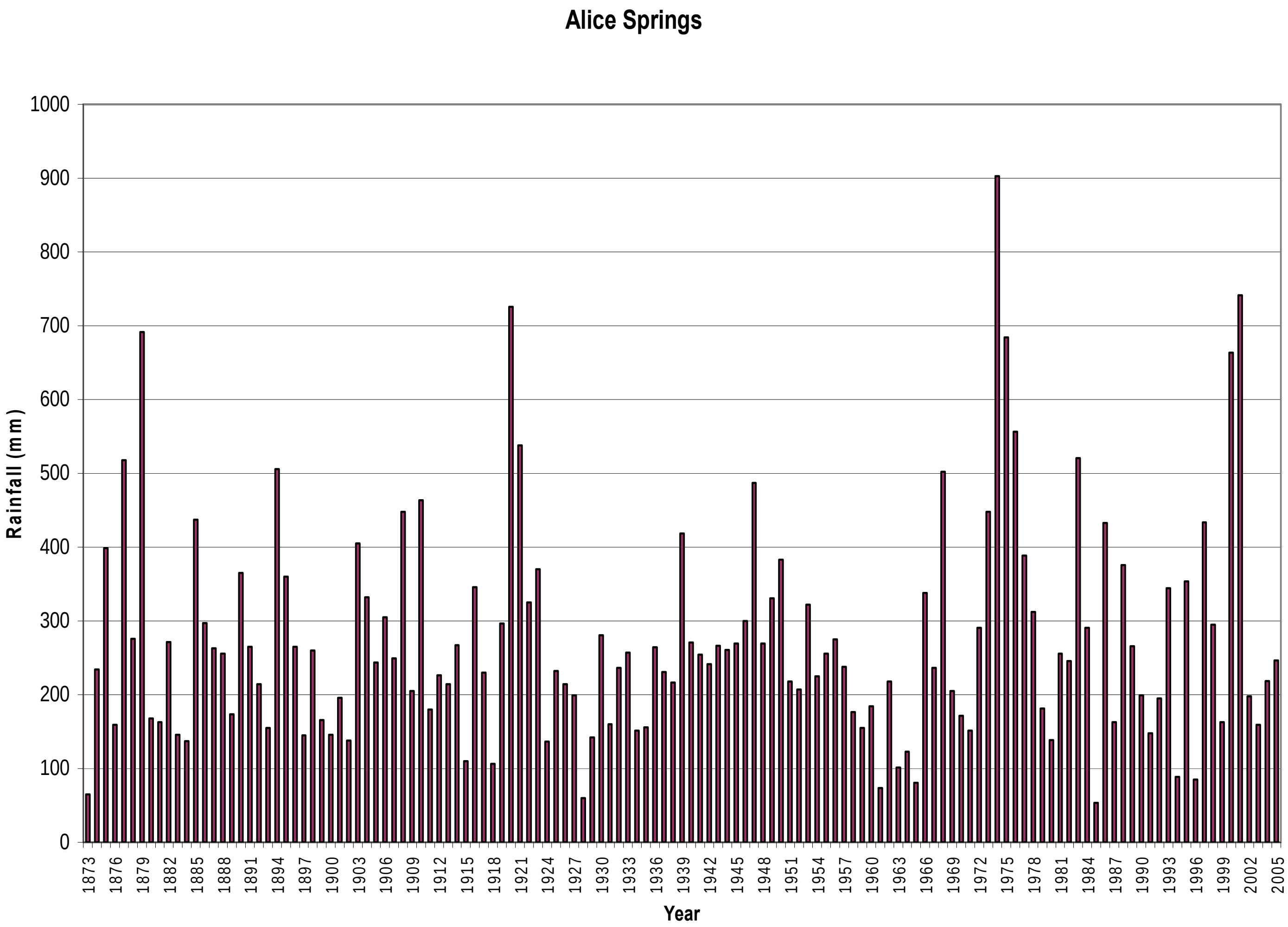
The surface water and groundwater systems of Alice Springs can be characterised by their interconnectivity. This Strategy incorporates the most recently updated scientific assessment of the relationship between surface water and groundwater systems, while identifying and describing the individual components of the system separately to allow for more efficient management of the available resource.

Water volumes are expressed as megalitres, or millions of litres (ML).

3.2 Rainfall

Figure 1 shows a continuous record of annual rainfall for Alice Springs from 1873 to 2005. Alice Springs has an average annual rainfall of 286 mm per year however annual rainfall totals from year to year are extremely variable, ranging from a minimum of 60 mm (1928) to a maximum of 903 mm (1974) with a median of 238 mm. Average annual rainfall over the entire Strategy region represents a total of 750 000 ML. Pan evaporation is very high, at approximately 3 000 mm per year, suggesting that much of the rainfall in the Strategy region is returned directly to the atmosphere.

Figure 1. Alice Springs annual rainfall 1873 – 2005



Source – BOM, 2005

The variability of rainfall patterns in space and time results in periods of extended drought, occasional years of higher rainfall and rare years of very high rainfall. The result is that it is very difficult to predict the amount of rainfall that might be expected to fall within the Strategy region from month to month or year to year.

There is little seasonality in monthly rainfall averages meaning that rainfall can occur at any time of year. The most intense rains occur as a result of localised thunderstorms associated with monsoonal activity in the tropics during summer months. Infrequently there are periods of widespread winter rains due to the influence of fronts moving across the Great Australian Bight. These winter rains are usually light but occasionally may be heavy.

The relationship between rainfall, surface water flow and groundwater recharge is complex and variable depending on such things as the timing, volume and geographical extent of seasonal rainfall events, topography, soil structure and underlying geology.

3.3 Surface Water

The surface water features of the Strategy region are dominated by the Todd River Catchment (see Map 5). The area contains a series of creeks that flow intermittently and drain into the Todd River. The elevation of the Todd River catchment ranges from 900 m AHD on Bond Springs Station north of the MacDonnell Ranges to 570 m AHD on the Emily Plain.

The upper catchment consists of broad shallow valleys and undulating plains with slopes of 1-3%. In contrast the central portion of the catchment consists of rugged terrain with rocky hills and steep mountain ranges with slopes of up to 60%. This steep bed slope leads to relatively high flow in stream channels, for example the maximum recorded flow, over 48 years of records, is 1.2 ML/sec in 1988 at the Anzac Oval gauge on the Todd River. The lower part of the catchment, south of Heavitree Gap, opens out to a broad alluvial plain.

The Todd River bisects the Strategy region, initially flowing in a southerly direction through the township, then passing through Heavitree and Blatherskite Ranges and eventually progressing in an easterly direction along the Emily Plain. Charles Creek flows east from Simpson's Gap National Park and becomes a tributary of the upper Todd River. Gillen Creek flows east from Mt Gillen and joins Chinaman Creek which drains into the Todd River just north of Heavitree Gap. On the eastern side of the Todd River, Emily Creek, Jessie Creek and Red Range Creeks travel southwards through a series of gaps in the Heavitree Range and individually join the Todd River on the Emily Plain. Roe Creek is another significant tributary to the west, running in a south-easterly direction through the MacDonnell Ranges, before channelling through Honeymoon Gap and Temple Bar to join the Todd River on the Emily Plain.

Stream records have been collected for the Todd River and a number of its tributaries since the 1960s. River height records confirm the highly episodic and ephemeral nature of surface water flow in the Strategy region. Flow occurred in the Todd River 142 times in the 31 years between 1973 and 2003. Few of these flows reached the eastern edge of the Emily Plain; river flow south of Heavitree Gap floods out into a number of minor channels and either evaporates or sinks into the sand and gravel of the flood plain, providing recharge to the groundwater system. Roe Creek responds to rainfall quite differently. It only flowed 40 times during the 31 year period between 1973 and 2003.

A number of proposals for dams have been investigated for the Todd River and Emily Creek for recreation, flood mitigation and augmentation of water supply. However, surface storage of water is largely recognised as unattractive except for stock dams because of the low rainfall, unreliable runoff, high evaporation, the relatively small catchments for many of the areas suitable as sites for storage dams, and issues relating to sacred sites, biodiversity and sedimentation.

There are no permanent surface water bodies in the Strategy region. Semi-permanent water bodies include: Wigley Waterhole, Junction Water Hole, Telegraph Station, and Heavitree Gap Water Hole on the Todd River; Simpsons Gap on Roe Creek; and the Emily Gap waterhole on Emily Creek, as well as a number of small stock dams. Intermittent creek and river flows support riparian vegetation dominated by river red gums (*Eucalyptus camaldulensis*). Other vegetation communities including those within Coolibah Swamp, Conlon's Lagoon, Ilparpa Swamp and smaller claypans are supported by drainage depressions and flood outs, and are not sustained by groundwater.

The amount of vegetation cover in the catchment varies from year to year in response to rainfall. Reduced vegetation cover during drier periods results in reduced rainfall capture and a greater proportion of surface water runoff. Changing burning practices and total grazing pressure further modify runoff. Because of the steep slopes within the catchment there is a potential for large flash floods to occur in Alice Springs.

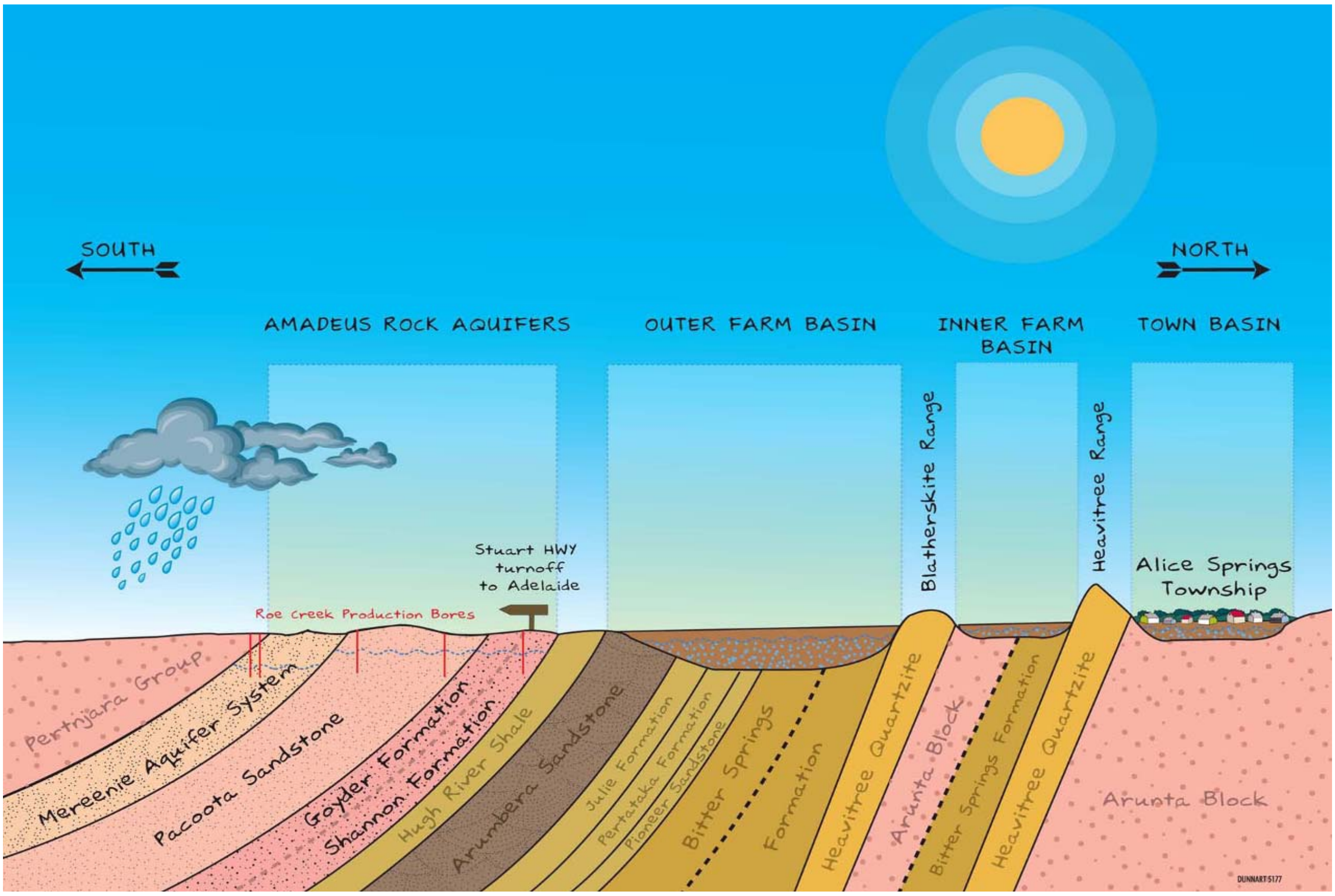
The Todd River continues to hold traditional significance for the Arrernte peoples of Central Australia. Sections of the Todd River and its tributaries form part of several Dreaming tracks. A number of river red gums located in the riverbed are listed as sacred sites and others are considered significant. Swamps, springs, water holes, soaks and their associated ecosystems continue to be of great spiritual and cultural importance to the Central Arrernte people. The Federal Court held that native title rights and interests exist in the Todd and Charles Rivers and elsewhere in the Alice Springs Determination area.

3.4 Groundwater

Geology

The dramatic landforms of the Alice Springs region reflect an ancient and complex geological history. Figure 2 shows schematic cross-section of geological features of the regional aquifers. A table of geological eras and periods and a description of geological formations are given in Appendix 1. The region is dominated by two major geological units, the Arunta Block and the Amadeus Basin. The Arunta Block is composed of extremely old rocks which generally do not contain useful quantities of water, unless fractured by earth movements. The Amadeus Basin is composed of relatively younger rocks formed by successive deposits of sediments which have been altered by pressure over time. Rocks in the northern part of the Amadeus Basin may be very porous and have good water holding potential. This Strategy deals with selected parts of the regional geology that are likely to be important because the aquifers contain known useful quantities of reasonable quality water, or are relied upon by existing users. Other, currently unused or poorly understood aquifers, which may also contain small supplies or poorer quality water, are not addressed within this Strategy; this however does not preclude their use in the future.

Figure 2. Cross section of the water-bearing formations of Alice Springs



Understanding Groundwater

Map 6 shows the groundwater features of the Alice Springs region. The aquifers of the Strategy region are dynamic systems in which characteristics such as storage volumes, flow rates, yields and water quality vary over time. The volumes referred to in this document should be understood as approximations within a range of possible values. The following sections provide a summary of the most up-to-date scientific knowledge about the occurrence and behaviour of groundwater water resources in the Alice Springs region.

Hydrogeologists make detailed studies of how water moves through the ground. By determining the rate and direction of groundwater flow, and by assessing aquifer characteristics, they are able to estimate how much water is available for use. The rate of groundwater flow indicates how quickly water moves in to replace water that is pumped out. An aquifer's ability to convey water is usually described as transmissivity, expressed as square metres per day. The storage coefficient indicates the volume of water available for extraction as a percentage of the total capacity of an aquifer; good aquifers generally range from 5% to 20%. The amount of water that flows from a bore, termed bore yield, is expressed in litres per second (L/s). A complete summary of the characteristics of the aquifers in the Strategy region is detailed in Appendix 2.

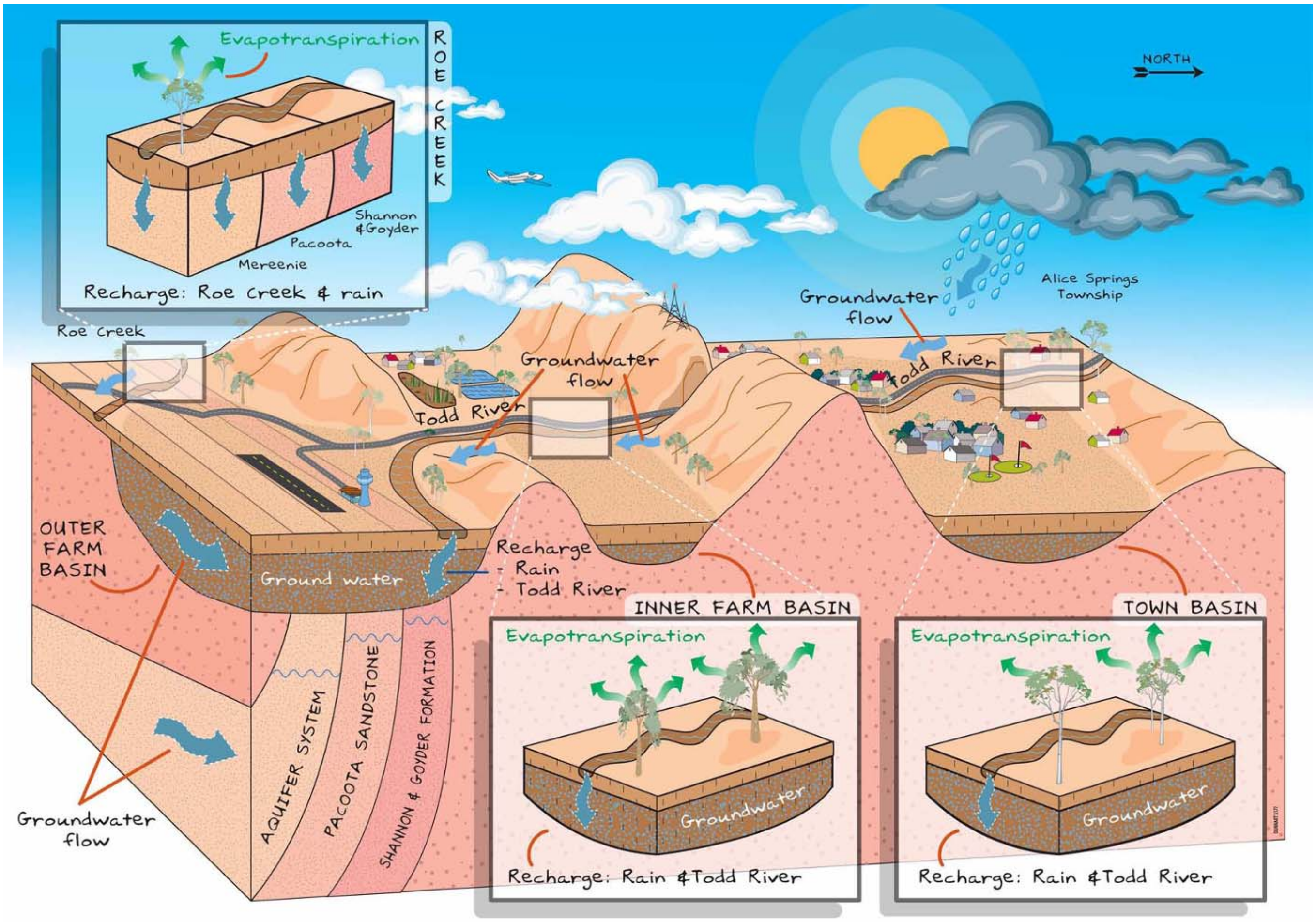
Groundwater Dependent Ecosystems

Groundwater dependent ecosystems are plant and animal communities that depend partly or completely on groundwater. Examples of these ecosystems in Central Australia might include spring-fed wetlands, vegetation growing along watercourses, animal and plant communities in areas where groundwater is close to the surface, and even animal communities that may live in aquifers.

Some species which are groundwater dependent have cultural significance. An example may be the river red gums along sandy watercourses. The Northern Territory government has obligations in law and through intergovernmental agreements to protect biodiversity and provide water for environmental needs. However at this stage knowledge about groundwater dependent ecosystems remains very limited.

There is uncertainty about which ecosystems are groundwater dependent, how much water is needed to maintain groundwater dependent ecosystems, or how sensitive they may be to changes in water quality or availability. Nevertheless there is sufficient qualitative understanding of the links to the main groundwater resources for allocations to be made. This Strategy adopts a conservative approach and specifies further work to improve understanding, as required by the national water reform agenda (see Section 2.1).

Figure 3. Surface water and groundwater interactions in the Alice Springs aquifers



General Extent and Quality of Groundwater

The locations and extent of the groundwater features of the Strategy region are shown in Map 7. The regional groundwater quality map is followed by a series of maps which show the water quality features of Alice Springs aquifers in greater detail; Map 8 Town Basin and Inner Farm Basin; Map 9 Outer Farm Basin; Map 10 Amadeus Basin Aquifers in the vicinity of Roe Creek borefield (existing Alice Springs public water supply) and Map 11 Rocky Hill (proposed future borefield for Alice Springs public water supply).

Total Dissolved Solids (TDS), referred to as salinity, broadly determines the potential uses of groundwater. According to the Australian Drinking Water Guidelines, water with a TDS of less than 500 milligrams per litre (mg/L) is regarded as good quality drinking water. Fair quality drinking water ranges between 500 mg/L - 800 mg/L and poor between 800 mg/L and 1000 mg/L. Water quality exceeding 1 000 mg/L is regarded as unacceptable for human consumption. These guidelines are based on taste; there are no known health effects specifically associated with high TDS concentrations (NHMRC, 1996). Preferred salinity for irrigation water is less than 1 000 mg/L, but some crops can tolerate salinity up to 1 500 mg/L. Presently there are few options for horticultural use where salinity is more than 1 500 mg/L. The maximum recommended TDS value for stock water is 10 000 mg/L. Stock may have an initial reluctance to drink if TDS is between 4 000 mg/L – 5 000 mg/L, but they should adapt without loss of production. From 5 000 mg/L to 10 000 mg/L loss of production and a decline in animal health would be expected.

Salinity has been used as the main determinant for water quality, however scope remains for more detailed assessment of other water quality parameters, for example hardness, to identify any other limits on the suitability of water quality in the Strategy region.

Alluvial Aquifers of Alice Springs

Town Basin

The Town Basin is defined as the area of alluvial sediments of the past and present Todd River extending north from Heavitree Gap. The aquifer has an area of 7.7 km^2 and maximum depth of 25 metres with groundwater generally 6 metres below the surface. The alluvial sediments consist of a mixture of gravel, sand, silt and clay. Most of the Basin is filled with silt of low permeability.

A key feature of the Town Basin is high variability in standing water levels and storage volume due to the intermittent and variable patterns of rainfall and recharge. Water levels since the early 1950s have fluctuated by about 9 metres and have remained unnaturally high since 1975.

The dominant direction of groundwater flow is southwards, towards and through Heavitree Gap, with an estimated average discharge to the Inner Farm Basin in the order of 80 ML per year in its natural state and 40 ML per year today. It must be remembered that this amount fluctuates greatly from year to year in response to rainfall variations.

The best quality groundwaters are in strips of sand and gravel marking buried courses of the former Todd and Charles rivers. Depth to groundwater varies in response to seasonal changes, pumping regimes, the effects of runoff from paved areas and over watering of grassed areas.

The underlying and fringing weathered bedrock of the Arunta Block contains large reservoirs of salt. This bedrock can significantly influence water quality in the Town Basin as saline water associated with this bedrock is drawn towards production bores in response to pumping.

The salinity of groundwater in the Town Basin has been increasing, partly as a result of rising water tables mobilising salt from the fringing weathered bedrock, and also because of increased evaporation and secondary salinisation associated with recharge from the potable town supply in the form of garden over-watering.

Overall water quality in the Town Basin is also influenced by urban and industrial development.

Inner Farm Basin

The Inner Farm Basin is situated immediately south of the Town Basin, straddling the Todd River in the area between Heavitree Gap and Mount Blatherskite. The Inner Farm Basin is composed of recent Quaternary alluvial sediments (1.6 million years ago to the present), older Tertiary sediments, and underlying Bitter Springs Formations consisting of dolomite, limestone and siltstone. The aquifer has an area of 0.8 km^2 and is formed from ancient flows of the Todd River. The sediments are up to 40 metres deep with groundwater generally 6 metres below the surface.

As in the Town Basin, the direction of groundwater flow is generally southwards beneath the Todd River and towards and through the Blatherskite Range, with an estimated discharge to the Outer Farm Basin of 310 ML per year.

Outer Farm Basin

The Outer Farm Basin extends south and southeast of Mount Blatherskite and is associated with the Emily Plains floodout. It comprises alluvial and other sediments overlying the northern part of the Amadeus Basin. The sediments are relatively low yielding clays and sandy clays.

In the northern parts of the western Outer Farm Basin the water table is relatively shallow (currently around 12 metres from the surface) but this increases to around 60 metres in the southern parts. There are large fluctuations in water levels between river recharge events particularly following successive years of high rainfall and during extended drought periods.

Wanngardi Basin

The Wanngardi Basin fans outwards from Honeymoon Gap to a maximum width of 2 kilometres, then reduces in width to 400 metres at Temple Bar Gap. The thickness of the alluvium is extremely variable but averages 15 metres. This basin provides water to the Wanngardi and White Gums rural subdivisions, although some bores in the area draw water from the underlying bedrock.

Detailed information on aquifer properties and processes is not yet available for the Wanngardi Basin and could be a priority for future investigations.

3.5 Alluvial Aquifers

Recharge

Recharge (replenishment) of groundwater to the Alluvial Aquifers in the Strategy region occurs from rainfall, surface water flow, and throughflow from adjacent geological formations. The groundwaters of the Alluvial Aquifers (Town Basin, Inner Farm Basin, Outer Farm Basin and Wanngardi Basin) are relatively recent and derive recharge from direct rainfall and periodic flooding. Storage volumes and depths to water table are highly variable in response to seasonal and annual rainfall patterns.

Groundwater Throughflow

Within the Town Basin, Inner Farm Basin and Outer Farm Basin the groundwaters move through the former, buried courses of the Todd and Charles Rivers in a southerly direction towards and through the Heavitree Range and Blatherskite Range and across the Emily Plain floodout.

Natural Discharge Mechanisms

Discharge (outflow) of groundwater occurs either as outflow to adjacent aquifers, or as evaporation from the soil, or as transpiration through vegetation.

Table 2. Estimate of Alluvial Aquifers pre-development groundwater storage and current groundwater storage (see Figures 5, 7, 8, 13 and 15)

Pre-Rural & Urban Development	**ALLUVIAL AQUIFERS**		
	Volume by Aquifer		
All Figures Megalitres (ML) = '000 000 litres Salinity under 1 000 mg/L (except Town Basin)	**Town Basin**	**Inner Farm Basin**	**Outer Farm Basin**
Total Recharge (ML/yr) (direct rain, river recharge and throughflow)	240	300	550
Evapotranspiration (ML/yr)	160	50	200
Groundwater outflow (ML/yr)	80 to Inner Farm Basin	250 to Outer Farm Basin	350 to Eastern Outer Farm Basin
Total Available Storage (ML)	**2 540**	**800**	**100 000**
2005 Current Development	**ALLUVIAL AQUIFERS**		
	Volume by Aquifer		
All Figures Megalitres (ML) = '000 000 litres Salinity under 1 000 mg/L (except Town Basin)	**Town Basin**	**Inner Farm Basin**	**Outer Farm Basin**
Total Recharge (ML/yr) (direct rain, river recharge and throughflow)	1 200	430	810
Evapotranspiration (ML/yr)	160	50	200
Groundwater outflow (ML/yr)	40 to Inner Farm Basin	310 to Outer Farm Basin	500 to Eastern Outer Farm Basin
Total Available Storage (ML)	**2 540**	**800**	**100 000**

Note: the apparent imbalance in the water balance equation in Table 2 (Current Development) is due to the large amount of groundwater extracted for consumptive use (see Chapter 4).

3.6 Amadeus Basin Aquifers

Recharge

Recharge (replenishment) of groundwater to the Amadeus Basin Aquifers in the Strategy region occurs from rainfall, surface water flow, and throughflow from adjacent geological formations. Recharge to the deeper rock aquifers in the northern part of the Amadeus Basin is principally associated with flooding occurring over a long time scale, although recharge continues from the rivers and creeks that run along the outcrops of Mereenie and Pacoota sandstones. Jolly et al., (2005) estimated annual average recharge of 2 100 ML per year (ML/yr) (100 ML/yr Roe Creek and 2 000 ML/yr Rocky Hill) to the Mereenie Aquifer System in the Strategy region, predominantly from the Roe Creek and Todd River across the Emily Plain floodout area.

Groundwater Throughflow

Before extraction began at the Roe Creek borefield the groundwaters of the Amadeus Basin Aquifers flowed in an easterly direction through the Roe Creek borefield towards Rocky Hill. Modelling undertaken by Jolly et al., (1994) suggested that the natural throughflow from the Roe Creek borefield to Rocky Hill, in the Mereenie Aquifer System, was in the order of 1 800 ML/yr.

Natural Discharge Mechanisms

Discharge (outflow) of groundwater occurs either as outflow to adjacent aquifers outside the Strategy region or as evaporation from the soil or transpiration through vegetation. Studies undertaken by Read and Paul (2002) estimated the average annual discharge from the Mereenie Aquifer System to the east of the Rocky Hill area ranges between 2 000 ML/yr and 4 000 ML/yr and suggested that the natural discharge mechanisms are dominated by evapotranspiration processes. Their hypothesis is reinforced by the higher salinity levels in the north-eastern part of the Amadeus Basin Aquifers (red areas in Map 7); indicating that evapotranspiration may be higher in this region.

Amadeus Basin Aquifers

Amadeus Basin Aquifers – Mereenie Aquifer System, Pacoota Sandstone and Shannon & Goyder Formations

Alice Springs lies on the north eastern edge of the Amadeus Basin. Map 1 shows the northern part of the Amadeus Basin, a broad elongated sedimentary basin covering an area approximately 21 000 km^2 (300 kilometres X 70 kilometres) trending east to west. The Amadeus Basin contains very large volumes of groundwater in storage. One of the most important aquifers in the northern part of the Amadeus Basin is the Mereenie Aquifer System, which consists of the geologically connected formations; Mereenie, Ooraminna and Hermannsburg Sandstones.

Other important aquifers within the northern part of the Amadeus Basin include the Pacoota Sandstones and Shannon and Goyder Formations. In these aquifers, groundwater flow is generally eastwards. Within the Alice Springs region the aquifers form a tilted series of thick porous layers, much like a layer cake (Figure 2). This Strategy deals with aquifers that contain known useful quantities of reasonable quality water, or are relied upon by existing users. Other currently unused or poorly understood aquifers which may also contain small supplies or poorer quality water are not addressed within this Strategy; this however does not preclude their use in the future.

The Government's current hydrogeological understanding of the aquifers associated with the Roe Creek area is far more advanced than its understanding of Rocky Hill. Although geologically and hydrologically connected, distinctions can be made between the aquifers of these two areas, particularly regarding; aquifer porosity, permeability, recharge, geomorphology, size and water quality (Appendix 2).

In the Roe Creek area (see Figure 3) the Mereenie sandstone dips down from the surface at approximately 30^o while in the Rocky Hill area the downward dip is shallower, approximately 10^o. Because of the shallow dips in the Rocky Hill area, a large area of the Mereenie Aquifer System aquifers occurs at economic drilling depth and provides a very large volume of available water in storage.

The depth to groundwater differs between aquifers (see Figure 4). At the Roe Creek borefield, water levels in Mereenie Aquifer System now lie approximately 150 metres below the surface. Water levels in the adjacent Goyder and Upper Shannon formations are shallower. Depths to groundwater at Rocky Hill are similar to the Roe Creek borefield, except for the Mereenie Aquifer System, where the standing water level is slightly higher around 110 metres below the surface.

Storage estimates are calculated to 300 metres below ground level for both the Roe Creek borefield and Rocky Hill (the economic pumping depth as recommended by technical input from the Department and industry input from the Power and Water Corporation). Water can be pumped from much deeper, however the greater the pumping head (lift) the higher the cost of pumping. There are substantial aquifers in the Hermannsburg Sandstone at Rocky Hill but at the moment these are less well understood and little used. The hydraulic gradient of the Mereenie Aquifer System has locally reversed because of extraction at the Roe Creek borefield. Similarly, pumping of the Pacoota Sandstone at Roe Creek has reduced the flow in that aquifer towards Rocky Hill. Water levels in monitoring bores show small periodic increases in response to flows in the Todd River and Roe Creek.

Figure 4. Cross-section along the strike of the Mereenie Aquifer System from Pine Gap to Rocky Hill, indicating the groundwater levels and response to pumping in the Roe Creek borefield and at Pine Gap (Source Jolly et al., 2005)

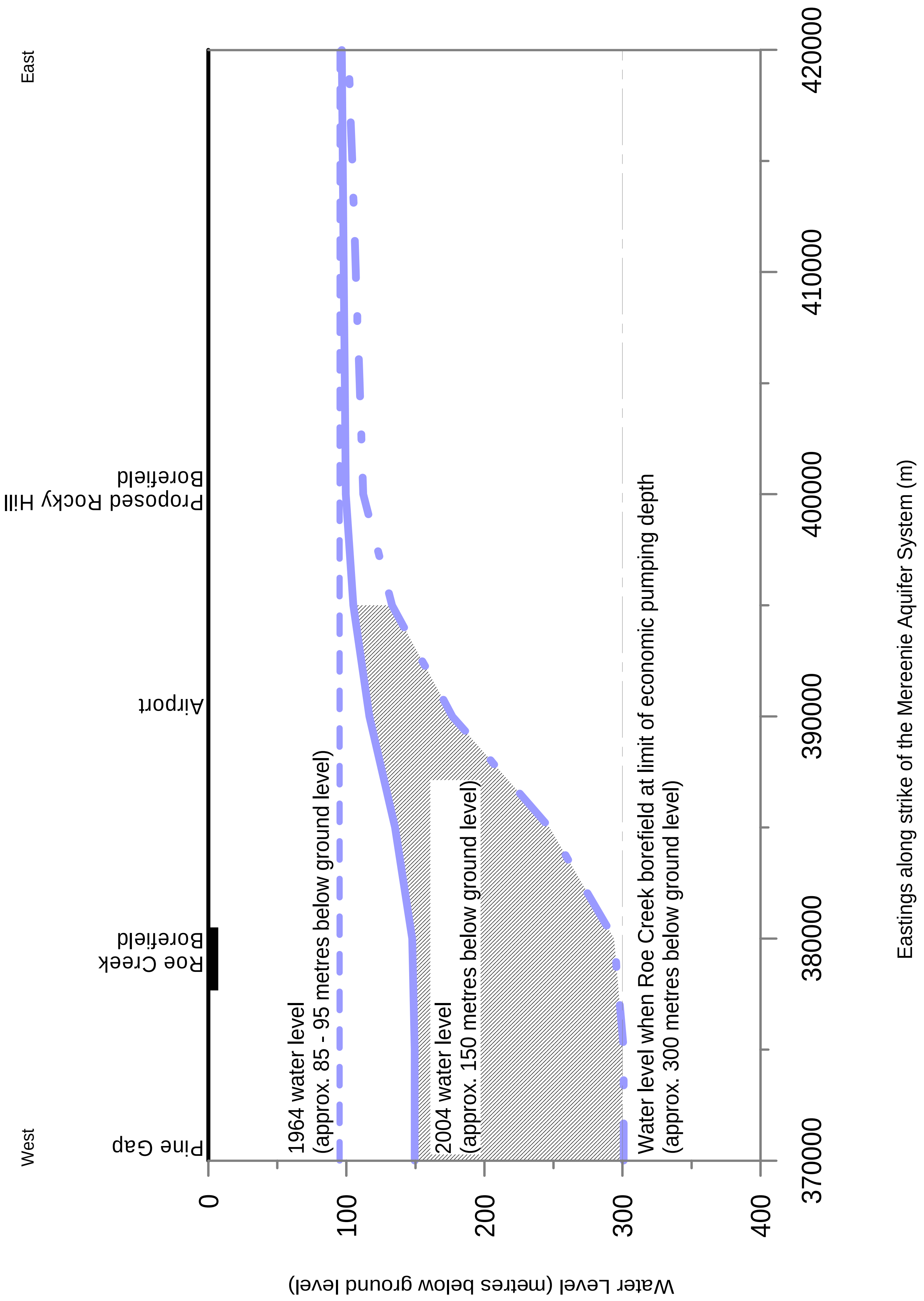


Table 3. Estimate of Amadeus Basin Aquifers pre-development groundwater storage and current groundwater storage (see Figures 6, 7, 9, 12, 14 and 15)

Pre-Rural & Urban Development	**AMADEUS BASIN AQUIFERS**					
	Volume by Aquifer			**Volume by Geographical Area**		**Combined Amadeus Basin Aquifers**
All Figures in Megalitres (ML) = '000 000 litres Salinity under 1 000 mg/L	**Mereenie Aquifer System**	**Pacoota Sandstones**	**Shannon & Goyder Formations**	**Roe Creek** **Mereenie, Pacoota, Shannon & Goyder**	**Rocky Hill** **Mereenie Aquifer System Only**	
Total Recharge (ML/yr) (direct rain, river recharge and throughflow)	3 900	800	80	2 780	2 000	4 780
Evapotranspiration (ML/yr)	3 000	0	0	0	3 000	3 000
Groundwater outflow (ML/yr)	900 to Mereenie beyond Strategy region	800 to Pacoota beyond Strategy region	80 to Eastern Outer Farm Basin	880	900	1 780
Total Available Storage (ML)	**5 069 000**	**430 000**	**302 000**	**2 046 000**	**3 755 000**	**5 801 000**

2005 Current Development	**AMADEUS BASIN AQUIFERS**					
	Volume by Aquifer			**Volume by Geographical Area**		**Combined Amadeus Basin Aquifers**
All Figures in Megalitres (ML) = '000 000 litres Salinity under 1 000 mg/L	**Mereenie Aquifer System**	**Pacoota Sandstones**	**Shannon & Goyder Formations**	**Roe Creek** **Mereenie, Pacoota, Shannon & Goyder**	**Rocky Hill** **Mereenie Aquifer System Only**	
Total Recharge (ML/yr) (direct rain, river recharge and throughflow)	3 900	800	80	2 780	2 000	4 780
Evapotranspiration (ML/yr)	3 000	0	0	0	3 000	3 000
Groundwater outflow (ML/yr)	900 to Mereenie beyond Strategy region	800 to Pacoota beyond Strategy region	80 to Eastern Outer Farm Basin	880	900	1 780
Total Available Storage (ML)	**4 810 000**	**400 000**	**300 000**	**1 760 000**	**3 750 000**	**5 510 000**

3.7 Pre-Rural and Urban Development Water Balances

Figures 5, 6, and 7 (below) represent inferred water balances of Alice Springs prior to rural and urban development. These figures provide a conceptual model of the system's natural state of flux prior to groundwater extraction and current land-use activities.

Figure 5. Alluvial Aquifers – water balances prior to development

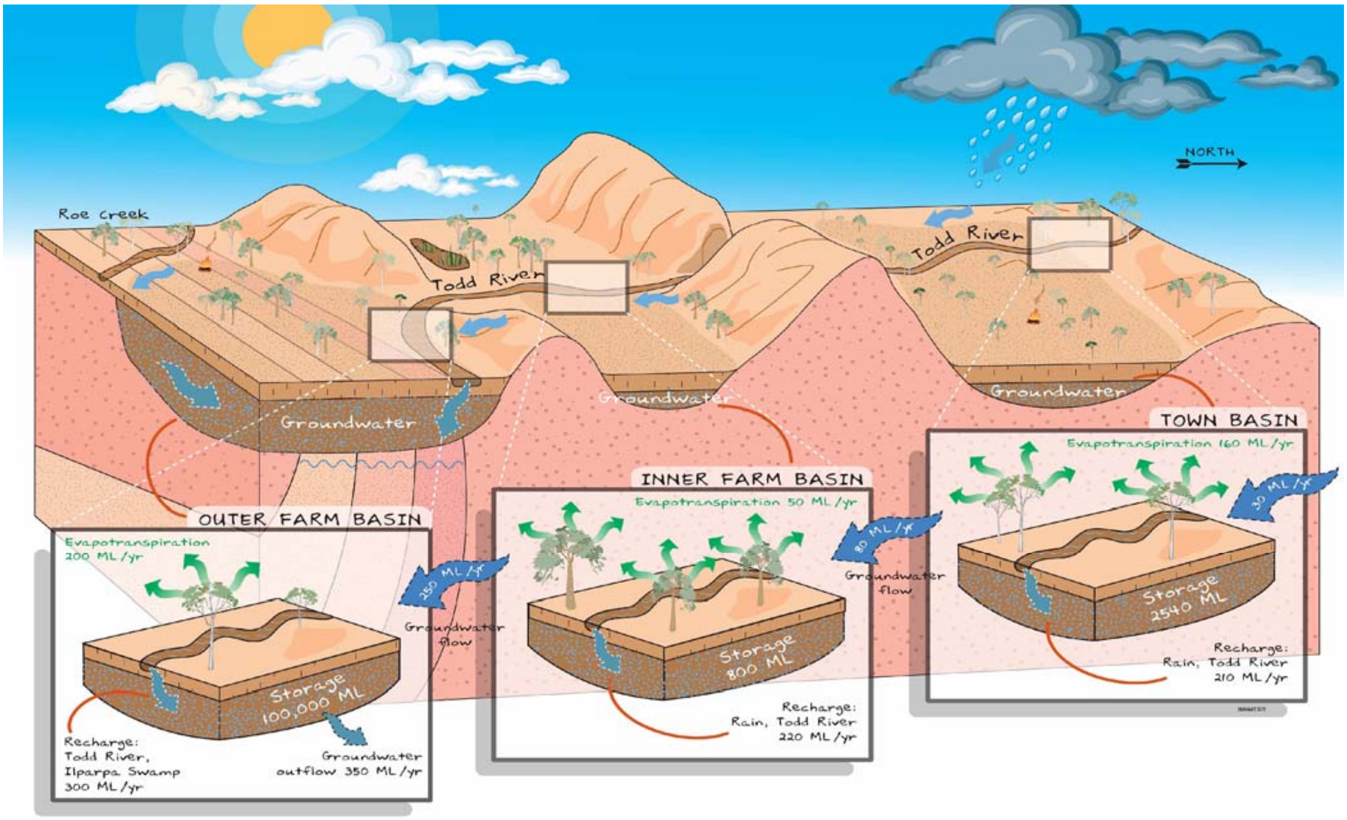


Figure 6. Amadeus Basin Aquifers – water balances prior to development

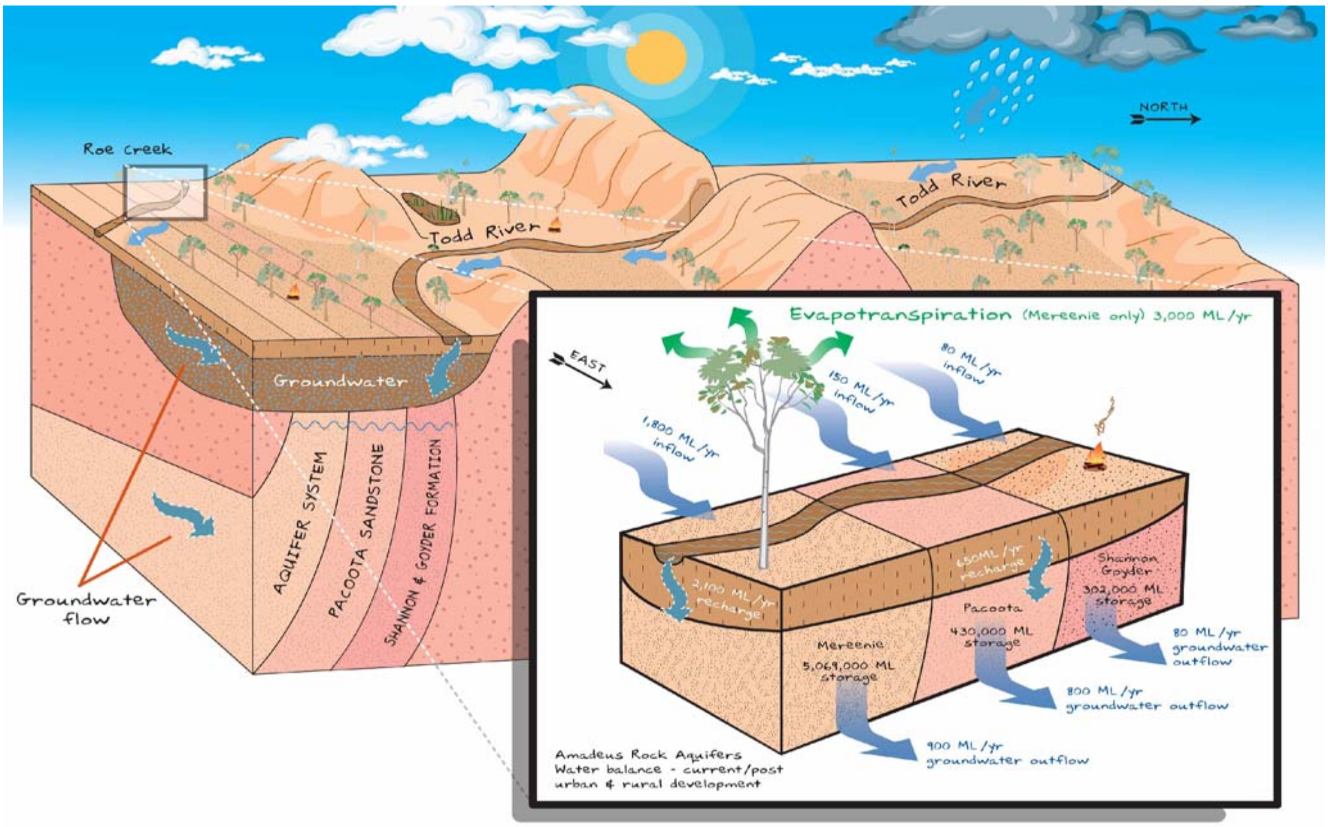
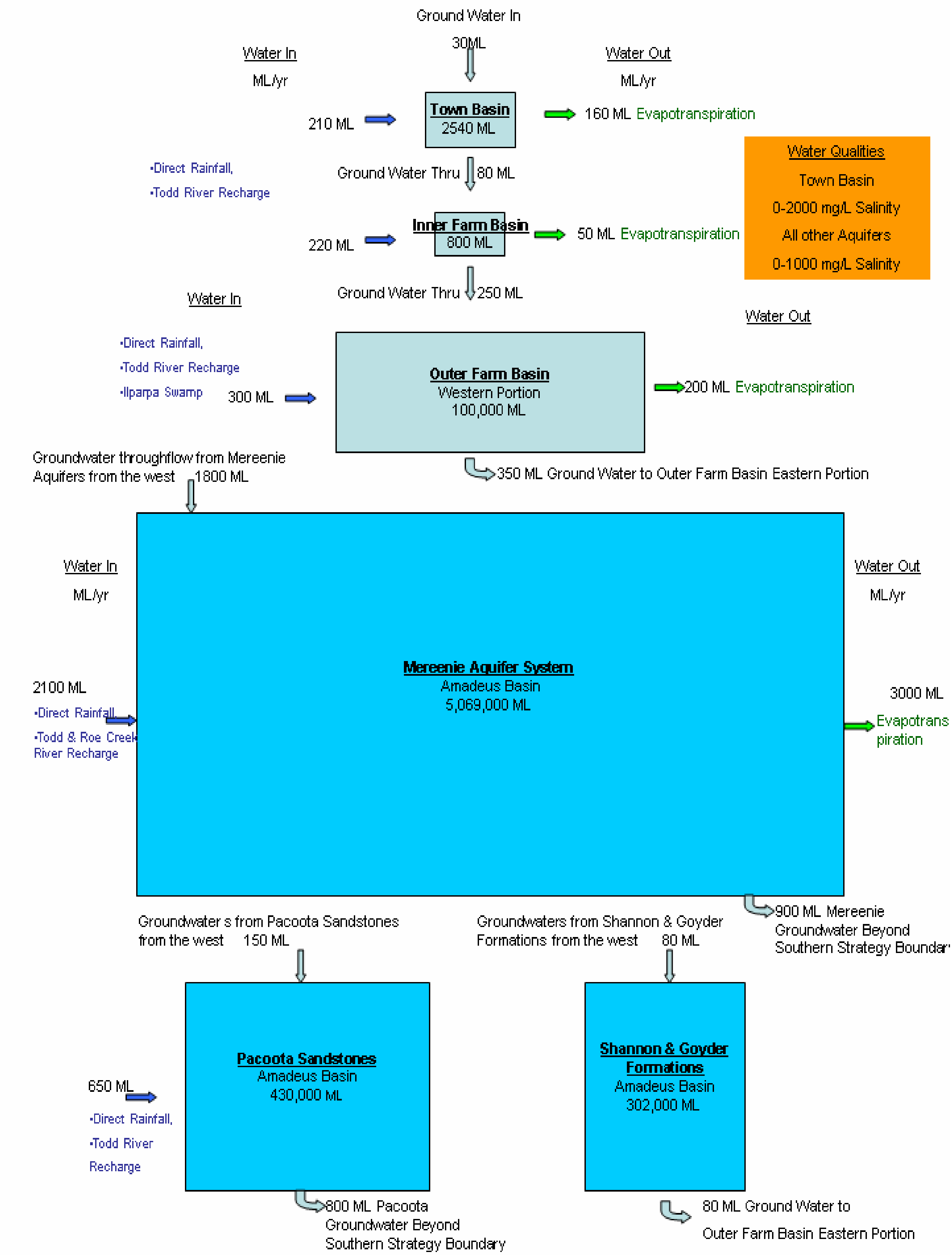


Figure 7. Water balance for Alice Springs prior to urban and rural development



PART 4 CURRENT WATER USE AND DEMAND FORECASTS

4.1 Current Uses

Non-consumptive uses: environmental and cultural

The identification of groundwater dependent ecosystems is a relatively recent focus of scientific research. Groundwater dependent ecosystems are animal and plant communities that rely on groundwater, for example some waterholes in seasonally dry environments; some plant communities in areas where groundwater is close to the surface; and some animal communities that are often found in association with aquifers.

The dependence of plant communities on groundwater is indicated by the depth of the water level below the ground. For plant communities to be dependent on groundwater, water levels must be within the root zone. Given the depths to water in the Strategy region shown in Appendix 2, only the shallow alluvial aquifers are likely to support groundwater dependent ecosystems. Eucalypt and associated vegetation along arid zone watercourses can be regarded, at least partially, as groundwater dependent.

Although the average depth to groundwater in the Alluvial Aquifers may sometimes be within the root zone, these water levels fluctuate with rainfall and surface water flow depending on the dynamics of the individual aquifer. Groundwater levels tend to rise to within the root zone after significant rainfall and surface water flow. Roots will also tend to follow water which is moving down towards the groundwater table. Although river red gums in the Town Basin depend on groundwater almost entirely and are obligated to use that resource, it is understood that some plant communities in the Town Basin, Inner Farm Basin and Outer Farm Basin can be regarded as opportunistically groundwater dependent. Little is known about the environment of the Wanngardi Basin.

Although there is no permanent surface water in the Strategy region, there are a number of semi-permanent waterholes in the MacDonnell Ranges that are partially groundwater-dependent. These semi-permanent waterholes are listed in Section 3.3 (Surface Water Resources) and shown in Map 12. The ephemeral swamps and claypans in the region are understood to be fed only by surface drainage.

The riparian vegetation along the Todd River has great cultural significance, but the cultural importance of groundwater is likely to extend beyond the river red gums. Local Aboriginal knowledge of the locations and characteristics of arid zone surface water sources such as soaks, rock holes, cave pools, river pools and seepages, all of which are potentially derived from groundwater, exceeds that documented by agencies. Many of these traditional sites have significant ceremonial, economic and social significance.

Consumptive uses

Over the past 40 years (since 1964) approximately 254 000 ML has been extracted from the Mereenie Aquifer System from the Roe Creek borefield for public water supply. A further 5 000 ML has been extracted from the Mereenie Aquifer System in the Rocky Hill area since the 1970's, principally for lucerne and various experimental crops.

Map 13, Tables 4 and 5 and Figures 8 and 9 show current rates of extraction from all aquifers in the Strategy region for consumptive purposes. Each year, in the Strategy region, just under 10 000 ML is used for public water supply; approximately 450 ML is used for agriculture; 835 ML is used for industrial purposes (predominately oval irrigation using renewable town basin water); and 107 ML is used for rural stock and domestic use.

Licensed and actual groundwater extraction rates were derived from volumetric entitlements and meter readings, where meter returns are a requirement of a groundwater extraction licence. There is currently no requirement for small-scale licensees in the Inner and Outer Farm Basins to report meter readings and, in that case, actual extraction is assumed to be equal to the licensed amount. Rural stock and domestic use was estimated by considering homestead use and stock use separately. Annual homestead use was estimated by (number of households x 2.7 kL x 365) and stock use by (carrying capacity x area grazed x .02 ML). A proportion of water used for stock is supplied by surface water dams.

All groundwater extraction within a Water Control District must be licensed, except that extraction for rural stock and domestic use is currently exempt. The Town Basin is a special case due to the dynamic nature of the resource and the need for close monitoring and careful management. Therefore in the Town Basin, rural stock and domestic use is also licensed. Table 5 shows licensed and actual extraction of groundwater in each management zone. Aquaculture is not included as there is no extraction for this use in the region.

Current Use of Alice Springs Alluvial Aquifers

Town Basin

The Town Basin aquifer originally supplied the town's demand for reticulated drinking water until increasing demand prompted the establishment of the Roe Creek borefield in 1964. The Town Basin now supplies water for irrigation of parks, schools, ovals, some domestic gardens and the golf course. The Town Basin also supports the culturally important river bed vegetation, including mature river red gums, some of which have traditional significance to the local Arrernte people.

Cessation of use of the Town Basin for Public Water Supply in the 1960s was followed by a period of exceptionally high rainfall in the 1970s (see Figure 1), resulting in high water tables and an associated increase in salinity due to mobilisation of salts from the fringing weathered bedrock.

Continued 'recharge' through the irrigation of gardens and playing fields with water from the Mereenie Aquifer System (i.e. Public Water Supply pumped from the Roe Creek borefield) has groundwater levels in the Town Basin remaining four to seven metres higher than those recorded before the establishment of the Roe Creek borefield.

Read (2003) reviewed data on water quality in the Town Basin, including fluoride, nitrate, potassium, sodium, total organic carbon, insecticides, bacteria, viruses and radionucleides. Levels of dieldrin (0.04 µg/L) in one bore at Traeger Park were high enough to warrant further investigation. Faecal coliform were detected in 6 of 36 samples.

It is clear that water quality in the Town Basin has deteriorated and is now unsuitable to be used for potable supply without additional treatment although it remains an important resource with some future potential.

The current volumetric entitlement for all water extraction licences (1 080 ML/yr) is just above estimated net recharge (total recharge less natural discharge = 1 000 ML/yr). Actual water extraction (739 ML/yr) remains below the estimated net recharge.

Inner Farm Basin

The Inner Farm Basin provides water for irrigation of small-scale horticulture and secondary industries including caravan parks. Current licences total 70 ML/yr. The aquifer remains unstressed with relatively stable and high groundwater levels.

Outer Farm Basin

The Outer Farm Basin is a much larger aquifer than the Inner Farm Basin, but the water is of poorer quality. Current extraction supports small-scale agriculture, domestic gardens, a camel farm and irrigation of the racecourse.

Current licences total 108 ML/yr. The aquifer remains unstressed with stable groundwater water levels.

Wanngardi Basin

This groundwater basin provides water to properties between Honeymoon Gap and Temple Bar Gap and is recharged from irregular flows in Roe Creek. The waters of this basin are used for rural stock and domestic purposes.

During long periods between flows, waters in this basin can become depleted.

Unfortunately water use figures for the Wanngardi Basin are too limited to incorporate into the Strategy at this stage. Clarification of water use within this basin should be a priority for future revisions of the Strategy.

Current Use of Alice Springs Amadeus Basin Aquifers

Amadeus Basin Aquifers – Mereenie Aquifer System, Pacoota Sandstone and Shannon & Goyder Formations

The major uses of the Amadeus Basin Aquifers in the northern part of the Amadeus Basin are the provision of public water supply to Alice Springs from the Roe Creek borefield 15 km SSW of Alice Springs and horticulture at Rocky Hill.

Roe Creek: The Roe Creek borefield draws water from four aquifers: the Mereenie Aquifer System, upper Pacoota Sandstone, lower Pacoota Sandstone and Upper Shannon formation (refer to Figure 3 and Appendix 2). Of these, the Mereenie Aquifer System provided 100% of the Alice Springs public water supply until the mid 1980s when extraction began from Pacoota aquifer. The Mereenie Aquifer System aquifer continues to provide 80% of water supplied to Alice Springs from Roe Creek borefield for public water supply. The current license for extraction from Mereenie Aquifer System aquifers for public water supply is 8,250 ML/yr, with actual extraction approximately 7 420 ML/yr (average 1999-2004 licence data). Power and Water Corporation draw water from 15 production bores and standby bores over a 3 km length of the aquifer, extracting water qualities ranging between 260 mg/L and 500 mg/L TDS (averaging 460 mg/L TDS) from the Mereenie Aquifer System at Roe Creek. Two production bores at the Joint Defence Facility Pine Gap are currently licensed to extract 250 ML/yr for public water supply and are extracting approximately 220 ML/yr per year of slightly poorer water quality averaging 640 mg/L TDS.

Exploitation of these groundwater systems results in an imbalance between the rate water recharges the aquifer and the rate water is removed. As a result water levels in the Roe Creek Borefield are in decline and the resource is being 'mined'. Since commencement of pumping in 1964 water levels in the bores have dropped 60 m from 90 m to 150 m below ground level today. However the rate of decline has slowed since the distribution of extraction between four aquifers since the late 1980s. Both operational pumping costs and capital costs for bore rehabilitation and augmentation will increase due to the falling water level of the aquifer, even if consumption remains constant.

Despite licence arrangements allowing significant water extraction from the Pacoota, Shannon & Goyder Formation aquifers for Public Water Supply, only a small proportion of the licensed entitlement for these aquifers is extracted (average extraction 1999-2004 was around 1 465 ML/yr). The reason for the greater reliance on the Mereenie Aquifer System for public water supply is due to the aquifer providing better water quality (300-500 mg/L salinity) and yield (80 L/s) than waters derived from the other formations (e.g. Shannon Formation 800 mg/L salinity and 25 L/s yield respectively).

Rocky Hill: Agriculture was first established on the Rocky Hill Horticultural Block accessing the Mereenie Aquifer System in the 1970s. 400 ML/yr is currently licensed for agriculture with a total area under irrigation approximately 48.5 ha. Current extraction is approximately 350 ML/yr for grapes, melons and experimental crops. The only other remaining water uses in the Rocky Hill/Ooraminna area include a few stock watering bores, the historic Ghan Railway bore and the Ooraminna Bush homestead water supply bores.

Further horticultural development exists within the Alice Springs Water Control District but outside the Strategy region. These farms currently comprise 10 ha of dates, 25 ha of dates and figs, and 32 ha of lucerne. All are irrigated by extraction from the Amadeus Basin Aquifers but at a sufficient distance to have no effect in the Strategy region. Water allocations for development in the southern part of the Alice Springs Water Control District will be addressed in future revisions of this Strategy, or a water resource strategy dedicated to that area.

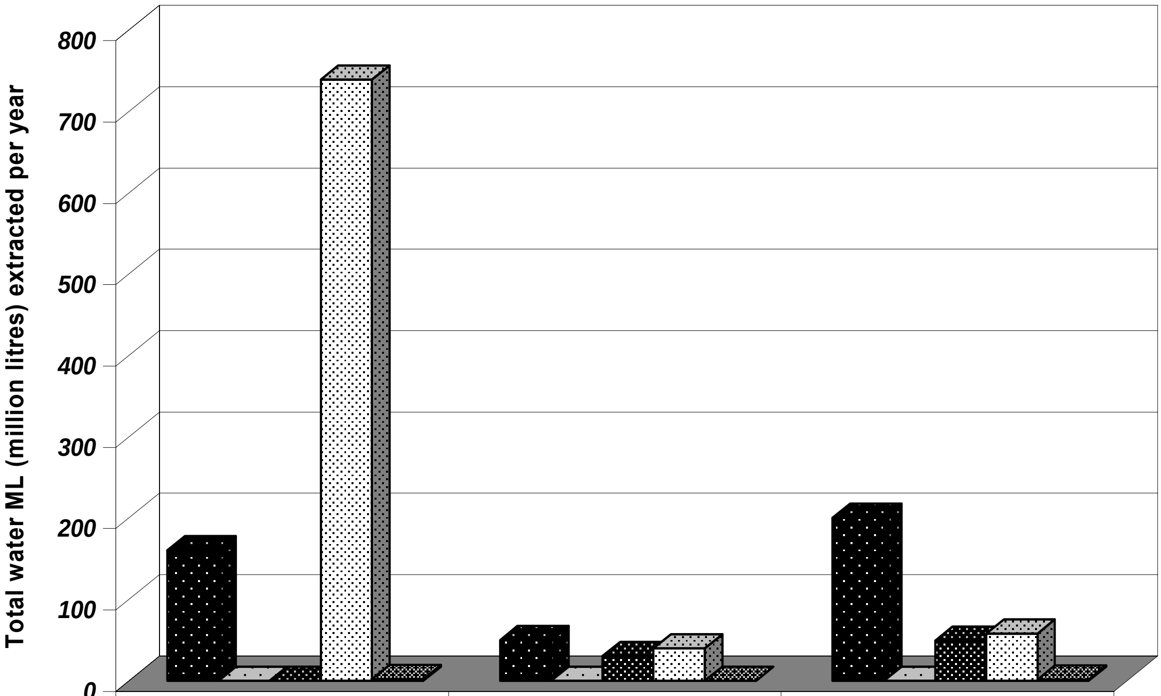
Table 4. Quantitative summary of the current licensed and annual extraction from Surface Water and Alluvial Aquifers

2004 All figures in Megalitres (ML) = '000 000 litres All figures represent water with salinity under 1 000 mg/L TDS (except Town Basin)			ALL SURFACE WATER (ML/yr)	ALLUVIAL AQUIFERS – Water from Aquifer Recharge – Extraction arranged by Aquifer Volume (ML/yr): Town Basin	Inner Farm Basin	Outer Farm Basin	ALL ALLUVIAL AQUIFERS (ML/yr)
Non-Consumptive Use	Environment and Cultural		12 000	160	50	200	**410**
Consumptive Use	Public Water Supply	Licensed	0	0	0	0	**0**
		Extracted	0	0	0	0	**0**
	Agriculture	Licensed	0	0	30	49	**79**
		Extracted	0	0	0	0	**0**
	Industry	Licensed	0	1 080	40	58	**1 178**
		Extracted	0	739	0	0	**739**
	Rural, Stock & Domestic		not quantified	2	0	1	**3**
Total Consumption ML/yr (Licensed figures used where extraction figures not available)			**?**	**741**	**70**	**108**	**919**
Number of Extraction Licences			0	7	6	9	**22**
Number of Licensed Bores			n/a	19	7	13	**39**

Table 5. Quantitative summary of the current licensed and annual extraction from Amadeus Basin Aquifers

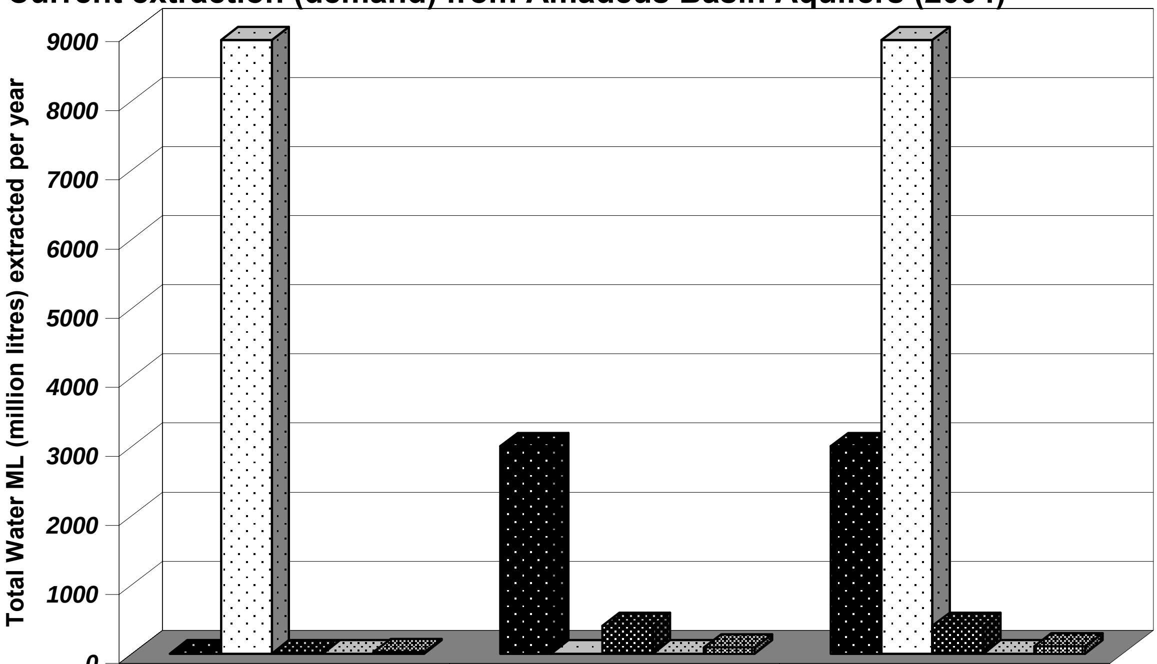
		AMADEUS BASIN AQUIFERS					
		Water from Aquifer Storage					
2004		Extraction arranged by Aquifer Volume (ML/yr)			Extraction arranged by Geographical Area Volume (ML/yr)		Combined Amadeus Basin Aquifers
All figures in Megalitres (ML) = '000 000 litres All figures represent waters with salinity under 1 000 mg/L TDS		Mereenie Aquifer System	Pacoota Sandstone	Shannon & Goyder Formations	Roe Creek Mereenie, Pacoota, Shannon & Goyder	Rocky Hill Mereenie Aquifer System Only	
Non - Consumptive Use	Environment and Cultural	3 000	0	0	0	3 000	**3 000**
Consumptive Use	Public Water Supply – **Licensed**	8 250	4 000	1 000	13 250	0	**13 250**
	Public Water Supply – Extracted	7 420	1 365	96	8 881	0	**8 881**
	Agriculture – **Licensed**	**400**	**0**	**0**	**0**	**400**	**400**
	Agriculture – Extracted	350	0	0	0	350	**350**
	Industry – **Licensed**	0	0	0	0	0	**0**
	Industry – Extracted	0	0	0	0	0	**0**
	Rural, Stock & Domestic	104	0	0	17	87	**104**
Total Consumption ML/yr (Licensed figures used where extraction figures are absent)		**7 874**	**1 365**	**96**	**8 898**	**437**	**9 335**
Number of Extraction Licences		5	2	1	7	1	**8**
Number of Licensed Bores		21	3	1	23	2	**25**

Figure 8. Current extraction (demand) from Alluvial Aquifers (2004)



	Town Basin	Inner Farm Basin	Outer Farm Basin
Environment & Cultural	160	50	200
Public water supply	0	0	0
Agriculture	0	30	49
Industry	739	40	58
Rural Stock and Domestic	2	0	1

Figure 9. Current extraction (demand) from Amadeus Basin Aquifers (2004)



	Roe Creek (Mereenie, Pacoota, Shannon & Goyder)	Rocky Hill (Mereenie)	Combined Amadeus Aquifers
Environment & Cultural	0	3000	3000
Public water supply	8881	0	8881
Agriculture	0	400	400
Industry	0	0	0
Rural Stock and Domestic	17	87	104

4.2 Regional Water Balances

Figures 10, 11 and 12 represent a distillation of rigorous and extensive resource assessment work undertaken by hydrogeologists. They contain extrapolations, approximations and many assumptions, nevertheless they summarise current understanding of the occurrence and behaviour of water resources in the Strategy region.

Figure 10. Alluvial Aquifers - current water balances with development

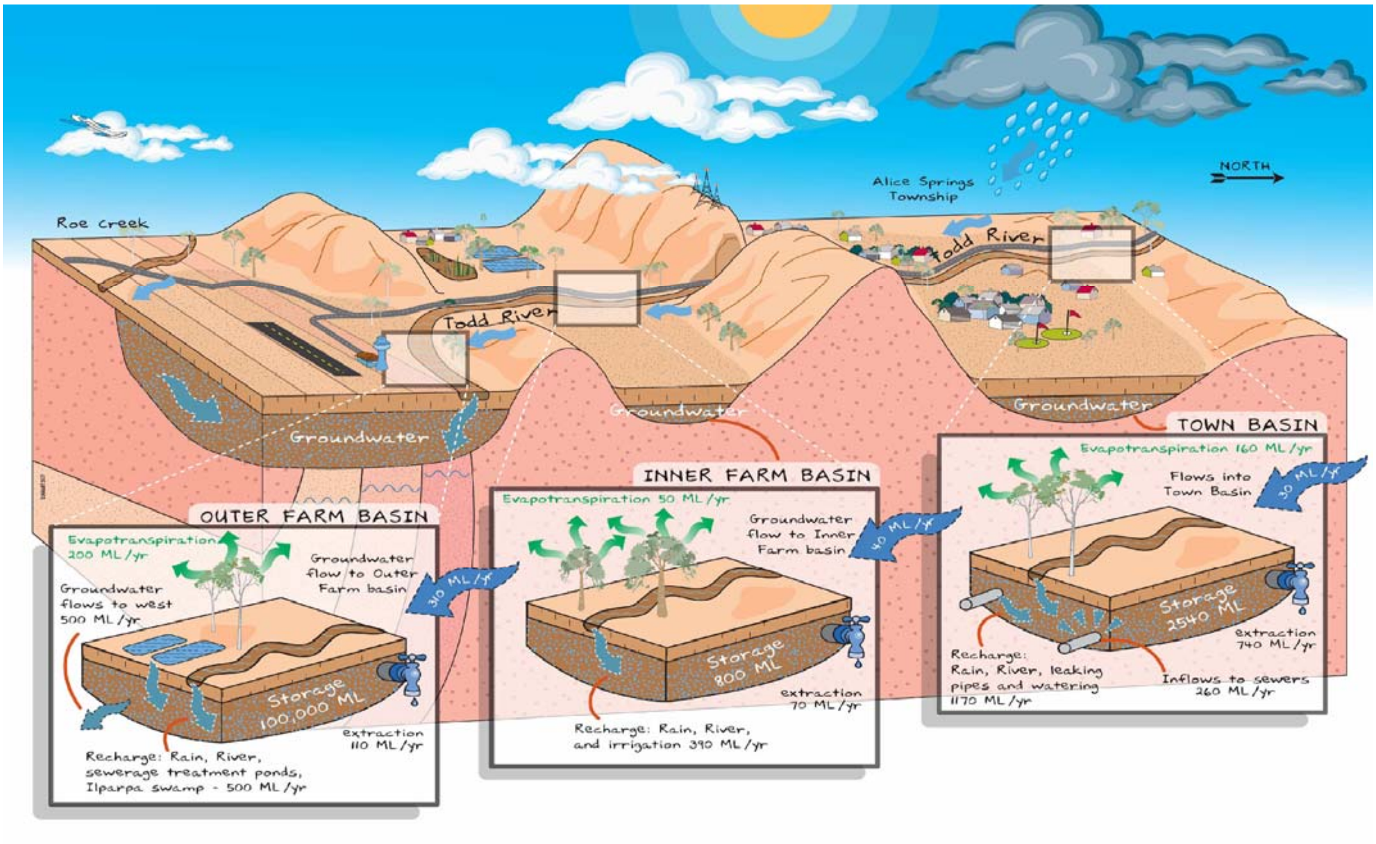


Figure 11. Amadeus Basin Aquifers - current water balances with development

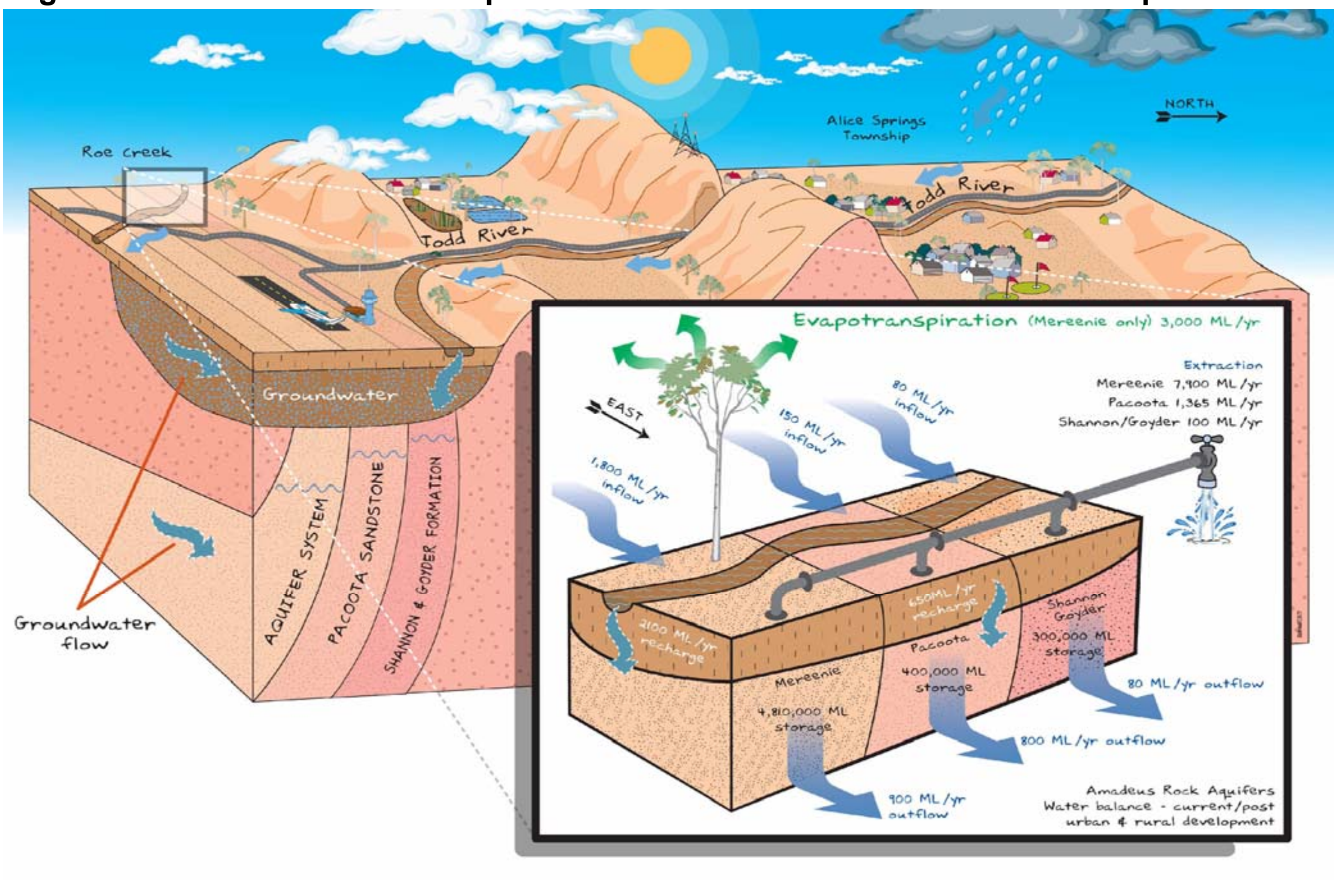
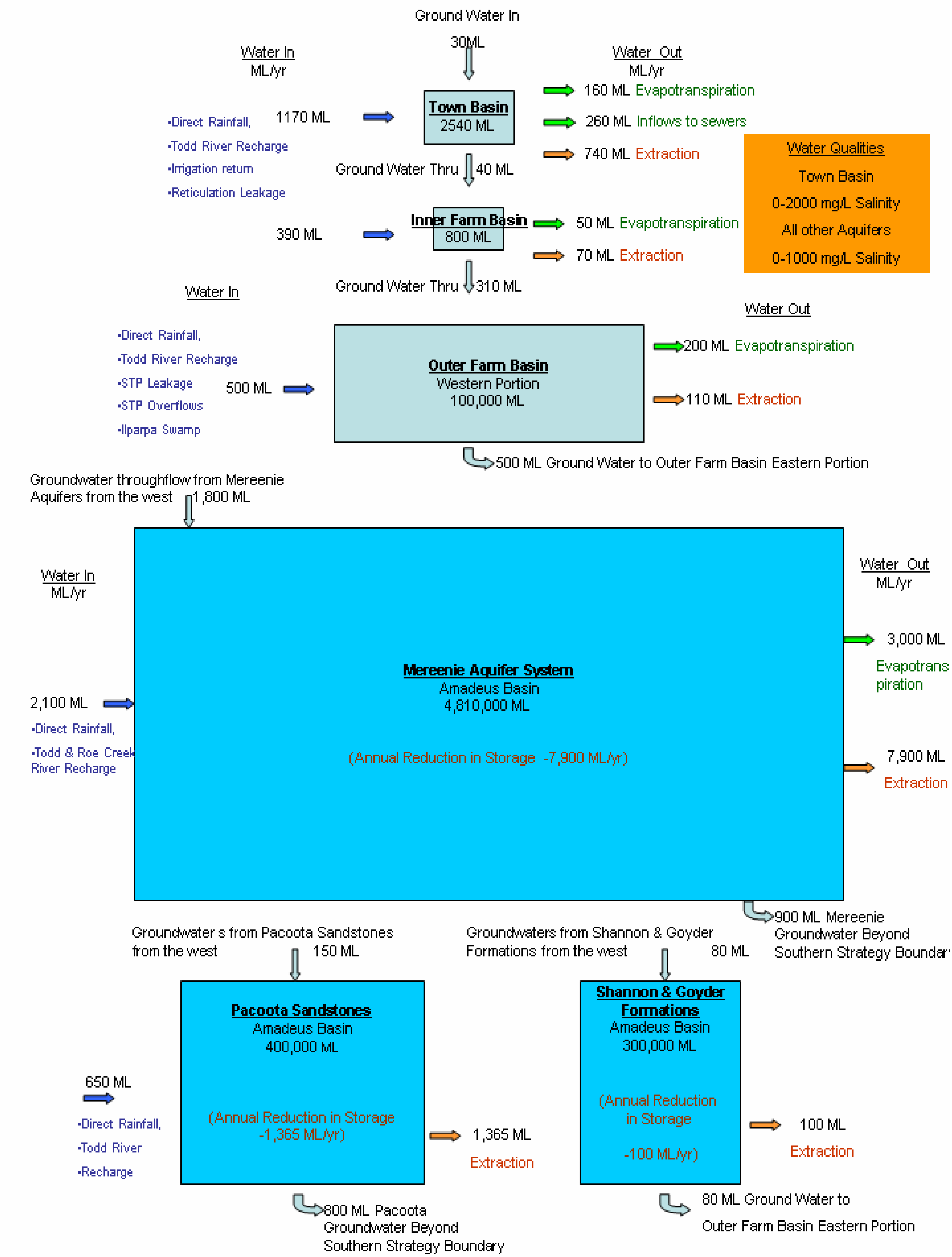


Figure 12. Current water balance subject to existing urban and rural development



4.3 Demand Forecasts

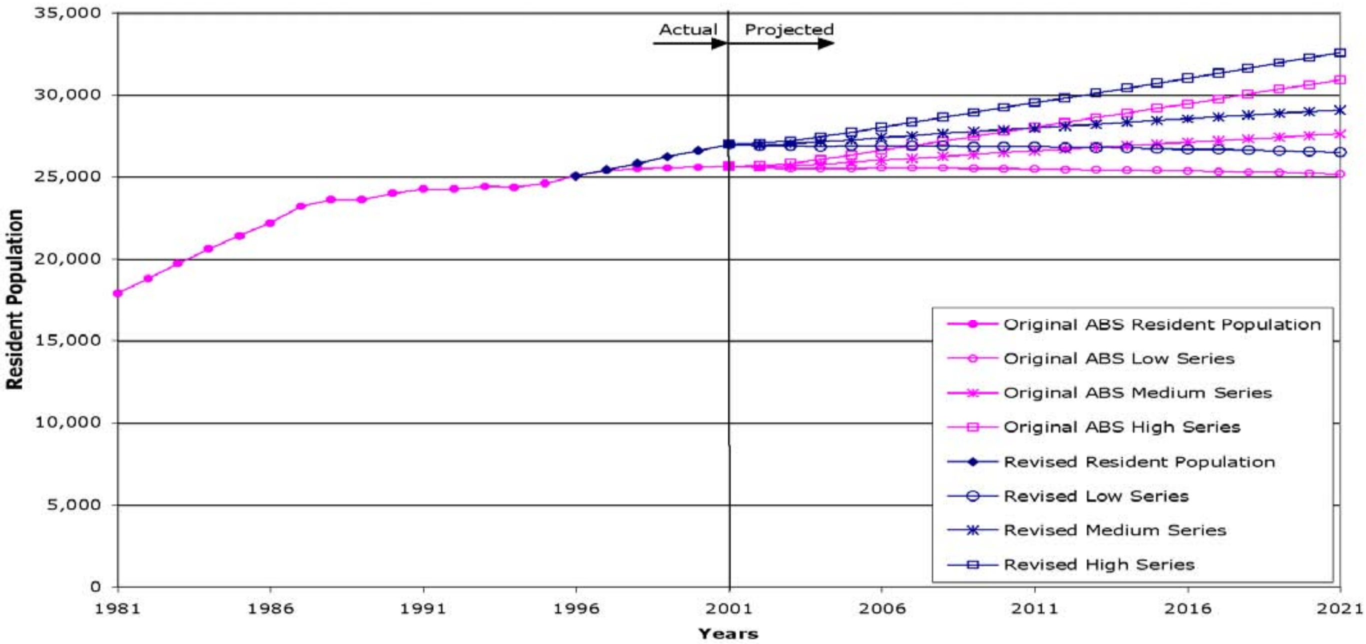
Forecasts of future demand for water must take into account projected population growth and potential growth in water usage. Demand forecasting should also consider the impacts of natural or induced events such as climate change. It is estimated that increased temperatures due to greenhouse warming will be more pronounced in Central Australia than in coastal regions. Rain events are expected to increase, however increased temperatures coupled with the existing variability in rainfall could result in greater evaporation and reduced runoff, resulting in reduced recharge to aquifers. Alternatively, more extreme rainfall events could produce more of the larger surface water flows, resulting in increased groundwater recharge in the Strategy region. These climate change effects are not expected to be a major factor within the life of this Strategy but should be considered in future revisions.

Recent Bureau of Statistics figures suggest the current population of Alice Springs is 26 058 (2004) with little growth over the past five years (population 26 054 in 1999). In 2003 the Institute for Sustainable Futures (ISF) undertook a Water Efficiency Study for Alice Springs and identified a range of projections for high, medium and low growth scenarios (Figure 13). The study identified that resident population had risen by more than 9 000 in the 20 years from 1981 (17 900) to 2001 (26 990). There were significant variations in the average annual growth rates between these years. In the six years between 1981 and 1987 the average annual growth rate was 4.4%, but in the nine years between 1987 and 1996 it was only 0.85%. The growth rate increased again to 1.5% between 1996 and 2001. The high growth scenario projection adopted by ISF is based on an average annual growth rate of 0.94% leading to a population of more than 32 500 by 2021. This high growth population projection does not include increased growth in water usage through tourism, industrial or agricultural activities (e.g. irrigated horticulture), which leads the Strategy to consider a high growth forecast of 1.5% annual increase in water demand.

Irrigated horticulture for table grapes within the Strategy region is currently at an early phase of development and consists of approximately 48.5 hectares, consuming approximately 350 ML/yr. Preliminary natural resource assessments of Rocky Hill area have identified approximately 500 hectares of land overlying the Mereenie Aquifer System with potential to support horticulture. Horticultural water demand for grape growing requires approximately 10 ML of water per hectare per year at maturity. If areas suggested by resource assessments (Read & Paul, 2000), (Read & Paul, 2002), (Read et al., 2002) are accurate and developed to their full potential, total projected agricultural demand for water in the Rocky Hill area could be in the order of 5,000 ML/yr.

Tables 6 and 7 and Figures 14 and 15 summarise the assumptions regarding maximum potential future demand for water in the Strategy region. The estimates of future demand used throughout this Strategy are based on cumulative increase at the high growth forecast rate (i.e. 1.5% annual increase in water demand). At that rate, the life of the Roe Creek borefield, which currently provides drinking water for Alice Springs, is expected to last many decades. However the drawdown of the Mereenie Aquifer System, in the vicinity of the Roe Creek borefield, will eventually reach a depth where it will become no longer economical to pump large amounts of water from that site. A future borefield site has been designated at Rocky Hill, approximately 25 km from the Roe Creek borefield. The Rocky Hill borefield will continue to extract groundwater from the northern part of the Amadeus Basin, particularly from the Mereenie Aquifer System.

Figure 13. Historical and projected population of Alice Springs (ISF, 2003)



Source – Institute for Sustainable Futures, 2003

Forecasted Use of Alluvial Aquifers

Town Basin

Future demand on the Town Basin will reflect policy decisions regarding source substitution of non-potable or potable urban demand. Currently there are problems associated with salinity and with infiltration/exfiltration between groundwaters and the sewerage system.

The SKM (2001a) assessment suggested that increasing the annual extraction of the Town Basin to 1 250 ML coupled with water efficiency measures would offer significant benefits. Proposed benefits included:

- Reduction of demand on Amadeus aquifers through source substitution (eg. Waters for oval irrigation to be sourced from renewable Town Basin waters rather than non-renewable waters sourced from Roe Creek borefield),
- Improved water quality in the Basin by increasing the depth to groundwater thus allowing greater recharge of fresh water,
- Water supply to additional customers, and
- Assist with alleviating infiltration of poorer quality water and salinity.

Further proposals have suggested the potential for extraction and use of Town Basin waters for emergency potable supply and contribution to the town's potable water supply following treatment.

SKM (2001a) also recommend that groundwater levels in the river corridor of the Town Basin should not be allowed to decline any more than eight metres below the Todd River bank level. This is a conservative estimate of the level required to maintain the health of the river red gums. The report suggested that an extraction of 1 500 ML/yr would cause groundwater levels to decline to eight metres within eight years.

Due to the accessibility of the Alice Springs Town Basin there may be an economic use of waters more than 1 000 mg/L Total Dissolved Solids (TDS), through blending and diluting smaller quantities of poorer water with better quality waters sourced from the Amadeus Basin, particularly from the Mereenie, Pacoota and Shannon Formations.

Inner Farm Basin

Projected demand from the Inner Farm Basin is not expected to increase significantly. Potential remains for water extraction up to its net recharge rate (total recharge, less evapotranspiration, less outflow), estimated to be 110 ML/yr.

Outer Farm Basin

Any increased extraction from the Outer Farm Basin is expected to exceed net recharge rate (total recharge, less evapotranspiration, less outflow), estimated to be 100 ML/yr. However the available water held in storage within this aquifer is large (estimated at 100 000 ML). When projected extraction exceeds the recharge rate, a limited reduction in storage is expected. This would result in a small lowering in water levels over time. Considering the storage available and depth to groundwater, a small reduction in storage and drawdown is considered acceptable within the Outer Farm Basin. However this assumption must be addressed through further studies.

Additionally, it is intended that a significant quantity of water will become available for future horticultural or industrial purposes through the Alice Springs Water Reuse Project at the Arid Zone Research Institute (AZRI) using treated effluent, recharged to the aquifer by a process of soil aquifer treatment (SAT). Agricultural demands in the Outer Farm Basin for re-used effluent will be added to the strategy when realised, as it intended to have no net impact on the water balance. The pilot SAT program aims to initially provide 600 ML/yr. If successful, a significant volume of water could be made available for agriculture or industrial purposes, possibly up to 3 000 ML/yr in the Outer Farm Basin.

Wanngardi Basin

There have been a number of expressions of interest in relation to further sub-division in the area. Increased water demands from this basin could lead to over-extraction and potential conflict between users, particularly during prolonged dry periods between river flows.

Forecasted Use of Amadeus Basin Aquifers

Amadeus Basin Aquifers – Mereenie Aquifer System, Pacoota Sandstones and Shannon & Goyder Formations

Roe Creek: Future demand for public water supply will be met by water extracted from aquifers at Roe Creek borefield, mainly the Mereenie Aquifer System. Water supply from the Roe Creek Borefield is expected to continue well beyond the life of this Strategy (2006-2015). When extraction from this borefield approaches economic viability public water supply will be supplemented with water from a second borefield site located at Rocky Hill. The Institute for Sustainable Futures study (ISF, 2003) estimates a business-as-usual scenario projection for potable water demand (including losses and leakages but not including demand management measures) of around 12 500 ML/yr by 2021. This Strategy estimates actual annual demand (not licensed entitlements) for potable water from the Roe Creek borefield to be ***10 417 ML/yr by 2015,*** based on 1.5% annual increase.

Demand for public water supply at the Joint Defence Facility Pine Gap from the Mereenie Aquifer System is projected to remain at current levels for the next ten years. Also rural stock and domestic use is expected to remain constant.

Rocky Hill: Considerable expansion of horticulture is proposed in the Rocky Hill / Ooraminna area (south-eastern portion of the Strategy region) using water sourced from the Amadeus Basin Aquifers, particularly the Mereenie Aquifer System. Land and water assessment of the region identified approximately 500 ha of land potentially suitable for horticultural development (Read & Paul, 2000), (Read & Paul, 2002), (Read et al., 2002). A regional rule of thumb suggests that 1 ha of mature grapes requires approximately 10 ML/year; implying full development has the potential demand of 5 000 ML/yr.

In 2001 a maximum 'in principle' entitlement of 1 000 ML/year was agreed with the landowners of Rocky Hill Horticultural Block to enable the development of the resource, while limiting the extraction of good quality water from the Mereenie Aquifer System.

Despite preliminary studies suggesting significant land potential for horticulture, input from the NT horticultural industry suggests demand for water from horticulture in the Rocky Hill / Ooraminna area may only reach 3 600 ML/yr by 2010 if land use agreements can be arranged between native title holders, pastoral leaseholders and the NT Government.

Table 6. Quantitative summary of projected extraction (demand) from Surface Waters and Alluvial Aquifers at 2015 (based on Table 4 figures)

			ALLUVIAL AQUIFERS — Water from Aquifer Recharge — Extraction arranged by Aquifer Volume (ML/yr)			
2015 — All figures in Megalitres (ML) = '000 000 litres. All figures represent waters with salinity under 1 000 mg/L TDS (except Town Basin)		ALL SURFACE WATER (ML/yr)	Town Basin	Inner Farm Basin	Outer Farm Basin	ALL ALLUVIAL AQUIFERS (ML/yr)
Non - Consumptive Use	**Environment and Cultural**	12 000	160	50	200	**410**
Consumptive Use	**Public Water Supply**	0	0	0	0	**0**
Consumptive Use	**Agriculture**	0	0	33	55	**88**
Consumptive Use	**Industry**	0	816	42	64	**922**
Consumptive Use	**Rural, Stock & Domestic**	not quantified	2	0	1	**3**
Total Consumption (ML/yr) (Licensed figures used where extraction figures are absent)		**0**	**818**	**75**	**120**	**1 013**

Assumptions for Table 6 (Projected Demand for Extraction from Alluvial Aquifers at 2015)

Environment and Cultural	(i) 100% of potential evapotranspiration from Alluvial Aquifers occurs over the course of a year.
Public Water Supply	(ii) Any gains from technological improvements that render Town Basin groundwater fit for human consumption will be directed toward industries with a higher economic return on investment.
Agriculture	(iii) 1% per year growth over 10 years Inner and Outer Farm Basins from current extraction (2004)
	(iv) Agricultural demands in the Outer Farm Basin for re-used effluent can be added to the Strategy when realised, as it has no net impact on the water balance.
Industry	(v) 1% per year growth (predominantly landscape irrigation from Town Basin) based on current extraction (2004) rates
Rural Stock and Domestic	vi) 0% per year growth from current extraction estimates (2004)

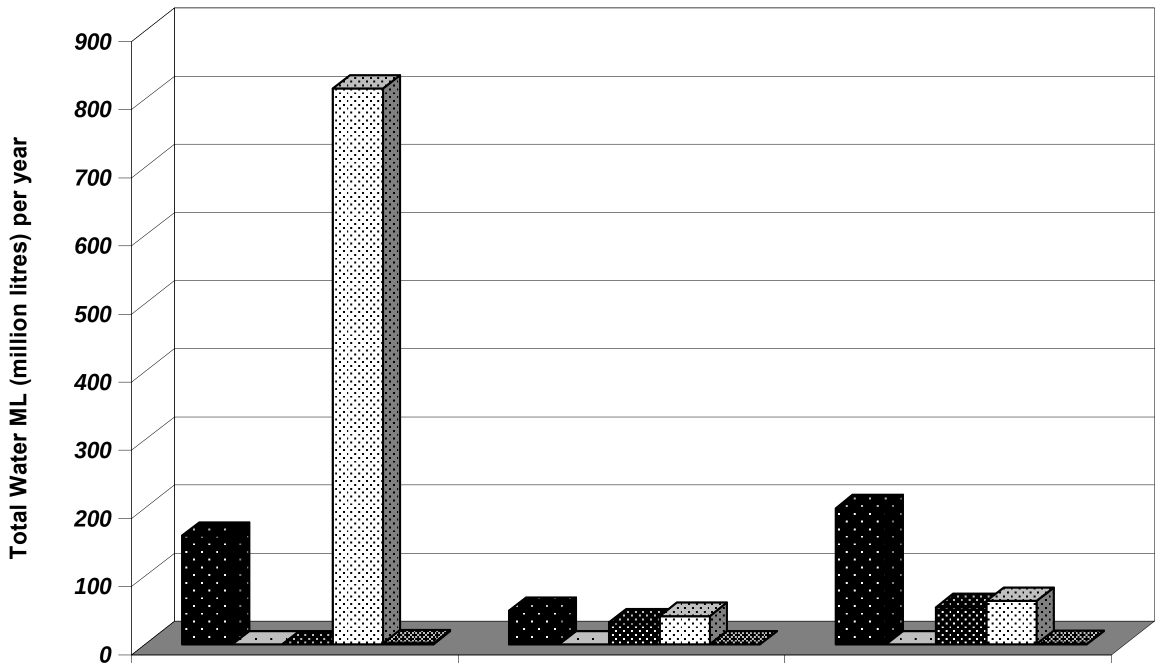
Table 7. Quantitative summary of projected extraction (demand) from Amadeus Basin Aquifers at 2015 (based on Table 5 figures)

		AMADEUS BASIN AQUIFERS – Water from Aquifer Storage					
2015		Extraction arranged by Aquifer Volume (ML/yr)			Extraction arranged by Geographical Area Volume (ML/yr)		Combined Amadeus Basin Aquifers
All figures in Megalitres (ML) = '000 000 litres All figures represent waters with salinity under 1 000 mg/L TDS		Mereenie Aquifer System	Pacoota Sandstone	Shannon & Goyder Formations	Roe Creek Mereenie, Pacoota, Shannon & Goyder	Rocky Hill Mereenie Aquifer System Only	
Non - Consumptive Use	Environment and Cultural	3 000	0	0	0	3 000	**3 000**
Consumptive Use	Public Water Supply	8 696	1 608	113	10 417	0	**10 417**
	Agriculture	3 600	0	0	0	3 600	**3 600**
	Industry	0	0	0	0	0	**0**
	Rural, Stock & Domestic	104	0	0	17	87	**104**
Total Consumption (ML/yr) (Licensed figures used where extraction figures not available)		**12 315**	**1 584**	**111**	**10 325**	**3 686**	**14 011**

Assumptions for Table 7 (Projected Demand for Extraction from Amadeus Basin Aquifers at 2015)

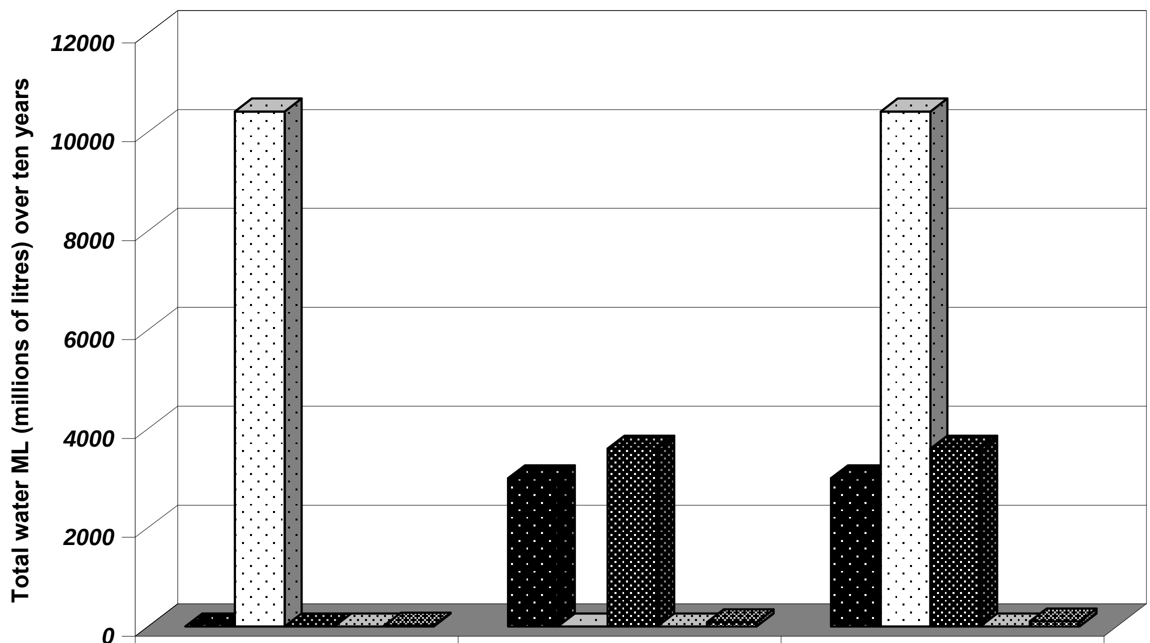
Environment and Cultural	(i) Cumulative evapotranspiration over 10 years in Amadeus Basin Aquifers
Public Water Supply	(ii) 1.5% per year cumulative growth in demand for potable water from the Amadeus Basin Aquifers over the next 10 years, based on current average annual extraction rates (1999-2004)
	(iii) demand from the Joint Defence Facility Pine Gap is not expected to exceed 250 ML/yr by 2015
Agriculture	(iv) Based on projected staged growth planned for Undoolya Horticultural Area over the next 10 years
Industry	(v) 0% per year growth from current extraction estimates (2004)
Rural Stock and Domestic	(vi) 0% per year growth from current extraction estimates (2004)

Figure 14. Projected extraction (demand) from Alluvial Aquifers (2015)



	Town Basin	Inner Farm Basin	Outer Farm Basin
Environment & Cultural	160	50	200
Public water supply	0	0	0
Agriculture	0	33	55
Industry	816	42	64
Rural Stock and Domestic	2	0	1

Figure 15. Projected extraction (demand) from Amadeus Basin Aquifers (2015)



	Roe Creek (Mereenie, Pacoota, Shannon & Goyder)	Rocky Hill (Mereenie)	Combined Amadeus Aquifers
Environment & Cultural	0	3000	3000
Public water supply	10417	0	10417
Agriculture	0	3600	3600
Industry	0	0	0
Rural Stock and Domestic	17	87	104

PART 5 WATER ALLOCATION AND USE RIGHTS

The regulatory framework presented below incorporates the best available understanding of the region's natural resource sciences, socioeconomic analysis and community input.

To reflect the diverse nature of the water resources of the Alice Springs region, approaches to declaring beneficial uses, allocations and licensing necessarily differ between Surface Water, Alluvial Aquifers and Amadeus Basin Aquifers (see Tables 8, 9 and 10). These differences are reflected in the various water management zones of the Strategy (see Map 14).

Consumptive and non-consumptive beneficial uses for each of the water management zones are shown in Map 15. The proportional allocations for each beneficial use in each water management zone are shown in Map 16. Proportional allocations are based on the definition of maximum allowable yield (see Section 2.5).

Under the NT *Water Act*, a Water Allocation Plan must include an allocation for environmental use. The purpose of this allocation is to provide a water regime that will ensure the survival of dependent ecosystems and be consistent with ARMCANZ and ANZECC National Principles.

With the exception of Heavitree Gap, groundwater extraction is unlikely to affect semi-permanent waterholes, wetlands and soaks in the Alice Springs region. The allocation of 95% of surface flows to the environment will safeguard the replenishment of these waterholes, and no current or planned surface water extraction occurs upstream of Heavitree Gap, except limited extraction for stock use. Also, springs which are fed by local groundwater systems have few consumptive users.

There is some possibility that groundwater extraction from the shallower alluvial aquifers in the Alice Springs region could affect groundwater dependent ecosystems associated with the Town Basin, Inner Farm Basin, Outer Farm Basin and Wanngardi Basin. The potential for these environments to be impacted upon will be assessed in close consultation with the Alice Springs Water Advisory Committee. More resource assessment work will assist in understanding the implications of any water allocations made in relation to the Wanngardi Basin.

The extraction of groundwater from Amadeus Basin Aquifers for consumptive use is considered to impose very low risks of compromising the health of ecosystems located near deeper rock aquifers of the Mereenie Aquifer System, Pacoota Sandstones, Shannon and Goyder Formations, particularly in the vicinity of the Roe Creek borefield where depths to water exceed 100 metres.

Until better information becomes available, total evapotranspiration and outflow estimates are considered sufficient to represent the water needed to maintain ecosystem function, Indigenous cultural values and other non-consumptive public benefits. These allocations are contingency allocations (see Section 2.1) and, as such, will be reviewed after five years. Future environmental water requirements will need to be defined not only in terms of volumes but also in terms of water levels and water quality.

The consumptive pool is determined by the physical characteristics of the aquifer, the limits of current pumping technology and the amount of water remaining after environmental, cultural and other public benefit requirements are met. The consumptive pool, including public water supply, agriculture, industry and rural stock and domestic use, is determined within the remaining available water resource.

In addition to providing the Alice Springs community improved certainty regarding water allocations, this Strategy also provides an adaptive framework to amend the allocations in light of new findings and improved understanding through ongoing research and a review process scheduled every five years.

The first five-year review of this Strategy will pick up on additional sources of available water not already allocated. At this stage, it is envisaged that any additional water generated from the Alice Springs Water Reuse Project will be taken up by increased demand for horticultural or industrial uses in the Outer Farm Basin, resulting in no net difference in the amount of water available for other beneficial uses or from other sources.

5.1 Surface Waters

Surface Water Management Zones

Map 14 shows the surface water management zones of the Todd River and Roe Creek Catchments, as determined by this Strategy, for the implementation of a Water Allocation Plan. The management zones identified are:

Management Zones for Surface Waters
• Upper Alice Springs Catchment Area
• Lower Alice Springs Catchment Area

Surface Water Beneficial Uses

The rivers and wetlands of Alice Springs are recognised for their primary ecosystem support role, cultural significance to the Arrernte peoples of Alice Springs and recreational benefit for Alice Springs residents. Accordingly, the beneficial uses of all surface waters of the upper and lower catchments, shown in Map 15 will be as follows:

Beneficial Uses for Surface Waters
Environmental use
Cultural use
Rural Stock and Domestic use

Surface Water Maximum Allowable Yield

Extraction from rivers and wetlands in the Strategy region is limited to small stock dams and is currently unlicensed. Considerable uncertainties remain regarding estimates of volumes and variability of rainfall and practical challenges associated with the capture and storage of potentially available surface water.

Environmental water requirements have not yet been estimated in the Upper and Lower Alice Springs Catchment Areas. Accordingly, a volumetric consumptive pool has not been determined. Research will continue into surface water – groundwater interactions and the environmental values associated with surface water in the Strategy region.

Consultation with native title holders, traditional land owners and traditional custodians will assist in identifying any impacts on cultural values arising from the Strategy and determine agreed definitions of maximum allowable yield for surface waters in the Strategy region.

Water will continue to be used for limited rural stock and domestic purposes while assessment, monitoring and reporting continues on regional rainfall, surface water flow and water quality in each of the management zones.

Additional research will be required to assess the capture of surface water runoff in small dams so as to assist with testing of the allocation policy.

Surface Water Allocations

Rivers and wetlands in the Alice Springs region are allocated primarily (95% of flow) for environmental and cultural use (non-consumptive use), with remaining allocation (5%) for rural stock and domestic water supplies (consumptive use), ensuring surface water and soil moisture dependent ecosystems are protected (see Table 8, Figure 16, Map 16).

Table 8. Water Allocations for Surface Waters (2006-2015)

SURFACE WATER ALLOCATIONS			
2006-2015		SURFACE WATERS	
		Upper Catchment Alice Springs Catchment	Lower Catchment Alice Springs Catchment
	BENEFICAL USES		
Non-Consumptive Pool	Environment and Cultural	≥ 95%	≥ 95%
Maximum Allowable Yield (Annual) Derived from Surface Water Flows (ML/yr)		?	?
Consumptive Pool	Rural, Stock & Domestic	≤ 5%	≤ 5%
	Total Consumptive Allocations (as a proportion of Maximum Allowable Yield)	≤ 100%	≤ 100%

Surface Water Use Rights

The predominant allocation to environmental use of all rivers and wetlands requires that only minor extractions, diversions or damming of streams for homestead and stock water supplies will be permitted. These water supplies will not divert more than 5% of stream flow or catchment runoff. In addition, water quality will continue to be protected against waste discharge and pollution to preserve the natural water quality as far as possible.

Water Use Rights for Surface Water Management Zones 2006 - 2015
SURFACE WATERS
Upper and Lower Alice Springs Catchment Areas Water allocations for harvesting surface water runoff will be prepared when adequate information is obtained and informed decisions can be made in consultation with the Alice Springs Water Advisory Committee.

Surface Water Implications

The allocation of 95% of surface water flow for environmental and cultural use will preserve the function of regional catchments in maintaining aquifer recharge.

Implications of Water Use Rights for Surface Waters
SURFACE WATERS
Upper and Lower Alice Springs Catchment Areas It will be necessary to develop estimates of environmental water requirements and cultural water requirements in surface water management zones so as to quantify values and prepare management rules for protecting environmental and cultural values and determine the scope for expanded use of the potentially available resource. In the past, indications are that, at least some of the local Arrernte inhabitants (traditional owners), have been opposed to surface water storage in the upper catchment for recreational or any other purpose.

5.2 Alluvial Aquifers

Alluvial Aquifer Management Zones

Map 14 shows Alluvial Aquifer management zones for aquifers which underlie the catchments of Todd River and Roe Creek, as determined by this Strategy, for the implementation of a Water Allocation Plan.

The Alluvial Aquifers of Alice Springs will be managed on an individual basis with clear recognition of their hydrogeological interconnectivity. The individual Alluvial Aquifers are delineated by ridgelines associated with the MacDonnell Ranges although the Todd River, Roe Creek and underlying groundwater flow through the gaps. Heavitree Gap separates the Alice Springs Town Basin from the Inner Farm Basin while the Inner Farm Basin is separated from the Outer Farm Basin by Blatherskite Range.

Management Zones for Alluvial Aquifers
• Town Basin,
• Inner Farm Basin
• Outer Farm Basin
• Wanngardi Basin*

Alluvial Aquifer Beneficial Uses

To reflect the nature of the resources and the range of existing and future water uses, the beneficial uses of all groundwaters (including waters exceeding 1000 mg/L TDS) shown in Map 15 will be as follows:

Beneficial Uses for Alluvial Aquifers
□ Environmental use*
□ Cultural use*
□ Agricultural use
□ Industrial use
□ Rural Stock and Domestic use*

(*) To reflect the current water demands and limited understanding, beneficial uses for the aquifers of the Wanngardi Basin will be limited to environmental, cultural and rural stock and domestic purposes only.

Declarations for environmental and cultural beneficial uses within the Alluvial Aquifers are notional and are contingent on further studies (stated in the strategic work plan) to determine the presence or absence of these non-consumptive demands. Apart from rural stock and domestic water supplies, all extraction of groundwater must be licensed under the NT *Water Act*.

Alluvial Aquifer Maximum Allowable Yield

Due to the dynamic nature of the Alluvial Aquifers (Town Basin, Inner Farm Basin and Outer Farm Basin) the maximum allowable yield (consumptive pool) is based on estimated average annual recharge from the Todd River and Roe Creek and urban and rural activities, less annual evapotranspiration and outflow estimates.

No estimate of maximum allowable yield is available for Wanngardi Basin. The water allocation for Wanngardi Basin will be reviewed when adequate information is obtained and informed decisions can be made in consultation with the Alice Springs Water Advisory Committee. Table 9 compares the projected water demands and available water resources for Alluvial Aquifers and provides a reference for the water allocations presented in Table 10.

Table 9. Comparison of projected water demands (2006-2015) with maximum allowable yield for Alluvial Aquifers

	2006-2015	ALLUVIAL AQUIFERS (RENEWABLE)		
	All figures in Megalitres (ML) = '000 000 litres All figures represent waters with salinity under 1 000 mg/L TDS (except Town Basin)	Town Basin	Inner Farm Basin	Outer Farm Basin
See Chapter 3		Water Sourced from Recharge (ML/yr)		
	Total Recharge (ML/yr) (direct rain, river recharge and throughflow)	1 200	430	810
	Evapotranspiration (ML/yr)	160	50	200
	Groundwater outflow (ML/yr)	40	310	500
	Current Available Storage (ML)	2 540	800	100 000
	Pre-Development Available Storage (ML)	2 540	800	100 000
	Maximum Allowable Yield (Annual) derived from current recharge to Alluvial Aquifers	**1 000 ML/yr**	**70 ML/yr**	**110 ML/yr**
	FUTURE WATER DEMANDS BY BENEFICAL USE	**Water in Alluvial Aquifers Sourced from Recharge**		
See Chapter 4 / Comparison of projected extraction 2006-2015 (From Table 6) and maximum allowable yield%	**Public Water Supply (2006-2015)**	0 ML/yr	0 ML/yr	0 ML/yr
	Proportion of maximum allowable yield	-	-	-
	Agriculture (2006-2015)	0 ML/yr	33 ML/yr	55 ML/yr
	Proportion of maximum allowable yield	-	47%	50%
	Industry (2006-2015)	816 ML/yr	42 ML/yr	64 ML/yr
	Proportion of maximum allowable yield	82%	60%	58%
	Rural, Stock & Domestic (2006-2015)	2 ML/yr	0 ML/yr	1 ML/yr
	Proportion of maximum allowable yield	0.25%	-	0.83%
	2006-2015 Estimated Annual Consumption from Alluvial Aquifers (see Table 6)	818 ML/yr **82%**	75 ML/yr **107%**	120 ML/yr **109%**

Alluvial Aquifer Allocations

Table 10 presents the proportionate non-consumptive and consumptive pools for the Alluvial Aquifers and defines the water allocations for consumptive uses including public water supply, agriculture, industry, rural stock and domestic use for 2006-2015 (see Figure 16, Map 16).

Table 10. Water Allocations for Alluvial Aquifers (2006-2015)

ALLUVIAL AQUIFER WATER ALLOCATIONS				
2006-2015		**ALLUVIAL AQUIFERS**		
All Figures Megalitres (ML) = '000 000 litres All figures represent waters with salinity under 1 000 mg/L TDS (except Town Basin)		**Town Basin**	**Inner Farm Basin**	**Outer Farm Basin**
	BENEFICAL USES			
Non-Consumptive Pool	**Environment and Cultural** **Non-consumptive demands are prescribed prior to determining the consumptive pool and consumptive allocations**	160 ML/yr	50 ML/yr	200 ML/yr
Maximum Allowable Yield (Annual) derived from Current Recharge to Alluvial Aquifers		**1 000 ML/yr**	**70 ML/yr**	**110 ML/yr**
Allocations from Annual (1yr) Consumptive Pool	**Public Water Supply**	**0%**	**0%**	**0%**
	Agriculture	**0%**	**≤ 44%**	**≤ 46%**
	Industry	**≤ 99%**	**≤ 55%**	**≤ 53%**
	Rural Stock and Domestic	**≤ 1%**	**≤ 1%**	**≤ 1%**
	Total Consumptive Allocations	**≤ 100%**	**≤ 100%**	**≤ 100%**

Alluvial Aquifer Water Use Rights

Non-consumptive uses are taken into consideration before any water is allocated for consumptive purposes to ensure that community values associated with those uses are protected as much as possible.

Water Use Rights for Alluvial Aquifer Management Zones 2006-2015	
ALLUVIAL BASINS	
Town Basin Total use by all groundwater extraction licences in the Town Basin will be allowed up to 1 000 ML/yr. During periods when groundwater levels are high, total extraction beyond 1 000 ML/yr will be subject to the outcomes from ecosystem studies detailed in the work plan, review by the Water Advisory Committee and determination by the Controller of Water Resources. **Inner Farm Basin** Total use by all groundwater extraction licences in the Inner Farm Basin will be allowed up to 70 ML/yr. Total extraction beyond 70 ML/yr will be subject to the outcomes from ecosystem studies detailed in the work plan, review by the Water Advisory Committee and determination by the Controller of Water Resources.	**Outer Farm Basin** Total use by all groundwater extraction licences in the Outer Farm Basin will be allowed up to 110 ML/yr, excluding waters provided through the Alice Springs Water Reuse Project using treated effluent recharged to the aquifer by soil aquifer treatment. Total extraction beyond 110 ML/yr will be subject to the outcomes from ecosystem studies detailed in the work plan, review by the Water Advisory Committee and determination by the Controller of Water Resources. Extraction licences may be issued up to the volume recharged through effluent reuse programs, subject to monitoring and review. **Wanngardi Basin** Water allocations for Wanngardi Basin will be developed when adequate information is obtained and informed decisions can be made in consultation with the Alice Springs Water Advisory Committee.

Alluvial Aquifer Implications

While projected demand in 2015 (see Table 9) from the Inner Farm Basin and Outer Farm Basin exceeds the maximum allowable yield, the consumptive allocation (see Table 10) for each of the Alluvial Aquifer management zones is within the maximum allowable yield. Overallocation of the groundwater resource in the Alluvial Aquifers is no longer an option because of the requirement to ensure that non-consumptive uses are protected. Future entitlements will reflect the importance of demand management, reuse programs and water trading to accommodate future development of the resource. The Water Advisory Committee will have an opportunity to review and refine the allocations in response to a detailed study of environmental flows, improved knowledge of aquifer dynamics, additional sources of recharge and technological innovations that improve water use efficiency.

Implications of Water Use Rights for Alluvial Aquifers	
ALLUVIAL BASINS	
Town Basin For the present and immediate future, the proposed allocation of the Town Basin recognises that groundwater levels will fluctuate. In the short term there may be a temporary lowering of the water table with equilibrium in groundwater storage maintained for the longer term. Extraction from the Town Basin in excess of net recharge is considered temporarily desirable to lower water tables underlying the Alice Springs township, ameliorate possible salinity issues and encourage recharge by better quality waters. However, excessive decline in groundwater levels may impact on the health of the river red gums. Extraction from the Town Basin therefore requires careful management. Groundwater levels in the river corridor must not be permitted to decline beyond 8 metres below ground level, measured from an index point that is yet to be determined. All extraction (including for rural stock and domestic use) shall be licensed and water levels and water quality monitored. Extraction up to 1000 ML/yr will be allowable to minimise the possible impacts of salinity. Management will aim to maximise extraction from the southern zone. Management will also consider options for future emergency and potable use after treatment.	**Inner Farm Basin** The groundwater levels of the Inner Farm Basin aquifer are relatively stable and high. The proposed use rights accept a limited lowering of groundwater levels in the area over the period of this Strategy. **Outer Farm Basin** Considering the large volume of available water, depths to the water table and no evidence of stress, the water use rights accept a limited lowering of groundwater levels over the period of this Strategy. The Strategy does not allow for significant expansion of demand for rural stock and domestic purposes in the Outer Farm Basin. Future demand for agricultural or industrial uses in the Outer Farm Basin may be offset by up to 1 800 ML/yr of recycled water made available through the Alice Springs Water Reuse Project at AZRI incorporating aquifer storage and recovery of treated effluent. **Wanngardi Basin** Environmental water requirements have not yet been estimated for the groundwater resource in the Wanngardi Basin. Accordingly, a consumptive pool has not been determined for this aquifer. Water use will continue to be limited to rural stock and domestic purposes.

5.3 Amadeus Basin Aquifers

Map 14 shows the management zones for Amadeus Basin Aquifers, as determined by this Strategy, for the implementation of a Water Allocation Plan. The individual aquifers of the Amadeus Basin are delineated and the volumes of water they contain have been estimated (Figure 14). The Amadeus Basin Aquifers will be managed on the basis of separate management zones with clear recognition of their hydrogeological interconnectivity.

Amadeus Basin Aquifer Management Zones

The sub-division of the Amadeus Basin Aquifers between Roe Creek and Rocky Hill / Ooraminna recognises the hydrogeological connectivity (particularly in the Mereenie Aquifer System); however distinctions can be made based on differing aquifer porosity, permeability, recharge, geomorphology, volumes in storage, differing levels of understanding, general water quality and demands for water extraction.

The Amadeus Basin Aquifers of Alice Springs will be managed by individual aquifer, which are further subdivided into two zones reflecting the connected but distinctive areas; Roe Creek Management Zone (portions of Amadeus Basin Aquifers west of 133^{o} 57' Longitude) and Rocky Hill / Ooraminna Management Zone (portions of Amadeus Basin Aquifers east of 133^{o} 57' Longitude).

Management Zones for Amadeus Basin Aquifers	
Roe Creek Management Zone	Rocky Hill / Ooraminna Management Zone
• Mereenie Aquifer System, • Pacoota Sandstone Formation, • Goyder and Shannon Formations	• Mereenie Aquifer System, • Pacoota Sandstone Formation, • Goyder and Shannon Formations

Amadeus Basin Aquifer Beneficial Uses

To reflect the nature of the resources and the range of existing and future water uses, the beneficial uses of all groundwaters (including waters exceeding 1000 mg/L TDS) shown in Map 15 will be as follows:

Beneficial Uses for Amadeus Basin Aquifers	
Roe Creek Management Zone	Rocky Hill / Ooraminna Management Zone
Public Water Supply Rural Stock and Domestic use	Environmental Use Cultural Use Public Water Supply Agriculture Rural Stock and Domestic Use

Declarations for environmental and cultural uses within the Rocky Hill / Ooraminna Management Zone are notional at this stage and are contingent on further studies (stated in the strategic work plan) to determine the presence or absence of these non-consumptive demands. Apart from rural stock and domestic water supplies, all extraction of groundwater must be licensed under the NT *Water Act*. To protect water supplies for current and future generations the beneficial uses of all waters with salinities under 500 mg/L will be declared to be to public water supply, excluding existing agricultural, rural stock and domestic entitlements.

Amadeus Basin Aquifer Maximum Allowable Yield

Due to the relatively large water storages and low recharge rates within the rock aquifer systems of the Amadeus Basin (Mereenie, Pacoota and Shannon & Goyder Formations) the maximum allowable yield (or consumptive pool) will be based on total available storage, including annual recharge, less annual evapotranspiration and outflow estimates. The maximum allowable yield for current and future water extraction from the combined volume of the Amadeus Basin Aquifers must not exceed 80% depletion of total available aquifer storage over a period no less than 320 years from start of extraction (this is equivalent to the maximum allowable yield not exceeding 25% depletion of the total available aquifer storage in 100 years). Table 11 matches the projected water demands and the available water resources to provide a comparative reference for the water allocations presented in Table 12.

Table 11. Comparison of projected water demands (2006-2015) with maximum allowable yield for Amadeus Basin Aquifers

		2006-2015	AMADEUS BASIN AQUIFERS (NON-RENEWABLE)		
		All Figures Megalitres (ML) = '000 000 litres All figures represent waters with salinity under 1 000 mg/L TDS	Roe Creek Mereenie, Pacoota, Shannon & Goyder	Rocky Hill Mereenie Aquifer System Only	Combined Amadeus Basin Aquifers
See Chapter 3			Water Sourced from Storage		
		Total Recharge (ML/yr) (direct rain, river recharge and throughflow)	2 780	2 000	4 780
		Evapotranspiration (ML/yr)	0	3 000	3 000
		Groundwater outflow (ML/yr)	880	900	1 780
		Current Available Storage (ML)	1 760 000	3 750 000	5 510 000
		Pre-Development Available Storage (ML)	2 046 000	3 755 000	5 801 000
Maximum Allowable Yield (***25% storage depletion over 100 years***) derived from pre-development available storage.			1 450 250 ML over 100 years		
Maximum Allowable Yield (2006-2015) sourced from pre-development available storage of Amadeus Basin Aquifers			**145 025 ML over 10 years**		
		FUTURE WATER DEMANDS BY BENEFICAL USE	**Water sourced from available storage**		
See Chapter 4	Comparison of projected extraction 2006-2015 (From Table 7) and maximum allowable yield%	**Public Water Supply (2006-2015)**	104 169 ML/10yrs	0 ML/10yrs	104 169 ML/10yrs
		Proportion of maximum allowable yield	71.8%	-	71.8%
		Agriculture (2006-2015)	0 ML/10yrs	36 000 ML/10yrs	36 000 ML/10yrs
		Proportion of maximum allowable yield	**0%**	**24.8%**	**24.8%**
		Industry (2006-2015)	**0** ML/10yrs	**0** ML/10yrs	**0** ML/10yrs
		Proportion of maximum allowable yield	-	-	-
		Rural Stock and Domestic (2006-2015)	170 ML/10yrs	870 ML/10yrs	1 040 ML/10yrs
		Proportion of maximum allowable yield	**0.12%**	**0.60%**	**0.72%**
		2006-2015 Estimated 10-year consumption sourced from available storage of Amadeus Aquifers (Table 7)	104 339 ML **71.9%**	36 870 ML **25.4%**	141 209 ML **97.4%**

Amadeus Basin Aquifer Allocations

Table 12 details the water allocations for the Amadeus Basin Aquifers. As long as no more than 2.5% of the total available resource is used in each decade, then the rate of use will not exceed the modified policy limit (i.e. maximum allowable yield). This gives a maximum rate of use against which proposed water demands can be assessed over a 10 year period (consistent with the life of the Strategy) (see Figure 16, Map 16).

Table 12. Water Allocations for Amadeus Basin Aquifers (2006-2015)

AMADEUS BASIN AQUIFER WATER ALLOCATIONS									
2006-2015		AMADEUS BASIN AQUIFERS							
All figures Megalitres (ML) = '000 000 litres		Combined Amadeus Aquifers (Roe Creek & Rocky Hill) Proportionate Allocations	Combined Amadeus Aquifers (Roe Creek & Rocky Hill) Total Volumes	Maximum Allowable Yield over 100 years (25% storage depletion)	Maximum Allowable Yield over 10 years (2.5% storage depletion)	Roe Creek			Rocky Hill
						Mereenie	Pacoota	Shannon & Goyder	Mereenie
BENEFICAL USES									
Non-Consumptive Pool	**Environment and Cultural** Non-consumptive demands prescribed prior to determining the consumptive pool and consumptive allocations (ML/yr)	n/a	30 000	n/a	n/a	0	0	0	30 000
Maximum Allowable Yield (ML/10 yrs) derived from aquifer storage depletion					**145 025**	**Proportion of total available storage available for extraction**			
10-year Consumptive Pool	**Public Water Supply**	**≤ 74%**	4 292 740	1 073 185	**107 319**	**≤ 99%**	**≤ 99%**	**≤ 99%**	**≤ 60%**
	Agriculture	**≤ 25%**	1 450 250	362 563	**36 256**	**0%**	**0%**	**0%**	**≤ 39%**
	Industry	**≤ 0%**	0	0	**0**	**0%**	**0%**	**0%**	**0%**
	Rural, Stock & Domestic	**≤ 1%**	58 010	14 503	**1 450**	**≤ 1%**	**≤ 1%**	**≤ 1%**	**≤ 1%**
	Total Consumptive Allocations	**≤ 100%**	5 801 000	1 450 250	**145 025**	**≤ 100%**	**≤ 100%**	**≤ 100%**	**≤ 100%**

Table 12 shows 100% of the 10 year maximum allowable yield (or consumptive pool) has been allocated. The proportional water allocations specified in Table 12 apply to waters of all qualities, including poor quality water more than 1000 mg/L. It is expected that future water storage estimates will improve. Due to a limited understanding to begin with and the remaining uncertainty, particularly of estimates of poor quality waters (and limited current demand), volumetric estimates only refer to waters of good to poor drinking water quality (0 to 1000 mg/L). Future revisions of this Strategy will incorporate refined volumetric estimates which reflect an improved understanding of the quantity and quality of the groundwater resource facilitated through ongoing research detailed in the strategic work plan.

Amadeus Basin Aquifer Water Use Rights

Of the 100% maximum allowable yield for the combined Amadeus Basin Aquifers, 74% of the total consumptive pool from the Roe Creek and Rocky Hill / Ooraminna Management Zones has been allocated to public water supply. This amount is expected to meet projected demand for public water supply over the life of the Strategy. Also, 25% of the total consumptive pool has been allocated for agricultural use to accommodate anticipated expansion in the horticultural industry over the next 10 years and 1% has been allocated to rural stock and domestic purposes, which is expected to meet estimated demand over the next 10 years.

Water Use Rights of Amadeus Basin Aquifers 2006-2015

AMADEUS BASIN AQUIFERS

Roe Creek Management Zone

Total use by all groundwater extraction licences within the Roe Creek Management Zone (including the Mereenie Aquifer System, Pacoota Sandstones and Shannon & Goyder Formations) will be allowed up to 107 569 ML over 10 years (2006-2015).

- Public Water Supply - Total groundwater extraction will be allowed up to 107 319 ML over 10 years (2006-2015).
- Rural Stock and Domestic - Total groundwater extraction will be allowed up to 250 ML over 10 years (2006-2015).

Rocky Hill Management Zone

Total use by all groundwater extraction licences in the Rocky Hill / Ooraminna Management Zone (Mereenie Aquifer System) will be allowed up to 37 456 ML over 10 years (2006-2015).

- Public Water Supply – the allocation for Public Water Supply will be met by extraction from Roe Creek for the period of the Strategy.
- Agriculture - Total groundwater extraction will be allowed up to 36 256 ML over 10 years (2006-2015).
- Rural Stock and Domestic - Total groundwater extraction will be allowed up to 1 200 ML over 10 years (2006-2015).

Amadeus Basin Aquifer Implications

The policy approach, stated in Section 2.5, is incompatible with unlimited future increases in water usage. The maximum allowable yield adopted by this Strategy (145 025 ML over 10 years) can be interpreted as depleting the total available aquifer storage by no more than 80% over 320 years. However it should be noted that the lifespan of the better quality water (less than 500 mg/L TDS) will be approximately half this period. Therefore it is desirable that good quality drinking water should be reserved for public water supply. This Strategy allows for some increase in demand for public water supply and further development of the horticulture industry while limiting the extent of usage over the 10 year life of the Strategy. It is not anticipated that these allocations will impose unacceptable constraints on either of these declared beneficial uses during the life of this Strategy. Beyond the life of this Strategy, the policy means that total extraction for public water supply cannot exceed the level of demand expected to be reached in 2017. Therefore, in the longer term, innovative methods of groundwater resource management will be required to provide opportunities for growth without exceeding the maximum allowable yield.

Implications of Water Use Rights for Amadeus Basin Aquifers

AMADEUS BASIN AQUIFERS

Roe Creek Management Zone

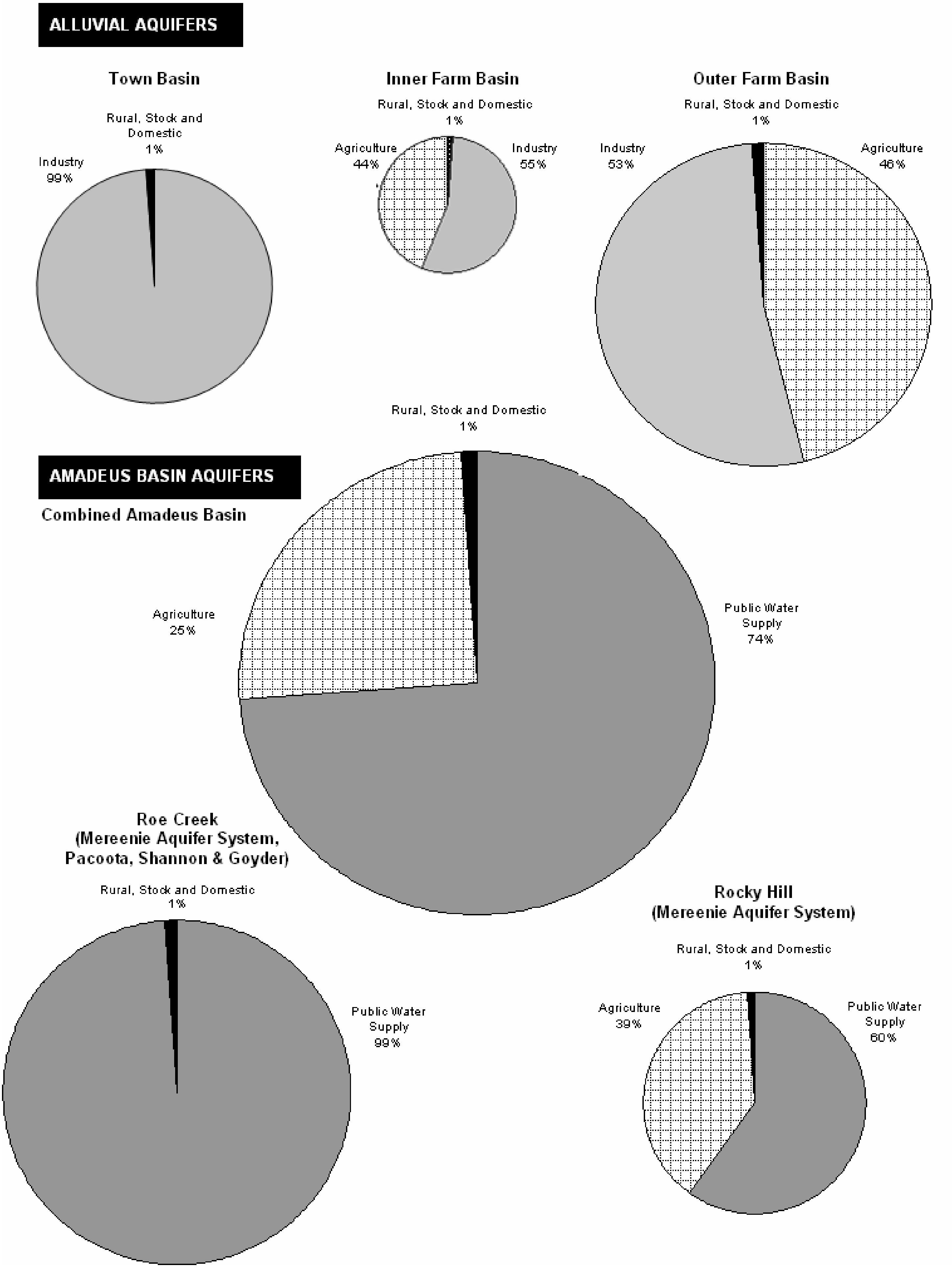
Except for a small proportion of water for rural stock and domestic use, all groundwater from the Roe Creek area is dedicated to public water supply. To preserve better quality waters (less than 500 mg/L TDS) of the Mereenie Aquifer System within the Roe Creek Management Zone, extraction should mix better and poorer quality water to achieve a blend of just less than 500 mg/L TDS. One way of achieving this may be to proportionally increase utilisation of the Pacoota and Shannon Formations (which yield poorer quality waters) while extraction is maintained within the overall limits set by the maximum allowable yield for the combined Amadeus Basin Aquifers.

Rocky Hill / Ooraminna Management Zone

No other proposals, apart from public water supply and horticulture, have been raised for the use of Amadeus Basin Aquifers in the Rocky Hill / Ooraminna Management Zone. Beneficial uses have not been declared for industrial or aquaculture use at this stage as there is no indication of demand for these alternative uses. Further declarations of beneficial uses and adjustments to allocations will be considered by the public, the Alice Springs Water Advisory Committee and the Controller of Water Resources if and when such demand emerges.

A total allocation of 36 256 ML over the next 10 years (or 3 625 ML/yr) for agriculture will meet the needs of the horticultural industry, while remaining consistent with the maximum allowable yield. Apart from the Rocky Hill freehold horticultural area, which for historical reasons has an 'in principle' entitlement up to but not exceeding 1 000 ML/yr, it is intended that all new horticulture envisaged under the Strategy shall draw upon areas further to the south and east of the land set aside for the future public water supply borefield at Rocky Hill. Only waters with more than 500 mg/L TDS (poorer quality water for drinking) will be available for new horticultural use to preserve the better quality waters for future public water supply purposes.

Figure 16. Groundwater Allocations for Alice Springs Water Control District



5.4 Licensing

All groundwater extraction licences in the Alice Springs region are to be renewed or issued for a ten year term (renewable) with the exception of public water supply. Ministerial approval has been provided to Power and Water Corporation allowing licences for public water supply purposes to be issued for periods of up to 50 years.

General Water Licensing and Water Trading Rules

1. Licensed water entitlements will identify the beneficial use(s) of extraction and must be used only for the purpose(s) stated in the licence.
2. Licensees will be required, at the discretion of the Controller of Water Resources, to report the volume of water pumped, water levels, water quality, management regimes and infrastructure installed, subject to location and scale of extraction. Where required pumpage for each month shall be recorded by a meter supplied, installed and maintained by the licence holder to the satisfaction of the Controller of Water Resources. The record of pumpage for each month shall be supplied to the Controller of Water Resources within two (2) weeks following the end of each month or as otherwise agreed between the licensee and the Controller of Water Resources.
3. Total licensed water entitlements cannot be issued in excess of the maximum allowable yield of a designated aquifer or management zone.
4. Licences, for which annual entitlements are not fully used, within a two year period after issue, will be reviewed and the unused portion may be revoked in full or in part.
5. Licensed extraction amounts may be reviewed by the Water Advisory Committee and the Controller of Water Resources.
6. Licensed water entitlements are able to be traded within a designated management zone in part or in full (and permanently or temporarily).
7. Trade in water licence entitlements is permitted within a single consumptive Beneficial Use category of a single management zone.
8. All applications for new groundwater extraction licences exceeding 100 ML/yr or trading water licence entitlements between Beneficial Use categories is subject to review by the Water Advisory Committee. Such applications must be accompanied by a business plan for review by the Water Advisory Committee (with an option for external independent assessment) and determination by the Controller of Water Resources, clearly demonstrating:
   - Feasibility of the project
   - Estimates of initial and ongoing volumetric and water quality demands
   - Efficient use of water, including the incorporation of water-efficient technologies and techniques appropriate for the particular purpose and best-practice
   - Economic and social benefits to the Territory, consistent with existing environmental and cultural values
9. All approvals for new groundwater extraction licences and trade in water licences rest with the Controller of Water Resources or Minister in accordance with the requirements of the declared Water Allocation Plan.
10. Records of all licences and water trades will be contained in a publicly-accessible water register. The register will include the identity of the licensee, third party interests, entitlement volumes, location, trade history, advice from the Water Advisory Committee; and a record of account taken on that advice by the Controller of Water Resources
11. The costs of administering water resource management programs are funded directly by the NT Government. However, the provisions of the Water Act allow the Controller of Water Resources to require a licensee to provide any data or information deemed necessary as part of the licence conditions and hence a significant proportion of monitoring and reporting costs are borne by licensees.
12. All failures to meet licence conditions will be investigated and reported to the Water Advisory Committee for advice to the Controller of Water Resources. Prosecution will be considered pending advice from the Water Advisory Committee and any investigation initiated by the Controller of Water Resources.

Specific Water Licensing and Water Trading Rules	
Town Basin	All licensees in the Town Basin will be required to submit samples to the Department from each bore every six months for water quality analysis.
Public Water Supply	Leakage and demand reduction measures will be a condition of licences for extraction for public water supply.
Aquifer Storage and Recovery	The Controller is responsible for the issuance of any aquifer recharge licence and will monitor compliance with the terms and conditions on any licence issued, including rigorous monitoring and reporting requirements. New groundwater extraction licences may be issued for any amount, up to the maximum volume recharged, on application from an appropriate end user. Any application for a groundwater extraction licence for reuse of non-potable water would be subject to standard assessment procedures and any licence issued will be subject to standard conditions for monitoring and reporting.
Agriculture	Annual reporting of irrigated crop areas for all licensed irrigation is compulsory. Unless otherwise approved, micro irrigation techniques shall be used for all irrigation. Chemical and/or fertiliser injection systems shall not be installed into the pump discharge lines without approval from the Controller of Water Resources.

PART 6 IMPLEMENTING THE STRATEGY

6.1 Priority Management Issues

A number of priority issues were raised through community consultations carried out in 2004 and 2005. A summary of these issues and those identified by the Alice Springs Water Resource Strategy Steering Committee are listed below. These issues should be addressed by the Alice Springs Water Advisory Committee during the periodic review of the Strategy (see Section 6.2).

Sustainability – The water that sustains Alice Springs is a finite resource. An agreed understanding and definition of sustainability needs to be discussed, developed and redeveloped with the community as more is learned about the resource.

Knowledge Gaps - Many uncertainties remain despite this Strategy incorporating more than 45 years of data and analyses. Well targeted research and further investigations are critical to address these knowledge gaps, especially the interrelationships and quantification of surface water flows, groundwater recharge, throughflow, discharge and storage and change in all of Alice Springs aquifers.

Indigenous water rights and values – Further consultation with and participation by Arrernte native title holders and Aboriginal traditional landowners and custodians are required to ensure Indigenous social, spiritual and customary needs of surface water and groundwater are incorporated into the water allocation process.

Groundwater dependent ecosystems - At present there is insufficient scientific information on arid zone groundwater dependent ecosystems. Research into the location, water requirements and acceptable levels of stress of the region's groundwater dependent ecosystems needs to be undertaken.

Protection from contamination – Groundwater contamination can be caused by a single localised activity or by widespread land-use practices. Contamination can occur from leaking underground storage tanks and pipelines, landfill leachate, residential, industrial and agricultural land use, septic tanks and wastewater treatment ponds. The flow of contaminants to an aquifer may take many years before it is noticed and, if it is technically possible, the costs of cleaning up pollution can be extremely high. Importantly, as Alice Springs is largely reliant on a single aquifer (the Mereenie Aquifer System) for its water supply, the implications of contamination could be severe.

Salinity and groundwater quality – Groundwater quality can be degraded by the excess removal of water stored in the aquifer. Over-extraction of groundwater can induce waters of greater salinity to enter and contaminate the good quality water. Excess watering and the modification of natural drainage systems can cause water tables to rise (such as in the Town Basin) and mobilise naturally occurring salts within soils to migrate and effect other land or water users.

Demand management and community education – Alice Springs residents are among the highest water users anywhere in Australia. On average approximately 65% of annual household water demand goes to outdoor gardens. A water efficiency program is needed to reduce per capita consumption in Alice Springs to allow sufficient water to maintain growth and development.

Source substitution (non-potable supply) – The Alice Springs Water Reuse Project is an innovative soil aquifer treatment system designed to allow for aquifer storage and recovery of treated effluent. The system has been designed and trialled, monitored and evaluated. Treatment of up to 600ML/yr of effluent is expected to begin in September 2007. The response of the underlying aquifer will be monitored and adaptive management measures put in place to ensure the sustainability of the soil aquifer treatment system. The volume of non-potable water generated from this source could be as much as 1 800ML/yr depending on such things as the amount of water that can be taken up by end users. The amount of non-potable water generated by the Alice Springs Water Reuse Project and the potential for other non-potable reuse options (e.g. desalination) will be evaluated from time-to-time

6.2 Water Advisory Committee

The NT *Water Act* provides for the establishment of a Water Advisory Committee to advise on the effectiveness of the Water Allocation Plan in maximising economic and social benefits within ecological restraints. A Water Advisory Committee may also carry out any other functions that the Controller of Water Resources may from time to time direct the Advisory Committee to perform. A Water Advisory Committee shall consist of such members as the Minister thinks fit and the members shall hold office at the Minister's pleasure.

Primary responsibility for promoting, reviewing and updating the Alice Springs Water Resource Strategy will require the **Alice Springs Water Advisory Committee** to:

- participate in decision-making about sustainable water resource management;
- advise on the implementation of the Strategy;
- liaise with and provide feedback from stakeholders;
- advise on regional development issues and policy matters that may influence the sustainable use and development of groundwater resources;
- review the allocations and provide advice regarding applications for water licence entitlements, trading, licensing conditions, infringements and any other functions directed to perform;
- advise on appropriate water conservation programs and projects;
- participate in ongoing monitoring and evaluation of work plan actions;
- provide an annual assessment of work plan outcomes;
- report annually on the implementation of the Strategy; and
- direct the periodic review of the Strategy.

These responsibilities will be reflected in formal Terms of Reference for the Alice Springs Water Advisory Committee to be approved by the Minister. A charter of operations will also be established, to define the committee's relationship with the **Department of Natural Resources, Environment and the Arts (NRETA)** and the **Department of Primary Industries, Fisheries and Mines (DPIFM)** in terms of:

- liaison with other industry associations and government committees;
- provision of technical support to assist in delivering the Strategy; and
- provision of a budget and administrative support for effective communication with stakeholders.

The Department of Natural Resources, Environment and the Arts will consult with the Alice Springs Water Advisory Committee and stakeholders to work towards the achievement of water resource management outcomes identified in the Strategy and will exercise due diligence in the implementation of regulatory and licensing powers. The Department will also undertake water resource assessment within available resources and provide the technical advice needed for informed decision-making.

Irrigators, the **Power and Water Corporation** and other licensees will monitor and report in accordance with regulatory requirements under the *Water Act* to:

- aid in the effective use of water;
- provide data for more sustainable extraction of water.

6.3 Strategic Work Plan

An approved work plan will be coordinated by the Department of Natural Resources, Environment and the Arts, assisted by other agencies where appropriate, under the guidance and direction of the Alice Springs Water Advisory Committee. The activities specified are consistent with management action targets and management actions detailed in the Integrated Natural Resource Management Plan for the Northern Territory 2006.

The work program is adaptive and will be reviewed and modified over time. The Alice Springs Water Advisory Committee will report progress and recommend revisions on the work plan to the Controller of Water Resources, in conjunction with government's annual budgetary processes. The inaugural Alice Springs Water Resource Strategy Work Plan is set out below.

To Improve Knowledge

	Action	Target
1.	Assess, monitor and report on regional rainfall, surface water flow, groundwater levels and water quality in each of the management zones. Regularly review assessment methodology.	Every 2 years 2008, 2010
2.	Report regional water balances for each management zone incorporating improved estimates of aquifer recharge, throughflow, water quality, storage and change in storage.	Every 5 years 2011
3.	Scope, prioritise and undertake groundwater modelling of priority aquifers to assess future impacts based on differing demand scenarios.	2007-2011
4.	Assess the full costs of water supply and determine an appropriate economic depth for water extraction from Amadeus Basin Aquifers to improve resource forecasting.	2007-2011
5.	Identify groundwater dependent ecosystems and develop indicators (such as adequate water levels) to determine operational definitions of sustainable yield. Develop estimates of environmental water requirements sourced from surface and groundwater resources in management zones within the Alice Springs Water Control District.	2007-2011
6.	Determine quantitative values for environmental water requirements sourced from surface and groundwater resources and prepare management rules for sustaining ecosystems in relevant management zones, including monitoring and regular program review.	2007-2011
7.	Consult with traditional land owners, native title holders and traditional custodians through representative organisations to identify impacts on cultural values arising from the Strategy and determine agreed definitions of sustainable yield. Develop estimates of cultural water requirements sourced from surface and groundwater resources in management zones within the Alice Springs Water Control District.	2007-2011
8.	Determine collaboratively with Indigenous representative organisations quantitative values for cultural water requirements sourced from surface and groundwater resources and prepare management rules for protecting cultural values, including monitoring and regular program review.	2007-2011
9.	Assess sustainable yield in the Wanngardi Basin Management Zone	2010
10.	Identify, assess and manage risks associated with Alice Springs water resources initially prioritising Roe Creek bore field; including the review of known groundwater pollution events, pollution vulnerability and the preparation of risk management plans.	2007 - 2008
11.	Assess the capture of surface water runoff in small dams to assist testing of allocation policy.	2010
12.	Assess and monitor salinity levels in the Town Basin and Inner Farm Basin Management Zones.	Continuing
13.	Assess the Town Basin aquifer for contribution to Alice Springs emergency and potable water supply.	2008-2011

To Improve Communication

Action	Target
14. Communicate the findings from water resource investigations and monitoring with stakeholders and the broader public on a regular basis.	Continuing
15. Build the capacity of stakeholders and the community to understand and contribute to decision making regarding Alice Springs water resources and policy processes.	Continuing
16. Establish a publicly available water register containing records of all water access entitlements in the Alice Springs Water Control District.	2007-2008
17. Institute regular reporting of water use, meter calibration, licensee compliance and total entitlements in the context of allocations.	2008; Annually thereafter
18. Publish natural resources atlas for the Alice Springs Water Control District with updates every 5 years in preparation for the next Strategy review.	2011

To Improve Management

Action	Target
19. Develop demand management and water sensitive design programs to reduce current levels of water use from Amadeus Basin Aquifers through water conservation education programs, town planning initiatives and building reforms, while accommodating economic and population growth.	Continuing
20. Determine an optimal water quality blending regime based on water quality and volumetric characteristics of the aquifers of Roe Creek Borefield to prepare operational rules to provide good quality water (500 mg/L TDS) for public water supply for the longest possible time.	2009-2011
21. Determine mechanisms to assess water licence applications considering the protection of beneficial uses, water efficiency and maximisation of economic and social benefits.	2007-2008
22. Adopt national water metering standards including specification, installation and ancillary data collection.	2007- 2008
23. Institute by all licence holders in the Alice Springs Water Control District, water level, salinity, crop area and pumpage monitoring, as appropriate.	2007; Continuing
24. Develop policy and regulatory linkages that deliver land development and planning consistent with long term protection of water resources	2007-2009
25. Prepare borefield management plans for the Town Basin, Roe Creek borefield and Rocky Hill borefield to achieve improved water quality, security of the resource	2007-2009
26. For the potable water supplies of Alice Springs undertake and integrate; (i) comprehensive demand modelling (including the implications of water efficiency), (ii) economic analysis of component costs/benefits for a range of development options, and (iii) Improved estimates of resource capacity for strategic review .	2007-2009
27. Prepare management regimes for zones where no borefield management plan is prepared, incorporating water level and water quality triggers as part of sustainable yield management	2009-2011
28. Preliminary assessment and investigation for development potential and/or alternative industries using poorer quality groundwaters (salinity >1,000 mg/L).	2009-2011
29. Audit water licenses to identify unused licenses and ensure that licensed extraction reflects actual use.	2009-2011
30. Review licensing exemptions currently provided for rural stock and domestic use within the Alice Springs Water Control District.	2009-2011
31. Determine the optimal source development options for the potable water supply of Alice Springs	2011
32. Review all licensed entitlements on the basis of reassessed sustainable yield and the strategic development of the Alice Springs Water Control District.	2011

National Water Initiative Definitions

Note: the following definitions have been developed as part of the National Water Initiative and remain aspirational goals for the NT to implement over time as part of the transition to a common national lexicon for water management. A review of the NT Water Act, and associated Regulations is needed before these definitions are incorporated into statutory documents such as this one.

environmental and other public benefit outcomes - environmental and other public benefit outcomes are agreed as part of the water planning process, are specified in water plans and may include a number of aspects, including a) environmental outcomes: maintaining ecosystem function (eg. through periodic inundation of floodplain wetlands); biodiversity, water quality; river health targets; b) other public benefits: mitigating pollution, public health (eg. limiting noxious algal blooms), Indigenous and cultural values, recreation, fisheries, tourism, navigation and amenity values.

consumptive pool - the amount of water resource that can be made available for *consumptive use* in a given water system under the rules of the relevant water plan. Within the Strategy region, the consumptive pool is determined by the physical characteristics of the aquifer, the limits of current pumping technology and waters remaining after environmental, cultural and other public benefit requirements are met. It represents the total volume of water that can be made available for consumptive use in a given water system, subject to the maximum allowable yield (see Glossary - *consumptive pool*).

consumptive use - use of water for private benefit consumptive purposes including irrigation, industry, urban and stock and domestic use (see Glossary - *consumptive use*).

environmentally sustainable level of extraction - the level of water extraction from a particular system which, if exceeded would compromise key environmental assets, or ecosystem functions and the productive base of the resource (see Glossary – *maximum allowable yield*).

overallocation - refers to situations where with full development of water access entitlements in a particular system, the total volume of water able to be extracted by entitlement holders at a given time exceeds the *environmentally sustainable level of extraction* for that system (see Glossary - overallocation).

overused - refers to situations where the total volume of water actually extracted for consumptive use in a particular system at a given time exceeds the *environmentally sustainable level of extraction* for that system. Overuse may arise in systems that are overallocated, or it may arise in systems where the planned allocation is exceeded due to inadequate monitoring and accounting.

reliability - the frequency with which water allocated under a water access entitlement is able to be supplied in full. Referred to in some jurisdictions as “high security” and “general security”.

water allocation - the specific volume of water allocated to water access entitlements in a given period, defined according to rules established in the relevant water plan (see Glossary - *entitlement*).

water access entitlement - a perpetual or ongoing entitlement to exclusive access to a share of water from a specified consumptive pool as defined in the relevant water plan. Total entitlements cannot exceed the specified allocation nor consumptive pool (see Glossary - *allocation*).

water plan - statutory plan for surface and/or groundwater systems, consistent with the Regional Natural Resource Management Plans, developed in consultation with all relevant stakeholders on the basis of best scientific and socio-economic assessment, to provide secure ecological outcomes and resource security for users. (see Glossary - *Water Allocation Plan*)

Abbreviations

ANZECC	Australian and New Zealand Environment and Conservation Council
AHD	Australian Height Datum (standard measure of vertical elevation)
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
COAG	Council of Australian Governments
GDE	groundwater dependent ecosystems
ha	hectares (10 000 m^2)
km^2	square kilometres (1 000 000 m^2)
L/s	litres per second
m	metre
M	million
mg/L	milligrams per litre ~ parts per million (ppm)
ML	megalitres = 1 million litres
ML/yr	megalitres per year
mm	millimetre
Mya	million years ago
NWI	National Water Initiative
TDS	total dissolved solids
µg/L	micrograms per litre ~ parts per billion (ppb)

GLOSSARY

allocation - perpetual or ongoing access to a share of water from a specified consumptive pool. Total entitlements for a particular beneficial use cannot exceed the specified allocation as defined in the relevant Water Allocation Plan nor can the total allocations for all beneficial uses exceed the consumptive pool (see NWI Definitions - *water access entitlement*).

aquifer - a geological structure or formation, or an artificial land-fill, containing rock or sediment that is porous, allowing large quantities of water to be stored, and permeable, or capable of being permeated permanently or intermittently with water allowing the water to move.

beneficial use - legal recognition of the values of a water resource and determines how water may be used, managed and protected as declared under the NT *Water Act* (see Table 1 - Section 2.6). Beneficial uses include: agriculture, aquaculture, public water supply, environment, cultural, industry, rural stock and domestic uses.

bore - a bore, hole, well, excavation or other opening in the ground, or a natural or artificially constructed or improved underground cavity, which is or could be used for the purpose of intercepting, collecting, obtaining or using ground water or for the purpose of disposing of water or waste below the surface of the ground, or which extends to an aquifer;

consumptive pool - the amount of water resource that can be made available for *consumptive use* in a given water system under the rules of the relevant water plan. Within the Strategy region, the consumptive pool is determined by the physical characteristics of the aquifer, the limits of current pumping technology and waters remaining after environmental, cultural and other public benefit requirements are met. It represents the total volume of water that can be made available for consumptive use in a given water system, subject to the maximum allowable yield (see NWI Definitions - *consumptive pool*).

consumptive use - use of water for private benefit consumptive purposes including irrigation, industry, urban and stock and domestic use (see NWI Definitions - *consumptive use*).

Controller - the Controller of Water Resources appointed under Section 18 of the NT *Water Act*.

dip - slope of rock layers relative to the horizontal.

entitlement - the specific volume of water licensed under the NT *Water Act* for extraction in a given period, according to rules established in the relevant Water Allocation Plan (see NWI Definitions – *water allocation*).

environment - all aspects of the surroundings of man, including the physical, biological, economic, cultural and social aspects;

environmental harm - any harm to or adverse effect on, or potential harm to or adverse effect on, the environment;

evapotranspiration - quantity of water transferred from the soil to the atmosphere by evaporation and plant transpiration.

extraction rate - the rate in terms of unit volume per unit time that water can be drawn from a surface or groundwater system. Used in the National Water Initiative in the context of a constraint that might exist due to the impact of exceeding a particular extraction rate at a particular point or within a specified system.

floodout - area of extensive alluvial plains formed by successive overflowing of a river channel.

flow - in relation to water, includes the discharge, release, escape or passage of water;

groundwater - water occurring or obtained from below the surface of the ground (other than water contained in works, not being a bore, for the distribution, reticulation, transportation, storage or treatment of water or waste) and includes water occurring in or obtained from a bore or aquifer;

groundwater - water stored underground in pores and cracks in rocks.

head - height to which water will rise in a monitoring bore connected to an aquifer.

hydraulic gradient - measure of the decrease in head per unit distance in the direction of groundwater flow.

licence (to take groundwater) - a licence to extract groundwater granted to a person by the Controller of Water Resources under the NT *Water Act*, subject to such terms and conditions, specified in the licence document.

maximum allowable yield - the maximum rate of extraction of water from an aquifer allowed for under this Strategy considering public acceptance, current values, future opportunities and intergenerational equity. The maximum allowable yield, in the case of alluvial aquifers, equates with recharge and, in the case of the Amadeus Basin Aquifers, is the maximum proportion of water that can be permanently removed from aquifer storage over a given period (see NWI Definitions – *environmentally sustainable level of extraction*).

national principles - A key objective of the ARMCANZ/ANZECC national principles is to sustain and, where necessary, restore ecological processes and the biodiversity of water-dependent ecosystems, recognising that appropriate water flow is critical for maintaining natural ecological processes and biodiversity.

overallocation - refers to situations where with full development of water access entitlements in a particular system, the total volume of water able to be extracted by entitlement holders at a given time exceeds the environmentally sustainable level of extraction for that system (see NWI Definitions – overallocation).

palaeo-channel - buried river course.

permeability - ability of a rock to allow water to flow through it.

pollution - in relation to water, means the physical, thermal, chemical, biological or radioactive properties of the water that render it less fit for a prescribed beneficial use for which it is or may reasonably be used, or to cause a condition which is hazardous or potentially hazardous to – (a) public health, safety or welfare; (b) animals, birds, fish or aquatic life or other organisms; or (c) plants.

porosity - proportion of a rock made up of pores.

public authority - includes (a) a statutory corporation; and (b) a municipal council or community government council within the meaning of the Local Government Act.

recharge - process by which water is added to an aquifer either from rainfall, stream flow infiltration, or from an adjacent aquifer.

re-use - in relation to water, includes using wastewater or effluent, whether or not it has been treated

specific yield - the volume of water that can drain from a unit volume of rock under gravity as a proportion or ratio. In a rock with large pores this will be close to the porosity, with small pores it will be much less.

storage coefficient - volume of water that an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change of head.

surface water - water that flows over land and in water courses or artificial channels and is able to be captured and stored and supplemented from dams and reservoirs.

sustainable yield - the groundwater extraction regime, measured over a specified planning timeframe that allows acceptable levels of stress and protects dependent economic, social, and environmental values.

take - in relation to water, includes to withdraw, pump, extract, use or re-use, and to divert for the purposes of using or re-using, that water and, where it is artesian water occurring in a bore, to allow the artesian water to flow from the bore.

throughflow - the movement of groundwater which enters and leaves an aquifer from/to an adjacent aquifer, or from/to the same aquifer across the boundary of a study area. Throughflow into an aquifer is included as part of the total recharge, while throughflow out of an aquifer is added to the total discharge.

transmissivity - rate at which water is transferred through a unit width of an aquifer under a unit hydraulic gradient.

waste includes matter or a thing, whether wholly or partly in a solid, liquid or gaseous state, which, if added to water, may pollute the water;

water means water, whether or not it contains impurities.

water balance - a method of accounting for the inputs and outputs of water to an aquifer.

water management zone - part or all of an aquifer system that is treated as a single unit for regulatory purposes.

water sensitive urban design - the integration of urban planning with the management, protection and conservation of the urban water cycle that ensures urban water management is sensitive to natural hydrological and ecological processes.

water system - a system that is hydrologically connected and described at the level desired for management purposes (eg sub-catchment, catchment, basin or drainage division and/or groundwater management unit, sub-aquifer, aquifer, groundwater basin).

Water Advisory Committee in relation to a Water Control District, means a committee established by the Minister, under Section 23 of the NT *Water Act*.

Water Allocation Plan means a document prepared for a particular Water Control District and declared by the Minister, under Section 22B of the NT *Water Act* (see NWI Definitions - *water plan*)

Water Control District includes any part of the Territory declared by the Minister to be a water control district under Section 22 of the NT *Water Act*.

See also the International Glossary of Hydrology, accessible via a link from http://www.unesco.org/water

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APPENDIX 1. GEOLOGICAL ERAS AND PERIODS – ALICE SPRINGS REGION

The oldest rocks of the Alice Springs region are the Precambrian rocks of the Arunta Block, formed about 1400 million years ago (Mya). The Arunta Block underlies the Alice Springs township and the catchments of the Todd River. The Arunta Block formed the bed of an ancient sea on which was deposited successive layers of sediment and later the minute bodies of single celled marine organisms to form limestone. These layers compose the Northern Amadeus Basin.

The oldest rock of the Amadeus Basin is Heavitree Quartzite which today tops the Heavitree Range to the south of the Alice Springs township. Heavitree Quartzite (silicified sandstone) and Bitter Springs Formation (dolomite, limestone and siltstone) represent the start of an ancient sedimentary sequence from the Late Proterozoic period (1000 Mya). Later carbonate and shale deposition during the Cambrian period resulted in the Shannon formations (510-570 Mya) amongst others. Marine conditions during the subsequent Ordovician period led to the deposition of sandstones, shale and limestone of the Goyder Formation and Pacoota Sandstones (510-435 Mya). A period of estuarine and terrestrial conditions during the Silurian and Devonian Periods (435-410 Mya) deposited the Mereenie Sandstone. The deposition of the Brewer Conglomerate and the Hermannsburg Sandstone marked the end of the development of the Amadeus Basin.

During the upper Devonian and early Carboniferous periods (355 Mya) a major earth movement known as the Alice Springs Orogeny folded the strata in the region resulting in deep troughs and ridges. Subsequent erosion and deposition of alluvial sediments in-filled the valleys during the Tertiary (65 Mya) and more recent Quaternary periods (from 1.6 Mya).

Era	Period	Millions of years before present	Geological formation/event
Cainozoic	Quaternary	1.6 - present	Deposition of shallower alluvial basins - sands, gravels & silts
	Tertiary	65 – 1.6	Deposition of deeper alluvial basins - clays, sands & silts
Mesozoic	Cretaceous	135 – 65	
	Jurassic	205 – 135	
	Triassic	250 – 205	
Palaeozoic	Permian	290 – 250	
	Carboniferous	360 – 290	Brewer Conglomerate Hermannsburg Sandstone Alice Springs Orogeny - ranges formed in Strategy region
	Devonian	420 – 360	Mereenie
	Silurian	440 - 420	Mereenie
	Ordovician	510 - 440	Goyder Pacoota
	Cambrian	570 - 510	Shannon
Late Proterozoic	Adelaidean	1 000 - 570	Bitter Springs Formation Heavitree Quartzite
Mid-Proterozoic		1 600 – 1 000	Arunta Block

APPENDIX 2. GEOLOGY AND GROUNDWATER SUMMARY

Groundwater System	Main Aquifers	Water quality Notional (mg/L)	Typical Bore Yields (L/s)	Current Water Level BGL (m)	Typical Transmissivity (m^2/day)
Town Basin	1. Shallow alluvial beds - gravel, sand, silt and clay	1 200	1 -10	6	400
	2. Weathered basement rock fracture zones – sandy clays, fractured granite & other rock	Greater than 5 000	Less than 0.5	1	5
Inner Farm Basin	1. Shallow alluvial beds - gravel, sand, sandy clay	1 500	1-5	6	400
	2. Fracture zones in basement rock – weathered granites	1 500	5	6	40
	3. Solution cavities & beds in Bitter Springs Formation – limestone, fractured sandstone	800	5	6	200
Western Outer Farm Basin	1. Alluvial sediments- boulders, gravel, sand, sandy clay	700	1 - 5	12	400
	2. Thin fine sand beds in upper Tertiary aged clays – fine sand and sandy clays	1 000	1	30	30
	3. Solution cavities & beds in Bitter Springs Formation – limestone, fractured sandstone	1 500	5	12	400
	4. Sandstone beds in Pertatataka formation -	2 000	2	15	30
Amadeus Formations - Pine Gap Borefield	1. Mereenie Aquifer System (including Mereenie Sandstone, Hermannsburg Sandstone) – fractured quartz sandstone	600	25	150	300
	2. Upper Pacoota Sandstone yet to be drilled in this area	?	?	?	?
	3. Lower Pacoota Sandstone yet to be drilled in this area	?	?	?	?
	4. Goyder Formation – yet to be drilled in this area	?	?	?	?
	5. Upper Shannon Formation – yet to be drilled in this area	?	?	?	?

Groundwater System	Main Aquifers	Water quality Notional (mg/L)	Typical Bore Yields (L/s)	Current Water Level BGL (m)	Typical Transmissivity (m^2/day)
Amadeus Formations - Roe Creek Borefield	1. Mereenie Aquifer System (including Mereenie Sandstone, Hermannsburg Sandstone) – fractured quartz sandstone	450	50	155	1,000
	2. Upper Pacoota Sandstone Inter-bedded sandstones, siltstone and shales	500	40	130	150
	3. Lower Pacoota Sandstone Inter-bedded sandstones, siltstone and shales	500	40	100	200
	4. Goyder Formation - sandstone	550	25	90	300
	5. Upper Shannon Formation – solution cavities in fractured dolomite	650	25	84	270
Amadeus Formations - Alice Springs Airport area	1. Mereenie Aquifer System (including Mereenie Sandstone, Hermannsburg Sandstone) – fractured quartz sandstone	400	25	90	300
	2. Upper Pacoota Sandstone Inter-bedded sandstones, siltstone and shales	500	20	100*	200*
	3. Lower Pacoota Sandstone Inter-bedded sandstones, siltstone and shales	500	20	98*	200
	4. Goyder Formation - sandstone	500	20	36	400
	5. Upper Shannon Formation – solution cavities in fractured dolomite	650	25	36	270
Amadeus Formations - Rocky Hill Borefield	1. Mereenie Aquifer System – fractured quartz sandstone (including Mereenie Sandstone, Hermannsburg Sandstone and Ooraminna Sandstone)	400-6 000	25	110-23	300
	2. Upper Pacoota Sandstone yet to be drilled in this area	?	?	?	?
	3. Lower Pacoota Sandstone yet to be drilled in this area	?	?	?	?
	4. Goyder Formation	500	20	36	400
	5. Upper Shannon Formation – yet to be drilled in this area	?	?	?	?