

Natural Resources
SA Murray-Darling Basin



Water Allocation Plan

EASTERN MOUNT LOFTY RANGES



Government of South Australia
South Australian Murray-Darling Basin
Natural Resources Management Board

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Aboriginal Cultural Knowledge

No authority is provided by Peramangk, Kaurna and Ngarrindjeri nations for the use of their cultural knowledge contained in this document without their prior written consent.

Document Status

This publication has been prepared by the SAMDB NRM Board and when adopted forms state government policy.

Document history

Date	Version
13 December 2013	First Water Allocation Plan for the Eastern Mount Lofty Ranges adopted by the Minister for Sustainability, Environment and Conservation
28 June 2018	Minor amendments made by SAMDB NRM Board under section 89(1)(a) of the <i>Natural Resources Management Act 2004</i>
13 February 2019	Amendments to include information on Aboriginal water interests made by the Minister for Environment and Water under section 89(2) of the <i>Natural Resources Management Act 2004</i>

Water Allocation Plan for the Eastern Mount Lofty Ranges

South Australian Murray-Darling Basin
Natural Resources Management Board

Adopted 13 December 2013

As amended 28 June 2018 and 13 February 2019

Water Allocation Plan

for the

Eastern Mount Lofty Ranges

I, Ian Hunter, Minister for Sustainability, Environment, and Conservation, hereby adopt this Water Allocation Plan pursuant to section 80 (3) (a) of the *Natural Resources Management Act 2004*.

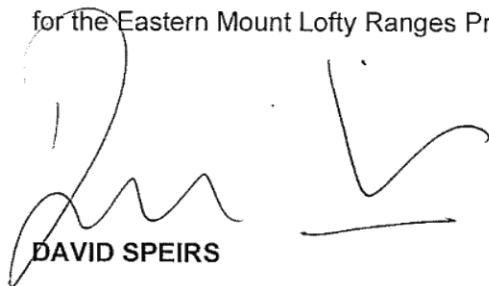


Ian Hunter MLC

Minister for Sustainability, Environment and Conservation

Date: 17/12/13

I, David Speirs MP, Minister for Environment and Water, after taking into account and in accordance with the requirements of section 89(2) of the *Natural Resources Management Act 2004* hereby adopt these amendments to the Water Allocation Plan for the Eastern Mount Lofty Ranges Prescribed Water Resources Area.

A handwritten signature in black ink, consisting of a large, stylized 'D' followed by a series of loops and a final horizontal stroke.

DAVID SPEIRS

MINISTER FOR ENVIRONMENT AND WATER

Date: 13 / 02 / 2019

Dedication

This plan is dedicated to Cameron Welsh, Water Resources Manager at Natural Resources SA Murray-Darling Basin for 2006-2013 who was tragically killed on Tuesday 26 November 2013.

Cameron offered his energy, passion and commitment to the development of this plan. Water resources in the SA Murray-Darling Basin has lost a dedicated ambassador.

Acknowledgement

The South Australian Government acknowledges and respects Aboriginal people as the State's first peoples and nations, and recognises Aboriginal people as traditional owners and occupants of land and waters in South Australia. Aboriginal peoples' spiritual, social, cultural and economic practices come from their lands and waters and they continue to maintain their cultural heritage, economies, languages and laws which are of ongoing importance.

It is acknowledged that the lands and waters of the Eastern Mount Lofty Ranges Prescribed Water Resources Area (PWRA) forms part of the traditional country of Peramangk, Kurna and Ngarrindjeri Aboriginal nations and the SAMDB NRM Board recognises the continuing connection to lands, waters and communities.

Whilst recent native title determinations have been made that give legal recognition to the Ngarrindjeri and Kurna native title holders over parts of the Eastern Mount Lofty Ranges PWRA, the area that is currently recognised as the traditional country of Peramangk is not currently the subject of a native title claim. Should a claim be made the SAMDB NRM Board will have regard to the native title claimants.

The SAMDB NRM Board pays its respects to Aboriginal culture and to Elders both past and present. The recognition of the aspirations that the Aboriginal nations have to legal rights to Aboriginal water interests in this Plan was a starting point in 2019 for ongoing commitment to engage with Aboriginal nations in water planning. Aboriginal people should be aware that this document contains names of people who have since passed away.

The term "Aboriginal" is used throughout this Water Allocation Plan instead of "Indigenous" as endorsed by the former South Australian Aboriginal State-wide Advisory Committee.

"Aboriginal nations" is also used throughout this Plan and is defined for the purposes of this Plan as a group or community of Aboriginal people who identify as descendants of the original inhabitants of the Plan area and may share a single common territory, or may be located as a nation within another larger nation. Where a native title determination has been made the native title holders will have native title interests within the nation and is the body that the Board will deal with for native title. It may also be the legal entity that represents the Nation for other purposes or be included as a member of a wider group representing a nation (e.g. a Regional Authority).

Nations are recognised as holding traditional authority and responsibility to speak for Aboriginal culture and heritage. The three nations whose traditional country within the Eastern Mount Lofty Ranges PWRA have distinct culture and identities and do not necessarily identify with the words 'Aboriginal' or 'cultural' as these are non-Aboriginal terms that do not capture the complexity of their culture and identity. Therefore, where possible, we identify nations and their objectives as either, Peramangk, Kurna or Ngarrindjeri.

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1 THE PRESCRIBED WATER RESOURCES

1.1 INTRODUCTION

This document is the Water Allocation Plan for the Eastern Mount Lofty Ranges ('the Plan'). A water allocation plan is a statutory instrument under the *Natural Resources Management Act 2004* (NRM Act).

The purpose of a water allocation plan is to provide for the sustainable taking and use of prescribed water resources to meet present and future water needs of the region. A water allocation plan guides the granting of licences and allocations to take and use prescribed water resources, for allocations made once existing user entitlements have been considered. It also guides transfers of licences and allocations, ongoing management of water allocations, and the granting of permits for relevant water affecting activities.

The water resources in the Eastern Mount Lofty Ranges were prescribed on 8 September 2005 under the NRM Act. The Eastern Mount Lofty Ranges region is located approximately 50 km to the east of Adelaide and occupies an area of 2,845 km². The area incorporates the eastern slopes of the Mount Lofty Ranges and the Murray Plains (Figure 1.1) and lies within the Murray-Darling Basin.

The Eastern Mount Lofty Ranges PWRA is the traditional lands and waters of the Peramangk, Kurna and Ngarrindjeri peoples. It is the obligation of Aboriginal nations in this area of the Adelaide Hills, Plains, Fleurieu Peninsula and River Murray to maintain kinship through the interconnectivity between these lands, waters, spirit and all living things (Ngarrindjeri refer to this as Ruwe/Ruwar). Part of the area is subject to a native title determination in the favour of the Kurna Peoples made on 21 March 2018. A native title determination was made in favour of the Ngarrindjeri and Others on 14 December 2017. These areas are outlined in Figure 1.2, but are not intended to be definitive of the boundaries of an individual nation's Country, recognising that some nations such as Peramangk have not claimed native title. Both the Kurna and Ngarrindjeri native title claimants will have Indigenous land use agreements (ILUAs) registered in the near future and this Plan will have regard to both the rights recognised in the native title determinations and any relevant provisions in the ILUAs.

1.1.1 Approach and objectives

The objects of the NRM Act include assistance in the achievement of ecologically sustainable development, which 'comprises the use, conservation, development and enhancement of natural resources in a way, and at a rate, that will enable people and communities to provide for their economic, social and physical well-being while—

- a) sustaining the potential of natural resources to meet the reasonably foreseeable needs of future generations; and
- b) safeguarding the life-supporting capacities of natural resources; and
- c) avoiding, remedying or mitigating any adverse effects of activities on natural resources. (section 7 (2) of the NRM Act).

The NRM Act requires a water allocation plan to achieve an equitable balance between environmental, social and economic needs when setting out principles for taking and use of water. It is important to acknowledge that these factors are inter-dependent. A healthy catchment is essential for supporting businesses and communities that depend on natural resources through provision of ecosystem services such as water quality improvement, provision of materials, waste decomposition, pollination, pest and disease control, and nutrient cycling. Healthy environments also support public benefit outcomes, such as public health, indigenous and cultural values, recreation, fisheries, tourism and amenity values. In turn, a prosperous, sustainable community has a greater capacity to support the environment, from individual land manager's decisions through to government policy direction.



Figure 1.1 The Eastern Mount Lofty Ranges region.

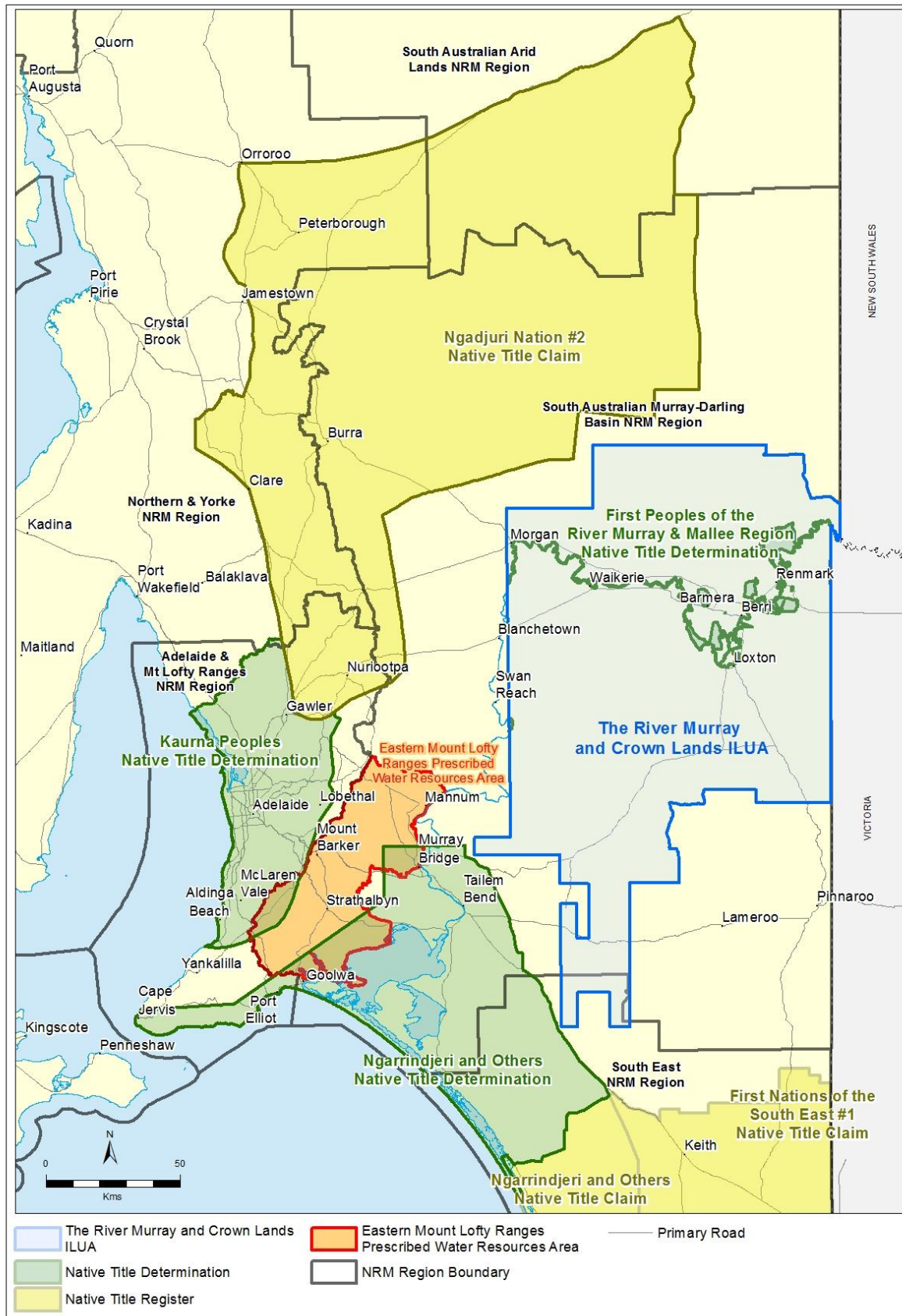


Figure 1.2 Native title and ILUA areas associated with the surface waters and groundwaters of the SA Murray Darling Basin.

A series of objectives have been developed for this water allocation plan that reflect the objects of the NRM Act and the role of the water allocation plan. These objectives are:

Allocation objectives

- a) Encourage efficient use of water resources in a sustainable manner.
- b) Maintain the quantity and quality of water resources.
- c) Maintain and where possible restore water-dependent ecosystems by providing their water needs.
- d) Minimise impacts of taking and using water on the environment, prescribed water resources, other water resources and water users.

Transfer objectives

- a) Enable the transfers of water allocations in a sustainable manner.
- b) Maintain the quantity and quality of water resources.
- c) Maintain and where possible restore water-dependent ecosystems by providing their water needs.
- d) Minimise impacts of taking and using water on the environment, prescribed water resources, other water resources and water users.

Water affecting activity objectives

- a) Maintain and where possible restore water-dependent ecosystems, by providing their water needs and addressing detrimental impacts from water affecting activities.
- b) Protect aquifer structure and geomorphology of drainage paths, watercourses, lakes and floodplains.
- c) Provide for equitable and sustainable sharing of water resources.
- d) Protect water quality from deterioration.
- e) Maintain hydrological and hydrogeological systems, including natural discharge and recharge between water resources.
- f) Minimise interference between water users.
- g) Minimise adverse impacts of water affecting activities on the environment, water resources and water users.

Environmental water requirements objective

- a) Maintain and/or restore self-sustaining populations of aquatic and riparian flora and fauna which are resilient in times of drought.

Aboriginal cultural objectives

In addition to the Plan's objectives set out above, Aboriginal nations developed cultural objectives through the Water Resource Planning process (section 1.3.3) and by participating in the Plan's engagement process conducted for the purpose of amending the Plan in 2019. The cultural objectives developed by nations through this process are set out below.

Where and how the Plan is able to address some of these objectives is further discussed in section 1.3.4.

Aboriginal cultural objectives:

- a) To pursue opportunities for legally recognised water entitlements for nations.
- b) For the hydrological and ecological conditions of the landscape to resemble, as closely as possible, those experiences by nations' ancestors.
- c) For water resources to be managed in a way that supports the ongoing spiritual, cultural, environmental, social and economic needs of current and future generations.
- d) For adequate monitoring and evaluation to be undertaken to ensure compliance with water management rules and to assess whether objectives are being achieved.
- e) To seek support to build capacity for nations' voices in water planning and management, building on and further developing nations' water co-ordinator roles.
- f) To create opportunities for nations' businesses to engage in the delivery of on-ground water planning monitoring and evaluation, particularly cultural health assessments of waterways.
- g) For water allocation plans and other water planning and management tools and instruments to promote awareness and respect for nations' cultural values, perspectives and worldview of water and its critical importance to the health of nations' cultural water and cultural living landscape.
- h) For continued conversation through meaningful engagement between nations and government to be invested in as an on-going priority and not be undertaken as disjointed and sporadic engagement driven by government planning and management timeframes.

1.1.2 Role of a water allocation plan

1.1.2.1 Water licensing

Under the NRM Act, a water allocation and licence is required to take and use prescribed water resources for licensed purposes. The three types of water resources covered by prescription in the Eastern Mount Lofty Ranges region are surface water (which flows over the land surface), watercourse water (which flows in rivers, streams or creeks or other natural watercourses) and underground water (water in aquifers generally accessed via wells).

Licensed purposes are defined by exclusion – that is, a licence is required to take and use water unless that purpose of use has been excluded from requiring a licence. Purposes of use that don't require a licence in the Eastern Mount Lofty Ranges at the time of adoption of the Plan include domestic use; watering stock that are not subject to intensive farming; commercial forestry; and purposes authorised by a notice under section 128 of the NRM Act that apply in the area (e.g. fire fighting; public road making; applying chemicals to non-irrigated crops or to control pests; use of up to 1,500 kilolitres per year of roof runoff for commercial (including irrigation), industrial, environmental or recreational purposes; and non-commercial native title rights to take water).

A licence is not required for such purposes, but the amount of water estimated to be used for these purposes is considered when determining the amount of water available for allocation for licensed purposes under the Plan. In addition, building new infrastructure to take water for non-licensed purposes (e.g. building a dam or drilling a well) may require a water affecting activity permit, which is managed by the Plan.

A water allocation plan does not set out the process for allocating water to those who are considered to be existing users prior to the start of the prescription process. Existing users are allocated water under a

separate process administered by the Minister's Department¹ in accordance with section 164N of the NRM Act.

The entitlements of existing users are considered before other potential licensed use, subject to the capacity of the water resources and consideration of the needs of the environment and non-licensed users. If any water remains available for allocation within sustainable limits after the entitlements of existing users have been considered, then that water may be allocated in accordance with the water allocation plan and the NRM Act. The Plan does not further discuss the existing user allocation process, except where specific water management principles in the Plan relate to existing user allocations.

The water allocation plan also sets out the rules for ongoing management of allocations and licences, such as transfer.

1.1.2.2 Water affecting activities

A permit may be required for certain water affecting activities as set out under the NRM Act, such as dam construction or enlargement, well drilling and repair, some works in and around watercourses, commercial forestry, and using effluent or imported water in the course of carrying on a business. A water allocation plan, and also its parent regional natural resources management plan, can set out the principles to be used to assess permit applications and to place conditions on permits.

1.1.3 Structure of the Plan

The Plan is made up of three main parts covering the following themes:

- understanding water resource supply and demand;
- a policy framework that aims to balance social, economic and environmental demands for water within the supply or capacity of the water resources; and
- a monitoring and evaluation framework to facilitate adaptive management.

Aboriginal water interests are presented in section 1.3. This section identifies both aspirational and current uses of water as Aboriginal water interests, describes Aboriginal cultural objectives and sets out the engagement principles for Peramangk, Kaurna and Ngarrindjeri nations. Aboriginal water interests are referred to throughout the Plan where relevant.

1.1.3.1 Supply and demand

One of the key approaches taken under the Plan is to keep water demand within supply, which requires an understanding of water resource supply and behaviour, and the different types of water demands.

The available water supply is examined in sections 1.5 and 1.6. These sections describe the characteristics of the different water resources, including the paths and quantities of natural water input and output across the landscape.

The Plan focuses on two main types of water demand, being consumptive use and environmental water requirements. Section 1.7 examines the current and likely future demand for water for consumptive purposes, including licensed and non-licensed purposes. Section 2 describes the environmental water requirements of the different water-dependent ecosystems across the Eastern Mount Lofty Ranges and outlines water provisions expected to achieve an acceptable level of risk to the environment, balanced against consumptive needs.

¹ The Department that administers the NRM Act ('the Department'). This is the Department for Environment and Water (DEW) as of 22 March 2018. Its former components include the former Department of Water, Land and Biodiversity Conservation (DWLBC) to 30/06/10, the former Department for Water (DFW) from 1/7/10 to 30/6/12, and the former Department of Environment, Water and Natural Resources (DEWNR) from 1/7/12 to 22/3/18. When referring to reports and historical material, this document refers to the department that was in place at that time.

Section 3 outlines an assessment of the impact of water taking within the Eastern Mount Lofty Ranges on water resources in adjoining regions.

1.1.3.2 Policy framework

Section 4 provides an overview of key parts of the Plan's management framework that aims to meet the Plan's objectives and provide an equitable balance between social, economic and environmental needs for water.

A key part of the management framework is the consumptive use limits for different water resources at different scales. 'Consumptive use limit' is a collective term for the quantum of water which is available for consumptive purposes, including licensed and non-licensed purposes, after considering system and environmental provisions. Consumptive use limits are discussed in section 4.

Sections 5 to 7 define the specific principles for achieving the Plan's objectives using the tools provided for a water allocation plan under the NRM Act, being water allocation (section 5), transfer of allocations and licences (section 6), and water affecting activity permits (section 7).

1.1.3.3 Monitoring and evaluation

Section 8 outlines a monitoring and evaluation framework that monitors and assesses the condition of the resources, water-dependent ecosystems and consumptive demand to trigger action if objectives are not met. This information will also improve understanding of supply and demand.

A water allocation plan needs to be reviewed within ten years of adoption. Monitoring and evaluation data collected over the life of the Plan will help to assess the effectiveness of the Plan and help to make decisions on whether improvement is required, and to inform those improvements.

A water allocation plan can be amended at any time, under the processes set out under the NRM Act. Other tools are also available under the NRM Act if required to take action to protect water resources and users (including the environment), or mitigate impacts, such as temporary restrictions on water taking, reductions in allocations, or notices specifying actions to be taken.

1.2 HISTORY OF WATER MANAGEMENT IN THE EASTERN MOUNT LOFTY RANGES

The Governor prescribed the water resources of the Eastern Mount Lofty Ranges on 8 September 2005 via regulations as follows:

- The *Natural Resources Management (Eastern Mount Lofty Ranges – Prescribed Watercourses and Surface Water Prescribed Area) Regulations 2005* refers to the Eastern Mount Lofty Ranges Water Resources Area (the area bounded by the bold red line in GRO Plan No 422/2003). All watercourses in that Area were declared to be prescribed watercourses. That Area is also declared to be a surface water prescribed area.
- The *Natural Resources Management (Eastern Mount Lofty Ranges – Prescribed Wells Area) Regulations 2005* refers to the Eastern Mount Lofty Ranges Prescribed Wells Area (the area bounded by the bold red line in GRO Plan No 423/2003). All wells in that Area were declared to be prescribed wells.

These Areas, together with the Angas Bremer Prescribed Wells Area (PWA) (see below), are collectively referred to as the Eastern Mount Lofty Ranges Prescribed Water Resources Area (PWRA) in the Plan.

The South Australian Murray-Darling Basin Natural Resources Management Board (the Board²) is required, under the NRM Act, to prepare a water allocation plan for the prescribed water resources of the Eastern Mount Lofty Ranges.

The Board prepared a concept statement in August 2006, in accordance with the requirements of section 78 (2) of the NRM Act at that time. The concept statement presented the proposed scope of the Plan and identified issues and topics for community discussion and consultation during the Plan's development.

Feedback on the concept statement from the community was taken into account during the development of the Plan.

The Southern and Northern Eastern Mount Lofty Ranges Community Advisory Committees, comprised of members of the community, were established in September 2006 to assist the Board develop the Plan.

The Eastern Mount Lofty Ranges PWRA encompasses the Angas Bremer PWA. The Angas Bremer region was first proclaimed on 1 July 1981 pursuant to the *Water Resources Act 1976*, following the publishing of a gazette notice in the South Australian Government Gazette on 23 October 1980.

The first policies for the Angas Bremer region were adopted in 1987 (named the Angas Bremer Proclaimed Wells Area Management Plan) and since then, there have been two updates to this management plan. The first statutory water allocation plan for the region, the Water Allocation Plan for the Angas Bremer Prescribed Wells Area, came into effect on 2 January 2001.

The Plan has been prepared to cover the entire Eastern Mount Lofty Ranges PWRA, including the Angas Bremer PWA, and so replaces the 2001 Water Allocation Plan for the Angas Bremer Prescribed Wells Area.

In 2019, amendments were made to the Plan in consultation with the Peramangk, Kurna and Ngarrindjeri nations to identify the desired objectives and outcomes with respect to Aboriginal interests in water and the management of water generally. These amendments improve consistency with the Murray-Darling Basin Plan and are a starting point to an ongoing conversation and involvement of Aboriginal nations in water planning and to ascertaining nations' views about cultural flows.

Table 1.1 summarises the history and timeline of water management in the Eastern Mount Lofty Ranges PWRA.

Table 1.1 Timeline of water management in the Eastern Mount Lofty Ranges PWRA.

Date	Event
23 October 1980	Angas Bremer region proclaimed by notice in the South Australian Government Gazette, in accordance with section 41 of the <i>Water Resources Act 1976</i> .
July 1987	First Angas Bremer Proclaimed Wells Area Management Plan came into effect.
July 1992	Second Angas Bremer Proclaimed Wells Area Management Plan came into effect.
1996	Third Angas Bremer Prescribed Wells Area Water Resource Management Plan came into effect.
1997	The relevant provisions of the <i>Water Resources Act 1990</i> were replaced by the <i>Water Resources Act 1997</i> .

² Plan development was started by the River Murray Catchment Water Management Board, which was incorporated into the South Australian Murray-Darling Basin Natural Resources Management Board in late 2004.

Date	Event
2 January 2001	First statutory Water Allocation Plan for the Angas Bremer Prescribed Wells Area came into effect.
16 October 2003	Notice of Prohibition and Notice of Intent to Prescribe water resources in the Eastern Mount Lofty Ranges came into effect.
8 September 2005	Regulation to prescribe water resources of the Eastern Mount Lofty Ranges came into effect.
27 October 2005	The relevant provisions of the <i>Water Resources Act 1997</i> were replaced by the NRM Act.
October 2005	Review of the Water Allocation Plan for the Angas Bremer Prescribed Wells Area submitted to the Minister for Environment and Conservation and the Minister for the River Murray.
August 2006	Concept Statement for the Water Allocation Plan for the Eastern Mount Lofty Ranges Prescribed Water Resources Area released by the Board. Decision to incorporate Angas Bremer PWA into the Eastern Mount Lofty Ranges PWRA.
September 2006	Establishment of Community Advisory Committees to assist the Board to develop the draft Plan.
May 2011	Draft Plan released for public consultation.
December 2013	Adoption for the Water Allocation Plan for the Eastern Mount Lofty Ranges by the Minister responsible for the administration of the NRM Act (the Minister).
June 2018	Amendments made pursuant to Section 89 (1) of the NRM Act to make minor updates.
February 2019	Amendments made pursuant to Section 89 (2) of the NRM Act to make minor updates and identify and include the objectives and desired outcomes of Peramangk, Kaurna and Ngarrindjeri with respect to management of Aboriginal water interests and incorporates their worldviews in the Plan to improve consistency with the Murray-Darling Basin Plan.

1.3 ABORIGINAL WATER INTERESTS

For thousands of generations Peramangk, Kaurna and Ngarrindjeri nations have cared for the waters and lands of the area of the Adelaide Hills, Plains, Fleurieu Peninsula and River Murray. This Country was formed by creation ancestors and it is the ongoing responsibility of current and future generations to care for and protect the waters and lands of their Country today and into the future.

Aboriginal nation's worldview is that water as a living body that is part of the landscape and connected to all living things. Cultural knowledge is founded on an extensive understanding of the relationship between water flow through and across the land, the ecosystems and species which are reliant on this water and the role and responsibility of Aboriginal people in caring for and protecting Country.

For Aboriginal nations, all water is cultural water – this includes water for spiritual, cultural, environmental, social and economic purposes. This is underpinned by the belief that water is life – it provides life to everyone and everything that ever lived and everyone and everything that ever will live. In this way, water is the lifeblood of the landscape and is connected to all the other elements of the landscape, supporting a wide range of spiritual, cultural, environmental, social and economic activities. Water and all of the connected elements must be managed as parts of the same living body of the landscape, to allow it to remain healthy and continue to function and support people to live, as it has for many thousands of generations.

Aboriginal people have expressed a desire for a future that maintains the continuation of their culture upon Country and that continues to give life to their people who live and work in and outside of the region. An important part of this objective that was articulated by all nations consulted was that access and use of cultural flows should be enabled through the inclusion and allocation of water for this purpose.

Cultural flows are defined as:

Water entitlements that are legally and beneficially owned by the Indigenous nations and are of sufficient and adequate quantity to improve the spiritual, cultural, environmental, social and economic conditions of those Indigenous nations. This is our inherent right. The provision of cultural flows will benefit Indigenous people in improving health, wellbeing and provides empowerment to be able to care for their country and undertake cultural activities.

This definition of cultural flows was endorsed by representatives from thirty-one Indigenous nations at a joint meeting of the Murray Lower Darling River Indigenous Nations (MLDRIN) and the Northern Basin Aboriginal Nations (NBAN) - The Echuca Declaration, September 2010.

1.3.1 National Water Initiative and the Basin Plan

The Intergovernmental Agreement on a National Water Initiative³ includes a commitment to include Aboriginal representation to incorporate Aboriginal social, spiritual and customary objectives and strategies in water planning and to take account of the possible existence of native title rights to water.

The Basin Plan, which provides an overarching plan for water management in the Murray-Darling Basin, requires accredited water resource plans to identify the objectives and outcomes of Aboriginal people related to the management of water resources and to have regard to Aboriginal values and uses of water, as well as cultural flows (MDBA, 2012). Water resource plans must also have regard to a range of other matters set out in section 10.53 of the Basin Plan.

South Australia recognises the importance of, and is committed to seeking and incorporating, Aboriginal interests in the development of water allocation plans. In 2019, amendments under section 89(2) of the NRM Act were made to improve the inclusion of Peramangk, Kurna and Ngarrindjeri interests and worldviews in this Plan as a step towards Basin Plan compliance and improved recognition of Aboriginal perspectives. The amendments incorporated into this Plan in consultation with the Peramangk, Kurna and Ngarrindjeri nations are a starting point to an ongoing conversation and involvement of Aboriginal nations in water planning.

1.3.2 Recognition of Aboriginal water interests

European colonisation of South Australia significantly disrupted Aboriginal nations' care, control, maintenance and governance of their Country. Water flow and connectivity has been disrupted with obstructions such as dams and weirs being built, and water quality and quantity has changed due to extraction. Aboriginal people's way of life significantly changed as they were forcibly removed from their Country and their lands and waters were granted to European settlers. This has impacted the ability of Aboriginal people to pass down knowledge of cultural connection, values and practices to the next generation. Nations are continuing to strengthen their identity through language, native title,

³ An agreement that is a blueprint for water reform between the Commonwealth of Australia and the Governments of New South Wales, Victoria, Queensland, South Australia, the Australian Capital Territory and the Northern Territory

Indigenous land use agreements and Aboriginal organisations – today the management of water unites all people, communities and users for a more sustainable future.

1.3.3 Aboriginal cultural objectives

The Eastern Mount Lofty Ranges water resource plan (DEW, in prep) identifies a number of Aboriginal cultural objectives and outcomes identified by nations that should be referred to when undertaking water planning. Through further consultation for the amendment of this Plan, Aboriginal nations additionally outlined eight key objectives which represent their collective position on the management of water resources (section 1.1.1 and Table 1.2). Incorporating Aboriginal nation's objectives and outcomes into water planning based on cultural values and uses is an iterative process that requires investment over time. The progress that this Plan has made towards meeting Aboriginal objectives and outcomes that are within scope of the Plan are described in Table 1.2.

1.3.4 Incorporation of Aboriginal interests in water planning

The process of integrating Aboriginal interests into water management is a complex and ongoing matter. The amendments to this Plan are a preliminary step towards recognising Aboriginal understanding of the relationship between healthy water, lands and all living things. The Plan makes some progress to addressing Aboriginal objectives and outcomes (see Table 1.2, and sections 1.3.4.1, 1.3.4.2 and 1.3.4.3). However some objectives/or components of, are outside of the scope of the water allocation plan, which sets out the rules for managing the take and use of prescribed water resources as set out in section 76 of the NRM Act.

Aboriginal peoples' knowledge of the relationship between flow, water-dependent ecosystems and sustainable livelihoods is a valuable addition to scientific knowledge, and addressing gaps in the understanding of water resources. In relation to water allocation planning this knowledge has only been partially taken into account. Through meaningful engagement and with Aboriginal nations starting to build capacity in water planning, future iterations of this Plan can make further progress to achieving the Aboriginal cultural objectives and outcomes set out in section 1.1.1, Table 1.2 and the Eastern Mount Lofty Ranges water resource plan (DEW, in prep). There is a need for ongoing discussion on how the notion of water use and cultural perspectives can co-exist within the water management regulatory framework to achieve water management outcomes that have integrity and demonstrate respect for Aboriginal and non-Aboriginal communities.

The approach of Aboriginal nations to caring for the Country that all South Australians live in, can be understood through the words of Ngarrindjeri Elder, Tom Trevorrow (deceased):

Our traditional management plan was: don't be greedy, don't take any more than you need and respect everything around you. That's the management plan – it's such a simple management plan, but so hard for people to carry out (Murrundi Ruwe Pangari Ringbalin, River Country Spirit Ceremony: Aboriginal Perspectives on River Country, 2010).

1.3.4.1 Protection of Aboriginal cultural heritage

Peramangk, Kaurna and Ngarrindjeri have identified a desired outcome in the Eastern Mount Lofty Ranges water resource plan that Aboriginal cultural heritage values and sacred water sites are protected and enhanced in the planning and implementation of water resource management activities. The Board is addressing this desired outcome in section 7 (relating to water affecting activity permits) through:

- Raising awareness of landholder legal obligations in the *Aboriginal Heritage Act 1988*.
- Ensuring compliance with the *Native Title Act 1993* (Cth), determinations of native title and any future Indigenous Land Use Agreements that may be registered.

Table 1.2 The progress that this Plan has made towards meeting Aboriginal objectives and outcomes that are within scope of the Plan. Cultural objectives and outcomes identified in the Eastern Mount Lofty Ranges water resource plan (DEW, in prep) that are outside of the scope of this Plan are not referred to within this table.

Aboriginal cultural objective/outcome	Progress of the Plan towards addressing Aboriginal cultural objective/outcome
<p>To promote awareness and respect for Aboriginal cultural values, perspectives and worldview of water and its critical importance to the health of nations cultural waters and cultural living landscape.¹</p> <p>The contribution of Aboriginal Nations to caring for Country, including water resources management is valued.³</p>	<p>Through the amendment of the Plan, relationships and meaningful engagement with Aboriginal nations have been progressed to establish stronger partnerships between the Board and Peramangk, Kurna and Ngarrindjeri nations. Awareness of Aboriginal values, perspectives and worldviews have been included in the updated content during the amendment of this Plan along with consideration of how Aboriginal water needs and future water needs can be met being discussed in section 1.7.1 and 1.7.6.1.</p> <p>Amendment of the Plan contributes to fulfilling South Australia's obligations under Basin-wide plans and legislation.</p>
<p>For the hydrological and ecological condition of the landscape to resemble, as closely as possible, those experienced by nations ancestors.¹</p> <p>To see our lands and waters healthy.²</p>	<p>The Plan's objectives include maintaining water quantity and quality, and maintaining (and where possible restoring) water-dependent ecosystems. Section 4 outlines the Plan's management framework for implementing the Plan's objectives, with key elements including:</p> <ul style="list-style-type: none"> • Setting surface water consumptive use limits and taking rules to support key parts of the flow pattern that are important to ecosystems e.g. dam capacity (see section 4.2.2); • Setting underground water consumptive use limits to maintain natural flow through aquifers and support dependent ecosystems, by setting aside water to maintain baseflow (underground water input to streams) and throughflow (flow between aquifers), and keeping total outflows (baseflow, throughflow and consumptive use) within resource capacity (see section 4.3.3); • Underground water buffer zones around dependent ecosystems to minimise impacts from trade, new allocations and new wells (see section 4.3.4.1); • Provisions for ecosystem allocations from the water set aside to support system provisions to enable specific water management/taking to support declining water-dependent ecosystems and red gum swamps in the lower Angas Bremer area (see section 4.1.3); • Taking rules for high flow diversions in the lower Angas Bremer area to allow the first flush to go through the system (to support fish movement through the system) while

Aboriginal cultural objective/outcome	Progress of the Plan towards addressing Aboriginal cultural objective/outcome
	<p>allowing higher flows to be diverted onto the floodplain which help support floodplain habitats (see section 2.4.2.3 – Angas and Bremer Rivers across the plains);</p> <ul style="list-style-type: none"> • Surface water can't be allocated or traded to locations containing significant environmental assets (see Table 4.1 – significant environmental asset scale); and • Water affecting activity principles to minimise impacts of construction on water-dependent ecosystems and water quality (e.g. protect significant habitat, minimise water quality impacts, allow migration of aquatic organisms - see section 7).
<p>Water resources to be managed in a way that supports the ongoing spiritual, cultural, environmental, social and economic needs of current and future generations of Aboriginal nations.¹</p> <p>To achieve the social and economic outcomes and wellbeing desired by the Nation.²</p> <p>To ensure Aboriginal water interests are equitably recognised along with other stakeholders in water resources plans, research and policy.²</p> <p>The Aboriginal cultural heritage values and sacred water sites are protected and enhanced in the planning and implementation of water resource management activities.³</p>	<ul style="list-style-type: none"> • An existing section 128 authorisation under the NRM Act regulates the native title right to take and use water by native title holders for personal, domestic, cultural, spiritual or non-commercial communal needs (see section 1.7.1). • Raising awareness and promoting for the protection of Aboriginal cultural heritage as set out within the Plan (see sections 1.3.4.1 and 7.1). • The Plan identifies current and future Aboriginal water needs (see sections 1.7.1). • The Plan includes provisions for further water resource development within sustainable limits to support water-dependent industries, through the consumptive use limits for surface water, watercourses and underground water, plus provision for sustainable access to and use of alternative water sources (e.g. roof runoff and urban runoff (see section 4.2.3, 5.2.3 and 5.2.4), managed aquifer recharge (see section 5.3.2 and 7.2.8), and imported water and effluent (see section 7.2.6)). • The Plan includes provisions to minimise impacts of new development on other users (e.g. underground water buffer zones around wells (see section 4.3.4.1), local scale surface water taking limits to minimise impact on downstream users (see Table 4.1, Dam and property management scale), underground water high intensity use zones to minimise concentrated use in an area (see section 4.3.4.2)).
<p>For adequate monitoring and evaluation to be undertaken to ensure compliance with water management rules and to assess whether objectives are being achieved .¹</p>	<p>Monitoring and evaluation of the Plan to ensure compliance with water use is discussed in section 8.</p> <p>Undertaking monitoring and evaluation of cultural objectives is discussed in section 1.3.4.2.</p>

Aboriginal cultural objective/outcome	Progress of the Plan towards addressing Aboriginal cultural objective/outcome
<p>To maintain our cultural connections between nations and to the lands and waters and all living things.²</p> <p>To establish and maintain strong and productive relationships and partnerships built on mutual respect and agreement-making.²</p>	<p>Through consultation for the amendment of this Plan in 2019, and review of future Plans, the Board will consult with relevant Aboriginal nations and their representative organisations (section 1.3.4.3).</p> <p>Through consultation for the amendment of this Plan in 2019, and the development of the Eastern Mount Lofty Ranges water resource plan (DEW, in prep) nations were engaged collectively with on-Country meetings and workshops. This engagement process further developed relationships between nation representatives and government agency staff.</p>

Tables notes

¹Aboriginal cultural objectives listed in section 1.1.1

²Eastern Mount Lofty Ranges water resource plan, chapter 14 identified objectives (DEW, in prep)

³Eastern Mount Lofty Ranges water resource plan, chapter 14 identified outcomes (DEW, in prep)

1.3.4.2 Monitoring and evaluation

The nations have expressed overwhelmingly the need for adequate monitoring and evaluation of the Plan to assess whether its objectives for sustainable water resource management are being achieved. How the Plan will try to achieve this is more specifically discussed in section 8 which sets out monitoring (and reporting) requirements for licensees and some permit holders that are designed to collect information about water demand and use. The Plan also outlines regional-scale monitoring, largely led by agencies such as the Board and the Department, while working with other bodies and the community.

Peramangk, Kaurna and Ngarrindjeri see the monitoring of their lands and waters as an ongoing process, embedded as part of their responsibility to speak for, care for and protect their Country. Through the monitoring, evaluation and reporting process, the Department and the Board will aim to:

- provide opportunities for the involvement of Aboriginal nations in the management, planning and monitoring of water resources; and
- provide opportunities for the capacity and experience building of Aboriginal nations in water resource management.

1.3.4.3 Plan review

The Board will review the Plan within 10 years of the Minister adopting the Plan, as the recommended timeframe for review of plans. As part of its review, the Board will directly consult with the Peramangk, Kaurna and Ngarrindjeri nations and native title holders and claimants in relation to Aboriginal objectives and desired outcomes.

Engagement to date with Kaurna has been conducted with the Kaurna Nation Cultural Heritage Association Board. In future the Kaurna native title holders will be consulted as well.

Engagement to date has been with Ngarrindjeri via the Ngarrindjeri Regional Authority (NRA) and undertaken according to the commitments set out in the water resource planning Statement of Commitment. The Ngarrindjeri Regional Authority included at the time the Ngarrindjeri native title claimants and now includes, as a member, the Ngarrindjeri native title holder prescribed body corporate.

Engagement to date has been with Peramangk via the Mannum Aboriginal Community Association Incorporated (MACAI), a NRA member organisation and an incorporated body that represents descendants of the named ancestors who comprise some or all of the traditional owners of the Peramangk nation. Whilst the Peramangk area is not subject to a native title claim, should one be made in the future then both MACAI and the claimants or holders of native title will be entitled to be consulted and dealt with in the Peramangk area about their respective responsibilities within the Peramangk nation.

Aboriginal engagement

For future review of the Plan there are some guiding documents that should be considered.

South Australia's three water resource plans, including the Eastern Mount Lofty Ranges water resource plan (DEW, in prep) provides six engagement principles to be considered when engaging Aboriginal nations during the review of water allocation plans in the South Australian Murray-Darling Basin.

Aboriginal nations have also developed their own engagement principles. MACAI has outlined a set of engagement principles in the Sugar Shack Complex Management Plan (NRA, 2015). Kaurna Regional

Authority has a Community Engagement Charter (ART 2016). The Ngarrindjeri is well progressed through the development of the Kungun Ngarrindjeri Yunnan Agreement (KNY Agreement) in 2009 between the NRA and the South Australian Government (Ngarrindjeri Tendi Incorporated, Ngarrindjeri Heritage Committee Incorporated, Ngarrindjeri Native Title Management Committee & the Crown in right of the State of South Australia 2009). The KNY Agreement seeks to support the integration of Ngarrindjeri cultural values into management planning and implementation in the Native Title Determined Area. A taskforce of state government and NRA representatives meet on a regular basis to support the consultation process. To specifically progress the involvement of the Ngarrindjeri in water planning, a Statement of Commitment (SOC) between the NRA, the SA MDB NRM Board, the South-East Natural Resource Management Board and the Department of Environment, Water and Natural Resources (DEWNR) was signed in 2015. The SOC sets out a framework for how the parties will work together in water resource planning, particularly to meet the requirements of Chapter 10 Part 14 of the Murray-Darling Basin Plan. In conjunction with this SOC is a Cultural Knowledge Protection agreement which enables Ngarrindjeri to work with government on planning and be confident that Ngarrindjeri cultural knowledge will be respected and understood as belonging to Ngarrindjeri.

Engagement is also conducted with native title holders and claimants as required under the *Native Title Act 1993* (Cth) or where modified by an ILUA according to the terms of the ILUA.

Following-on from the engagement principles outlined above, engagement with nations is conducted through various mechanisms based on the needs, interests and capacity of each nation. A key objective of undertaking good engagement is to build on and develop previous engagement principles. Specific engagement mechanisms for the individual nations may vary and it is recognised that some Aboriginal nations also desire to work and be engaged collectively. Collective engagement was undertaken during the amendment of this Plan and the desire by the nations was voiced to continue both collective and individual nation engagement for future water planning and management.

1.4 OVERVIEW OF THE EASTERN MOUNT LOFTY RANGES

The lands and waters of the Eastern Mount Lofty Ranges PWRA are the traditional country of Peramangk, Kaurna and Ngarrindjeri nations who continue to maintain their cultural heritage, economies, languages and traditional laws which are of ongoing importance – further description of these Aboriginal nations' connection to these lands and waters is described in section 1.3.

The Eastern Mount Lofty Ranges PWRA, which includes the Angas Bremer PWA, is located approximately 50 km to the east of Adelaide and occupies an area of 2,845 km². The area incorporates the eastern slopes of the Mount Lofty Ranges and the Murray Plains (Figure 1.1) and lies within the Murray-Darling Basin.

The Eastern Mount Lofty Ranges PWRA extends from the Milendella Creek catchment in the north to Currency Creek catchment in the south, and contains sixteen surface water catchments. Eleven of the catchments have watercourses that drain from the eastern side of the Mount Lofty Ranges to the River Murray and Lake Alexandrina, with the Bremer, Angas and Finnis Rivers being some of the larger watercourses (Figure 1.3). There are also a number of catchments that have streams that rise in the ranges but do not persist and contribute little water into the River Murray.

A number of different aquifers containing underground water lie under the Eastern Mount Lofty Ranges PWRA. These include fractured rock aquifers in the hills areas, where water is stored and moves through joints and fractures in rock, as well as sedimentary aquifers on the plains and in some valleys in the hills, where water is stored and moves through pore spaces within the sediments.

The western and south-western extent of the Eastern Mount Lofty Ranges PWRA is bounded by the Western Mount Lofty Ranges PWRA. The eastern extent (south of Tolderol Point, Lake Alexandrina) and the north-eastern extent (north of Caloote) are bounded by the River Murray Prescribed Watercourse (PWC). The mid south-eastern boundary is defined by the boundary of the incorporated Angas Bremer

PWA and abuts the Ferries-McDonald catchment. The northern extent of the Eastern Mount Lofty Ranges PWRA is bounded by the Marne Saunders PWRA (Figure 1.1).

The eastern slopes of the Mount Lofty Ranges fall away to the broad Murray Plains and eventually to the River Murray and the lower lakes of Lake Alexandrina and Lake Albert. Mean annual rainfall over the region is approximately 460 mm, varying from around 900 mm in the south-west to 300 mm in the north-east (Figure 1.4). Most of the rainfall and runoff occurs in winter and early spring. The Eastern Mount Lofty Ranges and the Marne Saunders PWRAs contribute about 0.5% of the total annual runoff to the Murray-Darling Basin (CSIRO 2007a).

Land use in the Eastern Mount Lofty Ranges is dominated by grazing and cropping which account for 77% of the total area. Other land uses include irrigated horticulture and pasture production (7%), conservation and natural environments including residual native cover (5%), intensive uses, which includes urban areas, mining, industrial and manufacturing land uses (5%) and forestry (less than 2%) (Figure 1.5).

There are wetlands of national significance within the region, and the confluences of the Finniss River and Currency Creek with Lake Alexandrina are part of the internationally listed Coorong and Lakes Alexandrina and Albert Ramsar wetland (Figure 1.6). There is no direct drainage to the Coorong from the Eastern Mount Lofty Ranges, although numerous rivers and streams drain from the ranges into Lake Alexandrina and the River Murray.

Significant environmental assets such as the Fleurieu Peninsula Swamps are located in the Currency Creek, Tookayerta Creek and Finniss River catchments (Figure 1.6). These swamps are considered a critically endangered ecological community under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and are home to listed endangered species such as southern brown bandicoot and southern emu wren.

There are numerous permanent pools and springs throughout the Eastern Mount Lofty Ranges. These pools/springs are considered environmental assets as they provide critical refuges over the summer months for water-dependent species. Watercourses within the Eastern Mount Lofty Ranges are home to numerous native fish species, including species listed as protected under the State's *Fisheries Management Act 2007*, such as southern pygmy perch and river blackfish. Other environmental assets include the red gum swamps located on the Angas and Bremer Plains (Figure 1.6).

The Eastern Mount Lofty Ranges PWRA includes the hundreds of Tungkillo, Kanmantoo, Monarto, Macclesfield, Strathalbyn, Kondoparinga and Bremer; and parts of the hundreds of Jutland, Kuitpo, Freeling, Myponga, Nangkita, Goolwa, Finniss, Mobilong and Alexandrina.

The Eastern Mount Lofty Ranges PWRA incorporates all or part of the local government regions of Mid Murray, Murray Bridge, Alexandrina, Mount Barker, Barossa, Adelaide Hills, Onkaparinga and Victor Harbor.



Figure 1.3 Eastern Mount Lofty Ranges PWRA surface water catchments.

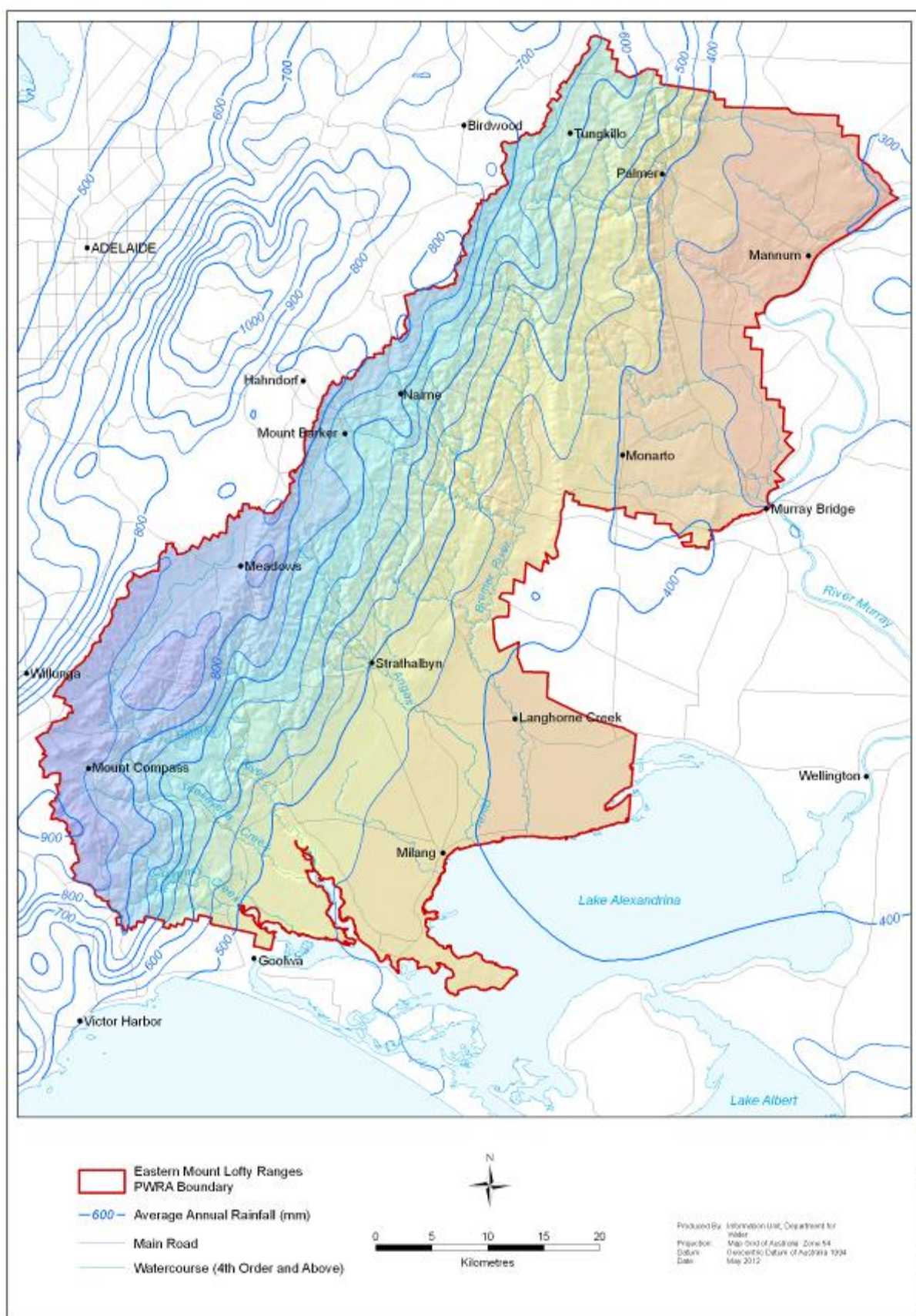


Figure 1.4 Eastern Mount Lofty Ranges PWRA mean annual rainfall.

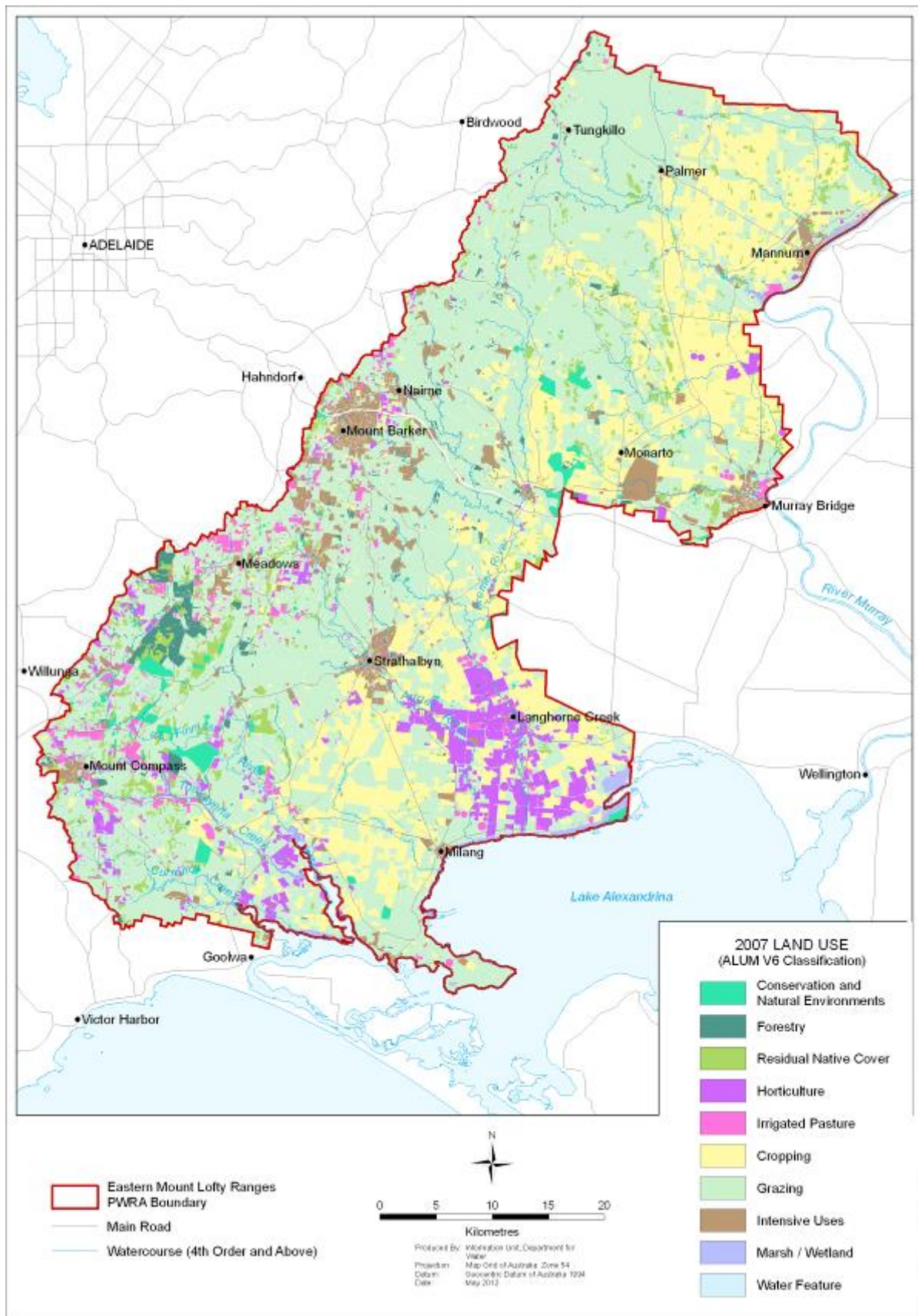


Figure 1.5 Eastern Mount Lofty Ranges PWRA land use.



Figure 1.6 Indicative locations of significant environmental assets and environmental assets within surface water catchments.

1.5 DESCRIPTION OF THE PRESCRIBED WATER RESOURCES

1.5.1 Surface water and watercourse resources in the Eastern Mount Lofty Ranges PWRA

There are sixteen catchments in the Eastern Mount Lofty Ranges PWRA which extend from Currency Creek in the south to Milendella Creek in the north (Figure 1.3). There are eleven major tributary catchments that drain from the ranges to the River Murray and Lake Alexandrina. These are Currency Creek, Tookayerta Creek, Finnis River, Angas River, Bremer River, Rocky Gully Creek, Preamimma Creek, Salt Creek, Reedy Creek, Long Gully Creek and Milendella Creek catchments. The larger watercourses in the region include Currency Creek, Tookayerta Creek, Finnis River, Angas River and Bremer River. There are also a number of watercourses that rise in the ranges but do not persist and contribute little water into the River Murray (Kawalec and Roberts 2005).

The streams in the Eastern Mount Lofty Ranges PWRA gain water from catchment runoff largely in the hills, and from discharge of underground water into the watercourses. Streams also lose water to underground water resources. This generally occurs in the foothills (refer to section 1.5.4). Flow in the Eastern Mount Lofty Ranges PWRA streams is seasonal or ephemeral, with the exception of Tookayerta Creek where underground water contribution to streamflow is sufficient to maintain permanent flow in most years.

Farm dam development is significant, particularly in the hills. Based on aerial surveys, there are approximately 7,000 farm dams in the Eastern Mount Lofty Ranges PWRA with an estimated total storage capacity of about 18,285 megalitres (ML).

Table 1.3 Surface water catchments within the Eastern Mount Lofty Ranges PWRA, giving number of dams and estimated dam storage capacity.

Catchment name	Approximate catchment area (km ²)	Number of farm dams	Estimated farm dam storage capacity (ML)
Angas Plains ⁴	87	33	128
Angas River	197	1,052	3,239
Bees Knees	31	0	0
Bremer River	583	1,895	4,846
Currency Creek	89	546	1,400
Deep Creek	68	165	420
Finniss River	371	2,063	5,464
Ferries-McDonald ⁵	114	29	255
Long Gully	54	7	55
Milendella Creek	108	34	68
Preamimma Creek	74	22	16
Reedy Creek	313	472	860
Rocky Gully Creek	99	15	24
Salt Creek	197	65	47
Sandergrove Plains	282	122	190
Tookayerta Creek	100	543	1,273
Total	2,767	7,063	18,285

⁴ Most of the dams on the Angas Plains and Ferries-McDonald catchments are turkey nest dams used for storage of imported water from the River Murray Prescribed Watercourse.

⁵ Only includes data from the section of the Ferries-McDonald catchment that lies within the Eastern Mount Lofty Ranges PWRA.

The number of farm dams within each catchment and the estimated storage capacity is displayed in Table 1.3 (data supplied by DFW). Farm dam construction and direct pumping from watercourses in the Eastern Mount Lofty Ranges PWRA have significantly changed the streamflow patterns, particularly during the drier months. More detail on each catchment and the impact of water extraction on the flow pattern is given in section 1.5.4.

1.5.2 Geology

The Eastern Mount Lofty Ranges PWRA is topographically separated into a highland (hills) and a lowland (plains) region. The type of geology, as described in this section, influences the topography as well as the characteristics of aquifers holding underground water, as described in section 1.5.3.

The hills region is underlain by consolidated basement rock of a number of different geological units, including the Barossa Complex, the Kanmantoo Group, Normanville Group and the Adelaidean Sedimentary Rocks, which form fractured rock aquifer systems. The plains region is underlain by unconsolidated sediments which forms the sedimentary aquifers of the Murray Basin. Underground water is also contained within the sediments of Permian Sand (Cape Jervis formation) and Quaternary alluvium within highland valleys and adjacent to drainage lines (refer to Figure 1.7).

1.5.2.1 Basement rocks

Barossa Complex

The Barossa Complex consists of gneisses, schists and pegmatites formed about 1,600 million years ago. They are the oldest rocks in the Mount Lofty Ranges, and have been exposed by erosion as part of the Myponga Inlier in the Tookayerta Creek and Finniss River catchments where the topography is highest. The Barossa Complex is surrounded by younger Adelaidean Sedimentary Rocks (Zulfic and Barnett 2003).

Adelaidean sequence

The rocks of the Adelaidean sequence were formed about 1,000 million years ago. These sedimentary rock sequences consist mainly of siltstone, shale and slate, with minor interbeds of sandstone and quartzite.

Normanville Group

The Normanville Group consists of calcareous shale, phosphatic phyllite and marble. This group includes the Macclesfield Marble unit, which is a white, coarsely crystallised marble that occurs in the Macclesfield area.

Kanmantoo Group

The Kanmantoo Group underlies the largest part of the Eastern Mount Lofty Ranges and consists of greywacke, schist and gneiss. A large trough was formed by rapid subsidence in a broad arc around the eastern side of the present Mount Lofty Ranges during the Cambrian period about 500 million years ago. A north-east and south-west trending fault zone (running along the Strathalbyn-Goolwa Road) forms the boundary between the ranges and the Murray Basin. The sediments of the Murray Basin overlie the Kanmantoo Group where down-faulting occurred on the eastern side of the fault.

1.5.2.2 Sediments

Permian Sands

About 280 million years ago in the Permian era, large continental ice sheets moving from the south-east to the north-west carved out several large U-shaped valleys from the older Kanmantoo Group basement rock. These valleys were later filled by glacial deposits consisting of unconsolidated sands, silts and

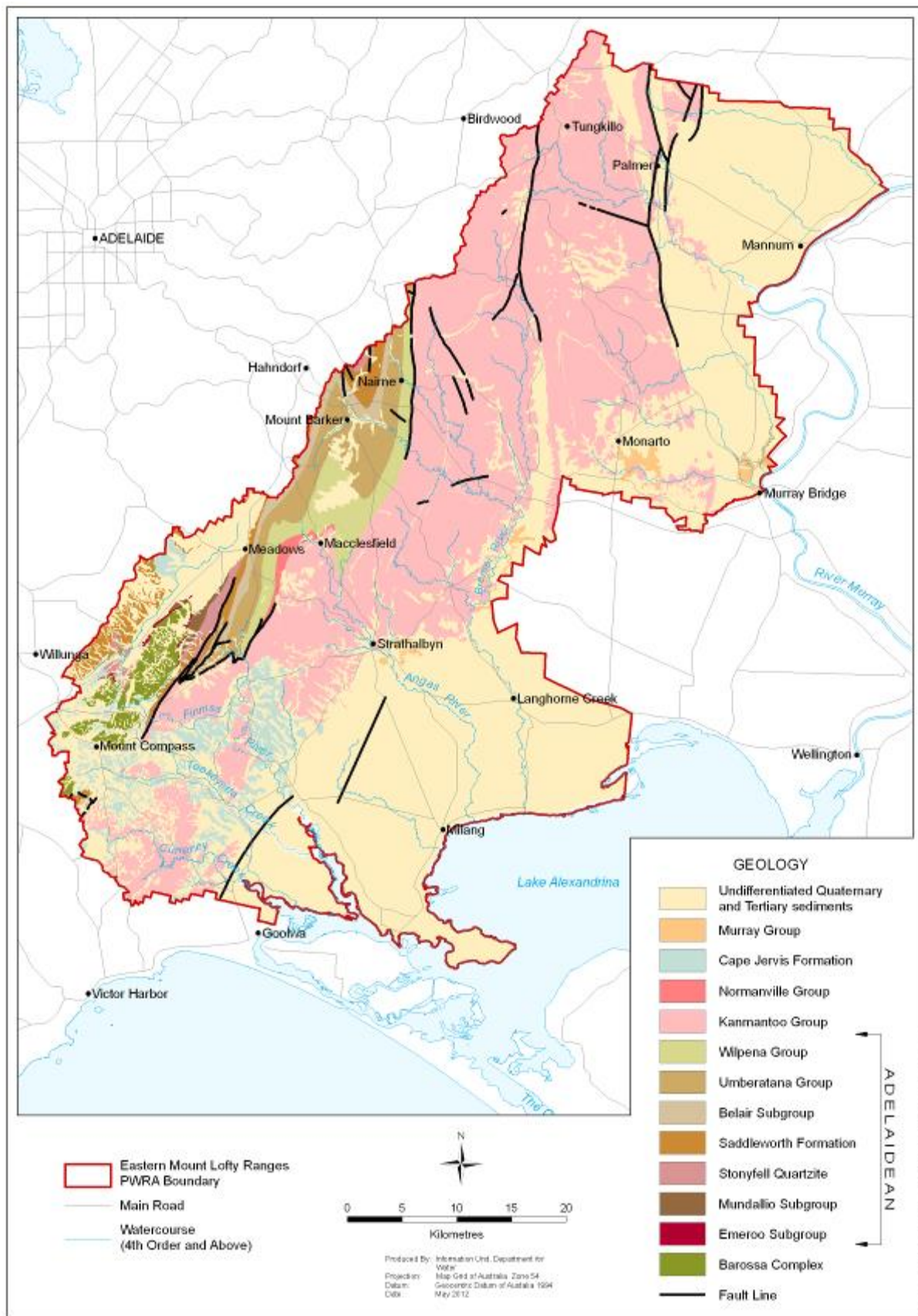


Figure 1.7 Eastern Mount Lofty Ranges PWR geology.

clays with occasional gravel beds, known as the Cape Jervis Formation or Permian Sands (Tookayerta Creek and Finniss River catchments). When uplift occurred to form the Mount Lofty Ranges, the Permian Sands were also uplifted and form part of the eastern slopes of the Mount Lofty Ranges. On the plains, they underlie the Murray Basin Sediments.

Quaternary sediments

The Quaternary sediments consist of unconsolidated alluvium which has been deposited adjacent to drainage lines. The 10 to 20 m thick sequence of Quaternary sediments consists of mainly clays, silt, sands and occasional gravels.

Murray Group Limestone

The Murray Group Limestone consists predominantly of a shallow marine fossiliferous limestone that was deposited about 50 million years ago in the Murray Basin. It overlies the Kanmantoo Group basement rocks, and in some areas, the Permian Sands.

1.5.3 Hydrogeology

The underground water in the Eastern Mount Lofty Ranges PWRA is sourced from two different types of aquifers (Zulfic and Barnett 2003):

- Fractured rock aquifers, which occur where underground water is stored and moves through joints and fractures in the basement rocks.
- Sedimentary aquifers, which occur in the valleys and beneath the Murray Plains where underground water flows through the pore spaces within the sediments.

Recharge to both these aquifers generally occurs directly from rainfall, where a proportion of rainfall percolates down to the watertable through the soil profile. Underground water moves from the higher points in the landscape (which are usually basement rocks around the catchment boundaries) towards the lowest areas, where discharge normally occurs through the sedimentary aquifers in the valleys to the streams. This discharge constitutes the baseflow of the streams, which dominates flow for much of the year, particularly over the summer and between rainfall events.

1.5.3.1 Fractured rock aquifers

Barossa Complex aquifer

The Barossa Complex aquifer is generally considered poor for irrigation supplies. These basement rocks are, in general, tight and impermeable with few open systems of fractures and joints in which underground water can be stored and transmitted. Weathered clayey materials may also in-fill joints and fractures, leading to reduced recharge and increases in salinity. Locally well-developed fracture zones may result in high yields and low salinities.

Adelaidean aquifer

The rocks of the Adelaidean sequence have not been subject to the same level of metamorphism as the Barossa Complex and are considered to be good aquifers because the joints and fractures are open and permeable, allowing greater recharge. This allows relatively high yields of up to 15 L/s and low salinities of 1,500 mg/L total dissolved solids (TDS) (Figure 1.8).

Normanville Group aquifer

The Normanville Group aquifer is represented by the occurrence of the Macclesfield Marble. The unit has developed secondary porosity (fissures) and is considered a good aquifer. The marble can provide greater yields, and allows greater recharge and hence lower salinities than surrounding rock units.

Kanmantoo Group aquifer

The Kanmantoo Group aquifer is generally considered to be a poor aquifer due to the impermeable nature of the rocks and generally poor yields. High salinities are also evident due to the lower rainfall to the east resulting in reduced flushing and recharge to this aquifer. Salinity ranges between 2,000 to 3,000 mg/L TDS (Figure 1.8). However, isolated instances of low salinity and high yields occur.

1.5.3.2 Sedimentary aquifers

Permian Sands aquifer

In general, the Permian Sands aquifer is permeable, allowing high recharge rates from rainfall resulting in very low salinities in some areas (below 500 mg/L TDS) and high yields of 10 to 30 L/s (see Figure 1.8). However this aquifer varies in productivity due to variable sedimentary deposition resulting in higher clay contents in some areas, leading to low yields and high salinity. The Permian Sands aquifer is widely developed for irrigation and town water supply in the Tookayerta Creek catchment, and for irrigation in the Finnis River catchment, to the south of Ashbourne.

Murray Group Limestone aquifer

The Murray Group Limestone aquifer occurs in the Murray Basin. It is confined by the overlying Quaternary clay sediments to the south-west of Murray Bridge, however it is unconfined to the north.

In the southern plains area of the Eastern Mount Lofty Ranges PWSA, the Murray Group Limestone aquifer is the main source of underground water for irrigation supply, particularly in the Angas Bremer and Currency Creek regions. Suitable quality underground water is limited to relatively narrow zones parallel to the Angas and Bremer rivers and the lower Tookayerta Creek, with salinity ranging from 1,000 mg/L to 4,000 mg/L TDS (Figure 1.8). Well yields vary from around 5 L/s to over 15 L/s with occasional yields of up to 40 L/s in very transmissive areas of the aquifer. To the north, the aquifer is more saline and consequently demand is low.

Significant fresh water recharge to the aquifer is thought to have occurred several thousand years ago during a much wetter climatic period. There is currently very little evidence of fresh water recharge (i.e. less than 1,500 mg/L TDS) to the Murray Group Limestone aquifer. Recharge to this aquifer is predominantly due to downward leakage from the overlying Quaternary aquifer, which generally has greater concentrations of salt. Another recharge mechanism is via throughflow from aquifers that are higher up the gradient of underground water flow. Both downward leakage and to a lesser degree, throughflow, contribute to increasing salinity to the aquifer. Current extraction is gradually depleting the lower salinity underground water resource, and as a result underground water salinity is increasing (e.g. Barnett 2008).

Quaternary aquifer

In the highland region, underground water moves from the higher to lower points in the landscape where discharge occurs to streams through the Quaternary sediments in the valley floors. These sediments are generally thin and form low yielding aquifers with salinities mostly below 2,000 mg/L TDS. Out on the Murray Plains, the regional Quaternary sediments contain an unconfined aquifer between Lake Alexandrina and the Eastern Mount Lofty Ranges highlands. This aquifer is generally saline (with salinities up to 10,000 mg/L TDS) and has low yields, and so has limited use.

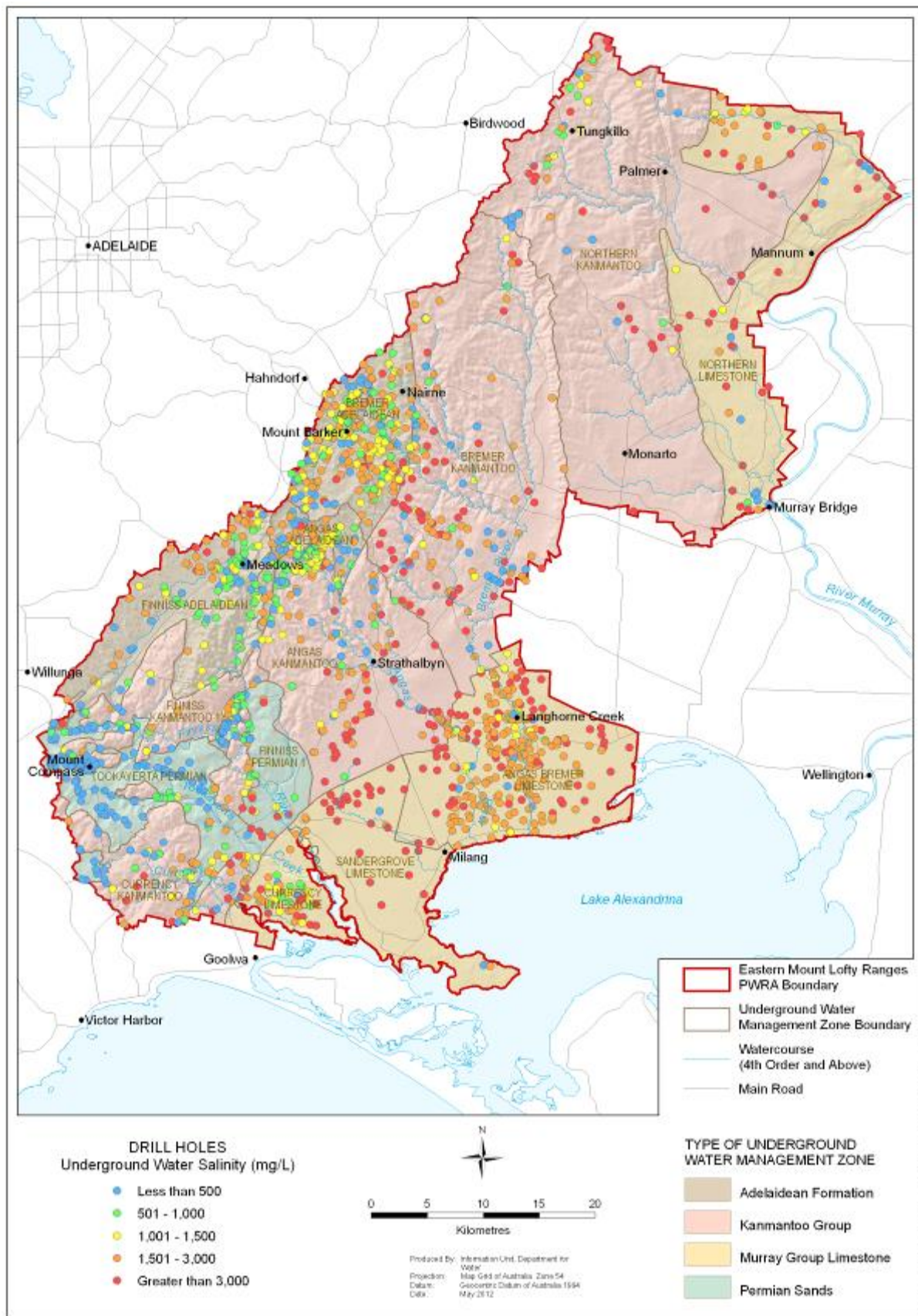


Figure 1.8 Eastern Mount Lofty Ranges PWRA underground water salinity.



Figure 1.9 Eastern Mount Lofty Ranges PWRA surface water and underground water interactions (from Green and Stewart 2008).

1.5.4 Description of surface water and underground water resources for each catchment within the Eastern Mount Lofty Ranges

1.5.4.1 Currency Creek catchment and plains

The Currency Creek catchment is located in the southern region of the Eastern Mount Lofty Ranges PWRA, approximately 60 km from Adelaide. The elevation ranges from around 380 mAHD⁶ in the west, falling to below 10 mAHD where the main watercourse flows into Lake Alexandrina. Mean annual rainfall in the catchment ranges from around 820 mm in the west to 500 mm in the east (Alcorn 2006).

Surface water models have been constructed for the catchments in the Eastern Mount Lofty Ranges that have flow gauging stations. These models simulate daily flow based on rainfall, runoff, landscape characteristics and water capture, and are calibrated using measured flow data from the gauging stations. The models incorporate the existing network of dams and watercourse diversions, and can be used to estimate what flow would be under current landscape conditions but without water interception by dams, watercourse diversions and plantation forests and the impact of urban areas on runoff, which is referred to as adjusted flow or adjusted runoff (see section 1.6.1). The models can also be used to simulate different water management scenarios.

Modelled long-term streamflow for the end-of-system for Currency Creek catchment (1971 to 2006) estimates mean annual adjusted flow of 8,058 ML, and mean annual flow under current development of 6,903 ML. Water resource development (e.g. farm dams, as described in Table 1.3) has led to a decrease in mean annual flow of 14% (Alcorn 2010).

Seasonal effects of farm dam development are greatest in autumn and summer, with modelled mean flow reductions of approximately 50% and 45% respectively. While farm dam development has minimal impact during high flows, it has decreased the range of low flows below around 20 ML per day. It has also led to a modelled decrease in the median daily flow from 5.6 ML to 2.8 ML, a reduction of 49% (Alcorn 2006).

The three main aquifers within the Currency Creek catchment are the Kanmantoo Group and Permian Sands aquifers in the hills, and the Murray Group Limestone aquifer on the plains. Both the Kanmantoo Group and Permian Sands aquifers contribute baseflow to the watercourses in the upper and mid reaches of the catchment. In the lower reaches of the Currency Creek catchment, streamflow is lost to the Kanmantoo Group fractured rock aquifer (Figure 1.9, Green and Stewart 2008). This losing stream reach provides some recharge to the Kanmantoo Group aquifer which, in turn, flows through to the Murray Group Limestone aquifer on the plains. In addition, the Permian Sands aquifer of the adjacent Deep Creek catchment also contributes throughflow to the Murray Group Limestone aquifer in the Currency Creek catchment.

While the Currency Creek Murray Group Limestone aquifer receives some recharge from throughflow, the primary recharge mechanism is downward leakage from the overlying Quaternary aquifer. This is due to drawdown in pressure levels in the Murray Group Limestone aquifer caused by extraction. Current trends in monitoring show both declining water levels and increasing salinity at a rate of up to 50 mg/L/y. Monitoring data (1990 to 2007) shows significant contraction of the fresh water lens in the aquifer where salinity is less than 1,500 mg/L. The current demand on the underground water resource is not considered to be sustainable in the long term (Barnett 2008).

1.5.4.2 Tookayerta Creek catchment

The Tookayerta Creek catchment is located in the southern region of the Eastern Mount Lofty Ranges PWRA, around 60 km south of Adelaide. The elevation of the catchment ranges from around 400 mAHD along the western ridges of the catchment to around 60 mAHD along the eastern end of the

⁶ mAHD – metres above the Australian Height Datum (approximately mean sea level).

catchment. The catchment receives high rainfall, varying between 850 mm in the western highlands, near Mount Compass, to around 500 mm to the east near Lake Alexandrina (Savadamuthu 2004). The main tributaries are Cleland Gully Creek and Nangkita Creek, which flow in an easterly direction before joining and flowing into Lake Alexandrina as Tookayerta Creek.

The Tookayerta Creek and its tributaries are typically perennial, due to significant baseflow from aquifers to the watercourse. It is one of the most ecologically diverse catchments in the Eastern Mount Lofty Ranges PWRA, characterised by swamps and wetlands that provide a variety of habitats supporting rare and endangered species.

The presence of extensive areas of the Permian Sands aquifer (Figure 1.9) is unique to the Tookayerta Creek catchment. This aquifer contains very good quality underground water which is a major contributor to the streamflow in Cleland Gully Creek and Nangkita Creek. In Nangkita Creek, at least 60% of streamflows are derived from the Permian Sands aquifer and up to 40% from the Barossa Complex fractured rock aquifer located in the upper northern reaches of the catchment, in the absence of recent rainfall and runoff (Green and Stewart 2008).

Good quality underground water and permanent streamflow has resulted in relatively low farm dam development (refer to Table 1.3), particularly when compared to other catchments within the Eastern Mount Lofty Ranges. Long-term modelled data (1971–2006) estimates mean annual end-of-system streamflow of 23,097 ML as adjusted flow, and 19,732 ML under current development. Current water resource development has reduced mean annual streamflow by around 15% (Alcorn 2010).

The modelled impact of farm dam development on mean monthly winter flows is negligible; however mean monthly summer flows are reduced by approximately 17% (Savadamuthu 2004). Mean daily flows do not appear to be seriously impacted by farm dam development. However, this analysis did not include the impact of watercourse diversions on the flow regime, which is likely to be significant given that this is the primary form of water extraction from the surface for irrigation in the catchment.

The strong interaction between underground and surface water in the catchment means that overuse of the underground water resource is likely to adversely affect both surface water users and the environment.

1.5.4.3 Finnis River catchment

The Finnis River catchment is located approximately 50 km south of Adelaide. The elevation of the Finnis catchment ranges from around 450 mAHD in the north-eastern highlands to 10 mAHD at the confluence with Lake Alexandrina. Rainfall across the catchment varies from 850 mm in the north-western highlands to less than 450 mm on the south-eastern side of the confluence with Lake Alexandrina (Savadamuthu 2003). Major tributaries to the Finnis River include Meadows, Blackfellows, Bull and Giles Creeks.

The modelled mean annual end-of-system streamflow (1971–2006) for the Finnis catchment is estimated at 40,092 ML as adjusted flow, and 34,714 ML under current conditions (a reduction of 13%) (Alcorn 2010).

There is a large amount of farm dam development within the Finnis River catchment (refer to Table 1.3). The impacts of farm dams on the flow pattern have been modelled in the upper Finnis catchment (upstream of gauging station AW426504, incorporating Meadows Creek, Blackfellows Creek and a portion of the Finnis River, as described in Savadamuthu 2003). The current level of farm dam development has reduced modelled median daily flow from 18.21 ML/day to 7.72 ML/day. Seasonal effects of farm dam development are greatest in autumn and summer, with modelled median summer flows reduced by 72% while median winter flows are reduced by 7%. Farm dam development has minimal impact during high flows, but low flows are strongly affected. For example, flows up to 10 ML/day were modelled to occur for 244 days per year on average without dams, and for 167 days per year on average under current conditions, a reduction of 32% (Savadamuthu 2003).

There are four main aquifers in the Finnis River catchment, being the Adelaidean fractured rock aquifer (west of Meadows Creek), the Barossa Complex fractured rock aquifer (close to Yundi, and east of Meadows Creek), the Kanmantoo Group fractured rock aquifer and the Permian Sands aquifer (refer to Figure 1.7 and Figure 1.9).

Discharge of underground water from the Permian Sands aquifer and Barossa Complex fractured rock aquifer up to 3 km east and west of Yundi provide a significant portion of flow in the Finnis River in that area. When rainfall runoff is insignificant, Meadows Creek gains much of its flow from the Adelaidean fractured rock aquifer (Green and Stewart 2008).

Disconnected sections of year-round flow within Bull Creek, to the north of Ashbourne, are dependent on underground water inflows from the Adelaidean fractured rock aquifer. South of Ashbourne, the Finnis River loses flow to the underlying Kanmantoo Group fractured rock aquifer. However, the Finnis River then becomes a gaining reach around the Braeside Road ford. The mid reach of Giles Creek also gains water from the Permian Sands aquifer (Figure 1.9) (Green and Stewart 2008).

Due to the strong connectivity and interactions between surface water and underground water resources, overuse of the underground water resource is likely to adversely affect the surface water resource and vice versa.

1.5.4.4 Angas River catchment and plains

The Angas River catchment is located in the Eastern Mount Lofty Ranges approximately 50 km south-east of Adelaide. The elevation of the Angas River catchment ranges from around 450 mAHD in the northern highlands to less than 5 mAHD at the confluence with Lake Alexandrina. The headwaters of the main river are located near Flaxley, and the river flows in a south-easterly direction to its confluence with Lake Alexandrina near Milang. Mean annual rainfall in the catchment varies from 800 mm in the western ridges to 400 mm on the plains area (Savadamuthu 2006).

Major tributaries to the Angas River include Dawson, Burslem, Paris, Middle, Doctors and Burnside Creeks. The modelled data (1971–2006) estimates the mean annual streamflow at the end-of-system is 8,408 ML as adjusted flow and 6,732 ML under current development (Alcorn 2010). This equates to a mean annual streamflow reduction of around 20% for the catchment.

Farm dam development in the Angas River catchment is comparable to other catchments in the Eastern Mount Lofty Ranges. Seasonal impacts of farm dams are greatest during summer, and account for a 50% reduction in mean summer flows and a 9% reduction in mean winter flows. Although summer flows are less than 10% of total annual flows, they are crucial to the catchment's water-dependent ecosystems (Savadamuthu 2006).

Modelled median daily flows for the upper Angas sub-catchment (i.e. upstream of gauging station AW426503, incorporating the upper Angas River and Doctors Creek) is reported by Savadamuthu (2006) as being 6.7 ML without farm dams, and 3.2 ML with farm dams. This equates to a 52% reduction in median daily flows. Flows greater than 10 ML/day show minimal impact of farm dam development as dams gradually fill up and then spill as flows increase.

The main underground water resources in the hills region of the Angas River catchment include the Adelaidean and the Kanmantoo Group fractured rock aquifers. Upstream of Macclesfield, watercourses receive some inflow from the Adelaidean fractured rock aquifer. Nearer to Macclesfield, the Normanville Group aquifer (Figure 1.7) is reported by Green and Stewart (2008) to contribute significant baseflow to the Angas River. In the absence of rainfall runoff, inflows from the Normanville Group aquifer are responsible for all of the flow in the Angas River from Macclesfield and up to 7 km downstream of the township. As the Angas River descends towards Strathalbyn, it becomes a losing reach, and the flow in the watercourse recharges (replenishes) the underlying Kanmantoo Group aquifer (Figure 1.9). Exploitation of the underground water resources in Macclesfield and the surrounding area has implications for water users, water-dependent ecosystems and aquifer recharge in much of the upper Angas River catchment (Green and Stewart 2008).

The Murray Group Limestone aquifer is the primary underground water resource on the plains of the Angas River catchment. The aquifer is confined by an impermeable layer. Direct rainfall is not the primary recharge mechanism, unlike other aquifers in the Eastern Mount Lofty Ranges. Instead, the primary recharge mechanisms are lateral throughflow in from the adjoining Kanmantoo Group aquifer, and downward leakage from the overlying Quaternary aquifer.

Downward leakage occurs where the water pressure level in the overlying aquifer is greater than the pressure level in the underlying aquifer. The greater the difference in pressure levels, the greater the potential for leakage. Where the pressure level in the underlying aquifer is greater than the level in the overlying aquifer, the converse is true and the potential for leakage will be upwards. The pressure level in an aquifer may be reduced by water extraction, which may induce or enhance leakage.

Trends in monitoring data in the Murray Group Limestone aquifer show annual recovery of water pressure levels after the irrigation season. Despite this, salinity has continued to increase since 1993 at a rate of around 20 mg/L/y. This suggests that the recovery of water levels in the confined Murray Group Limestone aquifer is due to inflows from more saline water sources (i.e. downward leakage and lateral inflows). Contoured salinity data from 1950, 1977 and 2007 shows contraction of the fresh water lenses within the aquifer (where salinity is less than 1,500 mg/L TDS). This depletion of fresh water in the aquifer was observed even during periods when annual extraction from the aquifer was at a minimum value of around 1,500 ML. This suggests that the rate of extraction is greater than the rate of replenishment of fresh water (i.e. water with a concentration less than 1,500 mg/L TDS) (Zulfic and Barnett 2007).

The fresh water lenses in the aquifer are likely to have been recharged around 5,000–8,000 years ago during a much wetter climatic period. This is supported by research undertaken by Cresswell and Herczeg (2004), where carbon-14 estimates of the age of underground water were reported to be between 4,000–8,000 years.

Due to the nature of the aquifer and inflows to the aquifer, future management will require artificial recharge of fresher water in order to maintain or reduce local salinity impacts. Desalination may also be an option.

1.5.4.5 Bremer River catchment and plains

The Bremer River catchment is located in the central area of the Eastern Mount Lofty Ranges approximately 30 km from Adelaide. The elevation of the upper catchment ranges from 500 mAHD at Mount Barker to 50 mAHD at the confluence of the Bremer River and Rodwell Creek. Below the confluence, the Bremer River flows out onto the Bremer plains, where it travels past the township of Langhorne Creek, to an elevation of less than 5 mAHD, and into Lake Alexandrina.

Rainfall in the catchment is highly variable due to the diverse topographical extent, and the mean annual rainfall ranges from over 860 mm in the north-west to 400 mm on the plains around Langhorne Creek (Alcorn 2008). Markedly lower rainfall occurs along the north-south ridgeline to the eastern side of the catchment (Figure 1.4).

Major tributaries to the Bremer River include the Upper Bremer River and Mount Barker, Nairne, Dawesley, Rodwell and Red Creeks. Mosquito Creek may receive flow from the Bremer River below Langhorne Creek, flowing to the east across the Ferries-McDonald catchment.

Modelled streamflow for the catchment estimates mean annual flows at the end-of-system of 17,925 ML as adjusted flow, and 9,729 ML under current development (a reduction of 46%) (Alcorn 2010).

The reduction in mean annual flows varies depending on rainfall and farm dam development levels within each sub-catchment. Reductions in mean annual flows due to dams are greatest in Rodwell Creek sub-catchment, where annual flows are reduced by 23%. In Mount Barker Creek, annual flows are reduced by 14% (Alcorn 2008).

Seasonal flows are also impacted by farm dam development, with mean summer flows reduced by 28% and mean autumn flows reduced by 32%. Median daily flows are reduced by 39% in Mount Barker Creek and 57% in the Bremer River (not including Mount Barker Creek) (Alcorn 2008).

The reduction in streamflow due to farm dam development and watercourse extractions in the Bremer River catchment has greatly reduced the natural frequency and duration of flood events on the Bremer plains. This has significant implications for the health of the floodplain red gum swamps reliant on flood waters (Figure 1.6), and migration of fish between Lake Alexandrina and the Bremer River catchment.

There are two main underground water resources in the hills region of the Bremer River catchment, which are the Adelaidean and Kanmantoo Group fractured rock aquifers. Like other catchments in the Eastern Mount Lofty Ranges, baseflow from aquifers is an important source of water to streams. There are numerous permanent pools and springs throughout the catchment, many of which are sustained by underground water discharge (Figure 1.6 and Figure 1.9). During times of no significant rainfall, flows in Mt Barker Creek are derived from discharge from the Kanmantoo Group fractured rock aquifer south-east of the Mount Barker. Up to 1 km downstream of Hartley, the Bremer River loses all of its flows to the subsurface during low flow periods. Green and Stewart (2008) reported loss of surface flows, estimated to be around 2 ML/day, into the underground water system during May 2007 in this area.

This important losing stream reach provides recharge to the Kanmantoo Group fractured rock aquifer, which in turn is likely to provide some throughflow to the confined Murray Group Limestone aquifer on the plains of the Bremer catchment. However, salinities of the Bremer River are generally in excess of 1,500 mg/L TDS, particularly during low flows. This means that if recharge did occur, it would be unlikely to contribute sufficient quantities of fresh water (i.e. less than 1,500 mg/L TDS) to the confined Murray Group Limestone aquifer located beneath the Angas and Bremer Plains.

For further details on the confined Murray Group Limestone aquifer on the Angas and Bremer plains, refer to section 1.5.4.4.

1.5.4.6 Reedy Creek catchment

Reedy Creek catchment is located in the northern extent of the Eastern Mount Lofty Ranges approximately 40 km east from Adelaide. The elevation of the catchment ranges from 500 mAHD along the western ridgeline to less than 5 mAHD near the River Murray.

Mean annual rainfall in the catchment varies from around 700 mm in the north-west to less than 350 mm in the east (Figure 1.4). Mean annual rainfall of below 450 mm may produce sporadic rainfall runoff events, but generally contributes no reliable surface water flows. Consequently, streamflow is predominantly generated in the upper reaches of the catchment (i.e. upstream of Palmer) and not below the 450 mm rainfall isohyets.

Mean annual flows in Reedy Creek catchment are estimated to be around 5,965 ML as adjusted flow (Alcorn 2010). Farm dam development is relatively high in the upper reaches of the catchment, with an estimated farm dam storage capacity of around 860 ML. As experienced in other catchments of the Eastern Mount Lofty Ranges, farm dam development is likely to affect annual, seasonal and daily flows.

Major tributaries to Reedy Creek include Loxton, Talbot, Dairy, Baker, Harrison and Palmer Creeks. The two main sub-catchments that drain the upper reaches are Dairy-Baker Creek and Harrison Creek which cover an area stretching almost from Mount Torrens and bounded by the Mt Pleasant-Sedan Road in the north and the Mt Torrens-Tepko Road in the south. These watercourses traverse very steep rocky terrain, with numerous natural rock barriers and waterfalls, as they converge towards a point above the Palmer to Mannum Road. Below this junction, Reedy Creek is a lowland stream containing interspersed pools, before reaching a steep rocky section containing the Mannum waterfalls. Below the falls and the Murray Bridge to Mannum Road crossing, the watercourse enters an extensive shallow wetland with an opening to the River Murray near Caloote (Hammer 2004).

Reedy Creek catchment predominantly overlies the Kanmantoo Group fractured rock aquifer. This aquifer contributes baseflow to watercourses throughout the year (Figure 1.9) and maintains numerous permanent pools/springs as displayed in Figure 1.6. The unconfined Murray Group Limestone aquifer on the plains has relatively high salinities (i.e. greater than 3,000 mg/L TDS) and consequently there is only limited use.

1.5.4.7 Minor surface water resource catchments

The Deep Creek catchment is in the southern part of the Eastern Mount Lofty Ranges, nestled between the Currency Creek and Tookayerta Creek catchments. It is a small, medium yielding catchment with mean annual rainfall in the upper reaches of between 450 and 600 mm. The headwaters are made up of two small tributaries flowing down from steep hillsides, descending into a highly incised (cut in) lowland channel (Hammer 2004).

Milendella Creek, Preamimma Creek, Rocky Gully Creek, Angas Plains and Sandergrove Plains catchments are low to medium yielding catchments with mean annual rainfall in the upper reaches of between 450 and 600 mm, although a significant part of the catchments lie in the low rainfall areas of the Murray plains. In general, the catchments cover undulating topography with a maximum elevation of approximately 400 mAHD. These catchments have minimal stream networks which do not persist as surface streams and contribute little water into the River Murray. Surface water availability in some catchments is highly variable (Kawalec and Roberts 2005).

The Salt Creek catchment is a medium sized catchment situated at the north-eastern extremities of the Eastern Mount Lofty Ranges. It has low topography and low, highly variable rainfall. Much of the catchment comprises plains, with only a small defined section of elevation in the upper sections stretching from near Bondleigh (located approximately 6 km south of Rockleigh) to Tepko. From below the Murray Bridge to Mannum Road, the main ephemeral watercourse is shallow and poorly defined and contributes little water into the River Murray (Hammer 2004).

Ferries-McDonald, Bees Knees, Rocky Gully, Long Gully and the small adjoining catchments bordering the River Murray are low yielding catchments with maximum mean annual rainfall less than 450 mm. Most of the catchments cover low lying topography of the plains with no clearly defined stream networks. Surface water resources from these catchments are unreliable and there is no to very little availability and use of surface water resources (Kawalec and Roberts 2005).

1.6 CAPACITY OF THE WATER RESOURCES

Section 1.5 provides a general description of the water resources of the Eastern Mount Lofty Ranges PWRA. Section 1.6 draws this information together to describe the water resource capacity, which is considered to be the total amount of water available to meet all water demands, including consumptive use and the needs of the environment, on a long-term average annual basis.

The demands for water against the resource capacity are described in sections 1.6.2.1 (natural losses from underground water as baseflow and throughflow), 1.7 (consumptive water needs), 2 (environmental water needs) and 3 (interactions with other water resources).

For the purposes of the Plan, resource capacity is considered to be the long-term mean annual volume or rate of water inflow to a water resource that is expected to occur in the current landscape in the absence of water resource development.

The long-term mean annual capacity of the resource to meet all demands is assessed based on previous resource behaviour and patterning, using best available information. However, the actual water availability in any year can be highly dependent on factors such as climate, water movement and other demands.

The resource capacities for surface water, watercourses and underground water are discussed further below.

1.6.1 Surface water and watercourse water resource capacity

Surface water and watercourse water are considered together in the Plan, including for the purposes of the water resource capacity and the sustainable evaporation and consumptive use limits.

The surface and watercourse water resource capacity is the mean annual adjusted runoff, which is the modelled long-term (1971–2006) mean annual runoff, adjusted to remove the impacts of dams, watercourse diversions, limited urban runoff⁷ and plantation forestry (Alcorn 2010). This is the capacity of the surface water resource that is available for all demands on a continuous basis, based on previous resource behaviour and patterning.

Table 1.4 presents the volume of the resource capacity for each surface water catchment in Eastern Mount Lofty Ranges PWRA, while the catchments are shown in Figure 1.10.

For the purposes of the Plan, the Long Gully and Bees Knees catchments and the small areas draining to the River Murray north and south of Bees Knees catchment and north of Long Gully have been grouped into the Long Gully Group catchment. References to Ferries-McDonald catchment only include those parts of this catchment that lie within the Eastern Mount Lofty Ranges PWRA.

Note that resource capacity can be expressed as a volume or as a depth of mean annual adjusted runoff from a given area. The Plan generally uses the term 'resource capacity' when referring to the volume, and 'mean annual adjusted runoff depth' when referring to the depth.

Table 1.4 Resource capacity for the surface water catchments of the Eastern Mount Lofty Ranges PWRA. Data from Alcorn (2010) and supplied by DFW.

Catchment	Resource capacity (ML/y)
Angas Plains	0
Angas River	8,407
Bremer River	17,925
Currency Creek	8,060
Deep Creek	1,603
Ferries-McDonald	0
Finniss River	40,094
Long Gully Group	0
Milendella Creek	547
Preamimma Creek	0
Reedy Creek	5,965
Rocky Gully Creek	0
Salt Creek	615
Sandergrove Plains	1,440
Tookayerta Creek	23,097
Total	107,753

⁷ Mean annual adjusted runoff has been adjusted for the effects of the Mount Barker, Nairne, Littlehampton and Strathalbyn urban areas, but not for other urban areas on the Eastern Mount Lofty Ranges PWRA.



Figure 1.10 Surface water catchments in the Eastern Mount Lofty Ranges PWRA for the purposes of water resource capacity.

1.6.2 Underground water resource capacity

The Eastern Mount Lofty Ranges PWRA has been divided into underground water management zones on the basis of the type of aquifer (as described in section 1.5.3), intersected with the surface water catchment boundaries. Figure 1.11 shows the majority of these zones, excluding those that lie over the top of other underground water management zones (i.e. each Limestone underground water management zone has a corresponding Quaternary zone that lies over it).

Resource capacity for underground water is considered to be the mean annual inflow. Inflows to underground water in the majority of the underground water management zones are predominantly from rainfall recharge, but may also include downward leakage from the overlying aquifer and throughflow (lateral inflows from one aquifer to another). As described in section 1.5.4, downward leakage and throughflow are the dominant recharge mechanism in the confined Limestone aquifer in the Angas, Bremer and Currency plains regions.

The underground water resource capacity for the underground water management zones which are primarily recharged by rainfall is the mean annual recharge for the aquifer in millimetres per year (mm/y) multiplied by the area of the zone in square kilometres (km²) to give a mean annual recharge volume in megalitres per year (ML/y). This is the capacity of the underground water resource that is available for all demands on a continuing basis.

Rainfall recharge in the majority of underground water management zones has been estimated using a chloride mass balance approach. This method assumes that the only source of chloride in underground water is derived from rainfall and that the rate of chloride input to the landscape is constant, and there are no other sources or sinks of chloride (Banks et al. 2007). Chloride mass balance is relatively accurate at discrete locations but may not accurately reflect actual recharge when applied over large scales.

Recharge rates in the Quaternary management zones have been determined from expert opinion. Future resource condition monitoring (as detailed in section 8) will assist with determining whether or not the recharge rates have been correctly estimated.

The resource capacity for the management zones that have no or minimal rainfall recharge (the Limestone aquifers except the Northern Limestone) has been set on the basis of estimated throughflow to the aquifer. The process for estimating throughflow is described in the following section.

Table 1.5 presents the resource capacity for each underground water management zone in the Eastern Mount Lofty Ranges PWRA.

1.6.2.1 Underground water baseflow and throughflow

Two natural sources of outflow or loss from aquifers are baseflow (discharge to watercourses) and throughflow as water moves from one aquifer to another. Key baseflow and throughflow characteristics of each catchment are described in section 1.5.4.

Baseflow and throughflow out of aquifers are natural demands against the resource capacity that need to be accounted for when considering the total amount of water available to meet all water demands within resource capacity. Table 1.5 shows the long-term mean annual volume of baseflow and throughflow from each underground water management zone.

Baseflow has been estimated using a standard baseflow separation calculation, which distinguishes streamflow components derived from rainfall runoff and baseflow. Throughflow from one aquifer to another has been estimated by multiplying the rate of underground water flow by the cross-sectional area of the aquifer. The rate of underground water flow is estimated from hydrogeological assessments of the aquifer properties and underground water levels/pressures and expert opinion.



Figure 1.11 Underground water management zones in the Eastern Mount Lofty Ranges PWRA.

Table 1.5 Resource capacity, baseflow and throughflow volumes for underground water management zones in the Eastern Mount Lofty Ranges PWRA. Text and figures in *italics* are for zones that are part of the same aquifer, and relevant values have been summed to give the total value for that aquifer in a separate row. Values are rounded.

Map ID*	Aquifer	Underground water management zone	Area (km ²)	Recharge rate (mm/y)	Resource capacity (ML/y)	Baseflow out (ML/y)	Throughflow out (ML/y)
19	Angas Adelaidean	Angas Adelaidean	40.1	64	2,567	946	-
24	Angas Bremer Limestone	Angas Bremer Limestone	250.0	0	6,576	-	-
(24)	Angas Bremer Quaternary	Angas Bremer Quaternary	250.0	1	250	-	-
17	Angas Kanmantoo	Angas Kanmantoo	258.4	20	5,167	2,850	500
20	Bremer Adelaidean	Bremer Adelaidean	124.6	54	6,729	2,492	-
21	Bremer Kanmantoo	Bremer Kanmantoo	466.3	19	8,860	3,900	1,500
4	Currency Kanmantoo	Currency Kanmantoo	97.2	27	2,623	1,241	200
3	Currency Limestone	Currency Limestone	50.1	0	1,000	-	-
2	Currency Permian	Currency Permian	6.7	97	649	311	-
(3)	Currency Quaternary	Currency Quaternary	50.1	2	100	-	-
18	Finniss Adelaidean	Finniss Adelaidean	168.8	62	10,468	4,959	-
16	Finniss Kanmantoo	Finniss Kanmantoo 1**	72.9	27–98	4,299	1,390	-
10	Finniss Kanmantoo	Finniss Kanmantoo 2	16.0	22	351	114	-
11	Finniss Kanmantoo	Finniss Kanmantoo 3	1.3	23	29	9	-
13	Finniss Kanmantoo	Finniss Kanmantoo 4	0.9	23	20	7	-
	<i>Finniss Kanmantoo</i>	<i>Finniss Kanmantoo – total</i>	<i>91.0</i>		<i>4,699</i>	<i>1,520</i>	-
15	Finniss Permian	Finniss Permian 1	61.8	67	4,140	1,578	300
14	Finniss Permian	Finniss Permian 2	0.6	100	62	24	-
	<i>Finniss Permian</i>	<i>Finniss Permian – total</i>	<i>62.4</i>		<i>4,202</i>	<i>1,602</i>	<i>300</i>
1	Goolwa Limestone	Goolwa Limestone	7.5	0	200	-	-
(1)	Goolwa Quaternary	Goolwa Quaternary	7.5	2	15	-	-
23	Northern Kanmantoo	Northern Kanmantoo	604.1	18	10,874	3,866	-
22	Northern Limestone	Northern Limestone	274.2	1	274	-	-
8	Sandergrove Limestone	Sandergrove Limestone	155.4	0	3,000	-	-
(8)	Sandergrove Quaternary	Sandergrove Quaternary	155.4	1	155	-	-
9	Tookayerta Kanmantoo	Tookayerta Kanmantoo 1	7.7	100	768	595	-
7	Tookayerta Kanmantoo	Tookayerta Kanmantoo 2	3.2	98	309	239	-
6	Tookayerta Kanmantoo	Tookayerta Kanmantoo 3	4.2	28	116	90	-
	<i>Tookayerta Kanmantoo</i>	<i>Tookayerta Kanmantoo – total</i>	<i>15.0</i>		<i>1,193</i>	<i>924</i>	-
12	Tookayerta Permian	Tookayerta Permian**	132.3	83.6	11,058	7,215	1,000
	Grand total		3,267.0		80,659	31,826	3,500

* Map ID column refers to Map IDs for zones in Figure 1.11. Map IDs in brackets are zones not shown in Figure 1.11 because they lie over zones shown on that figure.

** Variable recharge rate over zone. Range given from Finniss Kanmantoo 1, and mean given for Tookayerta Permian.

1.6.3 Effects of climate variability and climate change on water resource capacity

Any assessment of the capacity of the water resources to meet demands, particularly future demands, is complicated by climate driven changes in water supply.

Much of the work to set consumptive use limits and associated policy for the Plan is based on historical data on resource availability. The climate is quite variable from year to year and with patterns of wetter and drier periods. Future climate and hence water availability may not reflect historical patterns.

In addition, there is a trend towards hotter, drier conditions over large parts of south-eastern Australia and there is strong consensus that these higher temperatures reflect climate change. Modelling of climate change scenarios and resulting impact on water availability through the CSIRO Sustainable Yields project for the Eastern Mount Lofty Ranges region has predicted reductions in average water availability of between 3 and 52% by 2030 (CSIRO 2007a). Under the best estimate (median) climate for 2030, water availability was predicted to be reduced by around 18%, reducing net diversions from dams by 5% and increasing the likely frequency of cease-to-flow events in ephemeral catchments. Nearly all of the modelling results with different climate change projections showed a decrease in runoff, with the best estimate (median climate) of a 15% reduction in mean annual runoff by 2030, compared to a baseline of 1990 (CSIRO 2007b). The impact of this climate scenario was predicted to have very little impact on the fraction of rainfall-derived recharge that is extracted for use from underground water. Furthermore, increasing temperatures and evaporation may increase demand for water, placing further stress on the water resources.

All credible projections of climate change and its impacts in South Australia are made on a timescale of multiple decades. For example, the CSIRO and Bureau of Meteorology's 2007 Climate Change in Australia project provides projections of changes in South Australia's climate for time horizons of 2030, 2050 and 2070, compared to a 1990 climate baseline. On shorter timescales, unpredictable climate variations, such as a few hot and dry years followed by a few wetter and cooler years, are superimposed on the ongoing longer-term climate change.

This water allocation plan has a ten year review period. Over a shorter timescale such as this, applying a pro-rata of the changes projected between 1990 and 2030 may not be appropriate. Until improved climate change projections are available, the climate of recent decades remains the best indicator of the climate of the near future and it is appropriate to base estimates of water resource capacities on these historic data. Therefore the potential impacts of climate change have not been incorporated into the Plan, and it is expected that this will be reviewed in the future when further information is available. For example, the Department for Environment and Water (and its predecessors) is undertaking work to estimate the impacts of climate change on the capacity of water resources, including those in the Mount Lofty Ranges. The outcomes of this work will be used to inform climate change adaptation planning for water resources.

In the meanwhile, adequate monitoring and evaluation to support an adaptive management approach is of key importance to allow responsive management in the face of climatic uncertainty. Section 8 sets out the minimum monitoring framework required to assess water demand, trends in water resource behaviour, environmental responses and the capacity of the resource to meet demands.

1.6.3.1 Aboriginal nations position on climate change

This section has been adapted from the Ngarrindjeri Yarluwar-Ruwe Plan (Ngarrindjeri Tendi Incorporated, Ngarrindjeri Heritage Committee Incorporated, Ngarrindjeri Native Title Management Committee 2006), which describes how Aboriginal people have long experiences with climate change and sea-level changes. Their Creation stories tell them of the flooding of their lands and changes to rivers and coast lines. Their old people have watched the impacts of the degradation of their lands and waters since European occupation. They recognise the impacts of global warming on their lands and waters and all living things. In recent years, Ngarrindjeri have observed changes in their local

environment that tells them that climate change is a reality. They see that the breeding behaviour of birds is changing, as is the colour of fish and their behaviour and the fruiting and flowering of their bush foods is changing too. They have watched their water holes, creek lines and springs dry up or turn salty and they have seen the coastal camping places and middens washed away by rivers and rising sea levels. When Aboriginal people lose these places they lose part of their cultural heritage and an irreplaceable record of Ngarrindjeri adaption to climate change in the past. They have also noticed that some of their animal and plant species have declined in size and abundance and some species have disappeared altogether.

Peramangk, Kurna and Ngarrindjeri peoples support action to address climate change and are willing to work with all levels of government to reverse damage done by industrialisation and unsustainable practices.

1.7 WATER DEMAND

Demand for water can be broadly divided into the categories of environmental and other non-consumptive needs and values, and consumptive use:

- Environmental water requirements are described in section 2.
- Other non-consumptive needs and values may include mitigating pollution, public health, cultural values across the community, recreation, fisheries, tourism, navigation and amenity values. These non-consumptive needs and their associated water requirements have not been quantified in the Eastern Mount Lofty Ranges PWRA.
- Consumptive water use in the Eastern Mount Lofty PWRA is divided into the following purposes:
 - Non-licensed purposes
Includes domestic use; watering stock that are not subject to intensive farming; fire fighting; public road making; applying chemicals to non-irrigated crops or to control pests; commercial forestry; use of roof runoff of less than the gazetted threshold volume; and exercise of the native title rights by Native Title holders to use the natural water resources of the native title determined area for personal, domestic, cultural, spiritual or non-commercial communal needs providing the taking does not involve stopping, impeding or diverting the flow of water from a watercourse.
 - Licensed purposes
Considered to be taking water for any purpose besides non-licensed purposes. Licensed purposes may include irrigation, industrial use, intensive animal production, environmental use and recreational use.

Figure 1.5 shows the major types of land use in the Eastern Mount Lofty PWRA, giving an indication of the broad distribution of many of the water using activities in the area.

This section:

- provides an overview of the current range and size of key water using activities in the Eastern Mount Lofty Ranges PWRA (sections 1.7.1-1.7.5);
- estimates the likely amount of water required for the annual current demand where available; and
- discusses probable future demand for consumptive use of water over the life of the Plan (section 1.7.6).

1.7.1 Aboriginal water needs

Aboriginal water needs span the categories of water needs described above, including the different forms of water demand described in sections 1.7.2-1.7.6.

Aboriginal nations have a deep cultural and spiritual connection with traditional country, including the flora, fauna and other resources it provides. Water is extremely important to the way of life, supporting many different aspects of society and governance. From an Aboriginal perspective, historic and contemporary values and uses are seen as one, they do not need to be separated as they form part of Aboriginal identity. Aboriginal cultural objectives and outcomes discussed in section 1.3.3 are founded on Aboriginal cultural values and uses. Through ongoing engagement in water planning with Peramangk, Kaurna and Ngarrindjeri nations, Aboriginal values and uses in relation to water have been discussed to include:

- Economy, trade and travel
- Storytelling and identity
- Healing, health and well-being
- Ceremonies and lore
- Hunting, fishing and collection of bush food, medicine and resources
- Drinking and preparation of food
- Bathing, swimming and other recreational enjoyment
- Supporting flora, fauna and culturally significant species, and the landscape
- Protecting important cultural heritage sites and objects
- Forming relationships and understanding through reconciliation, education and awareness
- Supporting life – water as the lifeblood of the living body that is the landscape

Aboriginal nations call for environmentally sustainable management of the lands and water of their traditional country. Good health of water resources and the landscape as a whole living body has been identified by nations as critically important to achieving their Aboriginal cultural objectives and providing Aboriginal water needs into the future. A decline in the condition of water resources and the water-dependent ecosystems and species of the Eastern Mount Lofty Ranges PWRA impacts on many of the values and uses of water of Aboriginal people, and through their connection to Country, can also be understood as a threat to Aboriginal people's health and wellbeing.

An important part of Aboriginal water needs is a sufficient quantity and quality of water to support Aboriginal values and uses. Through consultation during the amendment of this Plan, Aboriginal nations stated that they would like to see the water resources of the Eastern Mount Lofty Ranges PWRA protected and restored to function as it did for previous generations and support all aspects of life.

Water needs based on Aboriginal values and uses are not limited to the water authorised under section 128 of the NRM Act that is taken in exercise of native title rights. The provisions in this Plan that aim to maintain water quantity and quality may help to support some other Aboriginal values and uses, particularly in relation to supporting flora, fauna and the landscape (see Table 1.2). Until the consultation that resulted in amendment to the Plan in 2019, Aboriginal values and uses had not been considered as part of the water licensing process in the Eastern Mount Lofty Ranges to date.

1.7.2 Non-licensed water needs – stock and domestic water requirements

Stock and domestic water needs make up the majority of non-licensed demand for water. Stock and domestic water is taken from a range of sources:

- mains water supplied to the townships;
- rainwater;

- dams, watercourses and springs; and
- wells (including bores and windmills that extract underground water).

The current and future stock and domestic water requirements from these different water resources have been estimated by the Board using a range of information, including land use and land capability mapping, aerial photography, spatial water databases and a community phone survey (SAMBD NRMB 2009).

1.7.2.1 Domestic water requirements

The majority of water use in the townships is supplied by the SA Water mains network rather than from the prescribed water resources, and therefore domestic water use in these townships has not been included in the domestic demand calculations.

Some townships are not supplied by the SA Water mains network, and in some cases have domestic water needs supplied from the prescribed water resources as follows:

- Mt Compass is supplied underground water by SA Water and a private water supply scheme.
- Meadows is supplied underground water by a private water supply scheme and by a non-potable supply to approximately 40 households maintained by the District Council of Mt Barker.
- A pipeline to supply potable water to Langhorne Creek has recently been completed.
- Macclesfield is not connected to the SA Water mains network or council managed schemes.

The measured and estimated domestic consumption for these townships were combined with the rural domestic consumption (as outlined below) in the calculations for domestic use.

A combination of the state government digital cadastral databases, land use codes and aerial imagery were used to identify the location of properties which could possibly contain households. The mean annual residential consumption per household was assumed to be 280 kilolitres (Government of South Australia 2005). Rainwater is the primary source of domestic water outside the townships, particularly within the house. This is supplemented by underground water and dam water, generally for garden watering and for some indoor purposes such as toilet flushing and laundry. For these households with no mains access, it was assumed that 50% of domestic water use is from rainwater tanks with the remaining 50% from surface water and underground water sources (SAMDB NRMB 2009).

The Board estimates that the total current domestic water requirement (outside the townships supplied by the SA Water mains network) is 503 ML/y, being 262 ML/y for surface water (Table 1.6) and 241 ML/y for underground water (Table 1.7).

1.7.2.2 Stock water requirements

A water licence is not required for watering stock that are not subject to intensive farming. A water licence is required for providing drinking water for intensively kept stock and use of water for other purposes related to stock (e.g. piggeries, permanent feedlots and chicken sheds).

The animal stocking rate was modelled using the Dry Sheep Equivalent⁸ to estimate the total stock drinking water requirement for the Eastern Mount Lofty Ranges PWRA.

The modelled total stock drinking water requirement for the Eastern Mount Lofty Ranges PWRA is estimated at 2,551 ML/y; split into 2,071 ML/y for surface water (Table 1.6) and 480 ML/y for underground water (Table 1.7).

⁸ The Dry Sheep Equivalent is a standard unit frequently used to compare the feed requirements of different classes of stock or to assess the carrying capacity and potential productivity of a given farm or area of grazing land.

These estimates of stock water requirements are expected to reflect future requirements for this purpose as they are based on land that is or is likely to be able to be grazed, and its carrying capacity for moderate to good production rates. The future demand for stock water use is expected to remain relatively stable, although drought and changing commodity prices may change the balance between cropping and grazing over time.

1.7.2.3 Stock and domestic requirements from surface water

The surface water modelling for the Eastern Mount Lofty Ranges PWRA assumes that usage from stock and domestic dams is 30% of dam capacity (Alcorn, Savadamuthu and Murdoch 2008 and references therein). The total capacity of stock and domestic dams in the Eastern Mount Lofty Ranges is approximately 11,611 ML, giving an estimate of stock and domestic water requirements from surface water of approximately 3,483 ML/y. Table 1.8 shows the estimated stock and domestic demand by this method by catchment.

The surface water modelling work has been used to estimate the capacity of the water resources given in section 1.6.1. The Plan will adopt the estimate of stock and domestic water requirements from surface water and watercourses as being 30% of the capacity of stock and domestic dams, in order to maintain consistency with the modelling that underpins the determination of the resource capacity.

Table 1.6 Estimated current annual stock and domestic (S&D) surface water and watercourse demand, based on Board methodology.

Rows in italics show catchment totals (not included in grand total).

Catchment name	Sub-cat. number ⁹	Sub-catchment name	Domestic demand (ML/y)	Stock demand (ML/y)	Total S&D demand (ML/y)
Angas River	A1	Upper Angas River	23	100	123
Angas River	A2	Burslem Creek	7	76	83
Angas River	A3	Dawson Creek	2	31	33
Angas River	A4	Burnside Creek	2	18	20
Angas River	A5	Lower Angas River	2	12	14
Angas River	A6	Lower Angas River	1	1	2
<i>Angas River – total</i>			37	238	275
Bees Knees	K1	Bees Knees	0	0	0
Bremer River	B1	Upper Bremer River	14	137	151
Bremer River	B2a	Nairne Creek	4	24	28
Bremer River	B2b	Dawesley Creek	8	77	85
Bremer River	B3	Upper Mount Barker Creek	37	104	141
Bremer River	B4	Rodwell Creek	16	56	72
Bremer River	B5	Lower Mount Barker Creek	11	59	70
Bremer River	B6	Red Creek	2	7	9
Bremer River	B7	Lower Bremer River	4	17	21
Bremer River	B8	Lower Bremer River	0	2	2
<i>Bremer River – total</i>			96	483	579

⁹ A map showing these sub-catchments is given in Appendix A of the Plan. These sub-catchments are similar to those used in the water affecting activity permits section of the SAMDB NRM (South Australian Murray-Darling Basin Natural Resources Management) Board's Regional Natural Resources Management (NRM) Plan.

Catchment name	Sub-cat. number ⁹	Sub-catchment name	Domestic demand (ML/y)	Stock demand (ML/y)	Total S&D demand (ML/y)
Currency Creek	C1	Upper Currency Creek	8	136	144
Currency Creek	C2	Lower Currency Creek	5	48	53
<i>Currency Creek – total</i>			<i>13</i>	<i>184</i>	<i>197</i>
Deep Creek	Dr1	Upper Deep Creek	1	23	24
Deep Creek	Dr2	Middle Deep Creek	3	32	35
Deep Creek	Dr3	Lower Deep Creek	0	5	5
<i>Deep Creek – total</i>			<i>4</i>	<i>60</i>	<i>64</i>
Finniss River	F1	Finniss River	8	69	77
Finniss River	F2	Meadows Creek	42	259	301
Finniss River	F3	Blackfellows Creek	3	38	41
Finniss River	F4	Finniss River	6	89	95
Finniss River	F5	Bull Creek	11	87	98
Finniss River	F6	Giles Creek	2	29	31
Finniss River	F7	Finniss River	2	16	18
<i>Finniss River – total</i>			<i>74</i>	<i>587</i>	<i>661</i>
Goolwa (part)	W1	Goolwa	0	0	0
Long Gully	Y1	Long Gully	0	1	1
Milendella Creek	Lr1	Milendella 1	1	14	15
Milendella Creek	Lr2	Milendella 2	0	3	3
Milendella Creek	Lr3	Milendella 3	0	0	0
Milendella Creek	Lr4	Milendella Plains	0	0	0
<i>Milendella Creek – total</i>			<i>1</i>	<i>17</i>	<i>18</i>
Preamimma Creek	P1	Preamimma Creek	0	8	8
Reedy Creek	Rr1	Dairy Creek	5	113	118
Reedy Creek	Rr2	Harrison Creek	9	129	138
Reedy Creek	Rr3	Loxton Creek	1	10	11
<i>Reedy Creek – total</i>			<i>15</i>	<i>252</i>	<i>267</i>
Rocky Gully Creek	G1	Rocky Gully Creek	0	3	3
Salt Creek	Nr1	Upper Salt Creek	1	25	26
Salt Creek	Nr2	Lower Salt Creek	1	18	19
<i>Salt Creek – total</i>			<i>2</i>	<i>43</i>	<i>45</i>
Sandergrove Plains	Er1	Upper Sandergrove Plains	0	13	13
Sandergrove Plains	Er2	Middle Sandergrove Plains	1	10	11
Sandergrove Plains	Er3	Lower Sandergrove Plains	1	15	16
<i>Sandergrove Plains – total</i>			<i>2</i>	<i>38</i>	<i>40</i>
Tookayerta Creek	T1	Nangkita Creek	8	55	63
Tookayerta Creek	T2	Cleland Gully	6	68	74
Tookayerta Creek	T3	Lower Tookayerta Creek	4	34	38
<i>Tookayerta Creek – total</i>			<i>18</i>	<i>157</i>	<i>175</i>
Grand total			262	2,071	2,333

Table 1.7 Estimated current annual stock and domestic underground water demand.

Rows in italics show zone totals not included in grand total.

Underground water management zone	Domestic demand (ML/y)	Stock demand (ML/y)	Total S&D demand (ML/y)
Angas Adelaidean	3	15	18
Angas Kanmantoo	50	56	106
Angas Bremer Limestone	35	33	68
Bremer Adelaidean	16	42	58
Bremer Kanmantoo	15	82	97
Currency Kanmantoo	1	16	17
Currency Limestone	2	14	16
Currency Permian	0	1	1
Finniss Adelaidean	47	38	85
Finniss Kanmantoo 1	1	10	11
Finniss Kanmantoo 2	0	3	3
Finniss Kanmantoo 3	0	0	0
Finniss Kanmantoo 4	0	0	0
<i>Finniss Kanmantoo – total</i>	<i>1</i>	<i>13</i>	<i>14</i>
Finniss Permian 1	2	11	13
Finniss Permian 2	0	0	0
<i>Finniss Permian – total</i>	<i>2</i>	<i>11</i>	<i>13</i>
Goolwa Limestone	0	0	0
Northern Kanmantoo	5	98	103
Northern Limestone	2	28	30
Sandergrove Limestone	1	11	12
Tookayerta Kanmantoo 1	0	1	1
Tookayerta Kanmantoo 2	0	0	0
Tookayerta Kanmantoo 3	0	0	0
<i>Tookayerta Kanmantoo – total</i>	<i>0</i>	<i>1</i>	<i>1</i>
Tookayerta Permian	61	21	82
Grand total	241	480	721

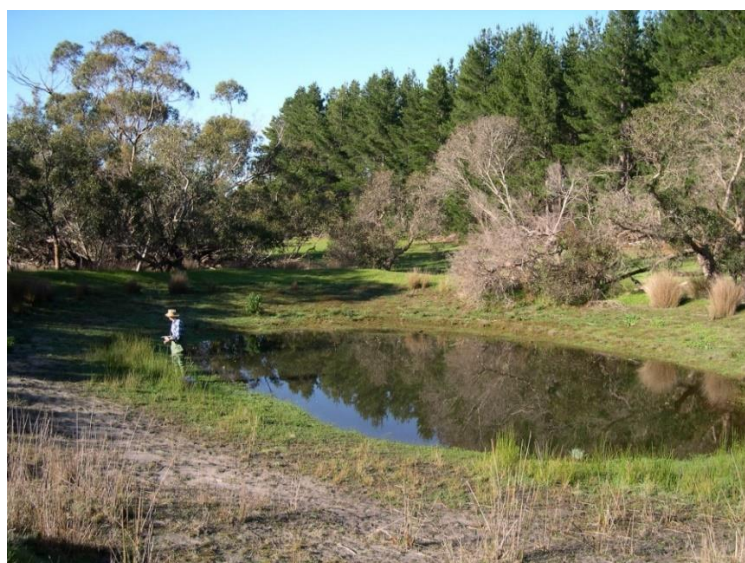


Table 1.8 Estimated stock and domestic surface water and watercourses demand by catchment, based on 30% of stock and domestic dam capacity.
Data supplied by DFW.

Catchment	Estimated S&D demand (ML/y)
Angas Plains	38
Angas River	642
Bremer River	953
Currency Creek	191
Deep Creek	71
Ferries-McDonald	76
Finniss River	943
Long Gully Group	17
Milendella Creek	20
Preamimma Creek	5
Reedy Creek	238
Rocky Gully Creek	3
Salt Creek	14
Sandergrove Plains	51
Tookayerta Creek	221
Total	3,483

1.7.3 Current plantation forestry

Plantation forestry can provide benefits across the landscape, including direct economic benefits from plantation products, as well as recreational uses, sequestration of carbon and assistance in managing dryland salinity issues where clearance has led to rising water tables. Plantation forestry can also affect water resources and it is important for the Plan to consider the potential for plantation forestry to affect the availability of water resources to other water users, including water-dependent ecosystems.

Plantation forestry can affect water resources by:

- intercepting rainfall at closed canopy which will:
 - reduce surface water runoff;
 - change the volume, timing and duration of flow, which may be critical for maintaining habitats; and
 - reduce underground water recharge; and
- directly extracting underground water in areas where plantation forestry overlies shallow watertables (Government of South Australia 2009).

In accordance with the state-wide policy framework for managing the water resources impacts of plantation forests, interception of rainfall by plantation forestry (regardless of species) is considered to reduce surface water runoff and underground water recharge by 85% (Government of South Australia 2009).

The total area occupied by plantation forestry in the Eastern Mount Lofty Ranges PWRA is 3,893 ha according to 2008 state government land use data, occupying less than 2% of the Eastern Mount Lofty Ranges PWRA. Forestry is mainly located within the Finniss River and Tookayerta Creek catchments.

Total surface water interception by forestry is estimated to be 3,191 ML/y in the Eastern Mount Lofty Ranges PWRA, shown by catchment in Table 1.9. The estimated reduction in surface water runoff due to forestry development equates to around 3% of the total surface water resource capacity. However, the impact can be significant on a local scale.

The reduction in underground water recharge as a result of forestry is estimated to be 1,483 ML/y, which equates to around 1.8% of resource capacity. Table 1.10 displays the reduction in recharge for each underground water management zone.

Shallow watertables in the Permian sands and fractured rock aquifers are most at risk from direct underground water extraction by forestry. Permian sands aquifers support critically endangered Fleurieu Peninsula swamps and wetlands. They are predominantly unconfined aquifers of varying depths consisting of sand that contain very low salinity water which is widely used for irrigation as well as town water supply at Mt Compass. Fractured rock aquifers are characterised by a thin topsoil layer over permeable fractured rock. Where these watertables are six metres or less below the ground surface, plantation forests may directly extract water (Government of South Australia 2009), unless an impermeable layer exists between the watertable and the tree roots (Barnett & Cresswell 2008).

For the purposes of the Plan, the adopted annual rate of direct underground water extraction for hardwood plantations is 1.82 ML/ha/y and for softwood plantations is 1.66 ML/ha/y (from the work of Benyon and Doody 2004). While the current area of plantation forestry in the Eastern Mount Lofty Ranges PWRA is known, there is currently insufficient information in relation to shallow watertables to estimate the volume of annual direct extraction of underground water by current plantation forests in the area.

Table 1.9 Estimated interception of surface water runoff by plantation forestry by catchment.

Data supplied by DFW.

Catchment	Interception of runoff by plantation forestry (ML/y)
Angas Plains	0
Angas River	0
Bremer River	52
Currency Creek	28
Deep Creek	0
Ferries-McDonald	0
Finniss River	2,519
Long Gully Group	0
Milendella Creek	0
Preamimma Creek	0
Reedy Creek	33
Rocky Gully Creek	0
Salt Creek	1
Sandergrove Plains	1
Tookayerta Creek	557
Total	3,191

Table 1.10 Estimated interception of underground water recharge by plantation forestry for underground water management zones containing forestry.
Data supplied by DFW.

Underground water management zone	Interception of recharge by plantation forestry (ML/y)
Angas Kanmantoo	1
Bremer Adelaidean	7
Bremer Kanmantoo	20
Currency Kanmantoo	7
Finniss Adelaidean	783
Finniss Kanmantoo 1	428
Finniss Permian 1	6
Northern Kanmantoo	17
Tookayerta Permian	214
Total	1,483

1.7.4 Other non-licensed water needs

The volume of water used for other non-licensed purposes is likely to be small and in some cases, highly variable from year to year. These purposes include public road making; fire fighting; applying chemicals to non-irrigated crops or to control pests; and use of roof runoff of up to 1,500 kilolitres per year for commercial (including irrigation), industrial, environmental or recreational purposes (excluding stock and domestic use). The volume of water used for these other non-licensed purposes has not been estimated for the purposes of the Plan.

1.7.5 Current licensed water demand estimates

The current likely demand for water for licensed purposes is estimated based on existing user requirements in the Eastern Mount Lofty Ranges as determined in accordance with section 164N of the NRM Act, which includes requirements of users taking water during the establishment period (1 July 2000 to 16 October 2003) as well as eligible prospective users that committed significant financial or other resources during the establishment period, excluding non-licensed use.

Data on provisional existing user requirements has been provided by DEWNR. Note that this data is provisional and is subject to change.

Table 1.11 shows the total area for irrigated crops in the Eastern Mount Lofty Ranges PWRA, based on existing user requirements and grouped by catchment (Northern is Milendella Creek to Rocky Gully Creek, Central is Bremer River to Sandergrange Plains, and Southern is Finniss River to Currency Creek). It can be seen that winegrapes and pasture are the most common crop, with substantial areas of lucerne, olives, vegetables and cereals/pulses as well. The crop area is largest in the higher rainfall southern catchments.

The total volumetric demand for water for existing user requirements is still being determined. It is likely to be in the order of approximately 12 GL for surface water and watercourses, and approximately 30 GL for underground water, based on maximum theoretical enterprise requirements, dam capacity and assumed split of demand between resources. This volume includes all types of existing user licensed demand, including irrigation, industrial use, recreational use and intensive animal production.

Table 1.11 Areas of provisional existing user demand for major irrigated types in the Eastern Mount Lofty Ranges PWRA. Data supplied by DFW.

Crop type	Northern catchments – crop area (ha)	Central catchments – crop area (ha)	Southern catchments – crop area (ha)	Total area by crop type (ha)
Cereal/pulse	87	420	21	528
Flowers	0	4	89	93
Fruit	0	78	117	195
Lucerne	52	417	454	923
Nuts	0	255	86	341
Olives	20	119	511	650
Other	4	48	58	110
Pasture	102	1,869	2,579	4,550
Trees/fodder	11	59	50	120
Turf	0	55	72	127
Vegetables	45	405	178	628
Winegrapes	463	2,020	1,883	4,366
Total area by catchment group	784	5,749	6,098	12,631

1.7.6 Future demands for water

This section outlines the expected future water demands in the Eastern Mount Lofty Ranges PWRA, based on trends in water use, and local knowledge of demand and limitations based on water quality and infrastructure. The NRM Act requires that the Plan is reviewed within ten years of adoption. The reality of the expected demand will be assessed during the review.

There are no current indicators that suggest the demand for water use will increase significantly over the life of the Plan. However, fluctuations in market forces, climate, and acknowledging and providing for Aboriginal water needs could change total demand for water, or how water demand is distributed between industries or users. The Plan establishes the management arrangements and limits for extraction of water within the Eastern Mount Lofty Ranges PWRA, and any future increase in water demand and water affecting activities will need to be accommodated within these management arrangements.

1.7.6.1 Future Aboriginal water needs

Peramangk, Kurna and Ngarrindjeri nations want a future that maintains the continuation of their culture upon their traditional country and that continues to give life to their people who live and work in and outside of the region. Water is an important part of this.

Section 1.7.1 outlines Aboriginal values and uses associated with water. If these needs (or components of them) are not being met through existing arrangements, then these unmet needs should be given consideration when future amendments of this Plan are contemplated or required.

The aspirations of Aboriginal nations to re-establish the economic benefits that flow from their traditional country into their communities and institutions have been articulated at workshop discussions, in-hand with referencing key documents such as the Ngarrindjeri Yarluwar-Ruwe Plan (Ngarrindjeri Tendi Incorporated, Ngarrindjeri Heritage Committee Incorporated, Ngarrindjeri Native Title Management Committee 2006). Aboriginal nations recognise new industries are here to stay and seek to share the economic benefits from Country. The Ngarrindjeri Yarluwar-Ruwe Plan outlines a range of opportunities relating to re-establishing economic benefits from Country that include:

- cultural education;
- protected area management;
- ecological restoration;
- natural resources management, including monitoring and research;
- nature-based tourism; and
- aquaculture, agriculture and wild produce.

For Ngarrindjeri, these things are what can be understood as the cultural flow of interconnected benefit between the lands, waters, people, spirit and all living things.

Future water needs of Peramangk, Kurna and Ngarrindjeri nations may include licences to take water for commercial purposes within the existing water licensing provisions of the NRM Act.

1.7.6.2 Future stock use (non-licensed)

Results from the stock and domestic survey suggest that future stock numbers would be more likely to stay the same or be reduced, rather than increase (SAMBD NRM 2009). The estimates of stock water requirements made in section 1.7.2.2 are based on the carrying capacity of land that is or is likely to be able to be grazed, and hence is expected to reflect likely future requirements for this purpose.

1.7.6.3 Future rural domestic use and town water supplies (non-licensed)

With the expansion of many of the rural townships in the Eastern Mount Lofty Ranges PWRA, domestic demand for underground water demand is likely to increase in locations not connected to the SA Water Mains supply network, such as Mt Compass, Meadows and Macclesfield.

Domestic water use is generally non-licensed in the Eastern Mount Lofty Ranges and so the volume taken from wells for domestic purposes is not managed through the licensing system. Therefore it is considered appropriate to set aside the expected domestic underground water demand over the expected life of the Plan (until the required plan review within ten years of adoption), as part of the process of determining the volume available for licensed use.

Population projection data from the Department of Planning and Local Government (2011) shows a projected population increase over 2011–2021 of:

- 11% averaged over the Mid-Murray and Murray Bridge local government areas (equates to the Northern Limestone and Northern Kanmantoo underground water management zones); and
- 24% averaged over Mount Barker and Alexandrina local government areas (equates to the remaining underground water management zones).

The current domestic demand volumes for underground water given in Table 1.7 have been increased by these percentages for the relevant zones, for the purposes of setting the expected domestic underground water demand to be counted against the underground water consumptive use limit for the Plan (see section 4.1.2 and Table 4.7). This adjustment increases the total domestic underground water demand from 241 to 297 ML.

Domestic requirements from surface water have not been adjusted for potential future demand. As outlined in section 4.2.2.1, when assessing an allocation, transfer, variation or permit, the estimated domestic (and stock) demand at that time is considered. Like underground water, the volume taken out of dams for domestic purposes is not managed through the licensing system. However, all new dam construction and enlargement (including stock and domestic dams) is assessed through the water affecting activity permit policies, providing a way to indirectly manage increasing non-licensed surface water demand within sustainable limits.

1.7.6.4 Future recreational and environmental purposes

It is not anticipated that there will be any change to the future water demand for recreational and environmental purposes.

1.7.6.5 Future intensive farming needs

Intensive animal production is expected to expand in the future. Feed-lotting and feed shedding of dairy cows is expanding. Chicken meat production is expected to expand around Murray Bridge and in the Mid Murray Council Area. Water re-use may increase investment prospects around the Rural City of Murray Bridge and Mid Murray Council Districts for intensive animal production (AHRDB 2008). Much of the water used in intensive animal production is used for animal welfare purposes (e.g. drinking, cooling).

Like other industries, potential expansion of intensive animal farming is influenced by a range of factors including policy drivers and constraints (e.g. planning and water policy), and access to infrastructure and resources, as well as market forces and individual business decisions.

1.7.6.6 Future industrial needs

Investment in a grape crushing plant/bottling plant strategically located in the Monarto area could provide important support for regional and neighbouring grape-growers and establish a new industry (AHRDB 2008).

1.7.6.7 Future irrigated horticulture needs

Conversion of traditional beef and sheep properties to various forms of horticulture is a major trend in the southern part of the Eastern Mount Lofty Ranges PWRA. Other growth crops include wine grapes, olive, vegetables and berries.

The Adelaide Hills wine region is also growing in reputation as a wine-tourism destination. There are increasing numbers of cellar door operations open to the public as well as vigorous marketing of regional wine-related events. Wine grapes of the region remain highly sought after, due to the widely-recognised quality of the fruit.

Whilst there are challenges, the established apple and pear industries are expected to continue in the Adelaide Hills region, with growth potential linked to a move into high density plantings. The expansion of cherries in the region is thought to have been sustainable over the last decade but it is likely that new plantings are slowing.

The Langhorne Creek wine region and, to a lesser extent, the Currency Creek wine region, are areas of significant growth in viticulture. At Langhorne Creek, strong demand for local wine processing facilities has led to the establishment of several new grape-crushing plants in an attempt to reduce transport time and costs. Some of the larger wineries also have plans to establish bottling facilities in the region.

An olive crushing and bottling facility has been established at Mount Compass to capitalise on the region's ongoing expansion of olive tree plantations. The olive industry and its associated value-added products represent significant potential for the region.

High-quality land and water resources for primary production make the region an excellent proposition for export value adding for production, such as olives, wine and aquaculture projects (AHRDB 2008).

1.7.6.8 Future mining needs

The resources boom in South Australia has spread to include renewed interest in the minerals resources potential of the Adelaide Hills Region. Major mining and quarrying operations include the Hillgrove copper and gold mine near Kanmantoo, Terramin Angas Zinc mine located at Strathalbyn, sand mining located near Mt Compass, and quarrying of sandstone, crushed rock, gravel etc. at Hartley, south of Callington, Mt Barker, Murray Bridge, Currency Creek and near Goolwa.

1.7.6.9 Future forestry needs

No substantive increase in plantation forestry is expected in the region for the life of the Plan. Current predictions indicate an increase in the area of plantation forestry to 2,000 ha by 2030 (CSIRO 2007a).

1.7.6.10 Saline and re-use water opportunities

Decreases in River Murray water allocations during drought conditions (particularly over 2007–2010), coupled with deteriorating water quality within the Murray Group Limestone aquifer located on the Currency Creek and Angas Bremer Plains areas has led some landholders to install desalination plants. Privately owned desalination plants have also been installed in the Bremer River catchment where water quality from the Kanmantoo Group fractured rock aquifer is poor. The costs of desalination previously outweighed the benefits for the majority of irrigators, but recent improvements in technology, and limited fresh water resources, has seen desalination becoming more viable. It is anticipated that desalination is likely to increase in the future.

Wastewater from both domestic and industrial sources represents a guaranteed and currently under-utilised water supply. Appropriate use of wastewater can have natural resources management benefits by reducing the demand on other water resources in the landscape. Authorised use of treated wastewater of appropriate quality may also provide recreational and environmental benefit in suitable locations, such as the Laratinga wetlands in Mount Barker.

There are a number of projects within the Eastern Mount Lofty Ranges that provide for re-use of wastewater from community wastewater management systems and industries, such as the re-use of recycled wastewater after treatment that includes the Laratinga wetlands at Mount Barker (District Council of Mount Barker 2013); and the upgrade of the Bird in Hand wastewater treatment system (east of Woodside) which enables recycled water to be used for irrigation purposes (SA Water 2013).

2 ASSESSMENT OF THE NEEDS OF WATER-DEPENDENT ECOSYSTEMS

2.1 INTRODUCTION

Section 76 (4)(a)(i) of the NRM Act requires that a water allocation plan must include 'an assessment of the quantity and quality of water needed by the ecosystems that depend on the water resource and the times at which, or the periods during which, those ecosystems will need that water'.

Section 76 (4)(aab) of the NRM Act also requires a water allocation plan to include:

- (i) an assessment of the capacity of the water resource to meet environmental water requirements;
- (ii) information about the water that is to be set aside for the environment including, insofar as is reasonably practicable, information about the quantity and quality, the time when that water is expected to be made available, and the type and extent of the ecosystems to which it is to be provided; and
- (iii) a statement of the environmental outcomes expected to be delivered on account of the provision of environmental water under the plan.

The Eastern Mount Lofty Ranges PWRA supports a range of water-dependent ecosystems. Water-dependent ecosystems have been defined as 'those parts of the environment, the species composition and natural ecological processes of which are determined by the permanent or temporary presence of flowing or standing water' (ARMCANZ & ANZECC 1996). They include watercourses, riparian zones, wetlands, floodplains, estuaries, and cave and aquifer ecosystems, and may depend on surface water, watercourses and/or underground water.

Hammer (2004) provides a good summary of the habitats associated with watercourses in the catchments of the Eastern Mount Lofty Ranges PWRA. Underground water-dependent ecosystems that are not associated with watercourses are poorly understood in the region, and require further investigation.

The Peramangk, Kurna and Ngarrindjeri have deep knowledge of the connectivity of underground water and surface water sources on their lands and waters. Through respectful partnership, this knowledge could assist in addressing knowledge gaps and assessment of the needs of water-dependent ecosystems in the region which is further discussed in section 1.3. Aboriginal nations refer to freshwater wetlands as 'nurseries' in recognition of the important role these areas play in providing food and shelter for many types of animals, birds and fish (ngartjis). Submerged plants in these nursery areas are critical for food and shelter for animals and their young. The nurseries are regarded as the lungs of the system that cleanse the body (land) (DEWNR, 2017).

A decline in the ecological condition of the surface and underground water systems can also be understood as a threat to Aboriginal people's health and wellbeing. In this way, Aboriginal nations support the intent of the Plan to sustainably manage this part of Country.

2.1.1 Environmental water requirements

The NRM Act defines 'environmental water requirements' to mean 'those water requirements that must be met in order to sustain the ecological values of ecosystems that depend on the water resource, including their processes and biodiversity, at a low level of risk' (section 76 (9)).

Environmental water requirements includes water quantity considerations (the pattern of flow or underground water level over time), and also water quality considerations. Water quality can be influenced by the pattern of water flow or movement. For example, discharge of saline underground water and pulses of fresh runoff from a rainfall event can influence salinity in a watercourse. Water quality is also influenced by land use and land management, such as potential pollutants from different

types of land use, and the influence of land cover on movement of material into watercourses. This chapter focuses the parts of the water regime to do with the pattern of water flow or movement and the water quality factors influenced by this, because the role of the water allocation plan is to manage water taking and use, rather than broader land management issues.

Environmental water requirements are commonly expressed in terms of magnitude (e.g. discharge, water level), frequency, duration, seasonality and rate of change in environmentally important components of the water regime. Different parts of the water regime support different ecological processes in the Eastern Mount Lofty Ranges region, such as:

- Low flows and baseflow that keep refuge pools wet.
- Flow pulses or 'freshes' that refresh oxygen levels and dilute salts in isolated refuge pools, and flush excess sediment from the stream bed.
- Flows that stimulate fish spawning.
- Larger flow events that inundate and connect habitats along a watercourse (longitudinal connection) and higher up on a watercourse (e.g. benches and bars in the channel, banks and floodplains – lateral connection).
- Underground water levels that are accessible to deep-rooted vegetation.

Water-dependent plants and animals have evolved in response to the water regime that they have experienced, and have become dependent on key water regime components to support important processes. Changes to environmentally important parts of the flow regime are likely to lead to changes in the condition and composition of the dependent ecosystems (e.g. Lloyd et al. 2004).

Section 2.2 describes the environmental water requirements of the Eastern Mount Lofty Ranges PWRA, including water quality in section 2.2.3, while section 2.3 assesses the capacity of the water resource to meet environmental water requirements under current conditions.

2.1.2 Environmental water provisions

The NRM Act requires a water allocation plan to achieve an equitable balance between social, economic and environmental needs for water; and that the rate of water taking and use is sustainable (section 76 (4)(b)(i) and (ii)). For the purposes of this plan, environmental water provisions have been defined as 'those parts of environmental water requirements that can be met at any given time. This is what can be provided at that time with consideration of existing users' rights, social and economic impacts'.

The objects of the NRM Act provide further guidance on achieving a balance between social, economic and environmental water needs. The objects of the NRM Act include assistance in achieving ecologically sustainable development in the State by establishing an integrated scheme to promote the use and management of natural resources in a manner that:

- recognises and protects the intrinsic values of natural resources;
- seeks to protect biological diversity and, insofar as is reasonably practical, to support and encourage the restoration or rehabilitation of ecological systems and processes that have been lost or degraded; and
- seeks to support sustainable primary and other economic production systems;

together with other matters (paraphrased from section 7 (1) of the NRM Act).

Section 2.4 describes how environmental water provisions have been set for the Eastern Mount Lofty Ranges PWRA, from the perspective of how much water can be taken for consumptive purposes while still maintaining water-dependent ecosystems at an acceptable level of risk.

2.2 ENVIRONMENTAL WATER REQUIREMENTS OF THE EASTERN MOUNT LOFTY RANGES PWRA

Environmental water requirements provided by water on the surface are described in section 2.2.1. Environmental water requirements from underground water are described in section 2.2.2.

2.2.1 Environmental water requirements provided by water on the surface

2.2.1.1 Summary of method to determine environmental water requirements

Water on the surface may come from rainfall that has run off, or may be underground water that has been discharged back to the surface via seeps and springs and as baseflow into watercourses. This section considers environmental water requirements provided by water on the surface from these different sources.

These different water sources can play different roles in providing environmental water. For example, baseflow from underground water is important in maintaining aquatic habitat during times of low rainfall in many areas, while runoff of rainfall can supplement baseflow during the wetter seasons. This means that many of the ecosystems described in this section can be considered to be dependent on surface water (including watercourses) and underground water.

Environmental water requirements provided by water on the surface for the Eastern Mount Lofty Ranges have been determined through a project managed by the Board and DWLBC. These projects are documented in VanLaarhoven and van der Wielen (2009). The information in section 2 is taken from that report, unless otherwise referenced.

An expert panel approach was used, where a panel made up of ecologists, geomorphologists, hydrologists and hydrogeologists reviewed available data and used professional, expert knowledge and experience to determine water requirements for local water-dependent ecosystems.

An environmental objective was set for the region to describe the desired state that is to be achieved by providing environmental water requirements. This objective is to maintain and/or restore self-sustaining populations of aquatic and riparian flora and fauna which are resilient in times of drought. This objective aims to conserve biota and ecosystems currently or likely to be present in the region through the establishment of a suitable water regime. This will promote resilience through increasing species population numbers and distribution. It is not the intention of the objective to restore the habitat and ecosystems to pre-European conditions.

The Eastern Mount Lofty Ranges covers a wide range of climate and landscape conditions, but it is considered that there are strong similarities in water-dependent ecosystem structure and function in similar landscape settings across the region. Hence a functional approach was adopted, where these similarities were used to classify watercourses and water-dependent biota into like groups as follows:

- Generic functional groups of aquatic and riparian flora and fauna that have similar life-cycles, habitat requirements and environmental water requirements. The functional groups are described in section 2.2.1.4.
- Generic reach types that represent the major types of water-dependent habitats in watercourses across the study area. Each reach type is a relatively distinct group of watercourses with similar structure, ecology and hydrology. The major reach types are briefly described in section 2.2.1.5.

The study focused on fish, aquatic macroinvertebrates and water-dependent plants, which are relatively well studied across the region. It is assumed that if environmental water requirements are met for these representative key groups, then they will also be met for the other water-dependent biota and ecosystems in the region (e.g. birds, frogs, mammals).

Environmental water requirements were described for each biotic functional group by identifying the flow-dependent ecological processes required to meet the environmental objective for the group, and

then identifying the water regime components required to support each of those processes. The environmental water requirements for each functional group are outlined in appendix B.

Biotic functional groups were matched to generic reach types based on the types of habitats present, creating a conceptual model per reach type of the biotic groups likely to be present, important physical processes and the collective environmental water requirements of the reach type. Reach types were mapped over the Eastern Mount Lofty Ranges, allowing identification of environmental water requirements for different locations.

Environmental water requirements were translated into measurable hydrologic 'metrics' or flow indicators that correspond to key parts of the flow regime (e.g. the duration of zero flow events in a given flow season). Limits were set for each metric in terms of how far it could deviate from its value under natural conditions while still maintaining the ecological process supported by that flow component at low risk. A metric that remains within these limits is considered to 'pass', while a metric that exceeds these limits is considered to 'fail' to provide an adequate environmental water requirement. Meeting the environmental water requirements equates to passing all of the metrics at a site. The metrics and their limits are described in section 2.2.1.6.

This approach was verified by comparing ecological monitoring data with the percentage of metrics passed at a site. This comparison showed a correlation between increasing ecological condition and increasing percentage of metrics passed.

The surface water models developed by DWLBC/DFW were used to assess whether the environmental water requirements, as described by the metrics, are being met under the current level of development (see section 2.3).

2.2.1.2 Describing environmental water requirements in the Eastern Mount Lofty Ranges

Some of the terms used to describe environmental water requirements in the Eastern Mount Lofty Ranges are outlined below.

Seasonality

Environmental water requirements, particularly those associated with biological responses, can be tied to particular 'flow seasons' during the year. These seasons are based on natural flow distribution during the year. The four flow seasons identified for the Eastern Mount Lofty Ranges are:

- Low Flow Season – generally constant low flows, or no flow, with infrequent shorter periods of high flow following rainfall (typically December–April, and often May).
- Transitional Flow Season 1 (low to high) (T1) – increasing flow level and duration (typically May, June and up to July).
- High Flow Season – higher baseflow and frequent periods of much higher flows (typically July–October).
- Transitional Flow Season 2 (high to low) (T2) – decreasing flow level and duration (typically November and sometimes December).

Flow components

Within the natural flow seasons, environmental water requirements can be described in terms of a number of different flow components in the Eastern Mount Lofty Ranges:

- Cease-to-flows or zero flows – no flows are recorded in the channel and during these periods; the stream may contract to a series of pools or ponds, or may dry completely.
- Low flows (Low Flow Season) – the low level of persistent baseflow during the Low Flow Season that maintains water flowing through the channel, keeping in-stream habitats wet and pools full;

the permanence of flow in a stream is a product of the combination of low flows and cease-to-flows.

- Low flow freshes – relatively small and short duration high flow events that last for one to several days as a result of localised rainfall during the Low Flow Season.
- Low flows (High Flow Season) – the persistent increase in baseflow with the onset of the wet season (beginning in T1), often lasting through to the end of T2.
- High flow freshes – long, sustained increases in flow during the transitional and High Flow seasons as a result of heavy rainfall events; may last for a number of weeks but are still contained in the channel.
- Bankfull flows – flows that fill the channel but do not spill on to the floodplain (can occur any time but more commonly associated with High Flow Season).
- Overbank flows – higher flows that spill out of the channel on to the floodplain (can occur any time but more commonly associated with High Flow Season).

2.2.1.3 Typical water regime requirements

The different aspects of the flow regime that make up a typical, generic annual environmental water cycle in the Eastern Mount Lofty Ranges are described below and in Figure 2.1. The actual flow regime will of course vary over time and from place to place depending on climate, input of baseflow and landscape characteristics.

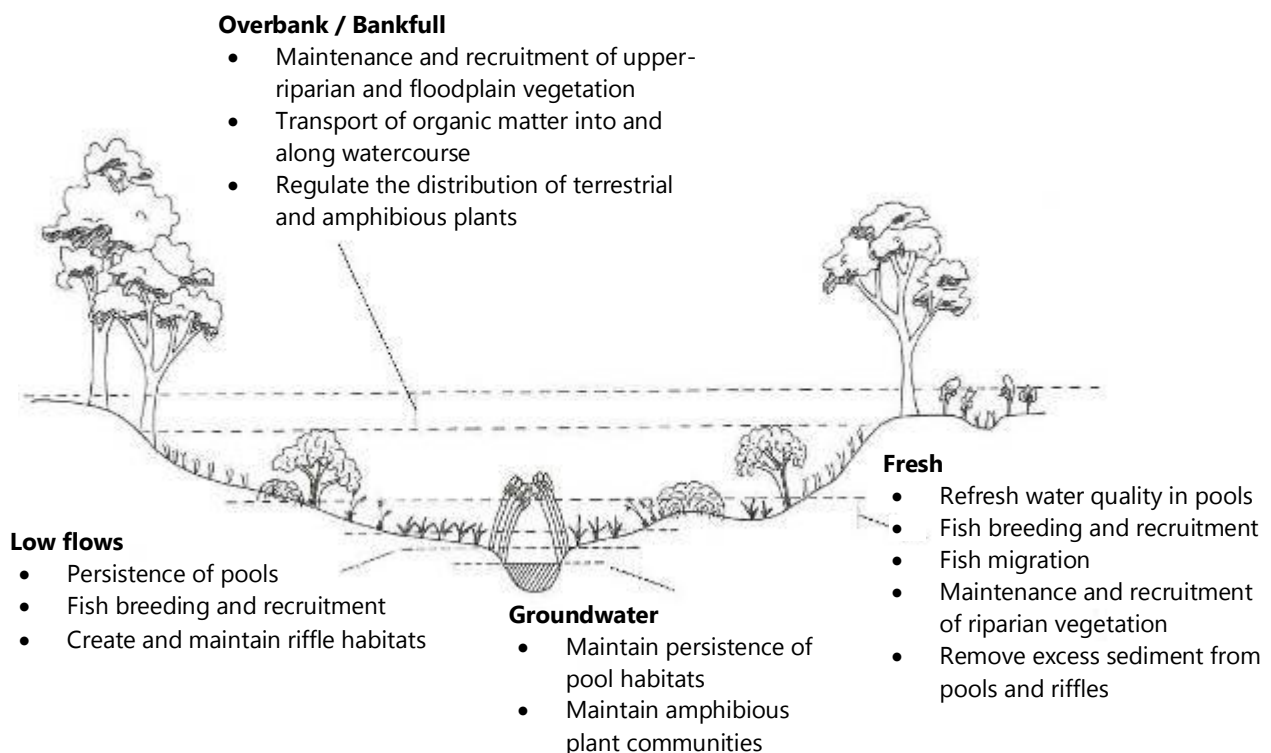


Figure 2.1 Common environmental water requirement processes linked to flow components (from Favier et al. 2004).

The Low Flow Season is characterised by relatively constant low flow rates and cease-to-flow events that are common in the Eastern Mount Lofty Ranges. Over time, between rainfall events, flows gradually decline and the amount of flowing water habitat decreases or disappears altogether. Permanent water habitats remain in individual pools that act as refuges where aquatic and semi-aquatic species persist over the drier months. Inflow of underground water and occasional rainfall-driven low flow fresh events maintain pool volume and water quality by flushing the system. Low water availability and declining water quality means that the Low Flow Season is generally a naturally stressful period for water-dependent ecosystems.

Transitional Flow Season 1 (from low to high flows) begins with the increase in westerly cold fronts. The additional rainfall creates flowing water habitat, filling pools and delivering water to habitats that have persisted through the summer months with little water input. As local underground water supplies are replenished, baseflow gradually increases over the season. The increase in flow wets up new habitats, such as the shallow, faster flowing riffles and runs that connect pools, providing plants and animals with access to different resources and allowing localised movement for breeding and recolonising.

The High Flow Season is characterised by higher, more permanent baseflows as catchments wet up under more rainfall. Larger rainfall-driven flows can trigger breeding events for many aquatic animals and plants, and allow movement throughout the catchment, including migration between freshwater and salt water habitats for many fish species. Higher flows (bankfull and overbank) are more common in this season.

Flow rates begin to decrease in Transitional Flow Season 2 with the onset of weather dominated by high pressure systems. The flow reduction exposes substrates for many plant species to germinate on, while maintaining sufficient depth to allow the continuing movement and migration of aquatic animal species.

2.2.1.4 Functional groups

A functional group is comprised of species that have similar life-cycles, habitat requirements and environmental water requirements. Functional groups in the Mount Lofty Ranges have been described for fish, aquatic macroinvertebrates and vegetation as outlined below.

Fish

The fish fauna of the Eastern Mount Lofty Ranges is described in Hammer 2004. Native freshwater fish of the Mount Lofty Ranges are of two broad types: resident freshwater species (which remain in a small range in a catchment throughout their life); and migratory species (which require extensive migration in a waterway, or between the waterway and the sea or estuary at some stage of their life-cycle). Within these two broad types, five primary functional groups of native fish have been identified in the Mount Lofty Ranges, as outlined below. A sixth functional group for Fleurieu wetlands has also been identified, where the species overlap other functional groups but the nature of the habitat means that the water requirements are slightly different.

Resident freshwater species

Obligate freshwater, stream specialised (Fs): Species that have particular habitat or environmental requirements for survival, and are specialised to live in stream habitats; often found as the only species in a reach but are restricted to specific habitats; includes southern pygmy perch, mountain galaxias and river blackfish.

Obligate freshwater, wetland specialised (Fw): Species that have particular habitat or environmental requirements for survival, and are specialised to live in wetland habitats; often found as rare species in diverse fish assemblages, being restricted to specific habitats in lowland or terminal stream reaches; includes Yarra pygmy perch, Murray hardyhead, chanda perch and southern purple-spotted gudgeon.

Obligate freshwater, generalists (Fg): Mostly found in association with other species and occupy multiple habitats in a reach; the types of habitats present determine community composition and

structure (and therefore water requirements); includes gudgeon species, numerous species from terminal wetlands, and euryhaline species able to adapt to a wide range of salinities, such as gobies.

Migratory freshwater species

Migratory, diadromous (D): Species requiring migration to and from the sea or estuary as part of their life-cycle such as climbing galaxias, congolli, common galaxias and lampreys.

Migratory, potamodromous (Fp): Species known to move extensively but remain within freshwater systems for all life-cycle stages, such as Murray-Darling golden perch.

Fleurieu wetlands

A habitat-based group has also been described for the Fleurieu wetlands. Species in this group come from the different functional groups, but the specific low-energy nature of the habitat means that the water requirements are slightly different from the general functional group requirements. Species include southern pygmy perch, river blackfish and potentially climbing galaxias.

Table 2.1 lists the freshwater fish recorded from the Eastern Mount Lofty Ranges, and their functional group and conservation status, based on information from Hammer 2007, Hammer, Wedderburn and van Weenan 2009, and McNeil and Hammer 2007. The environmental water requirements of each functional group are given in Appendix B.

Table 2.1 Freshwater fish recorded in the Eastern Mount Lofty Ranges, and their functional group and conservation status

Functional group as per text, and Ex = exotic

Conservation status:

National (Nat.):

VU=Vulnerable (*Environment Protection and Biodiversity Conservation Act 1999*)

State:

P = protected (*Fisheries Management Act 2007*)

CE = Critically Endangered, EN = Endangered, VU = Vulnerable, R = Rare (Hammer, Wedderburn and van Weenan 2009)

Functional group	Species	Scientific name	Conservation status	
			Nat.	State
D	Pouched lamprey	<i>Geotria australis</i>		EN
D	Shortheaded lamprey	<i>Mordacia mordax</i>		EN
D	Shortfinned eel	<i>Anguilla australis australis</i>		R
Fw	Freshwater catfish	<i>Tandanus tandanus</i>		P, EN
Fg	Bony herring	<i>Nematalosa erebi</i>		
Fg	Smelt	<i>Retropinna semoni</i>		
D	Climbing galaxias	<i>Galaxias brevipinnis</i>		R
D	Common galaxias	<i>Galaxias maculatus</i>		
Fs	Mountain galaxias 1	<i>Galaxias olidus</i>		VU
Fs	Mountain galaxias 2	<i>Galaxias</i> sp. 1		VU
Fg	Murray rainbowfish	<i>Melanotaenia fluviatilis</i>		
Fg	Smallmouthed hardyhead	<i>Atherinosoma microstoma</i>		
Fs	Murray hardyhead	<i>Craterocephalus fluviatilis</i>	VU	CE
Fg	Unspecked hardyhead	<i>Craterocephalus stercusmuscarum fulvus</i>		
Fw	Chanda perch	<i>Ambassis agassizii</i>		P,CE
Fs	River blackfish	<i>Gadopsis marmoratus</i>		P, EN

Functional group	Species	Scientific name	Conservation status	
			Nat.	State
Fg	Murray cod	<i>Maccullochella peelii peelii</i>	VU	EN
Fp	Murray-Darling golden perch	<i>Macquaria ambigua ambigua</i>		
Fs	Southern pygmy perch	<i>Nannoperca australis</i>		P, EN
Fw	Yarra pygmy perch	<i>Nannoperca obscura</i>	VU	P, CE
Fg	Silver perch	<i>Bidyanus bidyanus</i>		P, EN
D	Congolli	<i>Pseudaphritis urvillii</i>		VU
Fg	Midgley's carp gudgeon	<i>Hypseleotris</i> sp. 1		
Fg	Murray-Darling carp gudgeon	<i>Hypseleotris</i> sp. 3		
Fg	Carp gudgeon hybrid forms	<i>Hypseleotris</i> spp.		
Fw	Southern purple-spotted gudgeon	<i>Mogurnda adspersa</i>		P,CE
Fg	Flathead gudgeon	<i>Philypnodon grandiceps</i>		
Fg	Dwarf flathead gudgeon	<i>Philypnodon macrostomus</i>		
Fg	Western bluespot goby	<i>Pseudogobius olorum</i>		
Fg	Lagoon goby	<i>Tasmanogobius lasti</i>		
Ex	Goldfish	<i>Carassius auratus</i>		
Ex	Common carp	<i>Cyprinus carpio</i>		
Ex	Tench	<i>Tinca tinca</i>		
Ex	Rainbow trout	<i>Oncorhynchus mykiss</i>		
Ex	Brown trout	<i>Salmo trutta</i>		
Ex	Gambusia	<i>Gambusia holbrooki</i>		
Ex	Redfin	<i>Perca fluviatilis</i>		

Aquatic macroinvertebrates

A variety of programs have collected 338 aquatic macroinvertebrate taxa from the Mount Lofty Ranges. In the broadest sense, aquatic macroinvertebrates in the Mount Lofty Ranges belong to two functional groups – those that require flowing water (found in riffles, runs and cascades) and those with a distinct preference for still or very slow flowing water (found in pond or pool habitats, and slow flowing lowland streams).

Within these two broad groups, six different community types can be identified, depending on the type of habitats and persistence of flow regime (wet or dry climate). The same species can be found in a number of different community types and it is difficult to identify specific indicator taxa that are restricted to just one community. Often, the difference between types is in degrees of species diversity and relative abundance of different species from each group, with fewer or more still water or flowing water taxa found in particular habitat types.

Flowing water (permanent or seasonal flow) species

Flowing water, cascade: Macroinvertebrates in these habitats tend to live on the surface of the bedrock, and have adapted to withstand high flows during floods by evolving secure attachment mechanisms. Overall diversity is relatively low, as the number of species that require access to subsurface habitats at various times during their life-cycle is small (e.g. juveniles migrating into the stream bed, species that use the subsurface habitats as refuges during floods). These species are not well adapted to dry periods, as refuges in these habitats are limited.

Flowing water, riffle: The cobble/boulder habitats of riffles or the gravel habitats that characterise runs provide a wide diversity of microhabitats, so that these areas are generally the most diverse communities in stream systems. Cascade species are still present in riffles, living on the upper surfaces

of rocks but other taxa present can use other microhabitats. With significant subsurface refuge habitats, most species can survive short periods of no flow (although diversity is highest in permanently flowing streams).

Still water (permanent or seasonal water) species

Still water, persistent ponds and pools: The diversity of macroinvertebrates is highest among the still water communities in ponds or pools where water is present throughout the year. The diversity and abundance of plants in permanent ponds and pools ensure a wide range of microhabitats.

Still water, lowland streams: In the main, lowland stream macroinvertebrate communities reflect the types of taxa present in persistent ponds and pools. However, available habitats tend to be different, including the surfaces of woody debris (where species that are not present in persistent ponds and pools can be found) and the root-zone of trees present on the water's edge, as well as in-stream vegetation.

Still water (temporary water) species

Still water, temporary pools: Some of the species found in persistent ponds and pools can be found in temporary pools in the river channel. However, the drying period restricts the diversity of macroinvertebrates to those that are adapted to dry habitats – through characteristics like higher resistance to poor water quality, resistant egg stages, ability to survive in damp mud on the bottom of pools, or the ability to move out of the habitat and colonise other waterbodies nearby (returning when water is present again).

Still water, floodplain wetlands: In wetlands disconnected from the underground water and relying on stream floods, the macroinvertebrate community is determined by the frequency of the filling of wetlands and the subsequent persistence of the water. In general, the same species are present in all cases. The main differences are the diversity of the community, with lower diversity related to less frequent filling and lower levels of persistence. The environmental water requirements of this group are very similar to those of the still water, temporary pools group so environmental water requirements for the two groups are described together.

The environmental water requirements of these functional groups of aquatic macroinvertebrates are given in Appendix B.

Vegetation

In the Mount Lofty Ranges, 510 plant species have been identified that require the presence of surface water at some stage of their life-cycle. Three broad groups of vegetation types can be identified in the Mount Lofty Ranges: terrestrial species associated with waterways and wetlands; amphibious species that require or tolerate the presence of surface water at some stage of their life-cycle; and submerged species that require extended periods of free surface water. Within these three broad vegetation types, ten functional groups can be identified.

Terrestrial species

Many members of these groups are annual herbaceous species. The terrestrial group includes a large proportion of exotic species such as grasses and clovers that are often associated with watercourses. Soil disturbance associated with watercourses provides open habitat for these ruderal species to colonise.

Terrestrial dry (Tdr): Desiccation tolerant species that are intolerant of flooding but will persist in damper parts of the landscape and can invade or persist in riparian zones and the edges of wetlands. They do not have a flow requirement and are not considered further.

Terrestrial damp (Tda): These species germinate and establish on saturated or damp ground but cannot tolerate extended flooding in the vegetative state. They can persist in the environment in puddles as they dry, table drains, etc. To persist in riparian zones and wetlands they need high water events, where

water spreads out over the landscape long enough to saturate the soil profile, and then retreats. The soil profile needs to remain damp for around three months. In this climatic zone (cool wet winters, hot dry summers) the timing should be brief spring flooding, allowing maturation in the late spring and early summer. Examples include some *Allocasuarina*, *Centipeda* and *Chenopodium* species, as well as a range of grasses.

Amphibious species

Amphibious fluctuation tolerator, low growing (ATI): This functional group can germinate either on saturated soil or underwater, and grow totally submerged, as long as they are not inundated by the time they start to flower and set seed. They require shallow flooding for around three months in the spring. Shorter flooding times may eventually deplete the seed bank. Examples include *Isolepis*, *Elatine* and *Glossostigma* species.

Amphibious fluctuation tolerator, emergent (ATe): This functional group of emergent sedges and rushes has a wide tolerance to water presence. They survive in saturated soil or shallow water (unlike Tda) but also require their photosynthetic parts to remain above water (be emergent). The fluctuation toleration refers to the depth of water, as well as the presence of water. They prefer to keep their roots wet (damp soil to shallow surface water present), although the preferred duration varies widely between species (average of six months). They tolerate dry times as adults, preferably in the late summer to autumn. Examples include many *Eleocharis*, *Juncus* and *Cyperus* species.

Amphibious fluctuation tolerator, woody (ATw): This functional group of woody perennial species hold their seeds on their branches, and requires water to be present in the root-zone but will germinate in shallow water or on a drying profile. Generally restricted to permanently saturated areas, that don't dry out over summer, or if so, for short periods of time or areas in which they can access underground water most or all of the time. Examples include some *Eucalyptus*, *Leptospermum* and *Melaleuca* species.

Amphibious fluctuation responder, plastic (ARp): This functional group occupies a similar zone to the ATI group, except that they have a physical response to water level changes such as rapid shoot elongation or a change in leaf type. They can persist on damp and drying ground because of their morphological flexibility but can flower even if the site does not dry out. They occupy a slightly deeper/wetter for longer site than the ATI group. Examples include *Myriophyllum* and *Persicaria* species.

Amphibious fluctuation responder, floating (ARf): These species grow underwater or float on the top of the water, and require the year-round presence of free surface water of some depth. Many of them can survive and complete their life-cycle stranded on the mud, but they reach maximum biomass growing in free water all year round. They require the presence of permanent pools of water. Examples include *Azolla*, *Lemna* and *Nymphaeoides* species.

Submerged species

Submerged r-selected (Sr): Species that colonise recently flooded areas. Many require drying to stimulate high germination percentages, and they can complete their life-cycle quickly and die off naturally. They persist via a dormant, long-lived bank of seeds or spores in the soil. They prefer habitats that are flooded once a year or so, to a depth of more than 10 cm. If they do not receive flooding, they can persist in the seed bank and recover when water becomes available. Examples include annual *Chara* and *Nitella*, as well as *Lepilaena* species.

Submerged emergent (Se): Species that require permanent saturated soil or surface water, but they need to remain emergent. Many of the swamp cyperaceous and restionaceous species belong to this group. They require permanent shallow water or saturated root-zone for germination, growth and reproduction and freshes during the Low Flow Season to maintain water presence and quality. Examples include *Typha*, *Phragmites* and *Bolboschoenus* species, and *Triglochin procerum*.

Submerged k-selected (Sk): Species require that a site be flooded to >10 cm for more than a year for them to either germinate or reach sufficient biomass to start reproducing. Completely water-

dependent, true aquatic species. Essentially restricted to permanent pools and ponds. Examples include *Vallisneria* and some *Potamogeton*, *Chara* and *Nitella* species.

The water requirements of these functional groups are given in Appendix B.

2.2.1.5 Reach types

Figure 2.2 summarises the major reach types and their common position in the landscape, while Figure 2.3 shows the mapped distribution of the reach types across the Eastern Mount Lofty Ranges PWRA.

Headwaters include drainage lines and low order watercourses. They may be rocky or alluvial and may not have a defined channel. They provide generally damp or amphibious habitat and only temporary aquatic habitat unless there are springs or ponds. Headwaters support vegetation groups that prefer damp conditions or tolerate a mix of inundation and dry periods, with more aquatic species only found around wetter areas. Headwaters may support temporary macroinvertebrate communities typical of still and flowing habitats, but are unlikely to support permanent fish populations except in spring-fed areas with permanent water.

Upper pool-riffle channels represent the upper-most truly aquatic habitat. They are characterised by sequences of small to large pools connected by short riffles (shallow, broken fast flowing water) or long runs (shallow, smooth, fast flowing water). Surface water persists throughout the year in pools except in the drier catchments, supporting more aquatic biota such as fish and aquatic vegetation in addition to amphibious species. Mountain galaxias is the most common fish species present, with river blackfish present in some areas with significant springs, and potentially southern pygmy perch in wetter catchments.

The **mid pool-riffle channels** are the larger trunk stream in the upper to mid catchment. The general habitat and flow regime is similar to upper pool-riffle channels, but the habitat is larger and flow rates are higher due to the larger catchment area. This more reliable aquatic habitat supports a larger range of aquatic plants and animals, particularly where baseflow supports refuge habitats over the Low Flow Season.

Gorges are steep, rocky stream sections that support plants and animals adapted to the high energy environment, such as flowing water macroinvertebrate functional groups, woody and well rooted vegetation and fish that can tolerate such environments including mountain galaxias and gudgeons.

Lowland reaches are associated with a low-gradient large channel breaking or broken out of the hills, consisting of sequences of large and long pools separated by short runs and occasional riffles. In losing reaches (which recharge underground water) or very dry catchments, it may simply consist of a small channel with few in-stream features (ephemeral lowland channel). More confined or incised lowlands with limited floodplains often have pools, runs, riffles and in-channel surfaces such as bars and benches. Extensive floodplains can also include floodplain features such as flood-runners and wetlands/billabongs, many of which are paleo-channels (old/former channels). The ecosystems present depend on the availability of water, with ephemeral lowlands providing opportunistic habitat only while lowland reaches with extensive floodplains in wetter areas can support a wide range of species in the variety of habitats available.

Terminal wetlands are largely freshwater wetland habitats linking the stream with the discharge environment (River Murray or Lake Alexandrina). They can have a complex array of aquatic, semi-aquatic to terrestrial habitats, often including a deeper, open channel with shallower, well vegetated, low-energy benches and a variably inundated bank. The water regime will depend on the upstream catchment rainfall and flow regime, and the interactions with the River Murray and Lake Alexandrina. They commonly have relatively permanent freshwater due to back-filling from the River Murray/Lake Alexandrina under normal circumstances. Drier catchments will provide episodic flooding whereas wetter catchments or those with significant baseflow in the area will experience seasonal baseflow of fresher, clearer catchment water as well as occasional floods. The permanent water,

connection to receiving environment and wide variety of habitats with different water regimes means that terminal wetlands are often one of the most diverse habitats in a catchment.

Fleurieu wetlands: A total of 231 wetland bodies have been mapped from aerial photography in the Eastern Mount Lofty Ranges PWRA as part of the wetland inventory of the Fleurieu Peninsula (Harding 2005). The wetlands are typically low-energy, continuously wet environments with damp margins, with a seasonal increase in baseflow.

Swamps of the Fleurieu Peninsula are a subset of wetland on the Fleurieu Peninsula that are recognised as a critically endangered ecological community, and are protected under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Within the Eastern Mount Lofty Ranges PWRA, these Fleurieu swamps are generally found in the Currency Creek, Finniss River and Tookayerta Creek catchments.

Fleurieu wetlands support a large range of species including 742 plant species, of which 139 have conservation status, including 73 species with status under the state *National Parks and Wildlife Act 1972*, and 6 species under the EPBC Act. These wetlands have also been recorded as supporting 183 vertebrate species. Of these, 22 species have conservation status under the *National Parks and Wildlife Act 1972*, and 3 species are protected under the EPBC Act. Additionally, 3 of the bird species recorded are protected under international migratory bird treaties (Japan-Australia Migratory Bird Agreement, China-Australia Migratory Bird Agreement).

Conceptual models were developed for each of these reach types, identifying the different functional groups associated with the different habitats in the reach types. The sum of the environmental water requirements for each functional group in a reach type gives the environmental water requirements for a reach type.

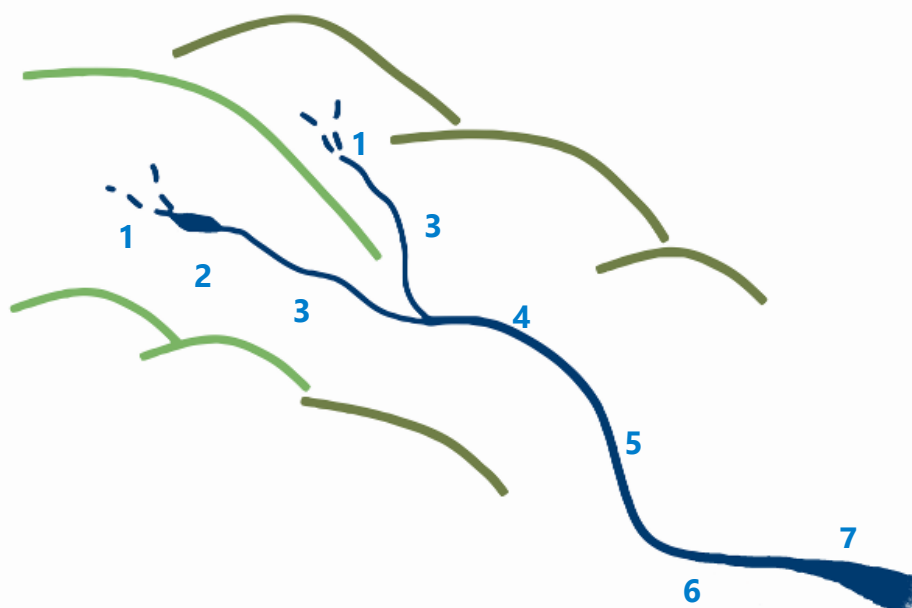


Figure 2.2 Schematic diagram of typical location of reach types in the landscape

- 1 Headwaters: drainage lines, damp or amphibious habitat
- 2 Fleurieu wetland
- 3 Upper pool-riffle channel: aquatic habitat first present (besides Fleurieu wetlands)
- 4 Mid pool-riffle channel: major watercourses in hills with reliable flow
- 5 Gorge: steep and rocky with fast flow
- 6 Lowlands: flatter, may be with or without floodplains
- 7 Terminal wetland, flowing into receiving waters



Figure 2.3 Distribution of reach types across the Eastern Mount Lofty Ranges PWR.

2.2.1.6 Representing environmental water requirements as metrics

The previous sections (and appendix B) outline the environmental water requirements of key functional groups across the different reach types across the Eastern Mount Lofty Ranges in a descriptive way.

Environmental water requirements need to be described in hydrological terms if they are to be used for testing the hydrological impacts of different water resource management policies. The approach used for the Eastern Mount Lofty Ranges is to express environmental water requirements as hydrological metrics that represent important parts of the flow regime (e.g. duration of zero flow events in the Low Flow Season). The impacts of water resource development on these metrics can be expressed in terms of varying levels of 'stress', for which targets or limits can be set to represent levels of acceptable environmental impacts.

Defining flow components

The absolute magnitude of each flow component (low flow, fresh, bankfull/overbank in each flow season) required to achieve environmental objectives varies between catchments in the Eastern Mount Lofty Ranges. This variation is due to differences in stream size and shape, climate and flow characteristics. If these magnitudes are described by standard hydrological measures, a single ecologically relevant hydrological descriptor can be used to define a flow component, regardless of where it is located.

Table 2.2 shows the standard hydrological measures used to define the flow components in the Eastern Mount Lofty Ranges. These measures were derived by examining the habitats and environmental assets found at different levels along stream cross-sections at a range of sites throughout the region, and then identifying the flow levels that are the best fit for supporting relevant ecological processes. For example, the depth of the different potential measures of the 'low flow' component in each season were checked against the depth inundated on the cross-sections to see which would support persistence of water in pools, wetting up riffles, and allowing localised or extensive fish movement as appropriate.

Table 2.2 Hydrological measures that represent flow components in the Eastern Mount Lofty Ranges. All values calculated using modelled flow adjusted for dam impacts.

Component	Hydrological measure
Low flow	80 th percentile exceedance daily flow for the flow season of interest (calculated on non-zero flows) ¹⁰
Fresh	2 times the median of all non-zero daily flows in the flow season of interest
Bankfull/overbank	ARI of 1.5 years, coming from an average daily flow record ¹¹

Environmental water requirement metrics

Appendix C shows the metrics that were selected to represent environmental water requirements for the Eastern Mount Lofty Ranges, along with the intended ecological function of the metric in meeting environmental objectives (Flow purpose column). Some metrics are only relevant for particular reach types (Reach type column). The 'Priority group' column is used to set the limit of acceptable deviation from natural for the metric, and is explained below.

¹⁰ The 80th percentile exceedance flow is the daily flow rate that is equalled or exceeded for 80% of the time in the period of interest, using non-zero daily flow values only.

¹¹ The ARI (average recurrence interval) of 1.5 years coming from an average daily flow record is the daily flow rate that is equalled, or exceeded, every 1.5 years on average.

Setting limits – evaluating metric success

The natural flow paradigm (Poff et al. 1997) states that the integrity of water-dependent ecosystems depends largely on the dynamics of the natural flow regime. The natural flow regime influences the diversity of in-channel and floodplain habitats over space and time. The local water-dependent ecosystems have evolved life-history strategies to utilise these different habitats and have become dependent on the pattern of habitat availability. An altered flow regime can change the availability of habitats over space and time, and form an environment that the native plant and animals may be poorly adapted to (Bunn and Arthington 2002). The negative ecological impacts of flow modification have been demonstrated in a range of environments (see Lloyd et al. 2004).

The environmental water requirements study set the levels of deviation from the natural flow regime that are acceptable with the aim of maintaining/restoring populations to a state where they are self-sustaining and able to withstand times of (natural) sub-optimal conditions such as droughts. Higher deviation from environmentally important parts of the natural flow regime is expected to be associated with higher ecological stress or risk.

The environment will be more sensitive to changes in some environmental water requirements metrics than others, depending on the resilience of the variable that the metric is representing. To represent this, environmental water requirements metrics have been split into 3 priority groups, where Priority 1 metrics represent ecological functions that are critical for maintaining habitats or biological processes, and Priority 3 metrics are more general or more resilient to change. The 'priority group' column in the table in Appendix C shows which priority group has been assigned to each metric.

An acceptable level of deviation has been defined as the proportional change in an environmental water requirements metric (comparing its value between current and natural flow) that will limit the risk of degradation to the environment to a low level. Table 2.3 shows the percentage deviation that a metric can have from natural values and still be associated with low ecological risk. For example, a Priority 1 flow metric can be reduced by up to 20% (e.g. low flow rate) or increased by up to 25% (e.g. average duration of zero flow spells) of the natural value and be considered a low risk change.

Passing all of the metrics represents the quantity and timing of water requirements to sustain water-dependent ecosystems in the Eastern Mount Lofty Ranges at a low level of risk.

These numbers have been developed in consultation with the expert panel, and are considered to be a 'first cut' with a need to monitor the system to ensure they are accurate.

Table 2.3 **Priority groups for metrics and percentage deviation from the natural value associated with low ecological risk.**

Priority	Functions	Low risk deviation from natural	
		Decrease	Increase
1	Maintenance of core refuge habitat, or critical life-cycle processes	20%	25%
2	Promote resilience in the long term (e.g. large breeding events)	30%	50%
3	General information or metrics that represent resilient water requirements	50%	100%

Input data

Natural flow has been calculated as the flow with the impacts of the 2005 level of dam development removed, as modelled using the WaterCress platform (e.g. Alcorn, Savadamuthu and Murdoch 2008). This approach accepts that some irreversible changes from pre-European flows have occurred due to land clearance and other landscape changes. It may be more accurately termed the 'adjusted' flow. There is little scope to determine or model the natural pre-European flow regime as there is no monitored flow data from the time, and because of the confounding interactions between land use change and water resource development on both the surface and underground water systems, and the relationships/connections between the two.

Using adjusted flow has a number of advantages:

- Given that it is unlikely that the landscape will return to pre-European settlement conditions, it provides a realistic flow regime for the 'best' that could be anticipated.
- It can be determined reliably using a defined method, based on a model calibrated with actual flow data (when constructing the model to represent current flow).

The environmental water requirements study describes the environmental water requirements of the biota expected to be present in the current landscape in the absence of water resource development, rather than expected under pre-European settlement conditions. The distribution of water-dependent habitats and species has changed since pre-European settlement as a result of factors including vegetation clearance, incision of watercourses and land management practices. Adjusted flow better represents the water regime that the current or likely distribution of species and habitats has adapted to since European settlement.

Environmental monitoring data has been used to compare ecological condition for fish and macroinvertebrates with the percentage of environmental water requirements metrics passed at monitoring sites. It was found that sites with better ecological condition passed a higher percentage of metrics (see VanLaarhoven and van der Wielen 2009), providing an empirical check of the adopted system of environmental water requirements metrics and limits.

2.2.2 Environmental water requirements for underground water

Both surface water (including flows in watercourses) and underground water play important roles in meeting the environmental water requirements in the Eastern Mount Lofty Ranges. Underground water may contribute to surface flows by discharging to the surface as springs or baseflow. The previous section focused on the environmental water requirements provided by water on the surface, including baseflow that has discharged to the surface.

Organisms may also utilise underground water while still below the surface, including stygofauna (fauna that live within underground water systems, including caves and aquifers) and phreatophytic vegetation (plants that draw water from the underground watertable to maintain vigour and function).

Information on presence, distribution and water requirements of stygofauna and phreatophytic vegetation in the Eastern Mount Lofty Ranges is currently very limited, and there is insufficient information to make an assessment of their environmental water requirements at this point.

The dependency of water-dependent ecosystems on direct underground water inputs at a local scale is largely unknown in the study area, although investigations show that it is likely that a significant proportion of wetlands and pools in the region are at least partially maintained through underground water inputs via baseflow (e.g. Barnett and Rix 2006, Green and Stewart 2008). Maintaining baseflow to watercourses and protecting interactions between surface water and underground water are critical environmental water requirements for the Eastern Mount Lofty Ranges PWRA.

2.2.3 Environmental water quality requirements

Water quality plays an important role in determining the nature and condition of water-dependent ecosystems. Water quality issues of particular local significance include dissolved oxygen, salinity, temperature, suspended solids, nutrients and toxins such as pesticides, herbicides and heavy metals.

Water quality is linked with water regime in many complex ways, and water quality objectives are often included as implicit components of flow regimes. For example, cool baseflows may maintain water temperature within ecosystem tolerance; high flows move organic matter from banks, riparian areas and floodplain into channels; and freshes flowing through riffles increase oxygen concentrations and dilute salts. Several of the environmental water requirements metrics identified in the table in Appendix C have flow purposes linked to such water quality requirements.

Specific targets for environmental water quality parameters have not been identified for the Eastern Mount Lofty Ranges PWRA, besides the flow purposes associated with environmental water requirements metrics in the table in Appendix C. In the absence of knowledge of specific tolerances and requirements of local water-dependent ecosystems, the default trigger values in the Australian and New Zealand Guidelines for fresh and marine water quality (ANZECC and ARMCANZ 2000) or the water quality criteria for freshwater aquatic ecosystems given in the *Environment Protection (Water Quality) Policy 2003* provide a first indication of water quality requirements.

It is important to note that these trigger values and water quality criteria have been set as a broad scale reference and may not reflect natural water quality values for a local area, such as catchments that are naturally saline or rich in some metals due to local geology. It is likely that water-dependent ecosystems will have adapted to tolerate the local water quality in areas where values naturally exceed these criteria. Therefore it is not considered necessary to improve water quality to meet these standards in such cases, unless required for specific circumstances such as creation of new refuges for threatened species when their original habitat cannot be restored.

2.3 CAPACITY OF THE WATER RESOURCE TO MEET ENVIRONMENTAL WATER

The current level of water resource development is affecting the volume of flow remaining in watercourses and the flow pattern as outlined in section 1.5.4, and is also likely to have affected discharge of baseflow into watercourses. The natural flow paradigm described earlier suggests that changes to environmentally important parts of the water regime are likely to lead to changes in the composition and condition of water-dependent ecosystems.

The system of environmental water requirements metrics and limits described in the previous section can be used to assess whether environmental water requirements are currently being met in the Eastern Mount Lofty Ranges PWRA, as described in section 2.3.1. The metric results can also be compared with ecological condition from environmental monitoring data as an empirical check of the metrics and limits system (section 2.3.2). These sections are summarised from VanLaarhoven and van der Wielen (2009).

2.3.1 Evaluating environmental water requirements success using metrics

Sixty nine sites were selected across the Mount Lofty Ranges for testing whether environmental water requirements are currently being met. Sites were selected based on location (to represent the different catchments and reach types, including the end-of-system) and availability of flow data. For each site, daily flow data was modelled under current and natural (adjusted flow) conditions for the period of 1974–2006 using the WaterCress platform (see Alcorn, Savadamuthu and Murdoch 2008, Alcorn 2010 and Alcorn 2011 for modelling process and assumptions). This period represents a range of wet and dry years, and corresponds to periods for which flow data is available for most catchments.

As described in section 2.2.1.6, the two sets of daily flow were used to calculate the long-term average values of each metric under current and natural conditions. The metric value for current conditions was

then expressed as a proportion of the natural value and assessed against the relevant deviation limit as set out in Table 2.3.

A metric was considered to fail if the deviation from the natural value exceeded the relevant deviation limit. This means that a priority 1 metric that passes may still deviate from the natural value by 25%, and that a passing priority 3 metric may still deviate from the natural value by 100%.

The number of metrics passed and failed under current conditions was then added for each site to give an indication of whether environmental water requirements are being met across the Eastern Mount Lofty Ranges. The percentage of sites that passed each metric was then examined to assess which parts of the flow regime have been particularly affected by dam development.

2.3.1.1 Results

Only 1 of the 69 test sites passed all of the metrics, and the average percentage of metrics passed over all the sites was 67%. Half of the sites passed 71% or less of the metrics. This suggests that water-dependent ecosystems are at an elevated risk of degradation at almost all of the test sites. Sites with higher water use generally passed fewer metrics.

The impacts on the flow regime that are accounted for in this analysis are due to dam development and extraction from watercourses. Dams change the flow regime by both reducing total volume of flow, and delaying flow events by holding back flows until they fill and begin to spill. This delay causes proportionally larger impacts when dams are not at capacity such as during the irrigation period of October to March, following on into the break-of-season. This means that flows during the stressful Low Flow Season are likely to be intercepted, and the duration of this time with little flow is likely to be extended because of interception of flows at the start and end of the flowing period. Smaller flows are proportionally more impacted than higher flows, as larger flows will cause dams to fill and spill much quicker.

This seasonal impact is reflected in the average percentage of metrics passed in each flow season as shown in Table 2.4. It can be seen that the average percentage of metrics passed over the test sites is lowest (i.e. most affected by water resource development) for the Low Flow Season, intermediate for the transitional flow seasons, and highest (least affected) for the High Flow Season.

Table 2.4 Average percentage of metrics passed in each flow season.

Season	Average % metrics passed
Low Flow Season	45%
Transitional Flow Season 1 (low to high)	63%
High Flow Season	86%
Transitional Flow Season 2 (high to low)	62%

More detailed analysis of the impact of water resource development on the different environmental water requirements is given in Table 2.5, which shows the number and percentage of sites passing each metric for the 69 test sites. It can be seen that measures of low flow (80th percentile exceedance non-zero flow) have very low pass rates in each of the flow seasons, while the larger bankfull flows are only marginally affected. The frequency and duration of freshes in the Low Flow and transitional seasons have also been substantially affected.

The duration of the flowing period has also been shortened at many sites, and hence extended the duration of the period of low flow. Only 20% of sites passed the metric representing delay in the onset of the first transitional flow season from low to high flow (current month reaching median flow of natural T1 median (delay)) and 42% of sites passed the metric representing the shortening of the

second transitional flow season from high to low flow (current month reaching median flow of natural T2 median (early onset)).

Table 2.5 Number of sites passing each metric for the Eastern Mount Lofty Ranges testing sites.

Metric	Number of sites tested	Number of sites passed	% sites passed
Low Flow Season			
Average daily LFS flow	69	48	70
80th percentile exceedance non-zero flow [low flow]	69	8	12
Number of years with LFS zero flow spells	69	37	54
Average number of LFS zero flow spells per year	69	64	93
Average duration of LFS zero flow spells	69	31	45
Number of years with one or more LFS freshes	69	35	51
Average number of LFS freshes per year	69	25	36
Average total duration of LFS freshes per year	69	3	4
Transition Flow Season 1 (low to high) (T1)			
Average daily T1 flow	69	56	81
80th percentile exceedance non-zero flow [low flow]	69	13	19
Current month reaching median flow of natural T1 median (delay)	51	10	20
Number of years with T1 zero flow spells	69	39	57
Average number of T1 zero flow spells per year	69	69	100
Average duration of T1 zero flow spells	69	44	64
Number of years with one or more T1 freshes	69	51	74
Average number of T1 freshes per year	69	47	68
Average total duration of T1 freshes per year	69	43	62
Number of years with 2 or more T1 freshes	66	49	74
Frequency of spells higher than LFS fresh level	6	6	100
High Flow Season			
Average daily HFS flow	69	69	100
80th percentile exceedance non-zero flow [low flow]	69	26	38
Number of years with HFS zero flow spells	69	47	68
Average number of HFS zero flow spells per year	69	68	99
Average duration of HFS zero flow spells	69	56	81
Number of years with one or more HFS freshes	69	68	99
Average number of HFS freshes per year	69	67	97
Average total duration of HFS freshes per year	69	63	91
Number of years with 1 or more spell greater than the annual 5th percentile exceedance flow in HFS	48	48	100

Metric	Number of sites tested	Number of sites passed	% sites passed
Number of years with 2 or more freshes early in the season (Jul, Aug)	18	17	94
Transition Flow Season 2 (high to low) (T2)			
Average daily T2 flow	69	66	96
Median non-zero daily T2 flow	66	18	27
80th percentile exceedance non-zero flow [low flow]	69	5	7
Current month reaching median flow of natural T2 median (early onset)	69	29	42
Number of years with T2 zero flow spells	69	45	65
Average number of T2 zero flow spells per year	69	69	100
Average duration of T2 zero flow spells	69	53	77
Number of years with one or more T2 freshes	69	51	74
Average number of T2 freshes per year	69	38	55
Average total duration of T2 freshes per year	69	29	42
Frequency of spells higher than LFS fresh level	6	5	83
Number of years with 1 or more spell greater than the annual 5th percentile exceedance flow	51	49	96
Number of consecutive years with no T2 fresh	1	3	33
Annual: at any time of the year			
Number of years with 1 or more bankfull flows	69	69	100
Average duration of bankfull flow spells	69	69	100
Average total duration of bankfull flow per year	69	69	100

2.3.2 Relationship between metric results and environmental condition

Ecological monitoring data was compared with the proportion of metrics passed at a number of monitoring sites to assess the usefulness of the metric tool compared to real data on ecological condition (as described in VanLaarhoven and van der Wielen 2009, and summarised below). Adequate monitoring data was available only for fish and aquatic macroinvertebrates.

Fish have been monitored at a range of sites throughout the Eastern Mount Lofty Ranges for up to 7 years, including sites containing two key species that have a strong ecological response to flow (southern pygmy perch and mountain galaxias). The data for these species has been interpreted to assess whether recruitment in any year, has been excellent, good, marginal or poor, where recruitment is the survival of new individuals into the adult population. The percentage of years that recruitment was marginal or poor was determined for each site, and compared against the percentage of environmental water requirements metrics passed for the site.

A relationship was found showing that poorer ecological condition (i.e. a higher proportion of time where recruitment is marginal or poor) is generally correlated with a lower number of metrics being passed at a site.

Macroinvertebrate data has also been collected over time at a range of sites in the Mount Lofty Ranges. The data was interpreted to rate the condition of the macroinvertebrate community as good, medium,

marginal or poor based on a combination of factors including expert opinion of community health over time for different habitats (pools and riffles), and the presence of different habitats over time.

Comparison of the average percentage of metrics passed for sites in each of the condition rating groups showed that poorer condition is generally correlated with a lower percentage of metrics passing at a site.

For both fish and macroinvertebrates, a range of other processes will also affect ecological condition, including habitat quality (e.g. degradation by stock access, clearance of vegetation), water quality and predation. However, land use at most monitoring sites is stable, so processes associated with land use that may affect ecological condition are likely to have a relatively consistent effect over time. The flow pattern is a key driver in the structure and function of ecological communities. Therefore it is reasonable to assume that part of the observed relationship between ecological condition and changes to the flow regime is driven by changes to the flow regime.

2.3.3 Ecological consequences of changes to the water regime

Water resource development in the Eastern Mount Lofty Ranges has affected environmentally important parts of the water regime, particularly in the Low Flow and transitional flow seasons, as well as the smaller flow components such as freshes and low flows. This is likely to increase the risk of degradation of processes that maintain water-dependent ecosystems. At-risk processes include maintenance of suitable habitat (including refugia), provision of adequate connectivity to allow localised or large-scale movement and migration, and provision of suitable conditions to promote breeding, recruitment and survivorship.

2.3.3.1 Increasing stress on refuges in Low Flow Season

Environmental water requirements in the Low Flow Season are often the most critical in supporting the continuing presence of aquatic plants and animals in the environment, largely due to the importance of maintaining viable aquatic habitat with little or no water input.

One of the critical functions of flow in the Low Flow Season is maintenance of refuge habitat such as pools that retain water over the drier months. The persistence of many aquatic species in the Eastern Mount Lofty Ranges depends on the presence of permanent aquatic habitat, especially for aquatic species that permanently live in water, such as fish. Such habitats maintain core populations of aquatic biota, and act as refuges during droughts from which species can recolonise other areas of the catchment when favourable conditions return.

Reductions in low flows (including baseflow) and freshes in the Low Flow Season means that refuge pools are at greater risk of drying up or becoming uninhabitable due to high salinity, high temperature and/or low dissolved oxygen. Smaller pools (with less inflow) also provide less habitat, potentially leading to increased exposure to predators within pools and competition for resources.

2.3.3.2 Truncation of higher flow period

Another factor exacerbating stress on water-dependent ecosystems is the effective extension of the Low Flow Season into Transitional Flow Season 1 (low–high (T1)), and the early onset of the Low Flow Season during Transitional Flow Season 2 (high–low (T2)). This extension has two key effects. Firstly, it extends the naturally stressful period of very low to zero flows and places permanent refuges at even higher risk. Secondly, the period of higher flow (T1–T2) is shortened at both ends, reducing the time available for organisms to complete their life-cycle and carry out key ecological processes such as recolonisation and reproduction. This means that communities will be less resilient to the stresses of the Low Flow Season. Repeated failures to contribute to the seedbank or for juveniles to survive to adulthood as a result of a truncated higher flow period may lead to extinctions of local populations.

2.3.3.3 Reduction in connectivity and access to habitats

Providing connectivity is a key component of environmental water requirements. This includes connectivity at a local scale (e.g. access to other habitats like fast flowing riffles or shallow benches), medium scale (e.g. access to new resources on a floodplain), and at a larger scale (e.g. migration within a catchment to recolonise sites, or to migrate between freshwater and marine habitats for species that require this for different life-cycle stages). The environmental water requirements have been defined to include these different types of connectivity needs.

Only 38% of the test sites passed the metric representing low flows in the High Flow Season. Reduction in low flows in the High Flow Season is likely to reduce the extent, frequency and duration of inundation of in-stream habitats such as riffles, bars, benches and edge vegetation. Some functional groups are primarily found in such habitats, such as the flowing water macroinvertebrate groups. Reduced inundation of these habitats is likely to lead to reduced diversity of such groups. Many stream-specialist fish also require access to these habitats for feeding, spawning, juvenile habitat, adult conditioning and predator avoidance. Reduced opportunity for conditioning, recruitment and predator avoidance make such populations less resilient to stress.

The current level of water resource development has also detrimentally affected the frequency and duration of freshes in the T1 and T2 seasons (42–74% of sites passing these metrics). Together with the reduction in low flows in the High Flow Season, this is likely to have reduced the opportunity for organisms to move around the catchments as propagules (eggs or seeds), juveniles or adults. Some species need to migrate between different habitats in order to breed or recruit, including fish species that move between freshwater and saltwater habitats. Migration also increases the resilience of populations by allowing recolonisation of habitats where species have been lost or greatly reduced through water regime stress or other factors. Maintaining multiple populations of a species across a landscape means that the species can persist even if individual populations are lost in the short term. Reducing the opportunities for migration means that local losses are less likely to be replaced.

2.4 ENVIRONMENTAL WATER PROVISIONS

This section includes information about the water that is to be set aside for the environment and a statement of the environmental outcomes expected to be delivered on account of the provision of environmental water under this plan.

As outlined in the previous section, analysis of the status of environmental water requirements under current conditions shows that the requirements are not being met in many locations throughout the Eastern Mount Lofty Ranges. Further work was done with the surface water models to test the impact on the environmental water requirements metrics if no water was taken from dams for licensed purposes (i.e. water only used for assumed current non-licensed use). It was found that the average percentage of metrics passed over the 69 test sites was 75% in this case, which still fails to provide the environmental water requirement of meeting 100% of the metrics.

The NRM Act requires a water allocation plan to achieve an equitable balance between social, economic and environmental needs for water (section 76 (4)(b)(i)). Having no water available for allocation for consumptive use will not meet social and economic needs for water. There are also a range of legislative drivers for protecting ecosystems, including the objects of the NRM Act, which aim to achieve ecologically sustainable development by promoting use and management of natural resources in a manner that (amongst other things), 'seeks to protect biological diversity and, insofar as is reasonably practicable, to support and encourage the restoration or rehabilitation of ecological systems and processes that have been lost or degraded' (section 7 (1)(b) of the NRM Act).

Therefore it is necessary to set environmental water provision objectives and associated environmental water provisions that are expected have an acceptable level of risk to the environment while recognising existing users' rights and social and economic impacts. Such objectives and provisions will involve

accepting a higher level of risk of environmental degradation, but should have an acceptable probability of maintaining water-dependent ecosystems in a sustainable state in the long term.

2.4.1 Environmental water provisions for underground water

As outlined in section 2.2.2, information on the presence, distribution and water needs of ecosystems that rely on underground water while it is still below the surface is currently very limited and insufficient for assessing their environmental water requirements at this point.

Baseflow discharging from underground water into watercourses is an important component of streamflow, particularly during drier periods. The environmental water requirements provided by baseflow are considered as part of the needs of ecosystems dependent on surface and watercourse water, as outlined below. Once baseflow has been discharged into a watercourse, it is managed via the surface and watercourse water environmental water provisions. However, the provision of baseflow to watercourses needs to be managed via underground water management policies.

The environmental water provision recommended for underground water is to ensure that baseflow is protected.

2.4.2 Environmental water provisions for surface water and watercourse water

2.4.2.1 Summary of process

The process for identifying an acceptable level of risk to surface water-dependent ecosystems and setting an associated environmental water provision is described in VanLaarhoven and van der Wielen (2012), and summarised in this section.

Environmental water provision objectives were set that aim to maintain water-dependent ecosystems at an acceptable level of risk for meeting the overall objective of maintaining and/or restoring self-sustaining populations of aquatic and riparian flora and fauna which are resilient in times of drought. These environmental water provision objectives were set using expert interpretation of fish and macroinvertebrate monitoring data from sites in the Mount Lofty Ranges. This interpretation identified a minimum acceptable ecological condition that is expected to allow populations to be self-sustaining (section 2.4.2.2).

The relationships between ecological condition and percentage of metrics passed for fish and macroinvertebrate monitoring sites, as described in section 2.3.2, were used to establish what percentage of metrics passed at a site was associated with the minimum acceptable ecological condition.

The next step was to determine what water management strategies would result in the desired percentage of environmental water requirements metrics being passed and hence what would be likely to achieve the minimum acceptable ecological condition (section 2.4.2.3). To this end, the surface water models were used to test different water management scenarios to determine what combination of strategies would achieve the desired percentage of metrics being passed for the majority of test cases. This scenario testing provides the basis for the evaporation and consumptive use limit and associated taking rules for surface water and watercourse water.

2.4.2.2 Environmental water provision objectives

Fish environmental water provision objectives

Fish monitoring data for southern pygmy perch and mountain galaxias was interpreted to assess the percentage of years that recruitment was marginal or poor. Poorer ecological condition (i.e. a higher

proportion of time when recruitment is marginal or poor) was found to correlate with fewer metrics passing at a site.

Mountain galaxias and southern pygmy perch are relatively short lived species (approximately 3 years). Therefore suitable breeding conditions need to occur with enough frequency to build population numbers and promote resilience to withstand poorer flow years and ensure the survival of these species.

Periods of poor to marginal breeding events occur under natural conditions and native fish species have developed strategies to persist through these periods. While marginal, enough recruitment is expected to occur in these years to maintain sufficient population numbers for these species to recover in subsequent years once better hydrological conditions prevail.

Expert opinion recommends that better-than-marginal recruitment events need to occur in at least seven years out of every ten to maintain sufficient population numbers.

The relationship between ecological condition and percentage metrics passed at monitoring sites was used to determine that the environmental water provision objective of seven out of ten years having better than marginal recruitment equates approximately to an environmental water requirements metric success rate of 85% (i.e. 85% of the relevant metrics listed in the table in Appendix C are passed).

Macroinvertebrate environmental water provisions objectives

Macroinvertebrate monitoring data was interpreted to assess the long-term community condition as good, moderate, marginal or poor. Poorer ecological condition was generally correlated with a lower percentage of metrics passing at a site.

Expert opinion recommends that a target of macroinvertebrate community condition between moderate and good is likely to promote resilience and allow populations to be sustainable in the long term. As with fish, this environmental water provision objective equates to an environmental water requirements metric success rate of 85% (i.e. 85% of the relevant metrics listed in the table in Appendix C are passed).

The environmental water provision objective is to pass 85% of the environmental water requirements metrics. This equates to:

- better-than-marginal recruitment in at least seven out of ten years for southern pygmy perch and mountain galaxias; and
- moderate to good macroinvertebrate community condition.

This is considered to maintain an acceptable level of risk to achieving the overall environmental objective of maintaining/restoring self-sustaining populations that are resilient to drought.

These environmental outcomes are expected to be delivered if the environmental water provisions set out in this plan are achieved.

2.4.2.3 Determination of environmental water provisions

The work to determine the management option(s) that would meet the environmental water provisions is described in VanLaarhoven and van der Wielen (2012), and is outlined below.

The surface water models were used to test the environmental water requirements metric success rate (i.e. % metrics passed) of a range of water management options at 69 test sites throughout the Eastern Mount Lofty Ranges PWRA. These sites were selected to cover a range of reach types, catchment conditions, and combinations of water-taking infrastructure (e.g. low to high development, dams and watercourse diversions, proportion of licensed and non-licensed extraction).

The purpose of the testing was to identify what management option(s) would achieve the environmental water provision objective of passing at least 85% of metrics. As part of the process of balancing social, economic and environmental water needs, it was considered that the environmental water provision objective should be met at the majority (at least 50%) of test cases within a management scenario. A test case is a single modelled scenario at a test site. All water management scenarios tested were based on the current level and distribution of dams and watercourse diversions as represented in the surface water models.

Managing volume of licensed use only

One set of water management scenarios tested the effects of varying the volume of water taken from licensed dams and watercourse diversions. The assumed volume taken for non-licensed purposes was held constant, as the volume of water taken from dams and watercourses for non-licensed purposes can't be managed through the Plan and associated licensing process. As outlined in section 1.7.2.3, non-licensed (stock and domestic) use from surface water is estimated as 30% of dam capacity for non-licensed dams.

The total mean annual volume lost from the resource for each scenario was expressed as a percentage of mean annual adjusted runoff from the catchment area upstream of the test site. The total volume lost included:

- consumptive demand – the volume the model attempts to take from dams and watercourse diversions, for both licensed and non-licensed purposes. Note that the modelled volume actually taken may be less in some years (e.g. insufficient water available in a dam); and
- net evaporative loss from dams – the modelled mean (1974–2006) net annual evaporation volume from dams in the relevant area. Net annual evaporation is the annual evaporation from the dam minus the annual rainfall falling onto the dam's surface, giving the net loss from the dam's surface (excluding inflow, spills and seepage).

All of this water is no longer available for downstream users and the environment, and so should be accounted for when setting water-taking limits that aim to meet water sharing and environmental provisions objectives.

It was found that the environmental water provisions objective of passing at least 85% of the metrics could only be met at the majority of test cases if total consumptive loss (consumptive demand plus net evaporation from dams) was up to 5% of mean annual adjusted runoff. Only 10% of test sites have an estimated current total consumptive loss of up to 5% of mean annual adjusted runoff. Estimated current total consumptive loss includes assumed current licensed demand (50% of licensed dam capacity and 100% of provisional watercourse existing user entitlement) as well as stock and domestic use (30% of non-licensed dam capacity) and modelled mean net annual evaporation. Capping demand plus evaporation at 5% of runoff is therefore not likely to meet social or economic requirements for water across the Eastern Mount Lofty Ranges PWRA. Therefore alternative water management scenarios involving diversion rules as well as evaporation and consumptive use limits were investigated.

Managing volume of licensed use together with diversion rules – threshold flow rates

The analysis of the impact of current water resource development on environmental water requirements metrics showed that it is the smaller flow components (freshest and low flows) that are particularly affected (section 2.3.1.1). If these lower flows were returned to the system, it may be possible to allocate larger volumes for consumptive use while maintaining an acceptable level of risk to water-dependent ecosystems.

The use of threshold flow rates is a method by which water can be shared between consumptive users and the environment. Under this management approach, flows at or below a given threshold flow rate are not captured or are otherwise returned to the environment, while a portion of the flows above the threshold flow rate may be captured.

Threshold flow rates were set based on the size of freshes in the two transitional flow seasons, as these are the largest of the flow components that have been strongly affected by surface water resource development. Examination of daily flow data from a range of sites showed that the 20th percentile exceedance non-zero flow encompasses the fresh flow rate at the majority of sites. The 20th percentile exceedance non-zero flow is the daily flow rate that is exceeded for 20% of the time when water is flowing.

As such, the threshold flow rate has been defined as the 20th percentile exceedance non-zero flow (i.e. flows that occur for 20% of the flowing period). A portion of the flows above the threshold flow rate can be captured. Note that these flows that may be captured are higher flow events, and generally account for 80–95% of the total annual flow volume.

The recommended ecologically significant threshold flow rate is the 20th percentile exceedance non-zero flow.

Threshold flow rates – licensed infrastructure only

Scenario testing was undertaken to test the effects of a combination of:

- varying licensed water use volumes, together with
- a diversion rule that flows at or below the threshold flow rate are returned to the system for existing licensed dams and watercourse diversions.

For these scenarios, it was found that the environmental water provisions objective of passing at least 85% of the metrics could be achieved for the majority of test cases if the total consumptive loss was up to 5% of upstream mean annual adjusted runoff. Protecting flows below the threshold flow rate at licensed dams and watercourse diversions made improvements to the environmental flow metrics and would be expected to have local-scale benefits, but was not enough to raise the level of consumptive water loss that could occur while also meeting the environmental water provisions objectives.

Licensed dams make up about 37% of the total dam capacity in the Eastern Mount Lofty Ranges PWRA. If flows at or below the threshold flow rate are only protected at licensed dams and watercourse diversions, then these provisions to the environment do not occur widely enough across the landscape to meet the objective, and in many cases are likely to be trapped in a downstream non-licensed dam. There would still be local-scale benefits as the returned water flows down to the next dam, but under this scenario, not enough of the flow below the threshold flow rate is passing down the catchments.

Therefore, in order to achieve a more equitable balance between social, economic and environmental water needs, while still meeting environmental objectives, investigations were made into scenarios where non-licensed dams were included in the diversion rule to protect flows at or below the threshold flow rate.

Threshold flow rates – licensed infrastructure and non-licensed dams \geq 5 ML

Water taken and used for non-licensed purposes is not managed by the prescription process in the Eastern Mount Lofty PWRA. However, other tools in the NRM Act may be used to require existing non-licensed dams to return flows at or below the threshold flow rate, in order to achieve the environmental water provision objectives at a wider geographic spread, and a more equitable balance between social, economic and environmental needs for water.

There are estimated to be 7,052 dams across the Eastern Mount Lofty Ranges PWRA. Table 2.6 shows the breakdown of these in terms of number of dams, and total capacity of dams, in categories of use and individual dam size. It can be seen that non-licensed dams make up the majority of dam numbers in the region, with 86% of them being non-licensed dams less than 5 ML in individual capacity. However these smaller non-licensed dams only make up about 32% of the total dam capacity.

Larger dams are more likely to interrupt the downstream flow pattern, because they generally take longer to fill and spill. Therefore it makes sense to direct efforts at protecting lower flows at larger dams as this is likely to have more environmental benefit. Non-licensed dams of 5 ML or more account for 31% of the total dam capacity, and together with licensed dams (37% of licensed dam capacity) are likely to play a significant role in affecting the current water regime. This group of dams represents 14% of the total number of dams. Hence a strategic approach was explored to see if protecting low flows at this relatively small group of dams, which are likely to have the largest impact of the water regime, would have benefits (in terms of a higher water-taking limit and achievement of environmental objectives more widely across the landscape) while minimising potential costs (in terms of number of dams/diversions affected and infrastructure/implementation costs).

Table 2.6 Number of dams and capacity of dams in categories of licensed and non-licensed, sub-divided by individual dam size.

Dam category	Number of dams	Capacity of dams (ML)
Licensed		
Less than 5 ML	308	559
5 ML or more	251	6,115
<i>Total</i>	<i>559</i>	<i>6,674</i>
Non-licensed		
Less than 5 ML	6,053	5,919
5 ML or more	440	5,692
<i>Total</i>	<i>6,493</i>	<i>11,611</i>
Grand total	7,052	18,285

Scenario testing was undertaken to test the effects of a combination of:

- varying licensed water use volumes, together with
- a diversion rule that flows at or below the threshold flow rate are returned to the system for existing licensed dams and diversion structures, as well as existing dams used only for non-licensed purposes with a capacity of 5 ML or greater.

For these scenarios, it was found that the environmental water provisions objective of passing at least 85% of the metrics could be achieved for the majority of test cases if the total consumptive loss (net evaporation plus consumptive use) was up to 20% of upstream mean annual adjusted runoff.

Seventy eight percent of test sites have a current total consumptive loss of 20% or less of upstream mean annual adjusted runoff. Setting an evaporation and consumptive use limit at this level is more likely to be socially and economically acceptable, and is considered a reasonable balance against meeting the environmental water provision objective for at least 50% of test cases.

In order to balance social, economic and environmental water needs, it is recommended that both:

- an ongoing evaporation and consumptive use limit of 20% of upstream mean annual adjusted runoff is set; and
- provisions be made for existing licensed dams and diversion structures, and existing dams used for non-licensed purposes with a capacity of 5 ML or greater, to return or not capture flows at or below the threshold flow rate.

It is also recommended that all new (and enlarged) dams and watercourse diversions should return or not capture flows at or below the threshold flow rate to allow the environmental water provision objectives to continue to be met as future development occurs.

Interception limit

The impact of dams on the water resources, users and the environment is not limited to the volume extracted from dams and watercourses. Dams trap all of the runoff from the upstream catchment area until they fill and spill. The presence of the dam as a physical barrier to water movement and the capacity of the dam have a key influence on the volume and pattern of downstream flow. The level of usage, evaporation and seepage from the dam will also affect how soon the dam fills and spills. Therefore it is important that both dam capacity and usage are both managed to meet the environmental water provision objectives.

The process to determine an interception limit was similar to that used to determine the evaporation and consumptive use limit. The total dam capacity for each test site was expressed as a percentage of upstream mean annual adjusted runoff. The percentage of metrics passed was identified under the different usage scenarios, with flows at or below the threshold flow rate returned at licensed dams and watercourse diversions and at non-licensed dams with a capacity of 5 ML or more.

For these scenarios, it was found that the environmental water provisions objective of passing at least 85% of the metrics could be achieved for the majority of test cases if the total volume of dam capacity was up to 30% of upstream mean annual adjusted runoff.

The recommended interception limit (total allowable volume of dam capacity and other interception such as interception by plantation forestry) is 30% of the upstream mean annual adjusted runoff.

This interception limit assumes the recommended requirement to return flows at or below the threshold flow rate is implemented.

Modifications to the evaporation and consumptive use limit and taking rules

The earlier part of this section describing the development of an evaporation and consumptive use limit applies to the majority of the Eastern Mount Lofty Ranges PWRA where the hydrology, ecology and method of water capture have reasonable similarities, albeit varying across a spectrum of climates from dry to wet. However, there are two parts of the region that are sufficiently different to warrant a modified approach to determining extraction rules and limits, being the lower Angas and Bremer Rivers, and the Tookayerta Creek catchment, as discussed below.

Angas and Bremer Rivers across the plains

The Angas and Bremer Rivers descend from the relatively wet hills down to the low rainfall Murray Plains and Lake Alexandrina, with the lower sections crossing a relatively flat floodplain with important water-dependent red gum swamps (shown in Figure 1.6). The lower sections flow in winter and spring most years, often at quite high levels due to rainfall in the wet upper catchments. However, the watercourse is otherwise dry except for permanent pools in the upstream parts of the plains, small wetlands at the mouths that are usually kept wet via water from Lake Alexandrina, and at least one semi-permanent pool on a blind tributary (Mosquito Creek) that is likely to be maintained by shallow underground water. Parts of the watercourse lose flow to the underlying quaternary underground water.

The flat topography, large size of the watercourse and the nature of the flow pattern mean that most water users in the area opportunistically divert water from the watercourse when it is available, rather than catching flow in dams. The unreliable nature of flow means that many users in the area have arranged access to other water sources in addition to river water.

The evaporation and consumptive use limit of 20% of mean annual adjusted runoff has been derived from modelling the impact of water capture (largely by dams) on the flow patterns experienced in the hills areas and in plains areas where there is not significant loss of flow to underground water. This means that this limit is less applicable to the lower Angas Bremer area, as the flow pattern is somewhat different and the opportunistic watercourse diversion will also affect the flow regime (and hence

environmental water requirements) differently. The flexible nature of operation of watercourse diversions provides more opportunity to manage when and how water is taken, compared with dams that intercept water as long as there is room in the dam.

The current demand for water for all purposes in the Angas and Bremer catchments is high. Work has been undertaken to assess whether more water could be taken on the plains under water-taking rules in addition to the 20% evaporation and consumptive use limit, while still meeting similar environmental water provision targets.

Many water users in the area divert river flow via in-stream weirs, sluice gates and flood pumps to flood irrigate crops bounded by levee banks. Water is kept on a property for a short time to allow wetting-up of the soil profile, and then moved onto the next property. In many cases, the unused portion of the diverted water ends up on red gums swamps or back in the watercourse. This water diversion appears to be the primary mechanism by which the red gum swamps receive water, as much of the watercourse is incised (cut down into the ground) and/or lined with levee banks. Only occasional large flood events are likely to reach some of the red gum swamps without intervention. The current landscape of levee banks and water movement means that the red gum swamp communities are likely to be at risk of degradation if water is not provided to them as a result of the current water diversion practices.

The preferred solution is to undertake a program to install infrastructure to provide water to the red gum swamps independently of the current irrigation mechanisms. In the meanwhile, an alternative solution needs to be found to maintain the health of the swamps. Restricting the volume taken by those who directly or indirectly provide water to red gum swamps is likely to mean that the swamps will not receive enough water. Hence it is recommended that some of the water from the system provisions (broadly, the difference between resource capacity and the evaporation and consumptive use limit) be available to be taken by irrigators who directly or indirectly provide water to red gum swamps.

The nature of the water-taking infrastructure in the area also means that significant volumes of water can be taken in a short period of time, which has implications for movement of water through to downstream users and systems, and availability of water in the watercourse for in-stream ecosystem processes.

Fish migration upstream and downstream through the lower sections of these rivers is another locally important ecological process. Fish monitoring data and anecdotal observations have been interpreted to identify the times when fish have been likely to move through the system. This information was then linked to flow data to identify the flow depth that appears to be associated with fish movement (Hammer 2009, M. Hammer pers. comm.). As a result, recommended environmental water provisions are that:

- the first flush of flow events be allowed to go all the way to the mouth before water is diverted, so that fish moving with the event have the opportunity to move down to Lake Alexandrina, and an attractant flow is provided into the lake to attract fish to move up the watercourses; and
- a threshold flow level equivalent to 0.3 m depth at the widest cross-section for the Bremer River is set to allow free movement of fish along the reach. Together with considerations to meet other flow metrics, this was found to be equivalent to 0.5 m³/s (Alcorn and Murdoch no date).

A threshold flow level equivalent to approximately 0.2–0.3 m depth has been adopted for the Angas River, given the smaller size of the fish species likely to be migrating in that system. Together with considerations to meet other flow metrics, this equates to a threshold flow level of 0.2 m³/s. This results in a flow depth of approximately 0.12 m at the widest cross-section (Alcorn and Murdoch no date).

Operable in-stream weirs are employed to push water out of the watercourses into crop areas via sluice gates. This practice is important to maintain provision of water to the red gum swamps as outlined above, but creates a barrier to fish migration and flow to downstream users. Hence it is recommended that in-stream weirs should be operated for a maximum of 48 hours within a flow event, to allow a balance between water diversion (reaching crops, red gum swamps and downstream users) and facilitating fish passage. This is longer than the period that these weirs are operated for under current

practices, according to information gathered from local users during land and water use surveys conducted by the Department for Water as part of the prescription process.

Assessment of water-taking rules on users and the environment is hampered by limited data on the volume of water diversions and natural losses to the stream bed and floodplain in the area. A simple flow model was constructed using available data. The model was used to test the effects of different water-taking rules as described above on the ability for water to be diverted to the floodplain, as well as the effects on the environmental flow metrics, modified to reflect the characteristics of the area and the nature of the available data.

It was considered that a reasonable balance between provisions for in-stream habitats, end-of-system habitats, floodplain habitats and floodplain consumptive needs occurred under the model conditions when the first flush of a flow event was allowed to reach the end of the system before water was taken, together with protection of flows at or below the threshold flow rate. The first flush is considered to have reached the end of the system in this case when the flow rate at the end-of-system flow gauge reaches 1.2 m³/s in the Bremer River or 0.6 m³/s in the Angas River. A flow event ends when flow has been below the threshold flow rate at the end of the system for more than 20 days. The first flush of the next flow event is to pass through again.

Under these water-taking rules, the simplistic modelling found that:

- Water could be taken in 25 out of 31 years for 1975/6 to 2005/6 in the Bremer River, with coarse estimates of the likely historical demand being met in 21 out of 31 years. Water could be taken in 30 out of those 31 years in the Angas River, with the likely historical demand being met in 16 out of 31 years (noting that the historical estimate of demand is almost 50% of mean annual flow in this case).
- One to two more flow metrics were failed in the Bremer River in addition to those already failed as a result of current modelled use in the hills if flows at or below the threshold flow rate are returned around all licensed dams and watercourse diversions, and non-licensed dams with a capacity of 5 ML or more, in the hills.

Hence it is recommended that an additional volume of water be available for allocation on the lower Angas and Bremer Rivers under these water-taking rules, capped at the volume to be allocated to existing users. Allocating this extra water means that no further water can be taken in these catchments, although water taking may still be able to move around within each catchment.

Environmental water provisions in the lower Angas and Bremer Rivers are a balance between providing for local in-stream habitats, floodplain habitats and downstream habitats (e.g. terminal wetland at the mouth). Tipping the balance too far in the favour of one habitat may jeopardise the condition of another. It will be essential to monitor the condition of the red gum swamps and the in-stream and end-of-catchment habitats to allow adjustment of the threshold flow levels or first flush trigger levels, or implementation of other management actions, if necessary to ensure sufficient water reaches the swamps and other habitats (see section 8).

Tookayerta Creek catchment

Tookayerta Creek catchment is recognised as being substantially different to other catchments in the Eastern Mount Lofty Ranges PWRA. The high level of perennial, low salinity baseflow supports a wide range of species and communities, including Fleurieu swamps and endangered species.

In addition, the largely permanent flow also means that the water-taking infrastructure is different here compared to most other catchments. Most of the water taken from the surface for consumptive use is directly extracted and used from the watercourse as needed throughout the year, rather than being caught in dams during winter to spring to be used over summer and autumn. For example, approximately 85% of provisional existing user demand from surface water and watercourses is from watercourses in Tookayerta, compared to 47% from the rest of the Eastern Mount Lofty Ranges (excluding flood diversions on the lower Angas Bremer). The dam density, which is a measure of the

intensity of dam development, is 13 ML of dam capacity per square kilometre of catchment for Tookayerta, compared to 30 ML/km² in the Upper Finnis which has a similar rainfall (data supplied by DFW and from Savadamuthu 2004).

This high reliance on direct use from watercourses in Tookayerta Creek catchment means that the requirement to protect flows at or below the threshold flow rate is likely to significantly affect the ability of water users to access sufficient water at the right times. However, the protection of lower flows is also important to protect the unique range of water-dependent species and communities in this area.

Fish monitoring data since 2002 shows that the fish communities are generally in good condition throughout the catchment, except where affected by external factors such as the severely lowered water level in Lake Alexandrina during the recent drought (e.g. Hammer 2009). However, observations during periods of low rainfall show that the catchment is still prone to loss or reduction of low flows due to water extraction, like other catchments in the Eastern Mount Lofty Ranges PWRA.

As a way of balancing consumptive and environmental needs for access to flow throughout the year, the threshold flow rate in this catchment has been set at the approximate level of the summer baseflow. This is lower than the 20th percentile exceedance non-zero flow rate used to set the threshold flow rate elsewhere, but is still expected to retain sufficient flow depth to sustain water-dependent ecosystems, in combination with the limitations on the total volume that may be extracted via the evaporation and consumptive use limit.

It will be essential to monitor and evaluate ecological condition and responses of the water resources to test whether the consumptive use limits and taking rules are maintaining ecological and water resource condition; and if not, then to provide a trigger for action (see section 8).

2.4.2.4 Scale of management for environmental water provisions

The scale that the evaporation and consumptive use limit is applied at is important. Managing use only at a broad scale means that localised impacts can occur in areas of high intensity water use. However it is also important to include a big-picture view (e.g. catchment scale) to provide for the needs of habitats at the end of the system and in connected systems. Managing use at a very small scale provides better protection of local environmental water needs, but is complex, resource intensive and likely to be very restrictive for consumptive users. Therefore a combination approach is required.

Catchment scale

The evaporation and consumptive use limit needs to apply at the scale of the whole catchment to ensure an adequate water regime is provided to habitats at the end of the system and to receiving environments.

Management zone scale

If evaporation and consumptive use limits are only set at the catchment scale, then there is likely to be an uneven distribution of water resource development throughout the catchment, with some areas heavily developed while others are left free flowing. Therefore impacts at a more local scale also need to be considered. Dams or other diversion structures will have a proportionally greater impact on the flow regime immediately downstream of the structure. The level of impact decreases further downstream as other sources contribute to flow.

Surface water management zones have been developed on the basis of reach types, which have varying ecosystems, habitats, processes and biota, and therefore different environmental water requirements. As a general rule, the confluence of reach types (not including headwaters which are not considered to have significant environmental water requirements in most cases) has been used to differentiate each surface water management zone. This ensures that each stretch of watercourse will have its local water needs met without being compromised by development in adjacent watercourses.

Significant environmental assets scale

The Eastern Mount Lofty Ranges PWRA includes a range of water-dependent ecosystems of particular significance that warrant special protection in terms of providing a suitable water regime at the scale of the asset itself. That is, the evaporation and consumptive use limit will also apply to the catchment area immediately upstream of such significant environmental assets.

Significant environmental assets include any wetland, watercourse or water-dependent ecosystem that contains:

- any water-dependent threatened ecological community listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act);
- any water-dependent species listed as threatened flora or threatened fauna under the EPBC Act;
- any water-dependent species listed in Schedules 7, 8 or 9 of the South Australian *National Parks and Wildlife Act 1972*; and/or
- any species protected under the South Australian *Fisheries Management Act 2007*.

The locations of significant environmental assets used for the purposes of the Plan will be identified in a database. Indicative locations of significant environmental assets identified to the date of map production are shown in Figure 4.11.

3 ASSESSMENT OF EFFECT ON OTHER WATER RESOURCES

Section 76 (4)(a)(ii) of the NRM Act requires that a water allocation plan includes an assessment of whether taking or use of water from the prescribed resource will have a detrimental effect on the quantity or quality of water that is available from any other water resource. This may include water resources in neighbouring prescribed and unprescribed areas. If a detrimental effect is occurring or is likely, then a water allocation plan must take account of the needs of those dependent on the affected resources, in accordance with section 76 (6) of the NRM Act.

The neighbouring prescribed areas (Figure 1.1) are the Western Mount Lofty Ranges PWRA, Marne Saunders PWRA, and River Murray PWC. The neighbouring unprescribed areas are the Mypolonga Flat catchment and part of the Ferries-McDonald catchment. These plains regions are pocketed between the Eastern Mount Lofty Ranges PWRA and the River Murray PWC. All of these areas, except the Western Mount Lofty Ranges PWRA, are part of the Murray-Darling Basin.

Aboriginal people do not categorise lands and waters, nor put boundaries around them and can therefore find the management processes of water resource plans, prescribed water resource areas and water allocation plans restrictive. There is an assessment within this Plan on the effect of other water resources, by viewing these resources as separate systems within defined areas. However, this does not accord with the Aboriginal worldview that it is one interconnected system and so makes water planning and management challenging for Aboriginal nations.

Figure 1.2 shows the complexities of native title boundaries that overlap with different water planning areas and NRM Regions, making water and natural resources management planning difficult and at times confusing for nations.

The 2019 amendments made to the Plan acknowledge that there is a current gap between the knowledge and understanding that Aboriginal people bring on the interconnectedness of water across the landscape and non-Aboriginal knowledge of this interconnectedness. To bridge this gap, investment is required over time and could be assisted by progressing the engagement principles of developing cultural knowledge agreements with Aboriginal nations, as described in section 1.3. Section 4 of the Plan provides an overview of the management framework developed to address detrimental effects of taking water from the Eastern Mount Lofty Ranges PWRA on other water resources, users and the environment, including those within and outside the area. This framework is implemented by the policy contained within sections 5 (Water allocation criteria), 6 (Transfer criteria) and 7 (Permits) of the Plan.

Section 76 (7) of the NRM Act allows this plan to include provisions relating to the taking and use of water from another resource where that taking and use affects, or is likely to affect, the management of water resources in the Eastern Mount Lofty Ranges PWRA.

3.1 MURRAY-DARLING BASIN

A Basin Plan has been developed under the Commonwealth *Water Act 2007* as an overarching plan for water management in the Murray-Darling Basin, including the Eastern Mount Lofty Ranges.

Under the Basin Plan, the Murray-Darling Basin has been divided into a number of water resource plan areas, each of which must have a water resource plan that is to be accredited under the Basin Plan.

The Eastern Mount Lofty Ranges is within one of these water resource plan areas. This current iteration of the water allocation plan is expected to be considered as a transitional plan under the *Water Act 2007*. Under the *Water Act 2007*, a transitional plan has a limited life as set out in the schedules or regulations of the *Water Act 2007*, and during that time prevails over the Basin Plan. After this, the transitional plan will need to be replaced by a water resource plan accredited under the Basin Plan. The

next iteration of the Water Allocation Plan for the Eastern Mount Lofty Ranges will be submitted for accreditation for the purpose of the Basin Plan as a key component of the Eastern Mount Lofty Ranges Water Resource Plan. Under current arrangements for Basin Plan implementation, this is required to occur by 30 June 2019.

Another important part of the Basin Plan is to set sustainable diversion limits (SDLs) across the Murray-Darling Basin that reflect an environmentally sustainable level of take. Under current Basin Plan proposals, sustainable diversion limits have been set for SDL resource units across the Murray-Darling Basin, including units corresponding to surface water and underground water in the Eastern Mount Lofty Ranges water resource plan area. Under current proposals, compliance with these SDLs will commence in 2019. Provisions have been included in this water allocation plan to cap use across the Eastern Mount Lofty Ranges to be within the currently proposed SDLs under the Basin Plan.

The Eastern Mount Lofty Ranges contributes flow to the lower River Murray and Lake Alexandrina, and ultimately to Lake Albert, the Murray Mouth and the Coorong. Ngarrindjeri have long asserted the importance of the Eastern Mount Lofty Ranges and Marne Saunders watercourses to the health and condition of the Coorong. The Eastern Mount Lofty Ranges, together with the Marne and Saunders catchments, generate about 0.5% of the total runoff of the Murray-Darling Basin (CSIRO 2007a), and the contribution of flow from the Eastern Mount Lofty Ranges needs to be considered together with flow from the rest of the Basin. The Basin Plan provides a mechanism for integrated management of water across the Basin to ensure appropriate water regimes and volumes are provided to connected downstream systems.

The local-scale interactions between the Eastern Mount Lofty Ranges and the River Murray and Lake Alexandrina are discussed in section 3.4.

3.2 WESTERN MOUNT LOFTY RANGES PRESCRIBED WATER RESOURCES AREA

The Western Mount Lofty Ranges PWRA shares the western and south-western boundary of the Eastern Mount Lofty Ranges PWRA. The Western Mount Lofty Ranges PWRA includes the South Para and Little Para Rivers, the River Torrens and Onkaparinga River sub-catchments, and the Southern Fleurieu Peninsula catchments. It also includes the main channels of the Onkaparinga River (downstream of Clarendon Weir), the River Torrens/Karawirra Parri (downstream of Gorge Weir) and Gawler River (downstream of the junction of the North Para River and the South Para River) to Gulf St Vincent.

3.2.1 Interconnection with the Eastern Mount Lofty Ranges PWRA

Surface and watercourse water resources of the Eastern Mount Lofty Ranges PWRA are separate from those of the Western Mount Lofty Ranges PWRA. They are defined by their respective surface water catchment boundaries. The boundaries are surface water divides; where rainfall falls on the eastern side of the divide runoff will flow towards the River Murray, and where rainfall falls on the western side of the divide runoff will flow towards Gulf St Vincent.

The fractured rock aquifer boundary between the prescribed water resources areas has a similar divide to that of surface water, as the basement rock outcrop aligns with the surface water boundaries.

There are limited extractions from the Kanmantoo Group aquifer and accordingly there is likely to be little impact between the PWRAs in the vicinity of the shared boundary for this aquifer.

The Adelaidean rocks are considered a good aquifer, particularly to the north and south of Mount Barker. Extractions within 200 metres of the boundary may have small drawdown impacts across the boundary, but not at a rate that is likely to be detrimental to the water quantity and quality in either PWRA.

The boundary between the PWRAs near Mount Compass is underlain by the high quality Permian Sands aquifer. Any intensive extractions within 200 metres of the boundary could have drawdown impacts

over the boundary. However the management arrangements set out in the Plan (e.g. buffer zones, consumptive use limits) should minimise impacts on quantity and quality of water in the Western Mount Lofty Ranges PWRA.

The boundary between the PWRAs near Currency Creek catchment is also underlain by the Permian Sands aquifer, but the extent of this aquifer in the Western Mount Lofty Ranges PWRA is small and there are not likely to be detrimental impacts on the water resources there.

The potential effect of taking water from the Eastern Mount Lofty Ranges PWRA is not anticipated or likely to have a significant impact on the Western Mount Lofty Ranges PWRA. Conversely, taking water from the Western Mount Lofty Ranges PWRA is not anticipated or likely to have a significant impact on the Eastern Mount Lofty Ranges PWRA. The management arrangements in the Plans for both areas are likely to mitigate the risk of adverse impacts on quantity and quality of water available in either PWRA.

3.3 MARNE SAUNDERS PRESCRIBED WATER RESOURCES AREA

The Marne Saunders PWRA shares the northern boundary of the Eastern Mount Lofty Ranges PWRA, and includes the Marne and Saunders catchments. The Marne River and Saunders Creek begin in the high rainfall hills area, flowing east down the hills, through gorges and then out onto the Murray Plains to eventually join the River Murray.

For Peramangk people, the flow of water within the Marne River and Saunders Creek aided travel and connection between the hills and Murrundi (River Murray). There is much Aboriginal cultural knowledge of the relationship between flow, water-dependent ecosystems and sustainable livelihoods that would be a valuable addition to scientific knowledge, and addressing gaps in the understanding of water resources. In relation to water allocation planning, this cultural knowledge has yet to be taken into account but consideration of this knowledge is further discussed in section 1.3.

3.3.1 Interconnection with the Eastern Mount Lofty Ranges PWRA

Surface and watercourse water resources of the Eastern Mount Lofty Ranges PWRA are separate from those of the Marne and Saunders PWRA because they are defined by their respective surface water catchment boundaries. The fractured rock aquifer boundary also aligns with the surface water boundaries.

The potential effect of taking water from the Eastern Mount Lofty Ranges PWRA is not anticipated or likely to have a significant impact on the Marne Saunders PWRA. Conversely, taking water from the Marne Saunders PWRA is not anticipated or likely to have a significant impact on the Eastern Mount Lofty Ranges PWRA.

3.4 RIVER MURRAY PRESCRIBED WATERCOURSE

The Water Allocation Plan for the River Murray Prescribed Watercourse covers the prescribed watercourse of the River Murray from the Victorian Border and encompasses Lake Alexandrina and Lake Albert. The River Murray PWC shares the north-eastern boundary (north of Caloote) and the eastern boundary (south of Tolderol Point, Lake Alexandrina) of the Eastern Mount Lofty Ranges PWRA. The boundary of the River Murray PWC is based on the 1956 flood level, and consequently incorporates the lower reaches of Currency Creek, Tookayerta Creek, Finniss River, Angas River and Bremer River (Figure 1.1).

As described in the draft River Murray water resource plan (DEW, in prep), Murrundi (the River Murray) is core to culture and identity of many Aboriginal people across the Murray Darling Basin. After Murrundi crosses from Victoria to South Australia, the River meanders through the traditional lands of the First Peoples of the River Murray and Mallee to the traditional lands of Peramangk and Ngarrindjeri before meeting the sea at a place that many refer to as *the meeting of the waters*. Along the way, the River meets with other watercourses, both above and underground, that join the journey bringing life

into the surrounding Country and its peoples. While each of the Traditional Owner groups along Murrundi have distinct cultural identities specific to their Country, this concept of connectedness to Murrundi is common to all Aboriginal nations, connecting them to each other, to upstream nations, and wider nations of connected watercourses.

3.4.1 Interconnection with the Eastern Mount Lofty Ranges PWRA

3.4.1.1 Surface water and watercourses

The Eastern Mount Lofty Ranges watercourses flow directly into the River Murray and Lake Alexandrina.

The Eastern Mount Lofty Ranges, together with the Marne and Saunders catchments, generate about 0.5% of the total runoff of the Murray-Darling Basin (CSIRO 2007a). At this scale, the contribution of the Eastern Mount Lofty Ranges to the River Murray, Lake Alexandrina, Lake Albert and the Coorong is small and the impact of the Plan is difficult to measure compared with the variables that affect the remaining inflow to these systems. It is difficult for the Plan to contribute to the water requirements of connected systems in isolation, and it is important that an integrated approach be taken with water allocation plans for adjoining areas and for overarching plans such as the Basin Plan.

Extraction of surface water and watercourse water will reduce outflow from the Eastern Mount Lofty Ranges to the River Murray PWC, but given the scale as outlined above, this not anticipated or likely to have a significant impact on the availability to divert water for irrigation from the River Murray PWC in general. However, reductions in flow are likely to have a local-scale negative impact on the water-dependent ecosystems that occur at the interface between the Eastern Mount Lofty Ranges catchments and Lake Alexandrina.

The local impact of the Eastern Mount Lofty Ranges is very important for influencing water quality and maintaining unique aquatic habitats at the interface between the region's streams and Lake Alexandrina and the River Murray (e.g. see Phillips and Muller 2006). The Eastern Mount Lofty Ranges catchments are also important for providing flowing stream habitats required by migratory species (e.g. fish species that use marine and stream habitats for different parts of their life-cycle), and for providing aquatic refuge habitat during times of low water level in the River Murray and Lake Alexandrina.

As outlined in section 2, the consumptive use limits for the Eastern Mount Lofty Ranges have been set to provide water to the local environment, including the terminal wetlands at the end of the system where they meet the River Murray and Lake Alexandrina. These limits and water-taking rules will also provide a significant flow contribution to the River Murray and Lake Alexandrina, flowing onto connected systems.

Conditions in the River Murray and Lake Alexandrina directly affect the environmental condition of the lower reaches of the Eastern Mount Lofty Ranges streams, and the ability of users there to access water. This interaction was particularly apparent during the drought of the mid to late 2000s, when terminal wetland habitats dried up with associated loss of water-dependent species (e.g. Hammer 2009) and impacts on local water users.

There may also be local-scale impacts on users and the environment where licensees on one side of the boundary between the prescribed areas take water under a different set of rules compared to users on the other side of the boundary, within the same stretch of watercourse. Protecting low flows (at or below the threshold flow rate) has been identified as a key tool for providing part of the environmental water requirements in the Eastern Mount Lofty Ranges. River Murray licensees are not subject to this requirement, and where there is direct hydrological connection between the prescribed areas (e.g. the administrative boundary cuts across a single stream reach), extraction of low flows by River Murray licence holders may affect environmental water requirements, and potentially the ability of other users to access water.

It is recommended that consideration be given to more closely aligned water management policy between the prescribed areas for future reviews of the water allocation plan for the River Murray PWC.

In the meantime, the Plan includes a principle that applies key principles set out in the Plan to new River Murray water management authorisations proposed after the date of adoption of the Plan that would take water from the Finnis River and Tookayerta Creek upstream of the Winery Road crossings (near the end of these catchments).

Angas and Bremer flow contribution

An agreement was made between the State government and irrigators in 1994 to convert 21 GL of Angas Bremer PWA underground water allocations to River Murray PWC allocations. The agreement was formalised to address the over-allocation in the Angas Bremer PWA. The rationalisation for the allocation conversions was based on the principle that water contributions into Lake Alexandrina from the Angas and Bremer Rivers were not considered within the Murray-Darling Basin Cap, and that that water extracted from the River Murray would be offset by the Angas and Bremer River inflow. Review of the River Murray Cap during the late 1990s incorporated 15 GL of the 21 GL. The remaining shortfall of 6 GL must flow from the Angas and Bremer Rivers to Lake Alexandrina each year.

Review of basin outflow data from the Angas (site A4261073) and Bremer (site A4261072) Rivers at Ballandown Road for the period 2005 to 2008 averaged 1.8 GL/y and 3.7 GL/y respectively, giving a total outflow of 5.5 GL. It is anticipated that the required flow of 6 GL/y would occur provided surface water and watercourse extractions are managed in accordance with the provisions of the Plan. Ongoing monitoring of basin outflows over the life of the Plan is required to assess whether or not the policies in the Plan adequately minimise the impact to the River Murray PWC (refer to section 8).

3.4.1.2 Underground water

The Murray Group Limestone aquifer lies at the boundary between the Eastern Mount Lofty Ranges PWRA and Lake Alexandrina. It is a confined aquifer, and although the extent of the confining layer is unknown, it is unlikely there is significant discharge from this aquifer into Lake Alexandrina (S. Barnett, DWLBC, pers. comm. August 2008). Therefore taking underground water from the Eastern Mount Lofty Ranges PWRA is not anticipated or likely to have a significant impact on the River Murray PWC over the life of the Plan.

3.4.1.3 Water usage

It is widely recognised that underground water discharges to the River Murray in South Australia deliver large amounts of salt, previously stored in the soil to the river channel. Water applied to the land can result in increased drainage to the underlying salt laden underground water, and accelerate the movement of this underground water into the River Murray. The use of licensed Eastern Mount Lofty Ranges PWRA water allocations in the River Murray high or low salinity impact zones has the potential to have a detrimental effect on the quality of water in the River Murray PWC.

The use of Eastern Mount Lofty Ranges PWRA water in existing irrigation districts is unlikely to have a significant detrimental effect on the River Murray PWC. This is due to the current limited extent of irrigation utilising Eastern Mount Lofty Ranges PWRA water allocations within the River Murray high and low salinity impact zones.

However, any increase in the use of Eastern Mount Lofty Ranges PWRA water within the River Murray high or low salinity management zones has the potential to have a detrimental effect over the long term. To address this issue, it is important that land is irrigated efficiently, and that the allocation of water within the Eastern Mount Lofty Ranges PWRA complies with objectives a) and d) of section 5.1 and principles 5–8 of this water allocation plan.

3.5 UNPRESCRIBED NEIGHBOURING CATCHMENTS

Irrigation water used within the Ferries-McDonald and Mypolonga Flat catchments is provided from the River Murray. The irrigation area is limited to the irrigated swamps around the banks of the River

Murray. This includes the Mypolonga Irrigation Area, which depends on water from the River Murray to irrigate dairies and orchards. There are no permanent watercourses within these catchments and overland surface water flows toward the River Murray. This water does not contribute to the water resources of the Eastern Mount Lofty Ranges PWRA.

The low yield and high salinity of the underground water in the unconfined aquifer in this area means that only a small amount of water is extracted from this resource, predominantly for stock and domestic purposes. There is currently minimal use from the confined aquifer in this area for the purpose of irrigation, due to the high salinity. Water that is taken from this aquifer for irrigation purposes requires desalination.

3.5.1 Interconnection with the Eastern Mount Lofty Ranges PWRA

The potential effect of taking water from the Eastern Mount Lofty Ranges PWRA is not anticipated or likely to have a significant impact on the unprescribed neighbouring catchments. Conversely, taking water from the unprescribed neighbouring catchments is not anticipated or likely to have a significant impact on the Eastern Mount Lofty Ranges PWRA.

4 THE WATER MANAGEMENT FRAMEWORK FOR THE PLAN

Section 1.3 described Aboriginal water interests and cultural objectives and water needs. Section 1.6 described the resource capacity or amount of water available to meet all annual demands, on average, for the Eastern Mount Lofty Ranges PWRA. Sections 1.7 and 2.2 described the consumptive and environmental demands for water respectively within the Eastern Mount Lofty Ranges PWRA, and section 3 outlined potential impact of demand on water resources outside the Eastern Mount Lofty Ranges.

Under current conditions, the resource capacity of the water resources is not able to meet all of the demands, as the environmental water requirements in some areas are not being met, as discussed in section 2.3. It is also possible that consumptive demands for water are not being met for some water users. The community is concerned about the sharing of water between users, both at a local scale (e.g. impacts of dams on downstream neighbours and impacts of underground water level drawdown on neighbouring wells) and at a broader scale (e.g. sharing within catchments).

As outlined in section 1, the NRM Act requires a water allocation plan to achieve an equitable balance between environmental, social and economic needs when setting out principles for taking and use of water. It is important to acknowledge that these factors are inter-dependent. A healthy catchment is essential for supporting businesses that depend on natural resources and for supporting public benefit outcomes. In turn, a prosperous, sustainable community has a greater capacity to support the environment.

This section outlines a water management framework that provides a balance between social, economic and environmental needs for water. The management framework aims to meet the Plan's objectives and will be implemented through the water allocation plan and the associated licensing process. This section provides an overview of key parts of the water management framework while sections 5, 6 and 7 detail the principles that implement the framework by managing allocation, transfer and water affecting activities.

The Board, in formulating these objectives and principles has considered:

- the present and anticipated future needs of the occupiers of the land for water resources;
- the anticipated future capacity of land within the Eastern Mount Lofty Ranges PWRA for uses which differ from the present uses and the likely needs for water in association with those different uses;
- the likely effect of the allocation criteria on the value of the land within the Eastern Mount Lofty Ranges PWRA;
- the needs of the ecosystems that depend on the water resources; and
- alignment with the objects and objectives of the *River Murray Act 2003*.

The water management framework to be implemented by the Plan has been developed based on the best available information. However the actual performance of the Plan in managing the capacity of water resources to meet demands will be evaluated from monitoring data, as outlined in section 8.

4.1 OVERALL APPROACH IN SETTING THE MANAGEMENT FRAMEWORK

4.1.1 Risk assessment

Key risks associated with taking and using water from the Eastern Mount Lofty Ranges PWRA include potential impacts on:

- water-dependent ecosystems (risks and current impacts described in section 2.3);
- water quantity and/or quality available to users of water resources within the Eastern Mount Lofty Ranges PWRA (where current and likely future demands are outlined in section 1.7, and the effects of taking water on the water resources and other users is outlined in sections 4.2.1 and 4.3.1);
- water quantity and/or quality available to users of water resources outside the Eastern Mount Lofty Ranges PWRA (where potential for interactions are described in section 3); and
- other natural resources (e.g. effects of irrigation on soil structure and salinity).

In the development of the Plan, the Board has considered the likelihood and consequences of these risks and addressed them as appropriate through the allocation, transfer, permits and monitoring sections of the Plan. Section 4 provides an overview of the water management framework developed to address key risks. Future risks and consequences will be managed through regular monitoring, evaluation and assessment of the resource and environment as set out in section 8, which will assist in the review of the Plan within ten years of adoption.

There are other processes that affect water resources that are outside the scope of the Plan to address. Rural and urban land use and land management practices have significantly affected the quantity and quality of surface and underground water resources. Activities that may affect water resources include native vegetation clearance, land management practices (e.g. stock access to watercourses, effects of different types of land cover on quantity and quality of runoff), the application of agricultural chemicals, domestic wastewater disposal, urban development and industrial activities. Such activities may present a risk to the sustainable use of water resources in the future.

There are a range of other statutory mechanisms that play a role in managing these other activities that may affect water resources, including:

- *Native Vegetation Act 1991* (manages clearance of native vegetation);
- *Development Act 1993* and council Development Plans (key mechanisms for managing development and land use);
- *Environment Protection Act 1993* and the *Environment Protection (Water Quality) Policy 2003* (key mechanisms for managing pollution of water); and
- NRM Act (includes requirement to act reasonably in relation to management of natural resources, with provisions in relation to management of land, water and pest plants and animals).

The Board's Regional NRM Plan aims to guide the approach to natural resources management throughout the region, complementing other tools such as the other statutory mechanisms outlined above. This water allocation plan forms a part of the Regional NRM Plan, which has a much broader scope to consider factors affecting water resources.

The Regional NRM Plan sets out targets for the desired state and condition of natural resources across the region, and identifies a range of strategies and actions for achieving those targets, including targets and actions relating to water quality (including land use and land management influences), water use, aquatic biodiversity and community engagement and capacity building. The Board will continue to work with stakeholders, including agencies, local government, other bodies and the broader community, towards achieving those actions and targets.

4.1.2 General approach for setting consumptive use limits

A key part of the water management framework is balancing competing demands within the supply or capacity of the resource. The overall approach has been:

1. Assessment of the water resource capacity that is likely to be available for all demands on a continuing basis, based on previous water resource behaviour and patterns (section 1.6).
2. Setting aside the system provisions (water for system processes and environment provisions), and determining a consumptive use limit with associated taking rules that will meet the stated environmental water provisions (section 2.4). Environmental water provisions have been determined that have an acceptable level of impact on water-dependent ecosystems in the context of other demands, existing water-taking infrastructure and available management tools. The consumptive use limit applies to the amount of water taken for all purposes, including non-licensed use (including stock and domestic use and commercial forests) and licensed use. In the case of surface water and watercourses, water loss via evaporation from dams is also included to create an evaporation and consumptive use limit (this term is included in the general definition of consumptive use limit).
3. Setting aside the full amount of estimated non-licensed demand (including stock and domestic use and commercial forests) and/or accounting for the impact of non-licensed water capture infrastructure, against the consumptive use limit. The amount of water taken for these purposes is generally not regulated by the Plan, except in the case of the potential requirement for a water affecting activity permit for new commercial forestry (see section 7.2.9), or indirectly by managing the size of the dam in the case of construction of new dam capacity. Therefore the full volume of non-licensed water requirements needs to be set aside to avoid consumptive use exceeding supply.
4. Assuming the remaining available water within the consumptive use limit will be available for allocation for licensed consumptive use to existing users.
5. Allowing new allocation, transfer and water affecting activities within the consumptive use limits, together with other taking and location rules as appropriate.

The consumptive use limits and water-taking rules apply at different scales. Sections 4.2 and 4.3 describe the application of this overall approach in surface water plus watercourse water; and underground water respectively.

The consumptive use limits have been set with regard to interaction between the resources. For example, 100% of estimated baseflow has been set aside when determining the consumptive use limit for underground water, in order to protect this ecologically important part of the water regime on the surface and in watercourses.

There are several types of allocations that sit 'outside' the consumptive use limits for accounting purposes (i.e. the volume of these allocations is not accounted for against the consumptive use limits). These include:

- Rollover allocations (see section 4.1.2.1) – allows allocation of unused allocation in later years, with the potential for the consumptive use limit to be exceeded by a limited amount in some years provided use is less than the consumptive use limit in others. Long-term average use is still within the consumptive use limit.
- Ecosystem allocations from the system provisions (see section 4.1.3) – where the system provisions (in its simplest form) is water that has been set aside from the resource capacity for system processes and environmental provisions, and is not available for allocation for consumptive purposes.

- Lower Angas Bremer allocations (see section 2.4.2.3) – water that may be allocated under the existing user allocation process to some watercourse diverters in the lower Angas Bremer region, under specific water-taking rules that aim to meet environmental water provision targets.
- Roof runoff and urban runoff allocations (see section 4.2.3) – allows allocation of ‘additional’ runoff generated from impervious surfaces (in addition to mean annual adjusted runoff, which is what the consumptive use limit is based on).
- Recharge allocations – allows allocation of water artificially discharged or drained into a well (in addition to natural recharge, which is what the consumptive use limit is based on).

4.1.2.1 Rollover of unused allocations

The amount of water required from a licensed source may vary over time. For example, crops may require more water in a drier year, or users with both licensed wells and dams may take more from a well in a drier year when their dam has captured less water. The Plan aims to provide users with some flexibility to manage varying water demand over time by allowing an unused water allocation to be rolled over for use in a later water use year under certain conditions as ‘rollover allocations’. Rollover allocations sit outside the consumptive use limit.

This flexibility needs to be balanced against resource management considerations. The amount that can be rolled over is capped at 10% of allocation. This is considered to be the maximum amount of water that the water resources can sustain to be taken in addition to the consumptive use limit, in the circumstance that all licensed users take their rollover allocation as well as their base allocation in the same year. The total volume taken over the long-term will be the consumptive use limit, as the years when extra water is taken as rollover allocations will be offset by the years when less than the full allocation is taken to give rise to rollover allocations. The rolled-over allocation also has a limited ‘life’ of one year (for surface water and watercourses) or two years (for underground water), to recognise that the saved water continues to move through the landscape and is only available at the source for a limited period.

4.1.3 Ecosystem allocations

The Plan makes provision for ecosystem allocations to be granted for the purposes of maintaining, rehabilitating or restoring locally indigenous water-dependent assets for a purpose and in a manner accredited by the Minister responsible for administration of the NRM Act (‘the Minister’). These allocations may be granted from within the consumptive use limit.

Ecosystem allocations may also be granted from within the system provisions, which in its simplest form is water that has been set aside from the resource capacity for system processes and environmental provisions, and is not available for allocation for consumptive purposes. That is, these ecosystem allocations from the system provisions are granted from outside the consumptive use limit. These allocations may only be granted for the purposes of maintaining locally indigenous water-dependent assets that are at risk due to an inappropriate, insufficient or declining water regime; or for providing water to red gum swamps on the floodplains of the lower Angas and Bremer Rivers (as discussed in section 2.4.2.3).

The system provisions support both consumptive and environmental users by supporting system maintenance processes, such as seepage losses, transmission of water through the catchment, transporting materials, channel maintenance and maintenance of water quality (e.g. flushing salt). The system provisions also include environmental water provisions.

4.2 SURFACE WATER AND WATERCOURSE WATER MANAGEMENT FRAMEWORK

4.2.1 Impacts of surface water and watercourse water resource development

Water interception and extraction by dams, watercourse diversions and plantation forestry reduces the volume of downstream flows. The reduced flow has the potential to reduce water availability to downstream users and the environment, and reduce recharge to the aquifers, particularly where losing stream reaches have been identified (as shown in Figure 1.9).

Farm dam construction and direct pumping from watercourses have significantly changed the streamflow pattern within the Eastern Mount Lofty Ranges PWRA, particularly during drier months (as described in section 1.5.4). Farm dams provide the primary source of surface water for stock, domestic and irrigation purposes in the upper part of the Eastern Mount Lofty Ranges PWRA. Although dams provide water for these purposes, they also prevent surface water flow downstream until the dams fill and over flow. This delays the commencement of flow at the beginning of the wet season and prolongs the summer low to no flow periods, affecting the downstream flow regime. This has a negative impact on water-dependent ecosystems, as described in section 2.3.

4.2.2 Management options for surface water and watercourses

Three major tools available for managing surface water and watercourse water taking are:

- interception or capture limits and rules: managing dam capacity and the volume intercepted by plantation forestry;
- consumptive use or extraction limits: managing the volume allowed to be taken from a dam or watercourse or by a forest; and
- diversion or taking rules: managing the pattern of water diversion or taking, such as not capturing flows below a defined threshold flow rate (bypassing low flow) or managing the pumping rate from a watercourse.

The framework manages surface water and watercourse water using these different tools at different scales in order to manage different types of impacts and issues, as outlined in Table 4.1. The limits and rules at all scales need to be considered in combination. If any limit is exceeded, then new allocation, transfer, new dam construction or new commercial forestry cannot occur. It is important to note that this table summarises key water management policies included in sections 5–7 of the Plan, but does not cover the requirements of these sections comprehensively. The principles in sections 5–7 of the Plan refer to the tables and figures included at the end of section 4, but not every aspect of these tables and figures are discussed in section 4.

Section 2.4.2 discusses environmental water provisions set for surface water and watercourse water management. Some of these provisions are specific to a local area, and are not included in Table 4.1 (e.g. watercourse diversion rules for lower Angas and Bremer Rivers). Selected aspects of the management framework are discussed further below.

Table 4.1 Major elements of the surface water and watercourse management framework.

Surface water and watercourses		
Management scale	Management objectives	Management approach
Catchment (Figure 4.2).	<ul style="list-style-type: none"> Sharing available water across the whole catchment. Provide for ecosystems at the end of the catchments. 	<p>A resource capacity for each surface water catchment has been set on the basis of local rainfall and runoff characteristics.</p> <p>Surface water catchment-scale evaporation and consumptive use limits (catchment evaporation and consumptive use limit) and interception limits (catchment interception limit) have been set. Transfers can occur within a surface water catchment and between surface water catchments provided the evaporation and consumptive use limit is not exceeded, or further exceeded.</p> <p>New allocations and use and evaporation from new dam capacity and new commercial forests* must not cause the catchment evaporation and consumptive use limit to be exceeded, or further exceeded.</p> <p>New dam capacity and new commercial forests must not cause the catchment interception limit to be exceeded, or further exceeded.</p>
Surface water management zones (Figure 4.3 to Figure 4.9)	<ul style="list-style-type: none"> Recognise different rainfall and runoff characteristics and levels of demand throughout the catchment. Protect water-dependent ecosystems throughout the catchment by setting management zones on the basis of reach types, and setting limits that provide an appropriate water regime by the downstream end of a zone/upstream end of the next zone. Allows flow extraction in a downstream zone to take up available water from 	<p>Evaporation and consumptive use limits have been set for each surface water management zone (given in Table 4.5) on the basis of meeting environmental water provision objectives (section 2.4.2). These are the runoff evaporation and consumptive use limit and the main watercourse evaporation and consumptive limit, as described in section 4.2.2.1.</p> <p>Transfers may occur between and within surface water management zones subject to these limits (and the limits at other scales outlined in this table – as applies to all other management approaches also).</p> <p>The volume that can be allocated as a new allocation or transfer must not cause evaporation plus consumptive use to exceed or further exceed either of these limits, either in the surface water management zone that the water will be allocated in, or in any downstream surface water management zones that may be affected by the allocation.</p> <p>This means that:</p> <ul style="list-style-type: none"> The total evaporation plus consumptive use in a surface water management zone that is not taken from the main watercourse can't exceed the runoff evaporation and consumptive use limit for that zone. Any allocation over the runoff evaporation and consumptive use limit can only be taken from the main watercourse (if there is water available within this limit), as the main watercourse is the source of any extra water.

Surface water and watercourses		
Management scale	Management objectives	Management approach
	<p>the limit of an upstream zones, as long as no zones exceed either the runoff evaporation and consumptive use limit or the main watercourse evaporation and consumptive use limit.</p>	<ul style="list-style-type: none"> • Able to transfer within a zone where relevant evaporation and consumptive use has reached the limits, with limitations including: <ul style="list-style-type: none"> ○ If the runoff evaporation and consumptive use limit is exceeded, allocations from the main watercourse cannot be transferred to be taken from the runoff evaporation and consumptive use limit in that surface water management zone. ○ If the main watercourse evaporation and consumptive use limit is exceeded, an allocation may be able to be transferred between the main watercourse and the rest of the zone, up to the runoff evaporation and consumptive use limit. • Transfers will not be allowed to a zone where the sum of upstream and local evaporation and consumptive use has exceeded the main watercourse evaporation and consumptive use limit, even if the local runoff evaporation and consumptive use limit has not been exceeded. <p>An additional volume of water has been identified for allocation to existing users in the most downstream zones in the Angas and Bremer catchments, subject to particular taking rules. This type of allocation has more limited transfer rules as it is specific to the nature of the landscape and infrastructure in the lower Angas Bremer area.</p> <p>Interception limits have been set at the surface water management zone scale (given in Table 4.5). New dam capacity and new commercial forests must not cause the surface water management zone interception limit to be exceeded, or further exceeded.</p> <p>Use and evaporation from new dam capacity and new commercial forests must not cause either of the evaporation and consumptive use limits to be exceeded or further exceeded, either in the surface water management zone that the activity would occur in, or in any downstream surface water management zones that may be affected by the activity.</p>
Dam and property	<ul style="list-style-type: none"> • Sharing water at a local scale. • Recognising physical limitations on the amount of water available at a location. 	<p>Flows at or below a threshold flow rate must be bypassed, returned or not captured by existing licensed dams and other diversion structures, as well as by existing dams only used for non-licensed purposes with a capacity of 5 ML or more, as a key part of the environmental water provisions. Any new diversion structure (used for licensed or non-licensed purposes) must bypass, return or not capture flows at or below the threshold flow rate.</p>

Surface water and watercourses		
Management scale	Management objectives	Management approach
Dam and property (cont.)	<ul style="list-style-type: none"> Protecting users from impacts at a local scale. 	<p>Allocations must not exceed dam capacity minus mean net annual evaporation, unless it can be demonstrated that more than that volume can be taken annually on average.</p> <p>Allocations and water intercepted by new commercial forests must not exceed available runoff, which is mean annual adjusted runoff to the point of taking, minus upstream consumptive use, ecosystem allocations (system provisions) and upstream estimated mean net annual evaporation from dams.</p> <p>Allocations, new dam capacity and new commercial forests must not affect the ability of downstream users to access their consumptive demand, on average. That is, these activities must not cause the total demand at and upstream of a point to exceed supply to that point for diversion structures that may be affected by the allocation.</p> <p>New dam capacity must not cause total interception on a property to exceed 30% of the runoff from that property, or total dam capacity on the property to exceed twice the reasonable requirements for water from dams for the property.</p> <p>New dams must be constructed off-stream, unless there is no suitable location on the property to do so.</p>
Significant environmental asset (SEA) (Figure 4.11)	<ul style="list-style-type: none"> Protect environmental water provisions for SEAs at a local scale. 	<p>Allocations, use and evaporation from new dam capacity and new commercial forests must not cause total evaporation plus consumptive use to exceed the local evaporation and consumptive use limit for the catchment area upstream of a significant environmental asset.</p> <p>Water will not be allocated to be taken from the location of a significant environmental asset, unless originally allocated to an existing user be taken from that point, with no subsequent change in location of point of taking, allocation volume or licence conditions.</p> <p>New diversion structures cannot be constructed at the location of a significant environmental asset.</p> <p>Setback distance between new commercial forests and significant environmental assets (also environmental assets, watercourses and drainage lines) – role in managing water regime (including water quality) and habitat.</p>

* References to new commercial forests in this table will only be applicable once commercial forestry is regulated as a water affecting activity – see sections 7.1 and 7.2.9.

4.2.2.1 Scales of management for surface water and watercourses

The management framework applies from the catchment scale down to the individual source scale (e.g. dam or watercourse diversion), as shown in Table 4.1. Section 2.4.2.4 describes the environmental significance of different scale of management.

Surface water management zones

The catchments have been divided into surface water management zones, shown in Figure 4.3 to Figure 4.9, in order to recognise different rainfall and runoff characteristics throughout the catchment. Managing water taking at the scale of the surface water management zone also ensures that an environmentally adequate water regime is provided by the end of each zone. To this end, the surface water management zones have partly been defined on the basis of environmental reach types, as described in section 2.4.2.4.

4.2.2.2 Evaporation and consumptive use limits for surface water and watercourses

The evaporation and consumptive use limit is the quantum of water which is available for consumptive purposes, including licensed and non-licensed purposes, and for loss from dams as mean net annual evaporation, after considering system and environmental provisions. The evaporation and consumptive use limit has been set for each surface water catchment and surface water management zone and is shown in:

- Table 4.3 (for catchments – called the catchment evaporation and consumptive use limit); and
- Table 4.5 (for zones – called the runoff evaporation and consumptive use limit and the main watercourse evaporation and consumptive use limit – discussed further in this section).

As described in section 2.4.2, the evaporation and consumptive use limit relies on flows at or below the threshold flow rate being returned around licensed dams and watercourse diversions as well as dams used for non-licensed purposes with a capacity of 5 ML or greater. Table 4.5 also includes the unit threshold flow rate for each surface water management zone, which is used to calculate the threshold flow rate for a dam or watercourse diversion as set out in section 5.

The flow metrics and environmental water provision objectives have been used to help set these evaporation and consumptive use limits, and associated water-taking rules, as described in section 2.4.2. Restricting total demand and evaporative loss to the evaporation and consumptive use limit, together with returning flows at or below the threshold flow rate around licensed dams and watercourse diversions and non-licensed dams of 5 ML capacity or more, is expected to provide sufficient flow and a water regime that provides an acceptable level of risk to the water-dependent ecosystems with the Eastern Mount Lofty Ranges PWRA. The environmental water provision objectives were set in the context of the existing level of development and the limited ability to manage existing non-licensed use. This level of environmental water provision is a balance between social, economic and environmental needs for water.

The volume of demand counted against the evaporation and consumptive use limit generally includes all water taken from an area, including estimated non-licensed use and net evaporation. This is because a downstream user or ecosystem is impacted by water that is taken or lost upstream, regardless of the purpose or mechanism.

Non-licensed use is to be estimated at the time of assessment of an allocation, transfer, variation or permit, based on infrastructure and commercial forest areas at the time of assessment.

Evaporation

Evaporation has been explicitly included as part of the limit for surface water and watercourses in the Eastern Mount Lofty Ranges. This provides a mechanism to allow more consumptive use from areas with lower evaporation (i.e. less dam capacity) while the total volume lost from the water resource stays the same. This situation may occur in an area with a high level of watercourse diversion and a low level of dam development.

A watercourse allocation is metered at the point of extraction from the watercourse, and so accounts for the total volume lost from the resource as part of the allocation. An allocation from a dam is metered at the point of extraction from the dam, and doesn't include the evaporation from the dam. Net evaporation from dams is accounted for against the evaporation and consumptive use limit separately through the water licensing system. In both cases, the total loss from the resource is accounted for against the evaporative and consumptive use limit.

If mean net annual evaporation decreases in an area (e.g. if dam capacity is removed), that evaporation volume is no longer counted against the evaporative and consumptive use limit and may become available for consumptive use, subject to the other rules and limits within the Plan.

Net annual evaporation is the annual evaporation from the dam minus the annual rainfall falling onto the dam's surface, giving the net loss from the dam (excluding inflow, spills and seepage). The principles in the Plan set out how mean net annual evaporation is calculated. In general, this will be calculated as a proportion of dam capacity, using the relevant value given in column 'Estimated evaporation factor' of Table 4.5. These values are based from relationships between rainfall and modelled mean net annual evaporation volume from dams expressed as a percentage of dam capacity, derived from the surface water modelling over the period of 1974–2006 (see Alcorn 2011). An alternative value may be used in some circumstances if a permanent difference in mean net annual evaporation can be demonstrated.

Surface water management zone types and the different consumptive use limits

Table 4.5 identifies each surface water management zone as a headwater zone or a receiving zone. Headwater zones don't receive inflow from another zone, while receiving zones do, as shown schematically in Figure 4.1. A main watercourse is the watercourse in a receiving zone that receives inflow from another surface water management zone. Main watercourses in the Eastern Mount Lofty Ranges PWRA are shown in Figure 4.3 to Figure 4.9.

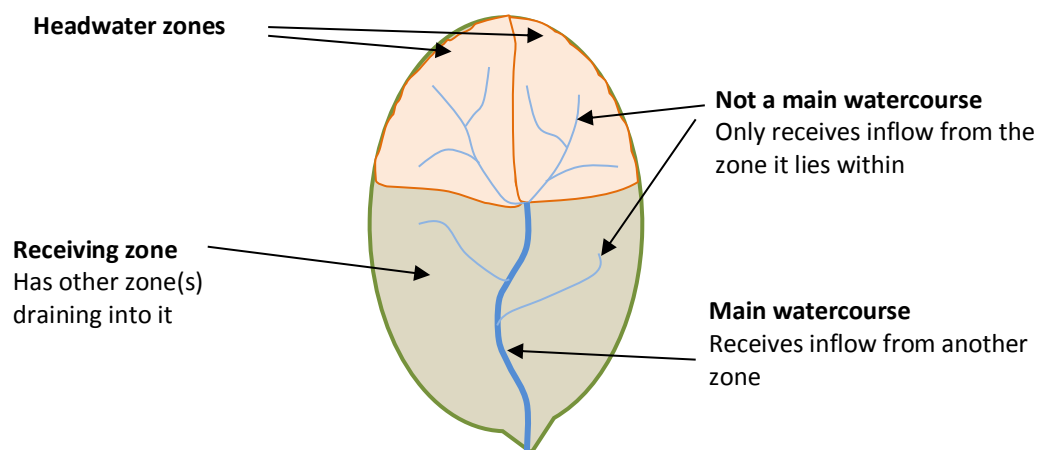


Figure 4.1 Schematic diagram of a catchment showing headwater zones, receiving zones, main watercourses and watercourses that are not main watercourses.

Table 4.5 gives two evaporation and consumptive use limits for each surface water management zone, which are the runoff evaporation and consumptive use limit and the main watercourse evaporation and consumptive use limit.

- **Runoff evaporation and consumptive use limit:** This limit is applicable to evaporation plus consumptive use from surface water and watercourses, outside of a main watercourse, within a surface water management zone. This limit has been calculated as 20% of the mean annual adjusted runoff from a surface water management zone.
- **Main watercourse evaporation and consumptive use limit:** This limit is a cumulative limit that applies to evaporation plus consumptive use from surface water and watercourses (including from main watercourses) for the surface water management zone being considered as well as all zones that drain into it. The limit has been calculated as the sum of (1) the runoff evaporation and consumptive use limit from the surface water management zone that is being considered; and (2) the runoff evaporation and consumptive use limit(s) of all surface water management zones that drain into it.

The purpose of the main watercourse evaporation and consumptive use limit is to recognise the movement of water through watercourses in the landscape, and allow a downstream surface water management zone to access runoff generated in an upstream zone which is not fully allocated.

These two limits work in tandem, and neither can be exceeded either locally or in downstream surface water management zones that may be affected by the allocation.

4.2.2.3 Interception limits for surface water and watercourses

It is important to note that the impact of dams on the water resources, users and the environment is not limited to the volume extracted from dams and watercourses. Dams trap all of the runoff from the upstream catchment area until they fill and spill. The presence of the dam (as a physical barrier to water movement) and the capacity of the dam have a key influence on the volume and pattern of downstream flow. The level of usage, evaporation and seepage from the dam will also affect how soon the dam fills and spills. Therefore it is important that the management framework takes both dam capacity and usage into consideration for all dams, including those used for licensed and non-licensed purposes.

The Plan includes volumetric interception limits that apply at the surface water catchment and surface water management zone scale (given in Table 4.3 and Table 4.5 respectively), set at 30% of mean annual adjusted runoff in order to meet the environmental water provision objective as described in section 2.4.2. These interception limits apply in the case of new dam capacity and commercial forestry.

4.2.3 Roof runoff and urban runoff

The management framework for surface water and watercourses discussed above does not apply to new allocations for roof runoff and urban runoff.

The volume of water that runs off a roof or an urban area is higher than the volume that would run off the same area of paddock or mixed land use. The Plan allows the difference in runoff between roofs/urban areas and mixed land use to be allocated on top of the evaporation and consumptive use limit, provided that the mean annual adjusted runoff and recharge from the site is returned to the environment. Returning adjusted runoff and recharge means that the site is still contributing flow as would be expected under the consumptive use limit calculations.

Urban runoff allocations given in this manner are only allowed for either:

- new urban developments approved and commenced after 16 October 2003 (coinciding with the date of the notice of intention to prescribe the water resources of the Eastern Mount Lofty Ranges). The extra runoff generated from this development is in addition to that considered during development of the Plan.

or

- urban development in catchments with very low runoff. The consumptive use limit in these areas is generally very low or even zero. Harvesting part of the additional intensive runoff events generated by

urban areas may provide benefits for stormwater management and water quality improvement. Such allocations are subject to an assessment on whether the requirements of water-dependent ecosystems and consumptive users will continue to be provided.

4.3 UNDERGROUND WATER MANAGEMENT FRAMEWORK

The underground water resources of the Eastern Mount Lofty Ranges PWRA, and their interactions with surface water and water-dependent ecosystems are highly complex and are not well understood, particularly for the Fractured Rock and Permian Sand aquifers. Therefore it is important to take a conservative approach to future use to protect the ecosystems and current users. An adaptive management framework is highly important.

4.3.1 Impact of underground water resource development

Pumping water from a well can result in a decrease in water level/pressure around the well ('drawdown'). The extent of drawdown around an individual well depends on the type of aquifer and the volume of water extracted from the well (i.e. the smaller the volume of water pumped from the well, the smaller the resultant drawdown).

Drawdown can adversely affect both neighbouring water users and the environment. If wells are located near a watercourse, drawdown during pumping can lower the water level so that underground water no longer discharges to the watercourse as baseflow. It may also lead to flow reversal where water flows from the watercourse to the aquifer.

At a larger scale, if the volume of outflows (extraction, throughflow and baseflow) from an underground water management zone is higher than the resource capacity, then the volume in storage, and hence the underground water level, may decrease. The water level may decrease below the depth of pumps or the roots of trees tapping into the underground water. A reduction in underground water level or pressure in an area with low salinity underground water may also draw in saline underground water from adjacent areas, either laterally or vertically.

As underground water moves through aquifers, a significant volume of water is naturally lost to watercourses via baseflow, and water also flows from one aquifer to another as throughflow. Alteration of the water balance by extraction of underground water can reduce the amount of water available for baseflow and/or throughflow, to the detriment of other users and the environment. For example, the confined Murray Group Limestone aquifer is not recharged by rainfall, and instead one of its recharge mechanisms is via throughflow. If the entire recharge rate of the aquifers contributing flow to the confined aquifer was extracted for consumptive use, then throughflow to the confined aquifer would be significantly reduced.

Baseflow also provides a significant contribution to many streams, particularly from the Permian Sands aquifers. Both the environment and water users reliant on that streamflow would be adversely impacted if high levels of extraction of underground water reduced the volume of water discharging to streams. Section 2.4.1 identifies the protection of baseflow as an important environmental water provision.

4.3.2 Management options for underground water

Three major tools available for managing the impacts of underground water taking are:

- limiting the volume of water that can be extracted for consumptive purposes from an underground water management zone;
- identifying areas of high intensity of use and restricting further licensed use in those areas; and
- managing the locations where transferred allocation can be taken or where new wells can be constructed, to minimise impacts to neighbouring water users and the environment.

As outlined in Table 4.2, the framework manages underground water using these different tools at different scales in order to manage different types of impacts and issues. The limits and rules at all scales need to be

considered in combination. If any limit is exceeded, then new allocation, transfer, new well construction or new commercial forestry cannot occur. It is important to note that this table summarises key water management principles included in sections 5–7 of the Plan, but does not cover the requirements of these sections comprehensively. The principles in sections 5–7 of the Plan refer to the tables and figures included at the end of section 4, but not every aspect of these tables and figures are discussed in section 4.

Key elements of the water management framework are outlined below.

A major difference between management of underground water compared with surface water is that dams used to capture surface water generally take more water from the resource than just the volume taken out of the dam, because of evaporative losses and physical blocking of flow. This means that the influence of the infrastructure needs to be taken into consideration when determining the volume being taken from the water resource. However, underground water users generally don't take more water than they need from a well. This means that the volume estimated to be taken from wells for non-licensed purposes (e.g. stock and domestic use) can be estimated as the volume needed for those purposes, rather than calculated at any point in time based on the number of dams like it is for surface water.

4.3.3 Consumptive use limits for underground water management zones

As described in section 1.6.2, underground water management zones have been defined based on aquifer type intersected with the surface water catchment boundaries. A consumptive use limit has been set at the underground water management zone scale to ensure that:

- outflows (consumptive use, throughflow and baseflow) does not exceed resource capacity; and
- water levels/pressures in the aquifer are maintained to enable continuation of natural processes such as baseflow and throughflow.

The approach for determining consumptive use limits for each underground water management zone (UWMZ) is to:

1. Determine the resource capacity. The resource capacity is equal to the long-term mean annual recharge or estimated throughflow into the aquifer (as described in section 1.6.2).
2. Estimate baseflow (as per section 1.6.2.1).
3. Estimate throughflow from underground water management zones where the primary recharge mechanism to aquifers that are down-gradient is not via rainfall (as per section 1.6.2.1).
4. From the resource capacity – subtract the sum of baseflow plus throughflow to give the consumptive use limit.

The consumptive use limit for each underground water management zone in the Eastern Mount Lofty Ranges PWRA is displayed in Table 4.7.

4.3.4 Local-scale underground water management

Identifying the volume of water that can be taken from an underground water management zone will not prevent local-scale impacts occurring, and additional management strategies are also necessary.

4.3.4.1 Buffer zones

In order to manage the impacts of drawdown on the environment and neighbouring water users, buffers are assigned to existing operational wells and environmental assets (including defined environmental assets such as permanent pools within watercourses, significant environmental assets and main watercourses). The buffer of a proposed new well or a well that a transfer would be taken from is not permitted to overlap the buffers assigned to environmental assets or existing wells, with some exceptions.

Table 4.2 Major elements of the underground water management approach.

Underground water		
Management scale	Management objectives	Management approach
Underground water management zone scale	<ul style="list-style-type: none"> • Allocate water sustainably. • Maintain natural flow through aquifers, including baseflow to the surface. • Maintain acceptable water quality. 	Establish consumptive use limit for each underground water management zone that sets aside baseflow and significant throughflow (where relevant).
High intensity use zone scale	<ul style="list-style-type: none"> • Maintain natural flow through aquifers, including baseflow to the surface. • Prevent future development of high intensity use zones. 	Prevent further development of high intensity use zones through allocation and transfer criteria
Well scale	<ul style="list-style-type: none"> • Minimise impacts to existing water users. • Minimise interference between wells. • Maintain water levels to acceptable levels/pressures. 	<p>Assign buffer zones to all new wells and existing operational wells. Allocation, transfer and new well not permitted if it would overlap another user's buffer zone (some exceptions).</p> <p>Transfer not permitted from wells with water of >1,600 mg/L to wells with water of <1,400 mg/L in Angas Bremer Limestone and Currency Creek Limestone underground water management zones.</p>
Environmental asset scale	<ul style="list-style-type: none"> • Protect environmental assets from degradation. 	<p>Assign environmental buffer zones to main watercourses, environmental assets and significant environmental assets. Allocation, transfer, and new wells not permitted if they or their buffer zone overlaps an environmental buffer zone.</p> <p>Assign buffer distances from new commercial forestry* to drainage lines, main watercourses, environmental assets and significant environmental assets – includes a role in protecting assets from potential drawdown of underground water by forestry</p>

* References to new commercial forests in this table will only be applicable once commercial forestry is regulated as a water affecting activity – see sections 7.1 and 7.2.9.

The nature and locations of significant environmental assets and environmental assets used for the purposes of the Plan will be identified in a database that is able to be updated over time as new information becomes available. Indicative locations of significant environmental assets and environmental assets identified to the date of map production are displayed in Figure 4.11.

The radius of the buffer around an environmental asset or well will depend on the type of aquifer and for wells will also consider the type of use and volume of water that is extracted from licensed wells. The size of a buffer around any given well corresponds to the anticipated drawdown effect, and has been determined on the basis of information from studies of drawdown around wells in the Mount Lofty Ranges (e.g. Costar et al. 2009) and modelling information, together with consideration of the effects of different levels of extraction or drawdown, and different aquifer characteristics.

4.3.4.2 High intensity use zones

High intensity use zones are areas of high intensity use where the level of licensed allocation in a given area exceeds four times the mean annual recharge rate. Often in these zones, drawdown occurs around multiple wells to form a cone of depression which can result in flow reversal within an aquifer. Assigning buffers to wells will assist to prevent the future development of high intensity use zones. For current high intensity use zones, allocation and transfer principles will be used to prevent a further increase in demand within these zones. Transfers will not be permitted into high intensity use zones, but transfers will be permitted within and from inside a high intensity use zone to outside that zone.

4.4 INTERACTIONS BETWEEN WATER RESOURCES IN THE EASTERN MOUNT LOFTY RANGES PWRA

Underground water, surface water and watercourse water are connected and interactions are observed throughout the Eastern Mount Lofty Ranges PWRA as detailed in section 1.5.4 and displayed in Figure 1.9.

There are a number of locations in the Eastern Mount Lofty Ranges PWRA where surface water and underground water connectivity are observed to be particularly significant. Of these, the most significant are in the upper Angas River catchment, the south-western Finniss River catchment, and in the northern Tookayerta Creek catchment. Surface water flows in these areas are dependent on substantial discharges from underground water. In the southern Bremer River catchment (approximately 1 km downstream of Hartley) there is significant loss from the river to the underlying aquifer (Green and Stewart 2008).

As outlined in sections 4.2.1 and 4.3.1, the interactions between the water resources mean that taking water from one resource may affect another within the Eastern Mount Lofty Ranges PWRA. For example, extraction of underground water may reduce discharge of baseflow into watercourses or draw flow from watercourses into underground water. Conversely, in areas where watercourses naturally lose water to underground water, water capture in dams or diversion from watercourses may result in a reduction in streamflow and recharge to aquifers, resulting in a decline in the underground water resources.

Recognising that surface water and underground water resources in the Eastern Mount Lofty Ranges PWRA are fundamentally linked requires co-ordinated management of these resources. The Plan has taken a co-ordinated management approach to provide for the connectivity of the water resources, as outlined in section 4.3. For example:

- Baseflow from underground water to watercourses has been accounted for by setting this volume aside when determining consumptive use limits for underground water (see section 4.3.3).
- At a local scale, buffer zones around main watercourses and environmental assets aim to reduce the likelihood of interference from new allocations, transfers or new wells (see section 4.3.4.1).

The unique situation in the Tookayerta Creek catchment provides an opportunity for limited joint management of the water resources in this area. Baseflow from underground water is a significant component of watercourse flow in the catchment, and there is close and rapid exchange between the

resources. The resulting permanent flow means many users use water directly from watercourses as required throughout the year, rather than relying on water captured in dams over winter to spring for use in summer and autumn.

It is anticipated that there is a high demand for underground water in that area. High demand for underground water may affect watercourse flow and the users that are highly dependent on that flow, including the environment. Conversely, taking less water from watercourses may mean that more water can be taken from the underground water, as less water needs to be set aside from the underground water resource capacity to provide for baseflow used for consumptive purposes.

The Plan includes a joint limit for all water resources in the Tookayerta area, which sets the limit to the total combined volume of surface water, watercourse and underground water resources that may be taken in the area. The value of the joint limit is set as the sum of the limit for surface water and watercourses in the Tookayerta catchment and the limit for the Tookayerta Permian underground water management zone. This approach provides more flexibility for allocations in the area (particularly for the separate existing user allocation process) by allowing higher demand in one resource to be offset if there is lower demand for the other.

The joint limit works together with the limits for each resource to help to mitigate potential effects of high demand by restricting further movement of water into the area or into individual resources, if necessary. In most circumstances, the limit at the scale of the surface water catchment and underground water management zone (described in sections 4.2.2.2 and 4.3.3) provide suitable caps for each water resource in the Tookayerta area.

However, if the joint limit has been exceeded, a further restriction applies to prevent new net water use in either resource – even if an individual resource is under its local limit. The joint limit would prevent additional water from being taken in the Tookayerta area in this case, but wouldn't restrict movement of allocations between water resources in the area. It would be undesirable for water to move from a high demand resource to a lower demand resource in this case. The lower demand resource is under its own limit, but would be under pressure from the high joint demand. Allowing more water to be taken from the lower demand resource would exacerbate this pressure.



Figure 4.2 Eastern Mount Lofty Ranges surface water catchments.

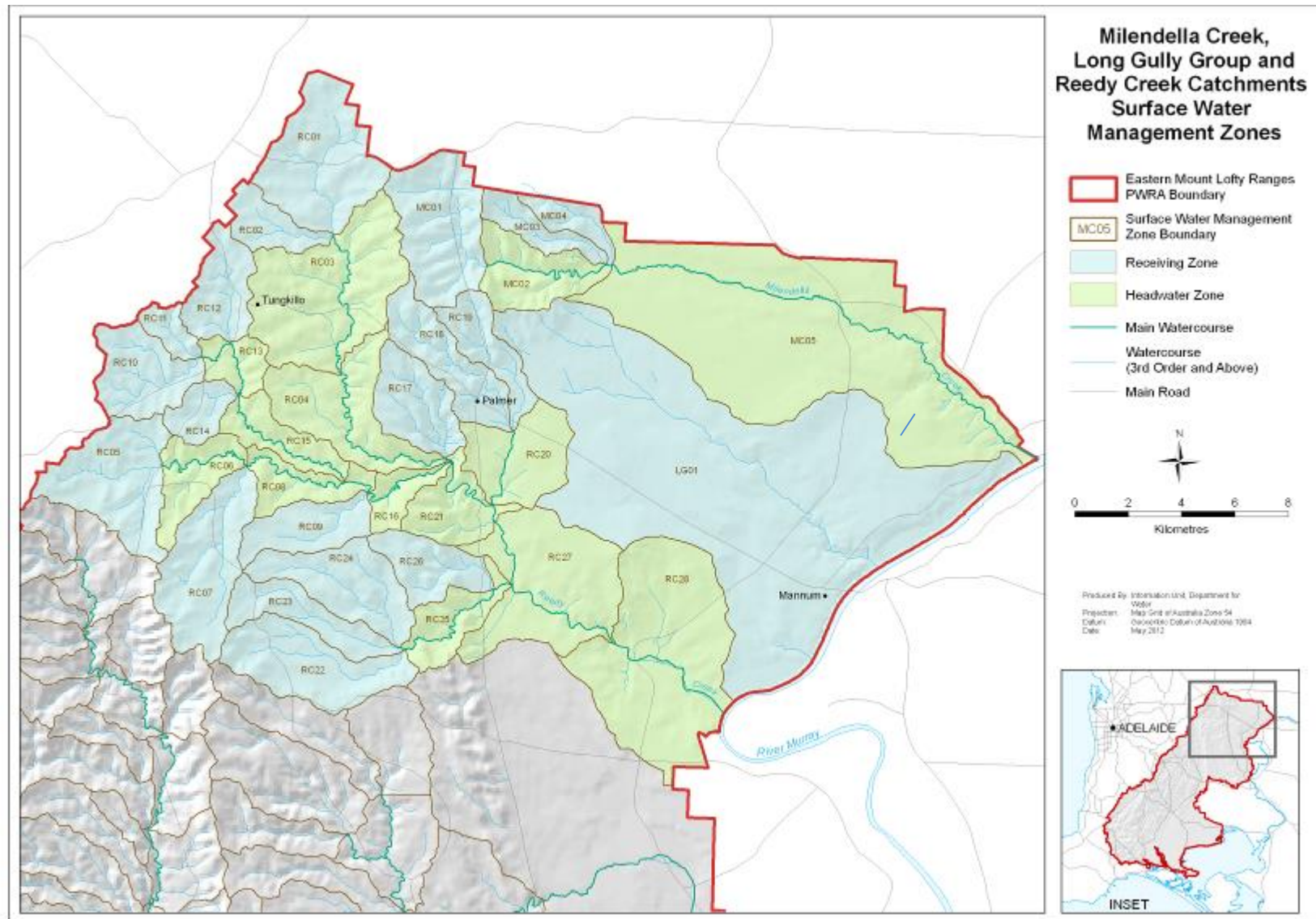


Figure 4.3

Eastern Mount Lofty Ranges surface water management zones (Milendella Creek to Reedy Creek).

Note that zone names have been shortened for clarity. The full zone name is 426yy0zz, where yy are the letters given in the map and zz are the numbers given in the map for the zone name.

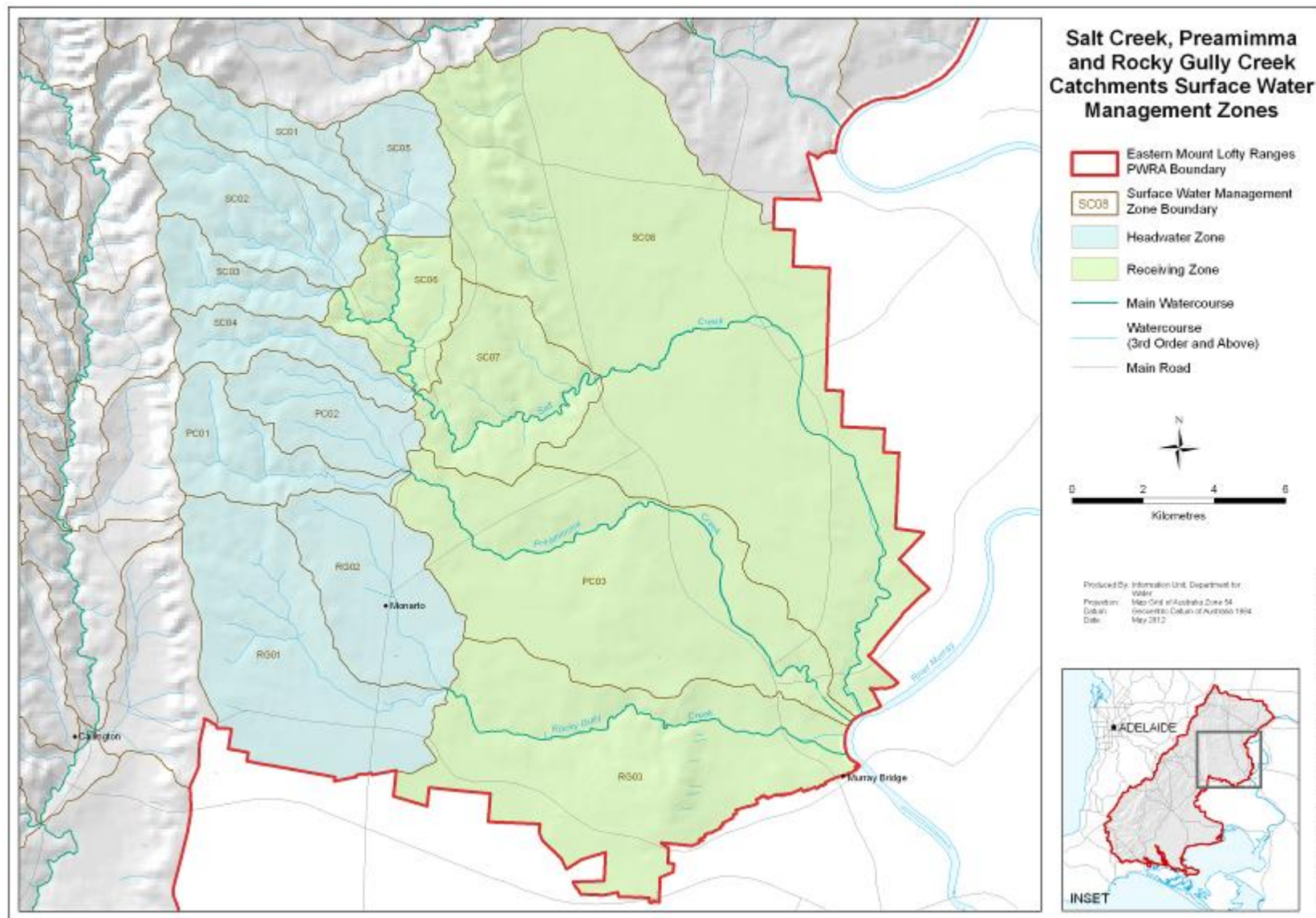


Figure 4.4 Eastern Mount Lofty Ranges surface water management zones (Salt Creek to Rocky Gully Creek).

Note that zone names have been shortened for clarity. The full zone name is 426yy0zz, where yy are the letters given in the map and zz are the numbers given in the map for the zone name.

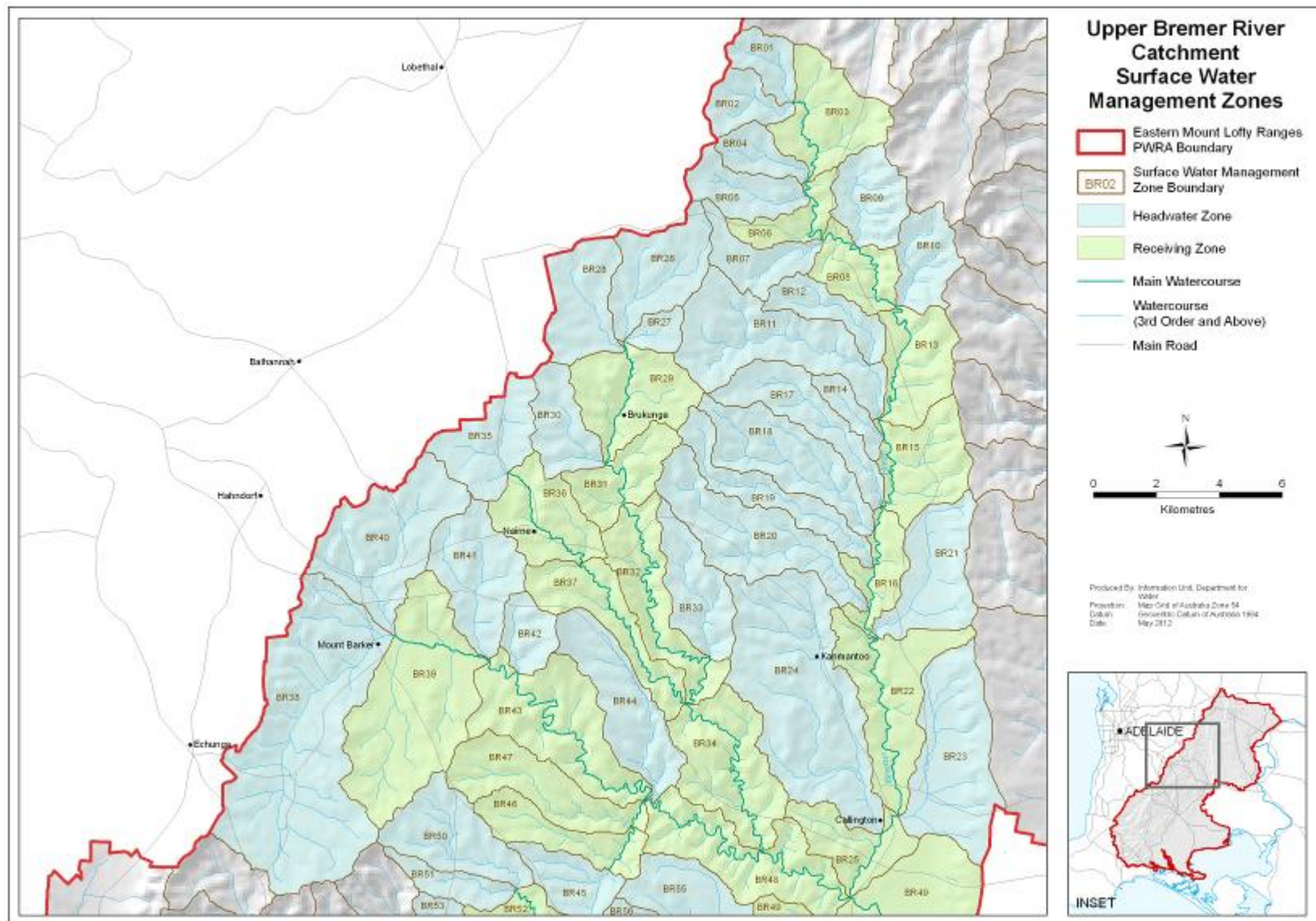


Figure 4.5 Eastern Mount Lofty Ranges surface water management zones (Upper Bremer).

Note that zone names have been shortened for clarity. The full zone name is 426yy0zz, where yy are the letters given in the map and zz are the numbers given in the map for the zone name.

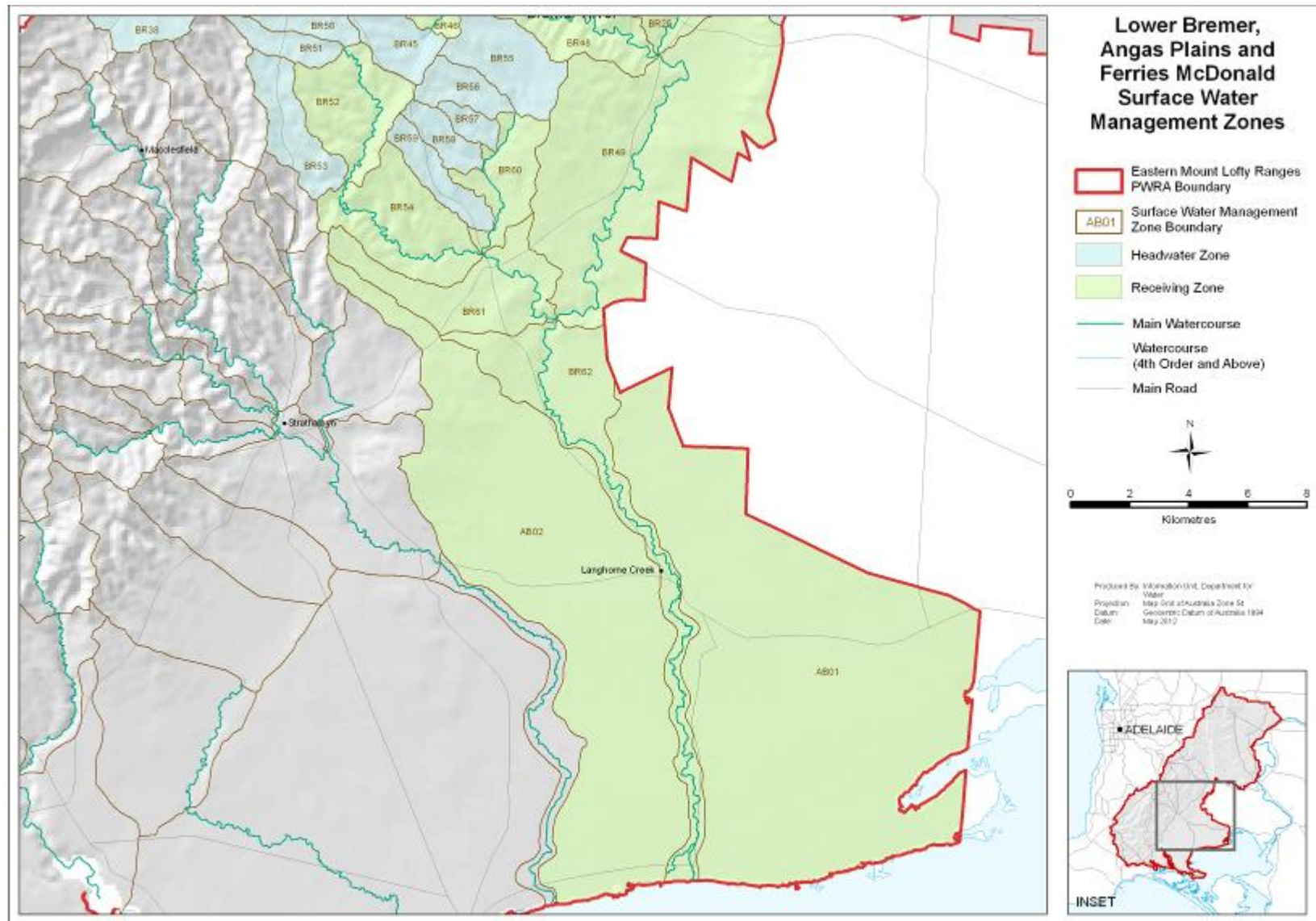


Figure 4.6 Eastern Mount Lofty Ranges surface water management zones (Lower Bremer, Angas Plains and Ferries-McDonald). Note that zone names have been shortened for clarity. The full zone name is 426yy0zz, where yy are the letters given in the map and zz are the numbers given in the map for the zone name.

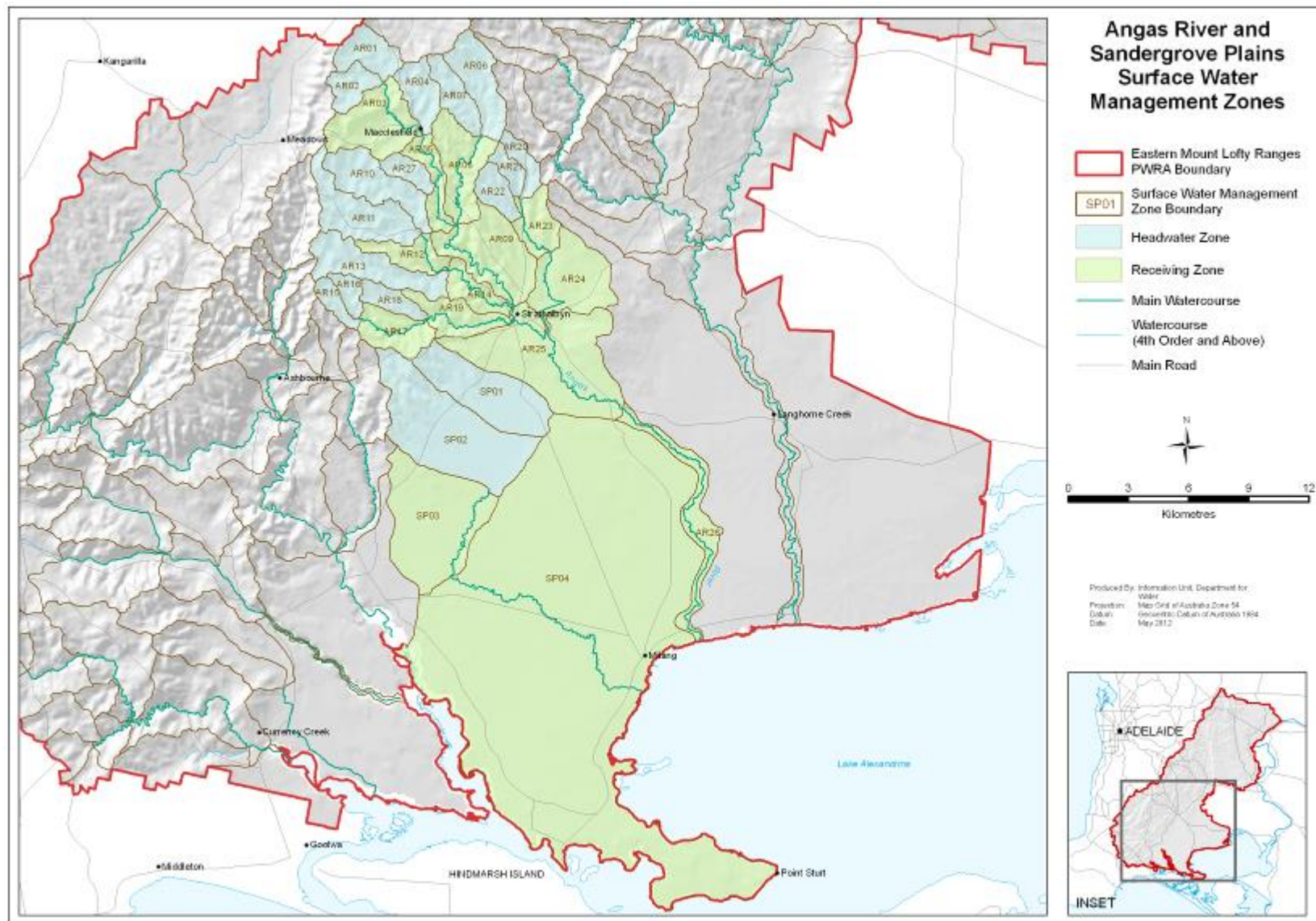


Figure 4.7 Eastern Mount Lofty Ranges surface water management zones (Angas River and Sandergrove Plains).

Note that zone names have been shortened for clarity. The full zone name is 426yy0zz, where yy are the letters given in the map and zz are the numbers given in the map for the zone name.

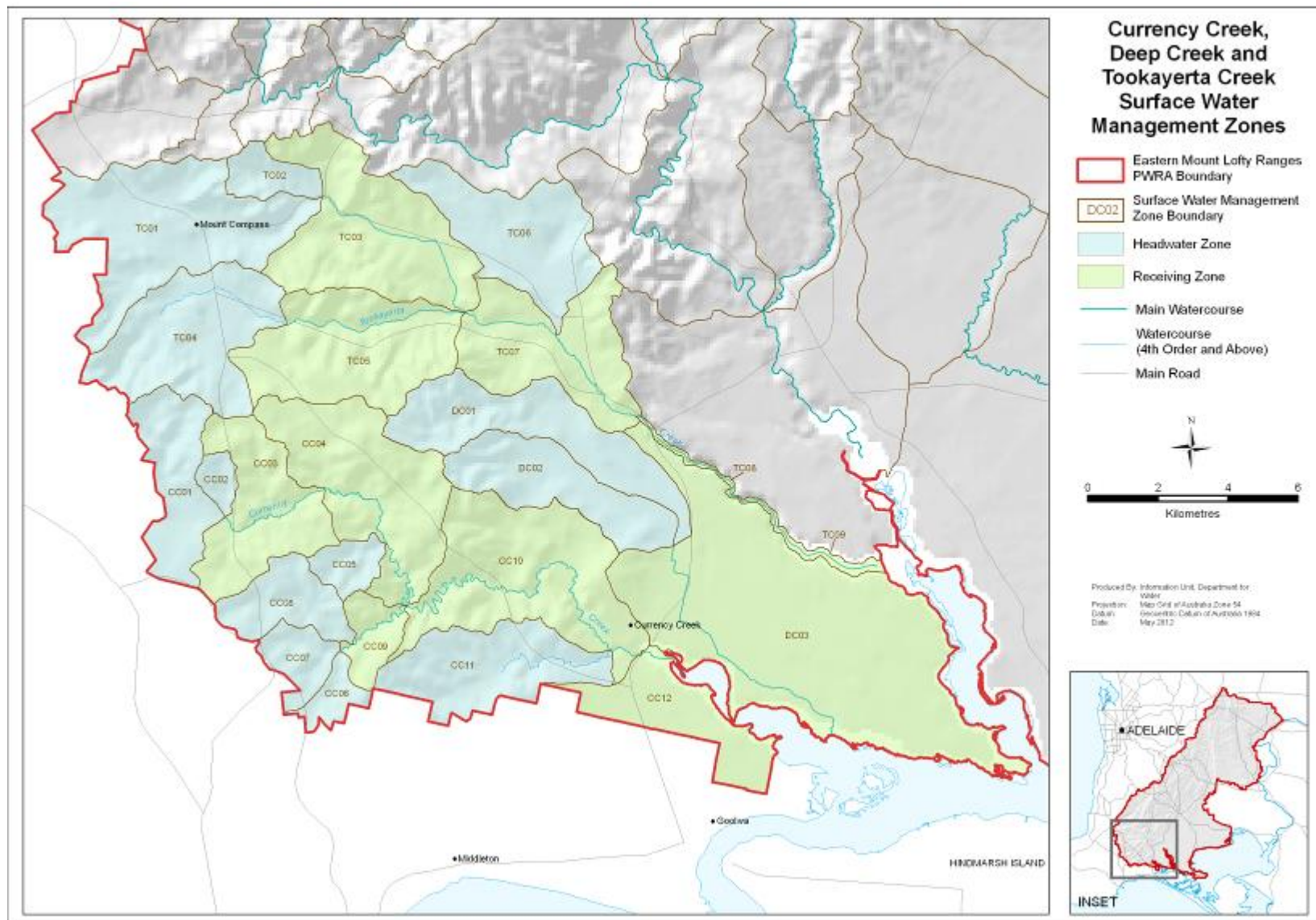


Figure 4.8 Eastern Mount Lofty Ranges surface water management zones (Currency Creek to Tookayerta Creek).

Note that zone names have been shortened for clarity. The full zone name is 426yy0zz, where yy are the letters given in the map and zz are the numbers given in the map for the zone name.

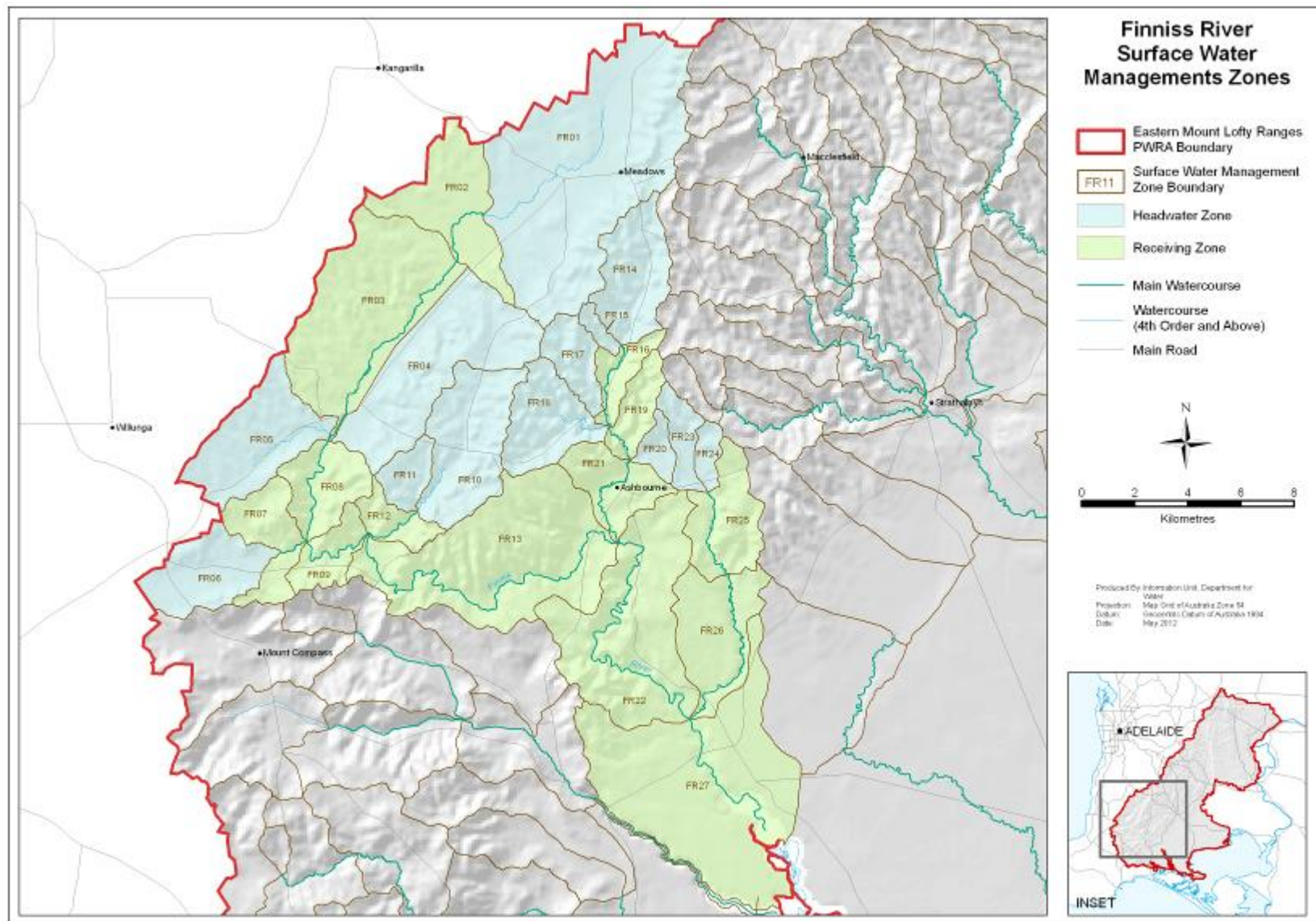


Figure 4.9 Eastern Mount Lofty Ranges surface water management zones (Finniss River).

Note that zone names have been shortened for clarity. The full zone name is 426yy0zz, where yy are the letters given in the map and zz are the numbers given in the map for the zone name.

Table 4.3 Catchment evaporation and consumptive use limit and interception limit for surface water catchments.

Surface water catchment	Catchment evaporation and consumptive use limit (ML)	Catchment interception limit (ML)
Angas Plains	0	0
Angas River	1,682	2,525
Bremer River	3,583	5,378
Currency Creek	1,612	2,418
Deep Creek	320	481
Ferries-McDonald	0	0
Finniss River	8,021	12,030
Long Gully Group	0	0
Milendella Creek	110	164
Preamimma Creek	0	0
Reedy Creek	1,192	1,790
Rocky Gully Creek	0	0
Salt Creek	123	184
Sandergrove Plains	288	432
Tookayerta Creek	4,620	6,928
Total	21,551	32,330

Table 4.4 Values for the regional limits and the joint Tookayerta limit

Limit	Value (ML)
Regional evaporation and consumptive use limit	21,551
Regional underground water consumptive use limit	45,333
Joint Tookayerta limit	7,463

Table notes for Table 4.4

The value of the regional evaporation and consumptive use limit has been calculated as the sum of the catchment evaporation and consumptive use limits for all surface water catchments in the Eastern Mount Lofty Ranges PWRA.

The value of the regional underground water consumptive use limit has been calculated as the sum of the underground water consumptive use limits for all underground water management zones in the Eastern Mount Lofty Ranges PWRA.

The value of the joint Tookayerta limit has been calculated as the sum of the catchment evaporation and consumptive use limit for the Tookayerta Creek catchment, and the underground water consumptive use limit for the Tookayerta Permian underground water management zone.

Table 4.5 Surface water resource capacity, evaporation and consumptive use limits, unit threshold flow rates, evaporation factor, interception limit, % roof runoff to return, and mean annual adjusted runoff + recharge depth, for surface water management zones.

Zone characteristics			Resource capacity		Evaporation and consumptive use limit (ECUL)		Unit threshold flow rate (all L/s/km ²)			Estimated evaporation factor (proportion of dam capacity)	Surface water management zone interception limit (ML)	% roof area to return	Mean annual adjusted runoff + recharge depth (mm)
Surface water catchment	Surface water management zone	Headwater / receiving	Resource capacity (ML)	Mean annual adjusted runoff depth (mm)	Runoff ECUL (ML)	Main watercourse FCUL (ML)	Surface water management zone	Main watercourse minimum	Main watercourse maximum				
Angas Plains	426AB002	Receiving	0	0	0	0	0.17	-	-	0.4	0	0	1
Angas River	426AR001	Headwater	592	103	118	118	2.52	-	-	0.1	178	20	167
Angas River	426AR002	Headwater	434	108	87	87	2.69	-	-	0.1	130	20	172
Angas River	426AR003	Receiving	1,013	86	203	408	1.94	2.22	2.69	0.1	304	15	106
Angas River	426AR004	Headwater	373	70	75	75	1.49	-	-	0.15	112	20	134
Angas River	426AR005	Receiving	227	46	45	562	0.92	1.18	2.22	0.2	68	10	66
Angas River	426AR006	Headwater	449	54	90	90	1.08	-	-	0.2	135	15	118
Angas River	426AR007	Headwater	286	58	57	57	1.18	-	-	0.15	86	15	122
Angas River	426AR008	Receiving	433	42	87	234	0.85	0.99	1.18	0.2	130	10	62
Angas River	426AR009	Receiving	283	20	57	853	0.44	0.99	1.74	0.3	85	5	40
Angas River	426AR010	Headwater	705	74	141	141	1.59	-	-	0.15	212	15	94
Angas River	426AR011	Headwater	885	79	177	177	1.74	-	-	0.1	266	15	99
Angas River	426AR012	Receiving	213	44	43	361	0.88	1.48	1.74	0.2	64	10	64
Angas River	426AR013	Headwater	632	62	126	126	1.27	-	-	0.15	190	10	82
Angas River	426AR014	Receiving	83	18	17	504	0.41	1.23	1.48	0.33	25	5	38
Angas River	426AR015	Headwater	185	76	37	37	1.64	-	-	0.1	55	15	96
Angas River	426AR016	Headwater	160	70	32	32	1.49	-	-	0.15	48	10	90
Angas River	426AR017	Receiving	271	41	54	123	0.81	1.07	1.64	0.25	81	10	61
Angas River	426AR018	Headwater	152	46	30	30	0.92	-	-	0.2	46	10	66
Angas River	426AR019	Receiving	132	21	26	179	0.47	0.82	1.07	0.3	40	5	41
Angas River	426AR020	Headwater	78	27	16	16	0.56	-	-	0.3	23	10	47
Angas River	426AR021	Headwater	69	30	14	14	0.62	-	-	0.25	21	10	50
Angas River	426AR022	Headwater	111	30	22	22	0.61	-	-	0.25	33	10	50

Zone characteristics			Resource capacity		Evaporation and consumptive use limit (ECUL)		Unit threshold flow rate (all L/s/km ²)			Estimated evaporation factor (proportion of dam capacity)	Surface water management zone intercession limit (ML)	% roof area to return	Mean annual adjusted runoff + recharge depth (mm)
Surface water catchment	Surface water management zone	Headwater / receiving	Resource capacity (ML)	Mean annual adjusted runoff depth (mm)	Runoff ECUL (ML)	Main watercourse ECUL (ML)	Surface water management zone	Main watercourse maximum	Main watercourse minimum				
Angas River	426AR023	Receiving	86	16	17	69	0.38	0.50	0.62	0.33	26	5	36
Angas River	426AR024	Receiving	129	10	26	95	0.28	0.38	0.50	0.35	39	5	30
Angas River	426AR025	Receiving	257	9	51	1,682	0.27	0.38	1.23	0.35	77	5	29
Angas River	426AR026	Receiving	0	0	0	1,682	0.16	A	A	0.4	0	0	1
Angas River	426AR027	Headwater	169	58	34	34	1.18	-	-	0.15	51	10	78
Bremer River	426BR001	Headwater	225	67	45	45	1.34	-	-	0.15	68	10	86
Bremer River	426BR002	Headwater	282	75	56	56	1.56	-	-	0.15	85	15	94
Bremer River	426BR003	Receiving	366	41	73	174	0.79	1.03	1.56	0.25	110	10	60
Bremer River	426BR004	Headwater	183	56	37	37	1.10	-	-	0.2	55	10	75
Bremer River	426BR005	Headwater	307	59	61	61	1.16	-	-	0.15	92	10	78
Bremer River	426BR006	Receiving	122	32	24	296	0.63	0.99	1.16	0.25	37	10	51
Bremer River	426BR007	Headwater	212	43	42	42	0.83	-	-	0.2	64	10	62
Bremer River	426BR008	Receiving	87	17	17	389	0.38	0.56	0.99	0.33	26	5	36
Bremer River	426BR009	Headwater	170	28	34	34	0.56	-	-	0.3	51	10	47
Bremer River	426BR010	Headwater	131	24	26	26	0.50	-	-	0.3	39	10	43
Bremer River	426BR011	Receiving	398	28	80	95	0.56	0.39	0.52	0.3	119	10	47
Bremer River	426BR012	Headwater	75	17	15	15	0.39	-	-	0.33	23	5	36
Bremer River	426BR013	Receiving	97	13	19	434	0.32	0.5	0.81	0.33	29	5	32
Bremer River	426BR014	Headwater	25	11	5	5	0.29	-	-	0.35	8	5	30
Bremer River	426BR015	Receiving	76	9	15	549	0.27	0.29	0.68	0.35	23	5	28
Bremer River	426BR016	Receiving	26	6	5	633	0.21	0.37	0.57	0.4	8	5	25
Bremer River	426BR017	Headwater	122	16	24	24	0.37	-	-	0.33	37	5	35
Bremer River	426BR018	Headwater	164	16	33	33	0.37	-	-	0.33	49	5	35
Bremer River	426BR019	Headwater	109	16	22	22	0.38	-	-	0.33	33	5	35
Bremer River	426BR020	Headwater	202	16	40	40	0.37	-	-	0.33	60	5	35

Zone characteristics			Resource capacity		Evaporation and consumptive use limit (ECUL)		Unit threshold flow rate (all L/s/km ²)			Estimated evaporation factor (proportion of dam capacity)	Surface water management zone intercession limit (ML)	% roof area to return	Mean annual adjusted runoff + recharge depth (mm)
Surface water catchment	Surface water management zone	Headwater / receiving	Resource capacity (ML)	Mean annual adjusted runoff depth (mm)	Runoff ECUL (ML)	Main watercourse ECUL (ML)	Surface water management zone	Main watercourse maximum	Main watercourse minimum				
Bremer River	426BR021	Headwater	65	7	13	13	0.23	-	-	0.35	19	5	26
Bremer River	426BR022	Receiving	52	4	10	696	0.18	0.23	0.49	0.4	16	5	23
Bremer River	426BR023	Headwater	65	5	13	13	0.19	-	-	0.4	20	5	24
Bremer River	426BR024	Headwater	184	7	37	37	0.23	-	-	0.35	55	5	26
Bremer River	426BR025	Receiving	24	4	5	751	0.18	0.19	0.43	0.4	7	5	23
Bremer River	426BR026	Headwater	647	76	129	129	1.58	-	-	0.15	194	15	95
Bremer River	426BR027	Headwater	111	59	22	22	1.16	-	-	0.15	33	10	78
Bremer River	426BR028	Headwater	671	88	134	134	1.91	-	-	0.1	201	15	107
Bremer River	426BR029	Receiving	541	56	108	393	1.09	1.16	1.91	0.2	162	10	75
Bremer River	426BR030	Headwater	435	79	87	87	1.65	-	-	0.1	131	20	133
Bremer River	426BR031	Receiving	253	42	51	531	0.82	1.34	1.65	0.2	76	10	61
Bremer River	426BR032	Receiving	217	23	43	602	0.48	0.43	1.34	0.3	65	5	42
Bremer River	426BR033	Headwater	142	20	28	28	0.43	-	-	0.3	42	5	39
Bremer River	426BR034	Receiving	104	9	21	900	0.26	0.85	1.11	0.35	31	5	28
Bremer River	426BR035	Headwater	660	86	132	132	1.86	-	-	0.1	198	20	140
Bremer River	426BR036	Receiving	464	59	93	225	1.17	1.47	1.86	0.15	139	15	113
Bremer River	426BR037	Receiving	262	32	52	277	0.63	1.11	1.47	0.25	79	10	51
Bremer River	426BR038	Headwater	2,906	87	581	581	1.89	-	-	0.1	872	20	141
Bremer River	426BR039	Receiving	1,283	61	257	1,076	1.22	1.64	1.89	0.15	385	15	115
Bremer River	426BR040	Headwater	1,190	85	238	238	1.83	-	-	0.1	357	20	139
Bremer River	426BR041	Headwater	612	64	122	122	1.29	-	-	0.15	184	15	118
Bremer River	426BR042	Headwater	203	58	41	41	1.14	-	-	0.15	61	15	112
Bremer River	426BR043	Receiving	464	33	93	1,332	0.65	1.14	1.64	0.25	139	10	52
Bremer River	426BR044	Headwater	240	24	48	48	0.49	-	-	0.3	72	5	43
Bremer River	426BR045	Headwater	123	24	25	25	0.50	-	-	0.3	37	5	43

Zone characteristics			Resource capacity		Evaporation and consumptive use limit (ECUL)		Unit threshold flow rate (all L/s/km ²)			Estimated evaporation factor (proportion of dam capacity)	Surface water management zone intercession limit (ML)	% roof area to return	Mean annual adjusted runoff + recharge depth (mm)
Surface water catchment	Surface water management zone	Headwater / receiving	Resource capacity (ML)	Mean annual adjusted runoff depth (mm)	Runoff ECUL (ML)	Main watercourse ECUL (ML)	Surface water management zone	Main watercourse maximum	Main watercourse minimum				
Bremer River	426BR046	Receiving	169	27	34	59	0.55	0.50	0.53	0.3	51	10	46
Bremer River	426BR047	Receiving	304	33	61	120	0.65	0.53	0.58	0.25	91	10	52
Bremer River	426BR048	Receiving	91	7	18	2,418	0.24	0.49	1.39	0.35	27	5	26
Bremer River	426BR049	Receiving	203	4	41	3,210	0.18	0.36	0.92	0.4	61	5	23
Bremer River	426BR050	Headwater	450	51	90	90	0.99	-	-	0.2	135	15	105
Bremer River	426BR051	Headwater	156	47	31	31	0.91	-	-	0.2	47	15	101
Bremer River	426BR052	Receiving	301	27	60	181	0.55	0.74	0.99	0.3	90	10	46
Bremer River	426BR053	Headwater	259	35	52	52	0.69	-	-	0.25	78	10	54
Bremer River	426BR054	Receiving	190	13	38	271	0.33	0.57	0.74	0.33	57	5	32
Bremer River	426BR055	Headwater	91	11	18	18	0.29	-	-	0.35	27	5	30
Bremer River	426BR056	Headwater	54	14	11	11	0.34	-	-	0.33	16	5	33
Bremer River	426BR057	Headwater	21	11	4	4	0.30	-	-	0.35	6	5	30
Bremer River	426BR058	Headwater	43	14	9	9	0.33	-	-	0.33	13	5	33
Bremer River	426BR059	Headwater	55	12	11	11	0.31	-	-	0.33	16	5	31
Bremer River	426BR060	Receiving	59	8	12	65	0.24	0.29	0.34	0.35	18	5	27
Bremer River	426BR061	Receiving	108	8	22	358	0.24	0.29	0.57	0.35	32	5	27
Bremer River	426BR062	Receiving	74	3	15	3,583	0.16	A	A	0.4	22	5	22
Currency Creek	426CC001	Headwater	1,303	148	261	261	3.87	-	-	0.1	391	20	175
Currency Creek	426CC002	Headwater	212	143	42	42	3.64	-	-	0.1	63	20	170
Currency Creek	426CC003	Receiving	1,537	131	307	610	3.14	3.45	3.87	0.1	461	20	158
Currency Creek	426CC004	Receiving	1,781	101	356	1,016	2.09	1.95	3.45	0.1	534	15	128
Currency Creek	426CC005	Headwater	248	97	50	50	1.95	-	-	0.1	75	15	124
Currency Creek	426CC006	Headwater	221	101	44	44	2.09	-	-	0.1	66	15	128
Currency Creek	426CC007	Headwater	375	108	75	75	2.29	-	-	0.1	112	15	135
Currency Creek	426CC008	Headwater	705	119	141	141	2.66	-	-	0.1	212	20	146

Zone characteristics			Resource capacity		Evaporation and consumptive use limit (ECUL)		Unit threshold flow rate (all L/s/km ²)			Estimated evaporation factor (proportion of dam capacity)	Surface water management zone intercession limit (ML)	% roof area to return	Mean annual adjusted runoff + recharge depth (mm)
Surface water catchment	Surface water management zone	Headwater / receiving	Resource capacity (ML)	Mean annual adjusted runoff depth (mm)	Runoff ECUL (ML)	Main watercourse ECUL (ML)	Surface water management zone	Main watercourse maximum	Main watercourse minimum				
Currency Creek	426CC009	Receiving	299	87	60	320	1.70	2.09	2.66	0.1	90	15	114
Currency Creek	426CC010	Receiving	769	37	154	1,588	0.65	0.72	2.69	0.25	231	10	64
Currency Creek	426CC011	Headwater	490	41	98	98	0.72	-	-	0.25	147	10	68
Currency Creek	426CC012	Receiving	120	13	24	1,612	0.29	1.35	1.58	0.35	36	5	15
Deep Creek	426DC001	Headwater	657	50	131	131	0.87	-	-	0.2	197	10	77
Deep Creek	426DC002	Headwater	401	39	80	80	0.67	-	-	0.25	120	10	66
Deep Creek	426DC003	Receiving	545	12	109	320	0.27	0.39	0.87	0.35	164	5	14
Ferries-McDonald	426AB001	Receiving	0	0	0	0	0.14	-	-	0.45	0	0	1
Finniss River	426FR001	Headwater	7,150	141	1,430	1,430	2.81	-	-	0.1	2,145	25	203
Finniss River	426FR002	Receiving	2,106	145	421	1,851	2.96	2.81	2.84	0.1	632	25	207
Finniss River	426FR003	Receiving	4,543	154	909	2,760	3.29	2.84	3.14	0.1	1,363	25	216
Finniss River	426FR004	Headwater	3,539	150	708	708	3.14	-	-	0.1	1,062	30	248
Finniss River	426FR005	Headwater	2,409	160	482	482	3.57	-	-	0.1	723	25	222
Finniss River	426FR006	Headwater	1,625	149	325	325	3.79	-	-	0.1	487	25	233
Finniss River	426FR007	Receiving	1,171	145	234	559	3.57	3.69	3.79	0.1	351	30	243
Finniss River	426FR008	Receiving	1,269	151	254	4,204	3.16	3.00	3.57	0.1	381	25	213
Finniss River	426FR009	Receiving	699	133	140	4,903	3.06	3.08	3.69	0.1	210	25	231
Finniss River	426FR010	Headwater	2,385	151	477	477	3.32	-	-	0.1	716	25	213
Finniss River	426FR011	Headwater	589	152	118	118	3.36	-	-	0.1	177	30	250
Finniss River	426FR012	Receiving	583	144	117	712	3.02	3.27	3.36	0.1	175	30	242
Finniss River	426FR013	Receiving	3,344	93	669	6,284	1.66	2.84	3.27	0.1	1,003	15	120
Finniss River	426FR014	Headwater	1,398	123	280	280	2.52	-	-	0.1	419	25	185
Finniss River	426FR015	Headwater	152	116	30	30	2.26	-	-	0.1	46	20	178
Finniss River	426FR016	Receiving	387	96	77	510	1.69	2.26	2.52	0.1	116	20	158
Finniss River	426FR017	Headwater	613	118	123	123	2.34	-	-	0.1	184	20	180

Zone characteristics			Resource capacity		Evaporation and consumptive use limit (ECUL)		Unit threshold flow rate (all L/s/km ²)			Estimated evaporation factor (proportion of dam capacity)	Surface water management zone intercession limit (ML)	% roof area to return	Mean annual adjusted runoff + recharge depth (mm)
Surface water catchment	Surface water management zone	Headwater / receiving	Resource capacity (ML)	Mean annual adjusted runoff depth (mm)	Runoff ECUL (ML)	Main watercourse ECUL (ML)	Surface water management zone	Main watercourse maximum	Main watercourse minimum				
Finniss River	426FR018	Headwater	1,280	126	256	256	2.64	-	-	0.1	384	25	188
Finniss River	426FR019	Receiving	419	87	84	850	1.45	2.23	2.64	0.15	126	15	114
Finniss River	426FR020	Headwater	173	72	35	35	1.11	-	-	0.2	52	15	99
Finniss River	426FR021	Receiving	538	68	108	993	1.02	1.11	2.23	0.2	161	20	135
Finniss River	426FR022	Receiving	1,365	45	273	7,550	0.65	1.89	2.84	0.25	409	20	112
Finniss River	426FR023	Headwater	294	76	59	59	1.23	-	-	0.15	88	15	96
Finniss River	426FR024	Headwater	139	65	28	28	1.01	-	-	0.2	42	15	85
Finniss River	426FR025	Receiving	516	50	103	190	0.73	0.86	1.23	0.25	155	10	70
Finniss River	426FR026	Receiving	436	33	87	277	0.46	0.65	0.86	0.3	131	20	100
Finniss River	426FR027	Receiving	972	22	194	8,021	0.32	0.65	2.31	0.33	292	15	89
Long Gully Group	426LG001	Headwater	0	0	0	0	0.10	-	-	0.5	0	0	1
Milendella Creek	426MC001	Headwater	388	24	78	78	0.43	-	-	0.3	116	10	42
Milendella Creek	426MC002	Receiving	84	9	17	95	0.20	0.32	0.43	0.4	25	5	27
Milendella Creek	426MC003	Headwater	52	11	10	10	0.23	-	-	0.35	16	5	29
Milendella Creek	426MC004	Headwater	23	6	5	5	0.17	-	-	0.4	7	5	24
Milendella Creek	426MC005	Receiving	0	0	0	110	0.10	0.13	0.32	0.5	0	0	1
Preamimma Creek	426PC001	Headwater	0	0	0	0	0.23	-	-	0.35	0	5	18
Preamimma Creek	426PC002	Headwater	0	0	0	0	0.18	-	-	0.4	0	5	18
Preamimma Creek	426PC003	Receiving	0	0	0	0	0.13	0.15	0.23	0.45	0	5	18
Reedy Creek	426RC001	Headwater	702	38	140	140	0.68	-	-	0.25	211	10	56
Reedy Creek	426RC002	Headwater	221	40	44	44	0.73	-	-	0.25	66	10	58
Reedy Creek	426RC003	Receiving	702	28	140	324	0.51	0.59	0.73	0.3	211	10	46
Reedy Creek	426RC004	Receiving	251	16	50	374	0.34	0.52	0.59	0.33	75	5	34
Reedy Creek	426RC005	Headwater	819	50	164	164	1.01	-	-	0.2	246	10	68
Reedy Creek	426RC006	Receiving	253	33	51	215	0.65	0.88	1.01	0.25	76	10	51

Zone characteristics			Resource capacity		Evaporation and consumptive use limit (ECUL)		Unit threshold flow rate (all L/s/km ²)			Estimated evaporation factor (proportion of dam capacity)	Surface water management zone intercession limit (ML)	% roof area to return	Mean annual adjusted runoff + recharge depth (mm)
Surface water catchment	Surface water management zone	Headwater / receiving	Resource capacity (ML)	Mean annual adjusted runoff depth (mm)	Runoff ECUL (ML)	Main watercourse ECUL (ML)	Surface water management zone	Main watercourse maximum	Main watercourse minimum				
Reedy Creek	426RC007	Headwater	548	34	110	110	0.66	-	-	0.25	164	10	52
Reedy Creek	426RC008	Receiving	105	16	21	629	0.34	0.66	0.88	0.33	32	5	34
Reedy Creek	426RC009	Headwater	130	16	26	26	0.34	-	-	0.33	39	5	34
Reedy Creek	426RC010	Headwater	520	51	104	104	1.03	-	-	0.2	156	10	69
Reedy Creek	426RC011	Headwater	132	45	26	26	0.90	-	-	0.2	40	10	63
Reedy Creek	426RC012	Headwater	343	41	69	69	0.81	-	-	0.25	103	10	59
Reedy Creek	426RC013	Receiving	138	32	28	227	0.62	0.81	1.03	0.25	41	10	50
Reedy Creek	426RC014	Headwater	151	35	30	30	0.69	-	-	0.25	45	10	53
Reedy Creek	426RC015	Receiving	131	19	26	283	0.40	0.69	0.86	0.33	39	5	37
Reedy Creek	426RC016	Receiving	33	8	7	662	0.22	0.34	0.71	0.35	10	5	26
Reedy Creek	426RC017	Headwater	94	10	19	19	0.25	-	-	0.35	28	5	28
Reedy Creek	426RC018	Headwater	101	10	20	20	0.24	-	-	0.35	30	5	28
Reedy Creek	426RC019	Headwater	49	7	10	10	0.21	-	-	0.4	15	5	25
Reedy Creek	426RC020	Receiving	0	0	0	30	0.13	0.18	0.24	0.45	0	5	18
Reedy Creek	426RC021	Receiving	27	3	5	1,090	0.15	0.18	0.63	0.45	8	5	21
Reedy Creek	426RC022	Headwater	189	13	38	38	0.29	-	-	0.35	57	5	31
Reedy Creek	426RC023	Headwater	116	14	23	23	0.31	-	-	0.33	35	5	32
Reedy Creek	426RC024	Headwater	142	11	28	28	0.27	-	-	0.35	43	5	29
Reedy Creek	426RC025	Receiving	27	4	5	102	0.15	0.18	0.31	0.4	8	5	22
Reedy Creek	426RC026	Headwater	41	5	8	8	0.18	-	-	0.4	12	5	23
Reedy Creek	426RC027	Receiving	0	0	0	1,192	0.11	0.24	0.45	0.45	0	5	18
Reedy Creek	426RC028	Receiving	0	0	0	1,192	0.09	0.31	0.36	0.5	0	0	1
Rocky Gully Creek	426RG001	Headwater	0	0	0	0	0.18	-	-	0.4	0	5	18
Rocky Gully Creek	426RG002	Headwater	0	0	0	0	0.15	-	-	0.4	0	5	18
Rocky Gully Creek	426RG003	Receiving	0	0	0	0	0.13	0.15	0.18	0.45	0	5	18

Zone characteristics			Resource capacity		Evaporation and consumptive use limit (ECUL)		Unit threshold flow rate (all L/s/km ²)			Estimated evaporation factor (proportion of dam capacity)	Surface water management zone intercession limit (ML)	% roof area to return	Mean annual adjusted runoff + recharge depth (mm)
Surface water catchment	Surface water management zone	Headwater / receiving	Resource capacity (ML)	Mean annual adjusted runoff depth (mm)	Runoff ECUL (ML)	Main watercourse ECUL (ML)	Surface water management zone	Main watercourse maximum	Main watercourse minimum				
Salt Creek	426SC001	Headwater	131	13	26	26	0.28	-	-	0.35	39	5	31
Salt Creek	426SC002	Headwater	199	12	40	40	0.27	-	-	0.35	60	5	30
Salt Creek	426SC003	Headwater	94	12	19	19	0.27	-	-	0.35	28	5	30
Salt Creek	426SC004	Headwater	74	8	15	15	0.22	-	-	0.35	22	5	26
Salt Creek	426SC005	Headwater	67	7	13	13	0.20	-	-	0.4	20	5	25
Salt Creek	426SC006	Receiving	50	5	10	108	0.16	0.20	0.28	0.4	15	5	23
Salt Creek	426SC007	Receiving	0	0	0	123	0.14	0.20	0.23	0.45	0	5	18
Salt Creek	426SC008	Receiving	0	0	0	123	0.12	0.15	0.2	0.45	0	0	1
Sandergrove Plains	426SP001	Headwater	327	21	65	65	0.34	-	-	0.33	98	10	41
Sandergrove Plains	426SP002	Receiving	675	25	135	200	0.39	0.34	0.37	0.33	202	10	45
Sandergrove Plains	426SP003	Receiving	438	18	88	288	0.30	0.34	0.37	0.35	132	10	38
Sandergrove Plains	426SP004	Receiving	0	0	0	288	0.20	0.22	0.34	0.4	0	0	1
Tookayerta Creek	426TC001	Headwater	5,957	291	1,191	1,191	1.00 ^B	-	-	0.1	1,787	40	375
Tookayerta Creek	426TC002	Headwater	820	270	164	164	1.00 ^B	-	-	0.1	246	40	353
Tookayerta Creek	426TC003	Receiving	3,850	209	770	2,125	1.00 ^B	1.00 ^B	1.00 ^B	0.1	1,155	40	293
Tookayerta Creek	426TC004	Headwater	4,406	290	881	881	1.00 ^B	-	-	0.1	1,322	40	374
Tookayerta Creek	426TC005	Receiving	3,873	232	775	1,656	1.00 ^B	1.00 ^B	1.00 ^B	0.1	1,162	40	316
Tookayerta Creek	426TC006	Headwater	2,157	167	431	431	1.00 ^B	-	-	0.2	647	35	251
Tookayerta Creek	426TC007	Receiving	1,938	137	388	4,600	1.00 ^B	1.00 ^B	1.00 ^B	0.25	581	35	221
Tookayerta Creek	426TC008	Receiving	38	67	8	4,608	1.00 ^B	1.00 ^B	1.00 ^B	0.33	11	30	151
Tookayerta Creek	426TC009	Receiving	58	47	12	4,620	1.00 ^B	1.00 ^B	1.00 ^B	0.35	17	10	49

^A The threshold flow rates for surface water management zones A26AR026 and 426BR062 are defined in principle 55.

^B As discussed in section 2.4.2.3, the unit threshold flow rate for Tookayerta Creek catchment has been set at the modelled summer baseflow rate.

Table notes for Table 4.5

Zones identified as **Headwaters** have one evaporation and consumptive use limit, the **runoff evaporation and consumptive use limit**; and one **unit threshold flow rate (UTFR)**, which is the surface water management zone UTFR.

Zones identified as **Receiving** have two evaporation and consumptive use limits: (1) **runoff evaporation and consumptive use limit**, and (2) **main watercourse evaporation and consumptive use limit**; and three unit threshold flow rates: (1) the **surface water management zone UTFR** for non-main watercourse extractions and (2 & 3) a minimum and maximum UTFR for extractions from the main watercourse. Maximum and minimum UTFR values provide the range, but the actual UTFR value at any point of extraction on the main watercourse needs to be assessed based on the location of the extraction point and the catchment area above.

Main watercourse unit threshold flow rate range = the maximum and minimum UTFR of surface water management zones immediately upstream of the watercourse, including the watercourse itself.

The main watercourse **evaporation and consumptive use** limit is the sum of the runoff **evaporation and consumptive use** limit for the zone and all the zones that drain into that zone.

Table 4.6 The surface water management zones (SWMZ) that drain into each zone.

Surface water catchment	SWMZ	Zones draining into this zone
Angas Plains	426AB002	-
Angas River	426AR001	-
Angas River	426AR002	-
Angas River	426AR003	426AR001, 426AR002
Angas River	426AR004	-
Angas River	426AR005	426AR001–426AR004, 426AR027
Angas River	426AR006	-
Angas River	426AR007	-
Angas River	426AR008	426AR006, 426AR07
Angas River	426AR009	426AR001–426AR008, 426AR027
Angas River	426AR010	-
Angas River	426AR011	-
Angas River	426AR012	426AR010, 426AR011
Angas River	426AR013	-
Angas River	426AR014	426AR010–426AR013
Angas River	426AR015	-
Angas River	426AR016	-
Angas River	426AR017	426AR015, 426AR016
Angas River	426AR018	-
Angas River	426AR019	426AR015–426AR018
Angas River	426AR020	-
Angas River	426AR021	-
Angas River	426AR022	-
Angas River	426AR023	426AR020–426AR022
Angas River	426AR024	426AR020–426AR023
Angas River	426AR025	426AR001–426AR024, 426AR027
Angas River	426AR026	426AR001–426AR025, 426AR027
Angas River	426AR027	-
Bremer River	426BR001	-
Bremer River	426BR002	-
Bremer River	426BR003	426BR001, 426BR002
Bremer River	426BR004	-
Bremer River	426BR005	-
Bremer River	426BR006	426BR001–426BR005
Bremer River	426BR007	-
Bremer River	426BR008	426BR001–426BR007, 426BR009
Bremer River	426BR009	-
Bremer River	426BR010	-
Bremer River	426BR011	426BR012
Bremer River	426BR012	-
Bremer River	426BR013	426BR001–426BR010
Bremer River	426BR014	-
Bremer River	426BR015	426BR001–426BR014
Bremer River	426BR016	426BR001–426BR015, 426BR017–426BR019
Bremer River	426BR017	-
Bremer River	426BR018	-
Bremer River	426BR019	-

Surface water catchment	SWMZ	Zones draining into this zone
Bremer River	426BR020	-
Bremer River	426BR021	-
Bremer River	426BR022	426BR001–426BR021
Bremer River	426BR023	-
Bremer River	426BR024	-
Bremer River	426BR025	426BR001–426BR025
Bremer River	426BR026	-
Bremer River	426BR027	-
Bremer River	426BR028	-
Bremer River	426BR029	426BR026–426BR028
Bremer River	426BR030	-
Bremer River	426BR031	426BR026–426BR030
Bremer River	426BR032	426BR026–426BR031, 426BR033
Bremer River	426BR033	-
Bremer River	426BR034	426BR026–426BR033, 426BR035–426BR037
Bremer River	426BR035	-
Bremer River	426BR036	426BR035
Bremer River	426BR037	426BR035, 426BR036
Bremer River	426BR038	-
Bremer River	426BR039	426BR038, 426BR040
Bremer River	426BR040	-
Bremer River	426BR041	-
Bremer River	426BR042	-
Bremer River	426BR043	426BR038–426BR042
Bremer River	426BR044	-
Bremer River	426BR045	-
Bremer River	426BR046	426BR045
Bremer River	426BR047	426BR045, 426BR046
Bremer River	426BR048	426BR026–426BR047
Bremer River	426BR049	426BR001–426BR049
Bremer River	426BR050	-
Bremer River	426BR051	-
Bremer River	426BR052	426BR050, 426BR051
Bremer River	426BR053	-
Bremer River	426BR054	426BR050–426BR053
Bremer River	426BR055	-
Bremer River	426BR056	-
Bremer River	426BR057	-
Bremer River	426BR058	-
Bremer River	426BR059	-
Bremer River	426BR060	426BR055–426BR059
Bremer River	426BR061	426BR050–426BR060
Bremer River	426BR062	426BR001–426BR061
Currency Creek	426CC001	-
Currency Creek	426CC002	-
Currency Creek	426CC003	426CC001, 426CC002
Currency Creek	426CC004	426CC001–426CC003, 426CC005
Currency Creek	426CC005	-
Currency Creek	426CC006	-

Surface water catchment	SWMZ	Zones draining into this zone
Currency Creek	426CC007	-
Currency Creek	426CC008	-
Currency Creek	426CC009	426CC006–426CC008
Currency Creek	426CC010	426CC001–426CC009, 426CC011
Currency Creek	426CC011	-
Currency Creek	426CC012	426CC001–426CC011
Deep Creek	426DC001	-
Deep Creek	426DC002	-
Deep Creek	426DC003	426DC001, 426DC002
Ferries-McDonald	426AB001	-
Finniss River	426FR001	-
Finniss River	426FR002	426FR001
Finniss River	426FR003	426FR001, 426FR002
Finniss River	426FR004	-
Finniss River	426FR005	-
Finniss River	426FR006	-
Finniss River	426FR007	426FR006
Finniss River	426FR008	426FR001–426FR005
Finniss River	426FR009	426FR001–426FR008
Finniss River	426FR010	-
Finniss River	426FR011	-
Finniss River	426FR012	426FR010, 426FR011
Finniss River	426FR013	426FR001–426FR012
Finniss River	426FR014	-
Finniss River	426FR015	-
Finniss River	426FR016	426FR014, 426FR015, 426FR017
Finniss River	426FR017	-
Finniss River	426FR018	-
Finniss River	426FR019	426FR014–426FR018
Finniss River	426FR020	-
Finniss River	426FR021	426FR014–426FR020
Finniss River	426FR022	426FR001–426FR021
Finniss River	426FR023	-
Finniss River	426FR024	-
Finniss River	426FR025	426FR023, 426FR024
Finniss River	426FR026	426FR023–426FR025
Finniss River	426FR027	426FR001–426FR026
Long Gully Group	426LG001	-
Milendella Creek	426MC001	-
Milendella Creek	426MC002	426MC001
Milendella Creek	426MC003	-
Milendella Creek	426MC004	-
Milendella Creek	426MC005	426MC001–426MC004
Preamimma Creek	426PC001	-
Preamimma Creek	426PC002	-
Preamimma Creek	426PC003	426PC001, 426PC002
Reedy Creek	426RC001	-
Reedy Creek	426RC002	-
Reedy Creek	426RC003	426RC001, 426RC002

Surface water catchment	SWMZ	Zones draining into this zone
Reedy Creek	426RC004	426RC001–426RC003
Reedy Creek	426RC005	-
Reedy Creek	426RC006	426RC005
Reedy Creek	426RC007	-
Reedy Creek	426RC008	426RC005–426RC007, 426RC010–426RC015
Reedy Creek	426RC009	-
Reedy Creek	426RC010	-
Reedy Creek	426RC011	-
Reedy Creek	426RC012	-
Reedy Creek	426RC013	426RC010–426RC012
Reedy Creek	426RC014	-
Reedy Creek	426RC015	426RC010–426RC014
Reedy Creek	426RC016	426RC005–426RC015
Reedy Creek	426RC017	-
Reedy Creek	426RC018	-
Reedy Creek	426RC019	-
Reedy Creek	426RC020	426RC018, 426RC019
Reedy Creek	426RC021	426RC001–426RC020
Reedy Creek	426RC022	-
Reedy Creek	426RC023	-
Reedy Creek	426RC024	-
Reedy Creek	426RC025	426RC022–426RC024, 426RC026
Reedy Creek	426RC026	-
Reedy Creek	426RC027	426RC001–426RC026
Reedy Creek	426RC028	426RC001–426RC027
Rocky Gully Creek	426RG001	-
Rocky Gully Creek	426RG002	-
Rocky Gully Creek	426RG003	426RG001, 426RG002
Salt Creek	426SC001	-
Salt Creek	426SC002	-
Salt Creek	426SC003	-
Salt Creek	426SC004	-
Salt Creek	426SC005	-
Salt Creek	426SC006	426SC001–426SC003, 426SC005
Salt Creek	426SC007	426SC001–426SC006
Salt Creek	426SC008	426SC001–426SC007
Sandergrove Plains	426SP001	-
Sandergrove Plains	426SP002	426SP001
Sandergrove Plains	426SP003	426SP001, 426SP002
Sandergrove Plains	426SP004	426SP001–426SP003
Tookayerta Creek	426TC001	-
Tookayerta Creek	426TC002	-
Tookayerta Creek	426TC003	426TC001, 426TC002
Tookayerta Creek	426TC004	-
Tookayerta Creek	426TC005	426TC004
Tookayerta Creek	426TC006	-
Tookayerta Creek	426TC007	426TC001–426TC006
Tookayerta Creek	426TC008	426TC001–426TC007
Tookayerta Creek	426TC009	426TC001–426TC008

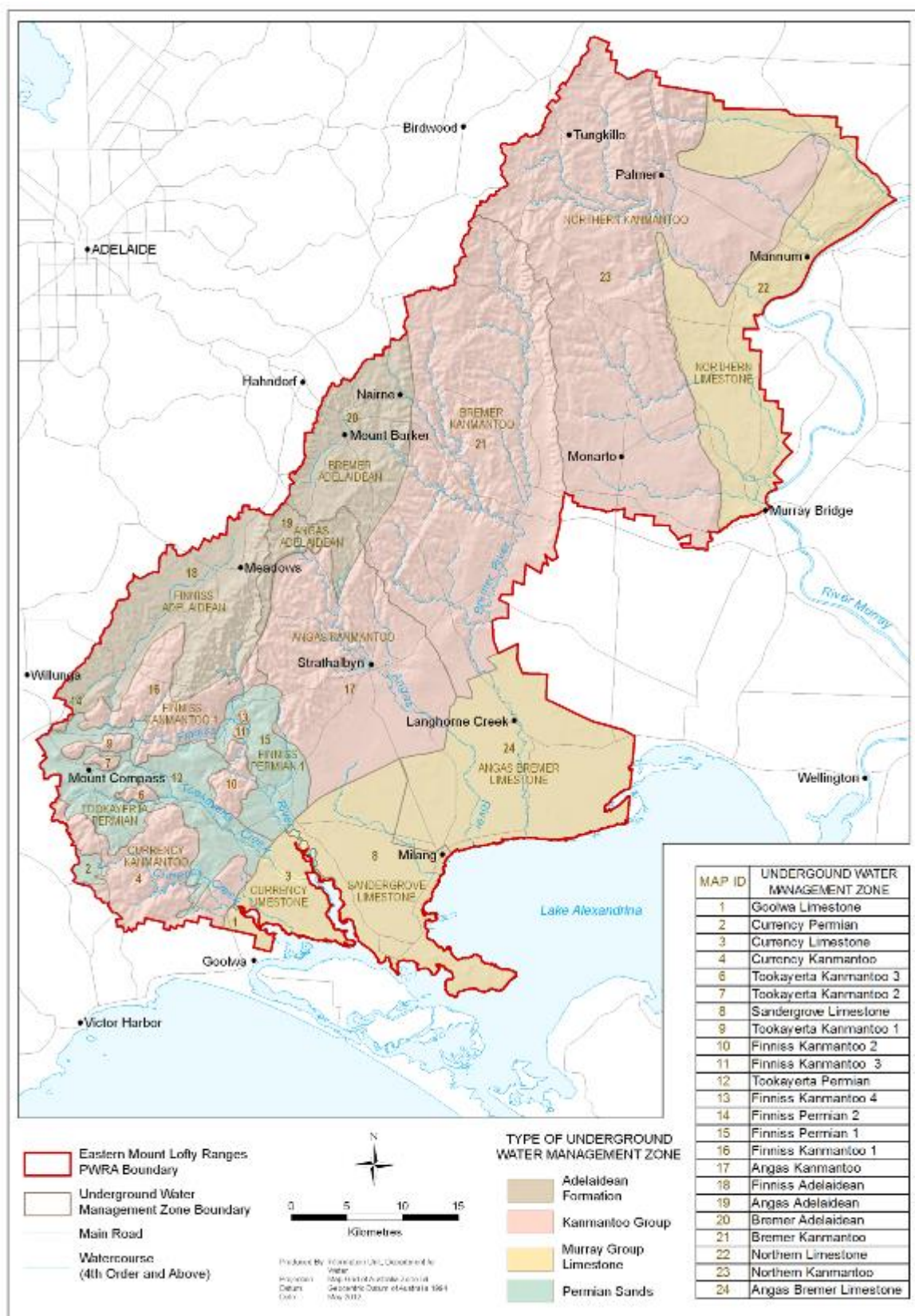


Figure 4.10 Underground water management zones.

Note that management zones that lie over other zones are not labelled on this map, but have the same extent as the underlying zone shown on this map with the same Map ID number, as indicated in Table 4.7



Figure 4.11 Indicative locations of significant environmental assets (SEAs) and environmental assets (EAs) identified to the date of map production. The locations of SEAs and EAs used for the purposes of the Plan will be identified in a database.

Table 4.7 Underground water resource capacity, demands, and underground water (UGW) consumptive use limits by underground water management zone.

Terms used in this table are briefly outlined below. See the glossary and relevant sections of the Plan for more information.

Map ID ^a	Aquifer	Underground water management zone	Area (km ²)	Recharge rate (mm) ^b	Resource capacity (ML) ^c	Baseflow (ML) ^d	Throughflow (ML) ^e	UGW consumptive use limit (ML) ^f	Stock and domestic (ML) ^g	Forestry (ML) ^h	Total non-licensed (ML) ⁱ
19	Angas Adelaidean	Angas Adelaidean	40.1	64	2,567	946	0	1,621	19	0	19
24	Angas Bremer Limestone	Angas Bremer Limestone	250.0	0	6,576	0	0	6,576	76	0	76
(24)	Angas Bremer Quaternary	Angas Bremer Quaternary	250.0	1	250	0	0	250	0	0	0
17	Angas Kanmantoo	Angas Kanmantoo	258.4	20	5,167	2,850	500	1,817	118	1	119
20	Bremer Adelaidean	Bremer Adelaidean	124.6	54	6,729	2,492	0	4,237	62	7	69
21	Bremer Kanmantoo	Bremer Kanmantoo	466.3	19	8,860	3,900	1,500	3,460	101	20	121
4	Currency Kanmantoo	Currency Kanmantoo	97.2	27	2,623	1,241	200	1,182	17	7	24
3	Currency Limestone	Currency Limestone	50.1	0	1,000	0	0	1,000	16	0	16
2	Currency Permian	Currency Permian	6.7	97	649	311	0	338	1	0	1
(3)	Currency Quaternary	Currency Quaternary	50.1	2	100	0	0	100	0	0	0
18	Finniss Adelaidean	Finniss Adelaidean	168.8	62	10,468	4,959	0	5,509	96	783	879
16	Finniss Kanmantoo	Finniss Kanmantoo 1	72.9	27–98 ^j	4,299	1,390	0	2,909	11	428	439
10	Finniss Kanmantoo	Finniss Kanmantoo 2	16.0	22	351	114	0	237	3	0	3
11	Finniss Kanmantoo	Finniss Kanmantoo 3	1.3	23	29	9	0	20	0	0	0
13	Finniss Kanmantoo	Finniss Kanmantoo 4	0.9	23	20	7	0	13	0	0	0
	<i>Finniss Kanmantoo</i>	<i>Finniss Kanmantoo – total</i>	<i>91.0</i>		<i>4,699</i>	<i>1,520</i>	<i>0</i>	<i>3,179</i>	<i>14</i>	<i>428</i>	<i>442</i>
15	Finniss Permian	Finniss Permian 1	61.8	67	4,140	1,578	300	2,262	13	6	19
14	Finniss Permian	Finniss Permian 2	0.6	100	62	24	0	38	0	0	0
	<i>Finniss Permian</i>	<i>Finniss Permian – total</i>	<i>62.4</i>		<i>4,202</i>	<i>1,602</i>	<i>300</i>	<i>2,300</i>	<i>13</i>	<i>6</i>	<i>19</i>
1	Goolwa Limestone	Goolwa Limestone	7.5	0	200	0	0	200	0	0	0
(1)	Goolwa Quaternary	Goolwa Quaternary	7.5	2	15	0	0	15	0	0	0
23	Northern Kanmantoo	Northern Kanmantoo	604.1	18	10,874	3,866	0	7,008	104	17	121
22	Northern Limestone	Northern Limestone	274.2	1	274	0	0	274	30	0	30
8	Sandergrove Limestone	Sandergrove Limestone	155.4	0	3,000	0	0	3,000	12	0	12
(8)	Sandergrove Quaternary	Sandergrove Quaternary	155.4	1	155	0	0	155	0	0	0

Map ID ^A	Aquifer	Underground water management zone	Area (km ²)	Recharge rate (mm) ^B	Resource capacity (ML) ^C	Baseflow (ML) ^D	Throughflow (ML) ^E	UGW consumptive use limit (ML) ^F	Stock and domestic (ML) ^G	Forestry (ML) ^H	Total non-licensed (ML) ^I
9	Tookayerta Kanmantoo	Tookayerta Kanmantoo 1	7.7	100	768	595	0	173	1	0	1
7	Tookayerta Kanmantoo	Tookayerta Kanmantoo 2	3.2	98	309	239	0	70	0	0	0
6	Tookayerta Kanmantoo	Tookayerta Kanmantoo 3	4.2	28	116	90	0	26	0	0	0
	<i>Tookayerta Kanmantoo</i>	<i>Tookayerta Kanmantoo – total</i>	<i>15.0</i>		<i>1,193</i>	<i>924</i>	<i>0</i>	<i>269</i>	<i>1</i>	<i>0</i>	<i>1</i>
12	Tookayerta Permian	Tookayerta Permian	132.3	83.6 ^J	11,058	7,215	1,000	2,843	97	214	311
	Grand total		3,267.0		80,659	31,826	3,500	45,333	777	1,483	2,260

- A Map ID refers to Map IDs for zones in Figure 4.10. Map IDs in brackets are zones not labelled in Figure 4.10 because they lie over zones shown on that figure that have the same Map ID, and have the same extent as the zones they lie over.
- B Recharge is the long-term mean annual rate or depth of recharge to the zone (see section 1.6.2).
- C Resource capacity is the long-term average annual volume of input to the zone (generally calculated as area multiplied by recharge). This is the total amount of water available to meet all demands, including consumptive use and the environment, on a long-term average annual basis (see section 1.6.2).
- D Baseflow is the long-term average annual volume of underground water discharged into watercourses from the zone (see section 1.6.2.1).
- E Throughflow is the long-term average annual volume of underground water that flows from the zone to another underground water management zone (see section 1.6.2.1).
- F UGW (underground water) consumptive use limit is the volume of water available from the zone for consumptive purposes, including licensed and non-licensed needs, after considering system and environmental provisions. The underground water consumptive use limit is calculated as resource capacity minus baseflow minus throughflow (see section 4.3.3).
- G Stock and domestic is the annual volume of stock and domestic demand from the zone, where domestic demand has been adjusted to account for projected population increase over ten years (maximum time from plan adoption to review) (see sections 1.7.2.1, 1.7.2.2 and 1.7.6).
- H Forestry is the average annual volume of reduction in recharge due to existing commercial forestry (prior to date of adoption) (see section 1.7.3).
- I Total non-licensed is the sum of stock and domestic plus forestry.
- J There is a variable recharge rate over this zone. A recharge rate range is given from Finnis Kanmantoo 1, and a mean recharge rate is given for Tookayerta Permian. An appropriate value in the range or around the mean will be determined at the time of assessment.

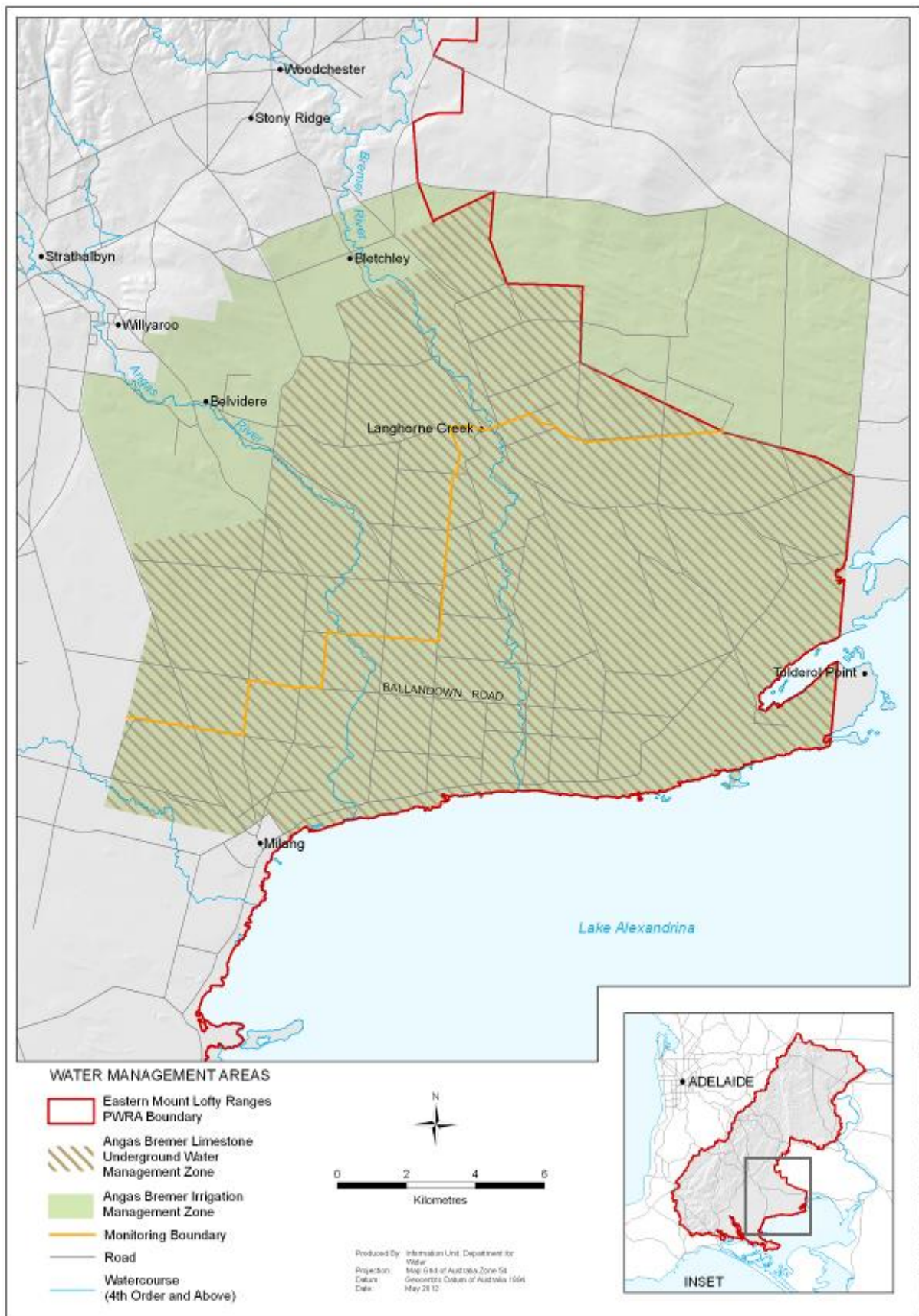


Figure 4.12 Angas Bremer Limestone underground water management zone and Angas Bremer Irrigation Management Zone.

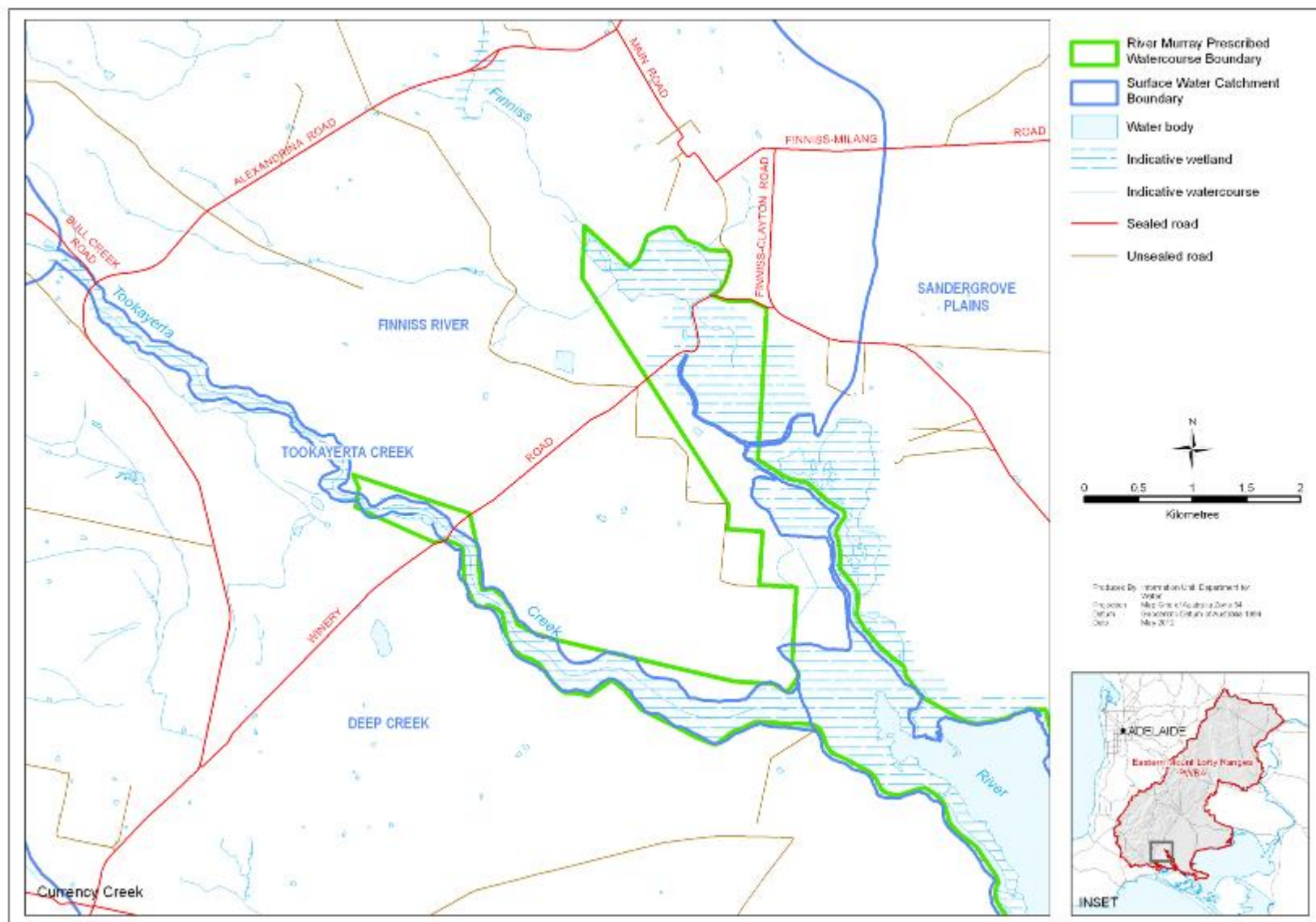


Figure 4.13 Winery Road in the vicinity of the River Murray Prescribed Watercourse and the Tookayerta Creek and Finnis River surface water catchments.



5 WATER ALLOCATION CRITERIA

5.1 GENERAL CRITERIA

The following objectives and principles apply to the allocation of underground water, surface water and watercourse water.

Definitions

For the purposes of sections 5–7 of the Plan:

- Any terms used in the Plan that are defined in the NRM Act carry the meanings given by the NRM Act, except where those terms are defined in the glossary (at the back of this document).
- Any terms used in the Plan that are defined in the glossary carry the meanings given in the glossary unless otherwise specified, or where used in a general sense.

Terms that are given in *italics* are defined in the glossary, except for references to legislation. Italics are generally only used the first time a term is used within a principle. Note that commonly used terms defined in the glossary are generally not italicised for the sake of visual clarity.

Objectives

- a) Encourage efficient use of water resources in a sustainable manner.
- b) Maintain the quantity and quality of water resources.
- c) Maintain and where possible restore water-dependent ecosystems by providing their water needs.
- d) Minimise impacts of taking and using water on the environment, prescribed water resources, other water resources and water users.

Principles

Basis of allocation

1. Water shall be allocated as a volume that may be taken and used in a *water use year*.

Allocation and taking of water

2. Water allocations must only be taken from the *source* or sources endorsed on the licence relating to that allocation, except if otherwise authorised by the Minister.

Order of taking of allocations

3. Water allocations shall be deemed to be taken in the following order:
 - a) *Base allocations*;
 - b) *Rollover allocations*;
 - c) *Recharge allocations*.

Variation of conditions

4. A water licence will specify intervals of at least 12 months at which the Minister may vary the conditions of the licence.

Impact of taking and use of allocations (general)

5. Water shall only be allocated where the taking and use of water will not cause, or be likely to cause, significant detrimental impacts on the water resources, water-dependent ecosystems or existing water users. Such impacts may include, but are not limited to:
 - a) the ability of other users to lawfully take from that water resource;
 - b) loss of ecosystems that depend on that water resource;
 - c) decrease in the amount and/or duration of discharge from underground water to surface water/watercourses or vice versa, or loss of ecosystems that depend on that discharge;
 - d) adverse alteration to the water regime; and/or
 - e) deterioration in water quality.
6. Water shall only be allocated where the taking and use of water will not cause, or be likely to cause, a significant detrimental impact on the productive capacity of land. Such impacts may include, but are not limited to:
 - a) unacceptable increases in soil and/or water salinity;
 - b) new or exacerbated rising, perched or shallow watertables; and/or
 - c) increased waterlogging or erosion.

Water use efficiency

7. Water shall be used or applied using water efficient technologies and techniques, appropriate for the particular circumstance and in accordance with industry best practice standards.
8. If, in the Minister's opinion, a licensee is not complying with principle 7, then the Minister may require the licensee to:
 - a) prepare, to the Minister's satisfaction, an environmental improvement program containing requirements specified by the Minister in relation to principle 7; and
 - b) comply with the requirements of that program to the Minister's satisfaction.

Ecosystem allocations – general

9. Water allocated as an *ecosystem allocation* shall only be taken and used to maintain, rehabilitate or restore locally indigenous water-dependent ecosystems, habitats, communities or species, for a purpose and in a manner accredited by the Minister.
10. Principles 7, 8, 24–32 and 69 do not apply to *ecosystem allocations*, provided that the Minister is satisfied that the taking and use of the allocation will not have a significant detrimental impact on water-dependent ecosystems, water users or natural resources.

Ecosystem allocations from the consumptive use limits

11. Water allocated as a permanent *ecosystem allocation* from a *consumptive use limit* shall not be allocated for any other purpose.

12. Water allocated as a temporary *ecosystem allocation* from a *consumptive use limit* shall revert to the original purpose of use at the end of the allocation or transfer period.
13. If a temporary *ecosystem allocation* from a *consumptive use limit* reverts to a different purpose of use, then principles 7, 8, 24–32 and 69 shall apply (where relevant), and the Minister may, subject to sections 149 and 156 of the NRM Act, and without limiting section 164P of the NRM Act, vary the allocation to be consistent with these principles.

Ecosystem allocations from the system provisions

14. An *ecosystem allocation* may be granted from the *system provisions* of a management zone on a temporary basis only. Such an allocation will be known as an '*ecosystem allocation (system provisions)*' for the purposes of the Plan.
15. *Ecosystem allocations (system provisions)* will only be granted if:
 - a) the allocation is for the purpose of maintaining locally indigenous water-dependent ecosystems, habitats, communities or species that are at risk due to an inappropriate, insufficient or declining water regime; or
 - b) the allocation will be taken from surface water or watercourse water within the boundary of the Angas Bremer Limestone underground water management zone (as shown in Figure 4.10), for the purpose of directly or indirectly providing water to red gum swamps (as shown in Figure 4.11). Such an allocation may include an allowance for conveyance of water to the red gum swamps.

The allocation must only be used for these purposes.

16. The total volume of *ecosystem allocations (system provisions)* in a management zone must not exceed the relevant *system provisions*, as determined in accordance with principle 17.
17. For the purpose of the Plan, the *system provisions* are determined as follows:
 - a) for an *underground water management zone*:

$$SP = RC_{UGW} - [\text{greater of } CUL_{UGW} \text{ or } CU_{UGW}]$$

where:

SP System provisions (in ML).

RC_{UGW} Resource capacity for the underground water management zone the ecosystem allocation would be taken from (given in Table 4.7) (in ML).

CUL_{UGW} *Underground water consumptive use limit* for the underground water management zone the ecosystem allocation would be taken from (given in Table 4.7) (in ML).

CU_{UGW} *Consumptive use from underground water* from the underground water management zone the ecosystem allocation would be taken from (determined in accordance with principle 91 b)) (in ML).

Note:

Underground water management zones are identified in Table 4.7 and shown in Figure 4.10.

- b) for a *surface water management zone* where the ecosystem allocation would be taken directly or indirectly from a *main watercourse*, (including by taking flow originally derived from a main watercourse):

$$SP = \Sigma RC_{SW} - [\text{greater of } (MWEUL + LAB) \text{ or } \Sigma ECU_A]$$

where:

SP	System provisions (in ML).
ΣRC_{SW}	The sum of the <i>resource capacities</i> for (1) the surface water management zone the ecosystem allocation would be taken from and (2) all surface water management zones draining into that management zone (resource capacities given in Table 4.5; and the zones draining into a zone are identified in Table 4.6) (in ML).
MWEUL	<i>Main watercourse evaporation and consumptive use limit</i> for the surface water management zone that the ecosystem allocation would be taken from (given in Table 4.5) (in ML).
LAB	The sum of <i>lower Angas Bremer allocations</i> sourced from the surface water management zone that the ecosystem allocation would be taken from.
ΣECU_A	The sum of the greater of: <ul style="list-style-type: none"> i. the <i>runoff evaporation and consumptive use limit</i> plus <i>lower Angas Bremer allocations</i>; or ii. <i>evaporation plus consumptive use from surface water and watercourses</i> plus <i>lower Angas Bremer allocations</i>; for each of (1) the surface water management zone the ecosystem allocation would be taken from and (2) all surface water management zones draining into that management zone.

Note:

Surface water management zones and main watercourses are shown in Figure 4.3 to Figure 4.9.

Evaporation and consumptive use from surface water and watercourses are calculated in accordance with principle 34.

- c) for all other cases where the ecosystem allocation would be taken from *surface water management zone*:

$$SP = RC_{SW} - [\text{greater of } REUL \text{ or } ECU]$$

where:

SP	System provisions (in ML).
RC_{SW}	Resource capacity for the surface water management zone the ecosystem allocation would be taken from (given in Table 4.5) (in ML).
REUL	<i>Runoff evaporation and consumptive use limit</i> for the surface water management zone that the ecosystem allocation would be taken from (given in Table 4.5) (in ML).
ECU	<i>Evaporation plus consumptive use from surface water and watercourses</i> taken from outside the main watercourse from the surface water management zone that the ecosystem allocation would be taken from (in ML).

18. *Ecosystem allocations (system provisions)* will only be granted if a management plan for the water-dependent ecosystem, habitat, community, species or site that is the target of the proposed allocation has been approved by the Minister. The management plan must address:
- a) the proposed source and volume of water to be used;
 - b) the manner the water is to be taken and applied;
 - c) the expected duration of the project;
 - d) the objectives and expected benefits of the project;
 - e) an assessment of the risks to other local water-dependent ecosystems, water users and water resources;
 - f) where a risk is identified, the proposed strategies used to minimise or remedy any such risk;
 - g) monitoring strategies that will be implemented to assess progress towards the objectives; and
 - h) any other information that may be requested by the Minister.
19. In addition to the principles identified in principle 10, the following principles do not apply to *ecosystem allocations (system provisions)*: principles 33, 36, 38, 40, 42, 47, 49, 51, 90, 92, 94 and 95.
20. The Minister may decide not to apply other relevant principles from the Plan when determining whether to grant an *ecosystem allocation (system provisions)*, provided that the Minister is of the opinion that:
- a) there are likely to be minimal adverse impacts on water users and water-dependent ecosystems as a result of the allocation, and/or those adverse impacts can be minimised or offset by actions proposed by the applicant; and
 - b) the water-dependent ecosystem that is the focus of the ecosystem allocation is at significant risk of local extinction or suffering significant damage due to an inappropriate, insufficient or declining water regime.
21. If an allocation granted in accordance with principle 15 b) is taken, then water must continue to be provided to red gum swamps directly or indirectly by the licensee.
22. If the Minister is satisfied that:
- a) the condition of a water-dependent ecosystem, habitat, community or species that is the subject of an *ecosystem allocation (system provisions)* is poor or declining; and
 - b) the taking and/or use of the *ecosystem allocation (system provisions)* is contributing to the poor or declining condition of the water-dependent ecosystem, habitat, community or species,
- the Minister may, subject to sections 149 and 156 of the NRM Act, and without limiting section 164P of the NRM Act:
- c) vary the conditions of the relevant water licence or water allocation to ensure that the taking and/or use of water is consistent with the purpose of the allocation; and/or
 - d) reduce the water allocation or the quantity of water included on the relevant water licence.
23. Water allocated as an *ecosystem allocation (system provisions)* shall revert to the *system provisions* of the relevant management zone:
- a) at the end of the allocation period; or
 - b) if voluntarily surrendered; or

- c) if the allocation is cancelled;
- and must not be used for any other purpose except as an *ecosystem allocation (system provisions)*.

Lower Angas Bremer requirements

24. Principles 26–32 apply within the boundary of the Angas Bremer Limestone underground water management zone only, as shown in Figure 4.12.

Exceptions to watertable monitoring wells and revegetation requirements

25. Principles 26–32 do not apply where:
- a) the water to be allocated would be applied to an area that is already the subject of an existing allocation (or allocations) that is considered by the Minister to be sufficient to meet the water requirements of the purpose of use; and
 - b) the requirements of principles 26–32 have already been met, or will be met, for that existing allocation or allocations.

Lower Angas Bremer requirements – watertable monitoring wells

26. Subject to principle 25, water shall not be allocated for irrigation in the area within the Angas Bremer Limestone underground water management zone that is south of the yellow line in Figure 4.12 ('Monitoring Boundary' in that figure), unless:
- a) where the total volume allocated to be taken on the property from all sources (including the River Murray Prescribed Watercourse) in any one *water use year* exceeds 500 ML — at least two watertable monitoring wells are situated either within, or as close as practicable to, the area to be irrigated; or
 - b) in any other case — at least one watertable monitoring well is situated either within, or as close as practicable to, the area to be irrigated.
27. For the purposes of principle 26, a watertable monitoring well must be constructed in accordance with principles 248 and 249.

Lower Angas Bremer requirements – revegetation

28. Subject to principle 25, water shall only be allocated for irrigation at the rate of 100 ML for every two hectares of non-irrigated vegetation planted and nurtured on *relevant land* in accordance with the Angas Bremer Irrigation Region Revegetation Booklet (set out in Appendix D of the Plan). The non-irrigated vegetation must be planted with sufficient density to minimise the potential for waterlogging on the land to be irrigated, or any other land in the *Angas Bremer Irrigation Management Zone* (shown in Figure 4.12).
29. For the purposes of principles 28–32:
- a) 'planted' means vegetation that has been planted, or will be planted, on *relevant land* (in the case of land not owned by the licensee, pursuant to a legally binding agreement or obligation);
 - b) 'nurtured' means reasonable and practical measures are taken to maintain the health of the plants in a satisfactory condition, for example but not limited to, periodic weeding, feral animal control and minimal disturbance by grazing (in the case of land not owned by the licensee, pursuant to a legally binding agreement or obligation);

c) *relevant land* means land within the *Angas Bremer Irrigation Management Zone* that is:

- i) owned by the licensee; or
- ii) owned by any other person, with the written consent of that person for the use of that land for activities in accordance with principle 28; or
- iii) under the care, control and management of the relevant Local Council (under the *Local Government Act 1999*, the *Crown Land Management Act 2009* or other relevant legislation), the South Australian Murray-Darling Basin Natural Resources Management Board, or a Minister, instrumentality or agency of the Crown; with the written consent of that Council, Board, Minister, instrumentality or agency for the use of that land for activities in accordance with principle 28.

- 30. Areas planted prior to the *date of adoption* of the Plan within the *Angas Bremer Irrigation Management Zone* to meet the requirements of principle 28, or similar principles in the Water Allocation Plan for the Angas Bremer Prescribed Wells Area or the Water Allocation Plan for the River Murray Prescribed Watercourse, will continue to be recognised for those purposes under the Plan.
- 31. Future plantings should be located upon *relevant land* in areas where there is a high risk of rising shallow watertables, for example but not limited to, where the shallow watertable is within 4 metres of the land surface and preferably south of the yellow line in Figure 4.12, unless it can be demonstrated it is not practical to do so.
- 32. The maximum spacing between individual plants should not exceed 10 m regardless of whether the planting is a single row or block. The area of plantings will be calculated by application of the following formulae:

a) The area of single row plantings is calculated as follows:

$$A_{SR} = 10_W \times (L + 10_L)$$

where:

A_{SR} Area of single row planting (in m²).

10_W 10 metres – assumed width of mature trees (regardless of the species planted) (in m).

L Length of the row (in m).

10_L 10 metres – allowance of additional length of 5 m either side of the first and last plant to be claimed and included in the row area calculation.

b) The area of block plantings is calculated as follows:

$$A_B = (L + 5_L) \times (W + 5_W)$$

where:

A_B Area of the block planting (in m²).

L Length of block planting (in m).

5_L 5 metres – allowance of additional length of 5 m to be claimed and included in the block area calculation (in m).

W Width of block planting (in m).

5_W 5 metres – allowance of additional width of 5 m to be claimed and included in the block area calculation (in m).

5.2 SURFACE WATER AND WATERCOURSE WATER ALLOCATION CRITERIA

5.2.1 Allocation criteria for surface water and watercourse water that is not roof runoff or urban runoff

The following principles apply to the allocation of surface water and water from watercourses only, excluding *roof runoff* and *urban runoff*. They apply in addition to the objectives and general principles set out in section 5.1 of the Plan. The principles that apply to the allocation of *roof runoff* and *urban runoff* are set out in sections 5.2.3 and 5.2.4 of the Plan respectively.

Maximum volume of allocation

33. Water shall not be allocated where it would cause any of the following limits to be exceeded:
- a) the limit at the regional scale (principle 38);
 - b) the limit at the surface water catchment scale (principle 36);
 - c) the limits at the surface water management zone scale (principles 40 and 42);
 - d) the limits at the dam and local catchment area scale (principles 43, 44 and 45);
 - e) the limit applicable to the protection of *significant environmental assets* (principle 46);
 - f) the limit on net increases in taking in the Angas River and Bremer River surface water catchments (principle 47);
 - g) the *joint Tookayerta limit* (principle 49);
 - h) the limit on net increases in taking in the Tookayerta Creek surface water catchment if applicable (principle 51).

34. For the purposes of sections 5–7 of the Plan:

- a) *Consumptive use from surface water and watercourses* is the volume of surface water and watercourse water estimated to be taken for licensed and non-licensed consumptive purposes (including stock and domestic use and water intercepted by commercial forests) from a given area or location, including the Eastern Mount Lofty Ranges PWRA, a surface water catchment, surface water management zone, catchment area, property or diversion point. *Consumptive use from surface water and watercourses* excludes *lower Angas Bremer allocations*, *rollover allocations*, *ecosystem allocations (system provisions)*, *roof runoff allocations* and *urban runoff allocations*.

Consumptive use from surface water and watercourses is calculated as follows:

$$CU_{SW} = \text{allocation} + (\text{NDC} \times 0.3) + \text{NCU}_L + \text{FU}_{SW}$$

where:

CU_{SW} *Consumptive use from surface water and watercourses* (in ML).

allocation The sum of the volume of *base allocations* (but excluding *lower Angas Bremer allocations*) deemed to be sourced from surface water and watercourse water from the given area or location (where relevant) (in ML). Note that base allocations exclude *roof runoff allocations*, *urban runoff allocations*, *rollover allocations* and *ecosystem allocations (system provisions)*.

NDC Non-licensed dam capacity: the sum of the capacities of *non-licensed dams* in the given area or location (where relevant) (in ML).

0.3	Conversion factor to estimate use from non-licensed dams.
NCU _L	Non-licensed consumptive use from licensed <i>diversion structures</i> : the sum of all volumes of non-licensed use taken from diversion structures used for licensed purposes in the given area or location, if such volumes have been determined by the Minister (where relevant) (in ML).
FU _{sw}	<i>Forestry use from surface water by commercial forests</i> in the given area or location, calculated in accordance with principle 267 a) (in ML).

b) *Evaporation* (E) is mean net annual evaporation from a dam (in ML), determined as:

i) $E = DC \times \text{evaporation factor}$

where:

E Evaporation: nominal mean net annual evaporation from a dam (in ML).

DC Dam capacity: the volumetric capacity of the dam (in ML).

evaporation factor Conversion factor to estimate mean net annual evaporation from a dam, given in column 'Estimated evaporation factor' in Table 4.5 for the surface water management zone that the dam lies within.

or

ii) such other value (in ML), demonstrated to the satisfaction of the Minister by the proponent, where the proponent has made changes to their dam or constructed a new dam which results in a permanent difference in the value of mean net annual evaporation compared to the value determined in principle 34 b) i).

Evaporation from a diversion structure that is not a dam is 0 ML.

c) When determining consumptive use from surface water and watercourses and/or evaporation as above, particular dams may be excluded from the determination of non-licensed dam capacity or evaporation where the Minister determines that this is appropriate for the purposes of proper accounting against the water balance for the specific calculation being made.

d) The *mean annual adjusted runoff depth* (R) for a catchment area upstream of a point (such as a diversion structure or a *significant environmental asset*) (in mm) is determined as follows:

i) where it is a catchment area upstream of a point that is not on a main watercourse and:

I. is entirely contained within a surface water management zone — R is the value given in column 'Mean annual adjusted runoff depth' in Table 4.5 for that surface water management zone.

II. lies over more than one surface water management zone — R is the value given in column 'Mean annual adjusted runoff depth' in Table 4.5 for the surface water management zone that the majority of the catchment area lies within.

ii) where it is a catchment area upstream of a point on a main watercourse — the catchment area will be split into parts in accordance with the boundaries of the surface water management zones that contribute to that point, and the R that applies to each part will be the value given in column 'Mean annual adjusted runoff depth' in Table 4.5 for the relevant surface water management zone. In cases where R is multiplied by area (A) (such as principles 44, 45, 46, 192, 194, 277 and 278), the area of each part (as described above) will be multiplied by the relevant R, and the values summed.

35. If a proposed allocation would arise from the transfer of an allocation from a dam and the allocation volume from that dam is reduced to zero as a result of the transfer, then that dam will be considered to be a *non-licensed dam* (and the use from that dam determined accordingly) for the purposes of determining the allowable allocation in accordance with principles 36–51.

Surface water catchment scale

36. Water shall not be allocated where it would cause the total volume of *evaporation plus consumptive use from surface water and watercourses* in a *surface water catchment* to exceed (or further exceed) the *catchment evaporation and consumptive use limit*.
37. For the purposes of sections 5–7 of the Plan:
- surface water catchments* are shown in Figure 4.2.
 - the *catchment evaporation and consumptive use limit* for each surface water catchment is given in Table 4.3.

Regional scale

38. Water shall not be allocated where it would cause the total volume of *evaporation plus consumptive use from surface water and watercourses* in the *Eastern Mount Lofty Ranges PWRA* to exceed (or further exceed) the *regional evaporation and consumptive use limit*.
39. For the purposes of the Plan, the *regional evaporation and consumptive use limit* is given in Table 4.4.

Surface water management zones scale

40. Where an allocation would be taken from outside a *main watercourse*, water shall not be allocated where it would cause:
- the total volume of *evaporation plus consumptive use from surface water and watercourses* taken from outside the main watercourse in a surface water management zone to exceed (or further exceed) the *runoff evaporation and consumptive use limit* for the zone that the allocation would be taken from; or
 - the total volume of *cumulative evaporation plus consumptive use* to exceed (or further exceed) the *main watercourse evaporation and consumptive use limit* for:
 - the surface water management zone from which the allocation would be taken; or
 - any surface water management zone affected by the proposed allocation.
41. For the purposes of the Plan:
- main watercourses* are shown in Figure 4.3 to Figure 4.9.
 - the *runoff evaporation and consumptive use limit* for each surface water management zone is given in Table 4.5.
 - cumulative evaporation plus consumptive use* is the sum of *evaporation plus consumptive use from surface water and watercourses* from (1) the surface water management zone being considered and (2) all surface water management zones that drain into that zone. Table 4.6 shows the surface water management zones that drain into each surface water management zone, where relevant.
 - the *main watercourse evaporation and consumptive use limit* for each surface water management zone is given in Table 4.5.
42. Where an allocation would be taken from a *main watercourse*, water shall not be allocated where it would cause the total volume of *cumulative evaporation plus consumptive use* to exceed (or further exceed) the *main watercourse evaporation and consumptive use limit* for:

- a) the surface water management zone from which the allocation would be taken; or
- b) any surface water management zone affected by the proposed allocation.

Dam and local catchment area scale – dam capacity

43. The total volume allocated to be taken from a dam shall not exceed the volumetric capacity of that dam minus *evaporation* from that dam, unless it can be demonstrated to the Minister's satisfaction that more than that volume can be taken annually from that dam.

Dam and local catchment area scale – available runoff

44. The maximum total volume (TV_{\max}) to be allocated from a *diversion structure* (D1) shall not exceed the mean annual adjusted runoff volume from the catchment area upstream of that diversion structure, taking into account (1) *upstream consumptive use from surface water and watercourses*, (2) *ecosystem allocations (system provisions)* allocated from surface water and watercourses, (3) *lower Angas Bremer allocations*, and (4) *evaporation*.

For the purpose of this principle, the total volume to be allocated from a diversion structure (D1) shall not exceed the following:

$$TV_{\max} = (A_{D1} \times R_{D1}) - (CU_{SW,UD1} + SP_{SW,UD1} + LAB_{UD1} + E_{UD1})$$

where:

TV_{\max}	Maximum total volume: the maximum allowable total allocation volume for diversion structure D1 (in ML). TV_{\max} includes the proposed allocation as well as any existing allocation taken from D1.
A_{D1}	Area upstream of D1: the area of the catchment area upstream of diversion structure D1 (in km ²).
R_{D1}	Runoff at D1: the <i>mean annual adjusted runoff depth</i> for the catchment area upstream of diversion structure D1, determined in accordance with principle 34 d) (in mm). A different value may be used for R_{D1} where the proponent can demonstrate a different value based on adequate data, to the Minister's satisfaction.
$CU_{SW,UD1}$	Consumptive use upstream of D1: the volume of <i>consumptive use from surface water and watercourses</i> in the catchment area upstream of diversion structure D1, immediately prior to the allocation, excluding <i>consumptive use from surface water and watercourses</i> at diversion structure D1 (in ML). If the allocation would result from the transfer of an allocation sourced from upstream of diversion structure D1, then the volume of this proposed transfer is excluded from $CU_{SW,UD1}$.
$SP_{SW,UD1}$	<i>Ecosystem allocations (system provisions)</i> taken from surface water and watercourses in the catchment area upstream of diversion structure D1, excluding any such allocations taken from D1 (in ML).
LAB_{UD1}	<i>Lower Angas Bremer allocations</i> in the catchment area upstream of diversion structure D1, excluding any such allocations taken from D1 (in ML). If the allocation would result from the transfer of a lower Angas Bremer allocation sourced from upstream of diversion structure D1, then the volume of this proposed transfer is excluded from LAB_{UD1} .
E_{UD1}	<i>Evaporation</i> upstream of D1: the total volume of mean net annual evaporation from dams in the catchment area upstream of diversion structure D1, excluding evaporation from diversion structure D1, determined in accordance with principle 34 (in ML).

Dam and local catchment area scale – minimising downstream impact

45. Water shall not be allocated where the allocation would cause the total demand for water in the catchment area of an affected downstream *diversion point* to exceed (or further exceed) the average supply of mean annual adjusted runoff to that point. Total demand for water includes (1) *consumptive use from surface water and watercourses*, (2) *ecosystem allocations (system provisions)* allocated from surface water and watercourses, (3) *lower Angas Bremer allocations*, and (4) *evaporation*.

For the purpose of this principle, the maximum total volume to be allocated from a diversion structure (D1) must not exceed the smallest volume returned by calculating the following at each *diversion point* x (Dx) downstream of D1 within the Eastern Mount Lofty Ranges PWRA that may be affected by the allocation.

$$TV_{\max} = [(A_{Dx} \times R_{Dx}) - (CU_{SW,BDx} + SP_{SW,BDx} + LAB_{BDx} + E_{BDx})] + CU_{SW,D1} + SP_{SW,D1} + LAB_{D1}$$

where:

TV_{\max}	Maximum total volume: the maximum allowable total allocation volume for diversion structure D1 (in ML). TV_{\max} includes the proposed allocation as well as any existing allocation taken from D1.
A_{Dx}	Area upstream of Dx: the area of the catchment area upstream of diversion point Dx (in km ²).
R_{Dx}	Runoff at Dx: the <i>mean annual adjusted runoff depth</i> for the catchment area upstream of diversion point Dx, determined in accordance with principle 34 d) (in mm).
$CU_{SW,BDx}$	Consumptive use both at and in the catchment area upstream of diversion point x: the total volume of <i>consumptive use from surface water and watercourses</i> at and in the catchment area upstream of diversion point Dx, immediately prior to the allocation (in ML). If the allocation would result from the transfer of an allocation sourced from upstream of diversion point Dx, then the volume of this proposed transfer is excluded from $CU_{SW,BDx}$.
$SP_{SW,BDx}$	<i>Ecosystem allocations (system provisions)</i> taken from surface water and watercourses both at and in the catchment area upstream of diversion point Dx (in ML).
LAB_{BDx}	<i>Lower Angas Bremer allocations</i> taken both at and in the catchment area upstream of diversion point Dx (in ML). If the allocation would result from the transfer of a lower Angas Bremer allocation sourced from upstream of diversion point Dx, then the volume of this proposed transfer is excluded from LAB_{BDx} .
E_{BDx}	<i>Evaporation</i> both at and upstream of Dx: the total volume of mean net annual evaporation from dams at and in the catchment area upstream of diversion point Dx, determined in accordance with principle 34 (in ML).
$CU_{SW,D1}$	Consumptive use at diversion structure D1: the volume of <i>consumptive use from surface water and watercourses</i> (if any) from diversion structure D1, immediately prior to the allocation (in ML).
$SP_{SW,D1}$	<i>Ecosystem allocations (system provisions)</i> from surface water and watercourses taken from diversion structure D1 (if any) (in ML).
LAB_{D1}	<i>Lower Angas Bremer allocations</i> taken from diversion structure D1 (if any) (in ML).

A *diversion point* is a diversion structure or an area of *commercial forestry*.

Where the equation returns a negative value, TV_{\max} will be zero.

Protection of significant environmental assets

46. Water shall not be allocated where it would cause the total volume of *evaporation plus consumptive use from surface water and watercourses* in the catchment area of a *significant environmental asset* to exceed (or further exceed) the *local evaporation and consumptive use limit* for that catchment area.

For the purposes of this principle, the total volume to be allocated from a diversion structure (D1) shall not exceed the smallest volume returned by calculating the following at each significant environmental asset that might be affected by the allocation:

$$TV_{\max} = (A_{\text{SEA}} \times R_{\text{SEA}} \times 0.2) - (CU_{\text{SW.USEA}} + E_{\text{USEA}})$$

where:

TV_{\max}	Maximum total volume: the maximum allowable total allocation volume for diversion structure D1 (in ML). TV_{\max} includes the proposed allocation as well as any existing allocation taken from D1.
A_{SEA}	Area: Size of the catchment area of the significant environmental asset (in km ²).
R_{SEA}	Runoff: the <i>mean annual adjusted runoff depth</i> for the catchment area of the significant environmental asset, determined in accordance with principle 34 d) (in mm). A different value may be used for R_{SEA} where the proponent can demonstrate a different value based on adequate data, to the Minister's satisfaction.
0.2	Multiplication factor to determine the local evaporation and consumptive use limit for the significant environmental asset (20% of runoff).
$CU_{\text{SW.USEA}}$	<i>Consumptive use from surface water and watercourses</i> in the catchment area of the significant environmental asset, excluding <i>consumptive use from surface water and watercourses</i> from diversion structure D1, immediately prior to the allocation (in ML). If the allocation would result from the transfer of an allocation sourced from the catchment area upstream of the significant environmental asset, then the volume of this proposed transfer is excluded from $CU_{\text{SW.USEA}}$.
E_{USEA}	<i>Evaporation</i> in the catchment area of the significant environmental asset: the total volume of mean net annual evaporation from dams in the catchment area upstream of the significant environmental asset, determined in accordance with principle 34 (in ML).

No net increase in taking in the Angas and Bremer catchments

47. Water shall not be allocated in the Angas River *surface water catchment* or the Bremer River surface water catchment (as shown in Figure 4.2) where that allocation would cause a net increase in the total volume of *evaporation plus consumptive use from surface water and watercourses* plus *lower Angas Bremer allocations* in that surface water catchment, compared with *initial evaporation plus consumptive use* in that catchment.

48. For the purposes of the Plan, *initial evaporation plus consumptive use* in a *surface water catchment* is determined as follows:

$$ECU_I = E_I + CU_{SW,I} + LAB_I - \text{reduction}$$

where:

ECU _I	Initial evaporation plus consumptive use in the relevant catchment (in ML).
E _I	<i>Evaporation</i> : the total volume of mean net annual evaporation from dams present in the relevant catchment at the <i>date of adoption</i> (and those approved as a result of the <i>existing user allocation process</i> after the date of adoption), determined in accordance with principle 34 (in ML).
CU _{SW,I}	The total volume of <i>consumptive use from surface water and watercourses</i> from the relevant catchment, representing conditions at the <i>date of adoption</i> for non-licensed use, and representing the outcomes of the <i>existing user allocation process</i> for licensed use. This value is determined using the equation given in principle 34 a) and values as of the date of adoption, except that the 'allocation' term is calculated as the final quantity of water allocated to existing users under the existing user allocation process from surface water and watercourses in the relevant catchment, excluding <i>lower Angas Bremer allocations, ecosystem allocations (system provisions), roof runoff allocations</i> and <i>urban runoff allocations</i> (in ML).
LAB _I	The total volume of <i>lower Angas Bremer allocations</i> granted to existing users under the <i>existing user allocation process</i> in the relevant catchment (in ML).
reduction	The total volume of reductions in allocations (if any) that have occurred since the <i>date of adoption</i> (or since issue of allocations to existing users under section 164N of the NRM Act if this occurs earlier) in the relevant catchment, through sections 132 or 155 of the NRM Act or other regulatory mechanisms intended to protect water resources and dependent users, including the environment (in ML).

Joint Tookayerta limit

49. Water shall not be allocated in the Tookayerta Creek *surface water catchment* where it would cause *joint Tookayerta demand* to exceed (or further exceed) the *joint Tookayerta limit*.
50. For the purposes of the Plan:
- Joint Tookayerta demand* means the sum of:
 - evaporation plus consumptive use from surface water and watercourses* in the Tookayerta Creek *surface water catchment* (in ML); and
 - consumptive use from underground water* in the Tookayerta Permian *underground water management zone* (in ML).
 - The *joint Tookayerta limit* is given in Table 4.4.

No net increase in taking in the Tookayerta catchment in some circumstances

51. This principle only applies if *joint Tookayerta demand* exceeds the *joint Tookayerta limit*.

Water shall not be allocated in the Tookayerta Creek *surface water catchment* where that allocation would cause a net increase in the total volume of *evaporation plus consumptive use from surface water and watercourses* in that surface water catchment, compared to that total volume immediately prior to the proposed allocation.

Threshold flow rates

52. Water shall not be allocated unless the applicant can demonstrate, to the satisfaction of the Minister, how compliance with principles 53–59 will be achieved.
53. Subject to principles 57 and 68, any water present in a surface water *flow path* or watercourse at or below the *threshold flow rate*:
 - a) must not be taken; or
 - b) if taken, must re-enter the same watercourse or surface water flow path immediately downstream of the *diversion structure* as soon as reasonably practical (and no longer than 24 hours after diversion), and must not be of poorer quality than the water that was diverted.
54. Subject to principles 57 and 68, when water is flowing over land or in watercourses at or above the *threshold flow rate*, water must not be taken in a manner that causes the flow rate to decrease below the threshold flow rate, unless flow at or below the threshold flow rate re-enters the same surface water flow path or watercourse in accordance with principle 53 b).
55. For the purpose of the Plan, the *threshold flow rate* at a point is determined as follows:
 - a) In the following surface water management zones, or for allocations sourced from those management zones, the threshold flow rate is:
 - i) 0.2 m³/s in surface water management zone 426AR026, or where appropriate, determined as the equivalent flow level at the point of taking, assuming that operable in-stream weirs have not been deployed (where the equivalent flow level is determined by a suitably qualified hydrologist or engineer);
 - ii) 0.5 m³/s in surface water management zone 426BR062, or where appropriate, determined as the equivalent flow level at the point of taking, assuming that operable in-stream weirs have not been deployed (where the equivalent flow level is determined by a suitably qualified hydrologist or engineer); or
 - iii) such other rate in surface water management zones 426AR026 and/or 426BR062 as determined by the Minister that, in the Minister's opinion, is necessary or appropriate to protect and manage the ecological communities specified in principle 56.
 - b) In all other surface water management zones, the threshold flow rate is calculated as:

$$\text{TFR} = \text{UTFR} \times A$$
 where:
 TFR Threshold flow rate at a point (in L/s).
 UTFR Unit threshold flow rate: given in the appropriate 'Unit threshold flow rate' group of columns of Table 4.5 for the surface water management zone that the point lies within (in L/s/km²).
 If the point is a diversion structure that takes water from a main watercourse, the UTFR will be in the range provided by the 'Main watercourse minimum' and 'Main watercourse maximum' columns in the Unit threshold flow rate group of columns of this table, where the final value will be determined at the time of assessment from within that range.
 Otherwise, the UTFR will be the relevant value from the 'Surface water management zone' column in the Unit threshold flow rate group of columns of this table.
 A Area of the catchment area upstream of the point (in km²).
 or
 - c) such other rate as determined in accordance with principle 57.

56. For the purposes of principle 55 a) iii), 67 c) iii) and 68 b), the following ecological communities are specified:
 - a) red gum swamp communities on the floodplains of the lower Angas and Bremer Rivers (as shown in Figure 4.11);
 - b) in-stream water-dependent ecological communities in surface water management zones 426AR026 and 426BR062 or in surface water management zones that receive water from these zones; and
 - c) end-of-system water-dependent ecological communities in or immediately downstream of surface water management zones 426AR026 and 426BR062.
57. The Minister may set an alternative threshold flow rate, and/or alternative rules for protecting environmental processes during times of zero or low flow, for an individual *diversion structure*:
 - a) in exceptional circumstances for allocations granted to existing users under section 164N of the NRM Act, where requirements reflecting principles 53–55 b) would significantly compromise the ability of that user to access sufficient water at appropriate times to meet their reasonable requirements; and
 - b) in a manner that does not compromise the persistence of water-dependent ecosystems or the ability of other users to access water.
58. The *threshold flow rate* (in litres per second) shall be endorsed on the licence(s) for each diversion structure in respect of which an allocation may be taken.
59. Any device or bypass mechanism that ensures compliance with principles 53–57 (where applicable):
 - a) shall be designed and constructed to ensure its correct operation is automated and cannot be manually overridden;
 - b) shall be designed and constructed so that its correct operation minimises the risk of erosion and damage to infrastructure;
 - c) shall not increase the area that directs water to the diversion structure beyond the natural size of the catchment area upstream of the diversion structure;
 - d) shall be maintained in such a condition that it continues to be effective in meeting principles 53–59; and
 - e) must not be obstructed or tampered with in any way.

Lower Angas Bremer allocations

60. '*Lower Angas Bremer allocations*' are allocations granted to take water sourced from a watercourse in surface water management zones 426AR026 and/or 426BR062, or that flows from these zones, that must be taken in accordance with principles 61–68 in addition to the rest of the relevant principles in the Plan.
61. A *lower Angas Bremer allocation* may only be granted as a *rollover allocation*, transfer or variation of an existing lower Angas Bremer allocation.
62. The volume of a *lower Angas Bremer allocation* must not be increased, except when granted as a rollover allocation in accordance with principles 71–79, or where existing lower Angas Bremer allocations are combined. In this case the resulting allocation volume must not exceed the sum of the volumes of the allocations that have been combined.
63. *Lower Angas Bremer allocations* are not accounted for against the *regional evaporation and consumptive use limit*, *catchment evaporation and consumptive use limit*, *runoff evaporation and*

consumptive use limit, main watercourse evaporation and consumptive use limit, or the local evaporation and consumptive use limit.

64. A lower Angas Bremer allocation shall not be granted where the allocation would result in a net increase in the area subjected to *flood irrigation* within the boundary of the Angas Bremer Limestone underground water management zone (as shown in Figure 4.12).
65. A lower Angas Bremer allocation must not be used for the practice of drainage or discharge to a well, unless the licensee:
 - a) held a drainage and discharge permit (upon which was endorsed either the Angas or Bremer Rivers as the nominated water source) during the period of the *Notice of Prohibition*; and
 - b) holds an appropriate authorisation to drain or discharge water into a well, such as a permit issued under section 127 (3)(c) of the NRM Act or an appropriate authorisation granted under the *Environment Protection Act 1993*.
66. A lower Angas Bremer allocation must not be stored in a dam, unless the licensee can demonstrate to the Minister's satisfaction that they carried out a similar practice prior to the *date of adoption*.
67. Lower Angas Bremer allocations must only be taken during a *flow event* in the surface water management zone that the allocation is sourced from.
 - a) A flow event starts when the flow rate is first measured to reach or exceed the *first flush trigger flow rate* at the relevant *end-of-system flow gauging station*, after the previous flow event has ended as set out in principle 67 b).
 - b) A flow event ends when the daily flow rate has been measured to be less than the *threshold flow rate* (expressed in ML/day) for 20 consecutive days at the relevant end-of-system flow gauging station.
 - c) The first flush trigger flow rate for each relevant surface water management zone is:
 - i) in surface water management zone 426AR026 — 0.6 m³/s;
 - ii) in surface water management zone 426BR062 — 1.2 m³/s; or
 - iii) such other rate as determined by the Minister that, in the Minister's opinion, is necessary or appropriate to protect and manage any of the ecological communities specified in principle 56.
 - d) The end-of-system flow gauging station means:
 - i) flow gauging station A4261220 (Ballandown Road) where water will be taken from the Angas River surface water catchment; or
 - ii) flow gauging station A4261219 (Ballandown Road) where water will be taken from the Bremer River surface water catchment;as appropriate, or their successors.
 - e) The threshold flow rate for each relevant surface water management zone is calculated in accordance with principle 55.
68. Once water taking may commence in a *flow event* in accordance with principle 67, operable in-stream weirs may be deployed (despite principle 53–54) for a maximum cumulative time of 48 hours within that *flow event*, provided that the flow rate is above the *threshold flow rate* at the point of taking when the weir is deployed. Operable in-stream weirs operated in this manner are exempt from principles 53 and 54, but must provide a passing flow rate of:
 - a) 10 ML/day to the downstream watercourse while in operation; or
 - b) such other rate as determined by the Minister that, in the Minister's opinion, is necessary or appropriate to protect and manage any of the ecological communities specified in principle 56.

Point of taking

69. Water shall not be allocated where the allocation would be taken from a location containing a *significant environmental asset* or assets unless:
- a) the allocation will be obtained on the basis of a transfer of an allocation or a water licence; and
 - b) immediately before any transfer referred to in paragraph (a) takes place, the allocation or water licence being transferred authorised the taking of water from the significant environment asset or assets; and
 - c) there is no change to the conditions of the allocation or to the location of the point of taking (unless such a change is expected to reduce impacts of water taking and/or use on the significant environmental asset); and
 - d) the allocation volume does not increase.
70. A water allocation to be taken from a dam that has been constructed or enlarged since the *date of adoption* shall only be approved if the dam complies with sections 7.1 and 7.2.1 of the Plan.

Rollover allocations

71. If part or all of a *base allocation* is not taken by the end of a *water use year*, the holder of that base allocation at the end of that water use year may be granted a '*rollover allocation*' to be taken from the same *source* in the following water use year only, subject to principles 72–79.
72. For the purposes of principles 71–77, a reference to a *source* that an allocation has or may be taken from, also includes a group of sources that the allocation has or may be taken from, as endorsed on the relevant licence.
73. The maximum volume of a *rollover allocation* granted to be taken from a *source* in a water use year is the lesser of:
- a) the volume of the *base allocation* that was not taken from that source in the previous water use year; or
 - b) 10% of the volume of the base allocation granted to be taken from that source as at the start of that water use year; or
 - c) if the rollover allocation is to be taken from a dam — the total dam capacity minus *evaporation* minus the base allocation deemed to be taken from that dam, unless it can be demonstrated to the Minister's satisfaction that more than that volume can be taken annually from that dam.
74. A *rollover allocation* expires at the end of the *water use year* in which it is granted.
75. A *rollover allocation* shall be deemed to be taken after the *base allocation* for a *source* in a water use year.
76. A *rollover allocation* will not be granted if the taking of the *base allocation* is not metered to the Minister's satisfaction.
77. A *rollover allocation* may only be taken from the *source* endorsed on the licence for the *base allocation* that gave rise to the rollover allocation.
78. A *rollover allocation* shall not be granted until the start of the second full *water use year* after the *date of adoption*.
79. *Rollover allocations* are not subject to principles 33 and 35–51.

5.2.2 Allocations from selected parts of the River Murray Prescribed Watercourse

80. Pursuant to section 76 (7) of the NRM Act, a water management authorisation shall not be granted to allow water to be taken from a watercourse of the Finnis River or Tookayerta Creek surface water catchment that lies within the River Murray Prescribed Watercourse upstream of where Winery Road crosses these watercourses (see Figure 4.13), unless the taking of that water is consistent with principles 33–46, 49–59 and 69–70 of the Plan (where relevant).
81. Principle 80 is only intended to apply in the case where a water access entitlement or allocation would first start to be taken from the area described after the *date of adoption*.

5.2.3 Roof runoff allocation criteria

The following principles apply to the allocation of surface water which is assigned to a *source* identified as roof runoff ('*roof runoff allocations*') only. They are in addition to the general objectives and principles outlined in section 5.1 of the Plan. These principles only apply to roof runoff allocations granted under the Plan.

82. Where *roof runoff* is taken in accordance with the Notice of Authorisation to take water in the *Gazette*, 30 August 2012, pages 3921–3928, or its successors ('*roof runoff Notice of Authorisation*'), an allocation is not required.
83. When the volume of roof runoff deemed to be collected from a *connected roof area* is above 1,500 kL/y (determined in accordance with the *roof runoff Notice of Authorisation*), water may only be allocated as a *roof runoff allocation* where runoff from a nominated percentage of the connected roof area (at a minimum) is returned to the environment:
 - a) as close as reasonably practical to the natural path;
 - b) as soon as reasonably practicable following precipitation; and
 - c) in a manner that does not cause significant detrimental impacts to the environment, including but not limited to erosion.
84. For the purposes of principle 83, the minimum nominated percentage of *connected roof area* from which runoff must be returned to the environment is the value given in column '% roof area to return' of Table 4.5 for the surface water management zone that the majority of the connected roof area lies within.
85. The maximum volume (in ML) that may be allocated as a *roof runoff allocation* shall not exceed the volume determined by:

$$TV = \frac{\text{Connected roof area} \times \text{rainfall} \times \% \text{ allocated}}{1,000,000}$$

where:

TV	Total volume. The total allocation volume of roof runoff that is not to be exceeded for a given connected roof area (in ML).
Connected roof area	The area of roof that drains (through gutters, downpipes or other means) to water storage facilities. Where there are multiple connected roof areas on a <i>property</i> , the connected roof area for the property is the total of all connected roof areas for that property (in m ²).
Rainfall	Average annual rainfall (in mm) determined in accordance with the <i>roof runoff Notice of Authorisation</i> .
% allocated	Maximum allowable proportion of roof runoff that may be allocated. Determined as: (100 - minimum nominated percentage to be returned determined in accordance with principle 84) ÷ 100
1,000,000	Factor to convert volume to ML.

86. Where *roof runoff* from a given roof is included within the calculations to determine *urban runoff* for *urban runoff allocations* for the purposes of principles 87 and 88, a *roof runoff allocation* shall not be granted to be taken from that roof.

5.2.4 Urban runoff allocation criteria

The following principles apply to the allocation of *urban runoff* from *designated urban land use development* only. They are in addition to the general objectives and principles outlined in section 5.1 of the Plan. These principles only apply to *urban runoff allocations* granted under the Plan.

Note: urban runoff allocations under the Plan are only available under limited circumstances for urban development that has been approved and commenced since 16 October 2003, or from particular areas.

87. An *urban runoff allocation* may only be allocated where:
- a) the allocation will be sourced as runoff from *designated urban land use development*;
 - b) the maximum volume of an urban runoff allocation is *urban runoff* minus *pre-development runoff and recharge* from the area of the designated urban land use development;
 - c) the pre-development runoff and recharge from the site is returned to the environment:
 - i) as close as reasonably practical to the natural flow path;
 - ii) as soon as reasonably practical following precipitation, unless detained on-site for water quality remediation and/or mitigation of flooding, in which case the pre-development runoff and recharge must be returned to the environment within three days of collection or diversion;
 - iii) in a manner that maintains the natural flow regime and aquifer recharge; and
 - iv) in a manner that does not cause significant detrimental impacts to the environment, including but not limited to erosion and detrimental impacts to stream bed and bank stability;
 - d) the *time to peak flow* matches that of the pre-development case, as far as reasonably practical, for up to the 5 year *average recurrence interval* event, provided this does not exacerbate downstream flooding (demonstrated to the satisfaction of the Minister by a suitably qualified hydrologist or engineer); and
 - e) the time to peak flow matches that of the pre-development case for the 5 year up to the 100 year average recurrence interval events, unless catchment wide benefits can be demonstrated, provided this does not exacerbate downstream flooding (demonstrated to the satisfaction of the Minister by a suitably qualified hydrologist or engineer).
88. *Urban runoff* from *designated urban land use development* as identified in principle 89 b) ii) II) may only be allocated as an *urban runoff allocation* where it can be demonstrated to the Minister's satisfaction by a suitably qualified expert that taking the allocation will not compromise the provision of water requirements of water-dependent ecosystems and existing consumptive users.

89. For the purposes of section 5–7 of the Plan:

- a) an *urban runoff allocation* is an allocation of water running off a *designated urban land use development*, granted in accordance with section 5.2.4 of the Plan;
- b) a designated urban land use development is development that is:
 - i) located in an area that the Minister considers to be urban, which may include, but is not limited to, land zoned as residential zone, regional town centre zone, neighbourhood centre zone, local centre zone or home industry zone in a relevant Development Plan under the *Development Act 1993*; and
 - ii) either:
 - I. authorised by a development approval under the *Development Act 1993* after 16 October 2003 and commenced after 16 October 2003; or
 - II. located in any of the following *surface water catchments*: Angas Plains, Ferries-McDonald, Long Gully Group, Milendella Creek, Preamimma Creek, Rocky Gully Creek, Salt Creek, or Sandergrove Plains.
- c) Urban runoff is the mean annual volume of water expected to run off a designated urban land use development, as determined to the satisfaction of the Minister by a suitably qualified hydrologist or engineer. The runoff from roofs that is already allocated as a roof runoff allocation in the designated urban land use development shall not be included in the calculation of urban runoff.
- d) Pre-development runoff and recharge is the mean annual volume expected to return to water resources from the site under conditions prior to the designated urban land use development, as determined to the satisfaction of the Minister by a suitably qualified hydrologist or engineer. The volume of pre-development runoff and recharge for a designated urban land use development shall not be less than:

$$PRR = A_D \times DRR$$

where:

PRR The minimum volume of *pre-development runoff and recharge* (in ML).

A_D Area of the *designated urban land use development* (in km²).

DRR Depth of recharge plus mean annual adjusted runoff for the surface water management zone that the majority of the *designated urban land use development* lies within, given in column 'Mean annual adjusted runoff + recharge depth' in Table 4.5 (in mm).

- e) the *time to peak flow* is the amount of time between the centre of mass of rainfall excess (the point at which half the rain that's running off has fallen) and the peak of the hydrograph (maximum flow rate generated by the runoff).
- f) the *average recurrence interval* is the average or expected value of the period between exceedances of a given discharge.

5.3 UNDERGROUND WATER ALLOCATION CRITERIA

5.3.1 Allocation criteria for underground water, excluding artificially recharged water

The following principles apply to the allocation of underground water only, excluding *recharge allocations*. They are in addition to the objectives and general principles set out in section 5.1 of the Plan.

Management zone limits

90. Water shall not be allocated where it would cause the total volume of *consumptive use from underground water* in an *underground water management zone* to exceed (or further exceed) the *underground water consumptive use limit* for that zone.
91. For the purpose of the Plan:
- a) *Underground water management zones* are identified in Table 4.7 and shown in Figure 4.10.
 - b) *Consumptive use from underground water* in an underground water management zone is the sum of the volumes of:
 - i) *base allocations* from underground water in the underground water management zone (in ML) (note that base allocations exclude *rollover allocations*, *recharge allocations* and *ecosystem allocations (system provisions)*); and
 - ii) estimated non-licensed use from underground water in the underground water management zone (in ML), including:
 - I. stock and domestic use from underground water for the underground water management zone, given in column 'Stock and domestic' of Table 4.7 (in ML); and
 - II. *Forestry use from underground water* by *commercial forests* for the underground water management zone (determined in accordance with principle 267 b)), including the volume estimated to occur for existing commercial forests at the *date of adoption* (as given in column 'Forestry' in Table 4.7) and the volume for commercial forests that has been planted or authorised in accordance with section 7.2.9 of the Plan or by a development approval under the *Development Act 1993* since the date of adoption; but excluding the volume for any of the above commercial forests that has been permanently removed and won't be replanted (in ML).
 - c) The *underground water consumptive use limit* for each underground water management zone is given in Table 4.7.

Regional scale limit

92. Water shall not be allocated where it would cause the total volume of *consumptive use from underground water* from all *underground water management zones* in the Eastern Mount Lofty Ranges PWRA to exceed (or further exceed) the *regional underground water consumptive use limit*.
93. For the purposes of the Plan, the *regional underground water consumptive use limit* is given in Table 4.4.

Joint Tookayerta limit

94. Water shall not be allocated in the Tookayerta Permian *underground water management zone* where it would cause *joint Tookayerta demand* to exceed (or further exceed) the *joint Tookayerta limit*.

No net increase in taking in the Tookayerta Permian in some circumstances

95. This principle only applies if *joint Tookayerta demand* exceeds the *joint Tookayerta limit*.

Water shall not be allocated in the Tookayerta Permian *underground water management zone* where that allocation would cause a net increase in the total volume of *consumptive use from underground water* in that zone, compared to that total volume immediately prior to the proposed allocation.

Impact on baseflow and throughflow

96. Water shall not be allocated where taking that allocation will have, or be likely to have, significant detrimental impacts on:
- a) the amount and/or duration of discharge from underground water to surface water/watercourses or vice versa;
 - b) the amount and/or duration of discharge between aquifers; and/or
 - c) ecosystems that depend on such discharge.

Buffer zones

97. Subject to principles 103, 104 and 109, water shall not be allocated if the allocation would cause the *well buffer zone* around the existing or proposed well from which the allocation is to be taken to overlap (or further overlap):
- a) a well buffer zone around an *operational well* linked to the same aquifer but owned by another landholder (to 'overlap another well buffer zone'); or
 - b) an *environmental buffer zone* linked to the same aquifer (to 'overlap an environmental buffer zone').
98. A *well buffer zone*:
- a) is a circular area centred upon the site of an *operational well*;
 - b) has a radius determined in accordance with Table 5.1 and principles 100 and 101; and
 - c) is linked to the aquifer that the well takes water from.
99. An *operational well* is any water well listed on the SA Geodata database that is not an investigation, abandoned or backfilled well. Alternative information on the existence, location, status and/or purpose of use of water wells may also be considered by the Minister. Where there is uncertainty on the existence, location, status and/or purpose of use of an operational well in relation to an assessment under the Plan, it shall be the responsibility of the applicant to determine the relevant information to the satisfaction of the Minister.
100. For the purpose of calculating a *well buffer zone* in accordance with principle 98 and Table 5.1, in situations where an allocation may be taken from more than one well, the entire allocation may be deemed to be taken from each such well, unless the licensee demonstrates, to the Minister's satisfaction, the precise manner in which the allocation is to be taken from the wells in question.
101. The Minister or relevant authority may assign a larger radius for a *well buffer zone* than the relevant figure given in Table 5.1, in cases where it is necessary to protect water users, public health, natural

resources and/or the environment. This may include, but is not limited to, investigation wells for contaminated sites to avoid extraction of contaminated underground water by adjacent wells.

Table 5.1 Radii for well and environmental buffer zones (in metres) for underground water management zones.

Underground water management zone (grouped by aquifer)	Radii of well buffer zones (m) for allocations less than 10 ML and non-licensed wells	Radii of well buffer zones (m) for allocations 10 ML or greater	Radii of environmental buffers zones (m)
Adelaidean fractured rock zones: Angas Adelaidean Bremer Adelaidean Finniss Adelaidean	100	200	50
Permian Sands zones: Currency Permian Finniss Permian 1–2 Tookayerta Permian	100	200	50
Kanmantoo Group fractured rock zones: Angas Kanmantoo Bremer Kanmantoo Currency Kanmantoo Finniss Kanmantoo 1–4 Northern Kanmantoo Tookayerta Kanmantoo 1–3	50	100	50
Murray Group Limestone Confined zones: Angas Bremer Limestone Currency Limestone Goolwa Limestone Sandergrove Limestone	100	200	0
Murray Group Limestone Unconfined zone: Northern Limestone	50	100	50
Quaternary zones: Angas Bremer Quaternary Currency Quaternary Goolwa Quaternary Sandergrove Quaternary	50	100	50

102. An *environmental buffer zone*:
- a) is an area radiating from:
 - i) the outermost perimeter of an *environmental asset* or *significant environmental asset*, with a radius determined in accordance with Table 5.1; or
 - ii) the centreline of a *main watercourse*, with a radius determined in accordance with Table 5.1. Main watercourses are shown in Figure 4.3 to Figure 4.9, and the centreline is determined from the spatial database held by the Department that was used to define main watercourses for the Plan; and
 - b) is linked to the aquifer that interacts with, or is likely to interact with, the environmental asset, significant environmental asset or main watercourse.
103. Despite principle 97, an allocation may be granted to be taken from a well where the *well buffer zone* will overlap another well buffer zone and/or overlap an *environmental buffer zone* if:
- a) the applicant holds an allocation where part or all of that allocation was originally granted to be taken from that well to an existing user pursuant to section 164N of the NRM Act; and
 - b) there has been no change to the location of the well from which the allocation may be taken (other than in circumstances where principle 109 applies), and no increase in the volume of the allocation.
104. Despite principle 97, an allocation may be granted to be taken from a well where the *well buffer zone* will overlap another well buffer zone if the applicant can demonstrate to the Minister's satisfaction (by means of an aquifer test properly conducted pursuant to principle 105) that there will be no significant detrimental impact on:
- a) water levels in the affected wells;
 - b) yield in the affected wells; or
 - c) water quality in the affected wells.
105. An aquifer test for the purposes of principle 104 must:
- a) be conducted no earlier than five years prior to the date of application; and
 - b) be carried out using a methodology approved by the Minister.
106. Prior to undertaking an aquifer test, the applicant must give written notification by registered post to each owner and/or occupier of land whose *well buffer zone* would be overlapped (or further overlapped) as a result of the proposed allocation, seeking:
- a) to verify the location of the well;
 - b) to verify that the well is an *operational well*; and
 - c) written permission to access the well for water level measurements and water sample collection.
107. Where written permission to access wells is not provided by the owner/occupier of land with overlapped *well buffer zones* to the Minister and applicant within 30 working days of the receipt of a registered letter from the applicant under principle 106, the potential of impact on those wells will not be considered.
108. Principle 104 does not apply where an allocation would cause the *well buffer zone* around the existing or proposed well to overlap an *environmental buffer zone*.

Replacement wells

109. Despite principle 97, where a well from which a water allocation may be taken is replaced, that allocation may be taken from the replacement well provided that:

- a) the replacement well is drilled in accordance with principle 245; and
- b) there is no increase in the volume of water allocated and no change to the conditions of the allocation.

High intensity use zones

110. Subject to principle 112, an underground water allocation shall not be granted:
- a) in a *high intensity use zone* if the allocation results in an increase in the total volume allocated in the high intensity use zone; or
 - b) if a new high intensity use zone will be created as a result of the allocation.
111. For the purpose of the Plan:
- a) A *high intensity use zone* is a circular area centred on a licensed well with a radius of 600 metres where the total volume allocated in the area exceeds four times the mean annual recharge rate for the area, pursuant to the following formula:

$$AV > RR_{MZ} \times 4 \times 1.13$$

where:

AV	Allocation volume in the area: the total volume of underground water <i>base allocations</i> in the area (in ML).
RR_{MZ}	Recharge rate for the underground water management zone that the majority of the area lies within (in mm), as given in Table 4.7.
4	Recharge multiplier to calculate the multiple of the recharge rate.
1.13	Area of the high intensity use zone (circle of 600 m radius) (in km ²).
 - b) For the purposes of identifying *high intensity use zones*, in situations where an allocation may be taken from more than one well, the entire allocation may be deemed to be evenly divided between all of the wells it may be taken from, unless the licensee demonstrates, to the Minister's satisfaction, the precise manner in which the allocation is to be taken from the wells in question.
112. Principles 110–111 do not apply in Quaternary and Confined Limestone *aquifer types*, where the underground water management zones corresponding to aquifer types are given in Table 5.2.

Rollover allocations

113. Subject to principles 114–121, if part or all of a *base allocation* is not taken by the end of a *water use year* (the 'credit year'), any untaken volume of up to 10% of the base allocation at the end of the credit year may be granted as a '*rollover allocation*' to be taken from the same source within the following two water use years only¹².
114. The combined volume of a *base allocation* and *rollover allocations* granted to be taken from a *source* in any *water use year* must not exceed 110% of the base allocation from that source at the start of that water use year.
115. For the purposes of principles 113–123, a reference to a *source* that an allocation has or may be taken from, also includes a group of sources that the allocation has or may be taken from, as endorsed on the relevant licence.

¹² The untaken volume (capped at 10% of the base allocation at the end of the credit year) may be taken in either the first or second water use year after the credit year; or spread over both.

116. A *rollover allocation* shall be deemed to be taken after the *base allocation* for a *source* in a *water use year*.
117. *Rollover allocations* shall be deemed to be taken in the order in which they accrue.
118. A *rollover allocation* will not be granted if the taking of the *base allocation* is not metered to the Minister's satisfaction.
119. A *rollover allocation* may only be taken from the *source* endorsed on the licence for the *base allocation* that gave rise to the rollover allocation.
120. If the *date of adoption* is part way through a *water use year*, then a *rollover allocation* will not be granted as a result of untaken *base allocation* from that first water use year including the date of adoption, except for rollover allocations granted in accordance with principles 122–123.
121. *Rollover allocations* are not subject to principles 90–112.

Rollover allocations from the Angas Bremer Water Allocation Plan earned before date of adoption

122. Principle 123 only applies to underground water allocations granted from the Angas Bremer Limestone underground water management zone.
123. If, immediately prior to the *date of adoption*, a licensee is able to take an unused portion of an allocation in accordance with principles 2–4 of section 5 of the Water Allocation Plan for the Angas Bremer Prescribed Wells Area (2001), a *rollover allocation* may be granted subject to principles 115–121 and all of the following:
 - a) The volume of the rollover allocation shall not exceed the volume of unused allocation that could be taken in later *water use years* (as determined through the application of principles 2–4 of section 5 of the Water Allocation Plan for the Angas Bremer Prescribed Wells Area (2001)) that has not yet been taken.
 - b) The rollover allocation may only be granted within the three water use years following the water use year in which part or all of the original allocation was not taken.
 - c) The combined volume of:
 - i) a *base allocation*;
 - ii) *rollover allocations* granted in accordance with principles 113–114; and
 - iii) rollover allocations granted in accordance with principle 122–123;granted to be taken from a *source* in any water use year must not exceed 130% of the base allocation from that source at the start of that water use year.

5.3.2 Allocation of artificially recharged water

The following principles apply only to the allocation of water drained or discharged into a well in accordance with a permit issued under section 127 (3)(c) of the NRM Act or an authorisation granted under the *Environment Protection Act 1993*. They are in addition to the general objectives and principles set out in section 5.1 of the Plan.

124. Subject to principles 125–134, water that has been drained or discharged into a well during a *water use year* (the '*recharge year*') may be allocated to be taken as a '*recharge allocation*' within the specified number of water use years immediately after the recharge year.
125. For the purposes of principle 124, the specified number of years is:
 - a) given in the 'Specified number of water use years' column of Table 5.2, corresponding to the *aquifer type* that the *recharge allocation* would be taken from; or
 - b) determined in accordance with principle 130–131.
126. A *recharge allocation* will not be granted unless a permit has been issued pursuant to section 127 (3)(c) of the NRM Act or an authorisation granted under the *Environment Protection Act 1993* to drain or discharge water into a well.
127. The volume of a *recharge allocation* will be calculated as a percentage of the volume measured to have been drained or discharged into a well during the *recharge year*, and shall not exceed:
 - a) 100% of the volume of water drained or discharged into a well during the recharge year where the well is completed in a Confined Limestone *aquifer type* and the corresponding underground water management zones;
 - b) 80% of the volume of water drained or discharged into a well during the recharge year where the well is completed in a Quaternary, Permian Sands or Unconfined Limestone *aquifer type* and the corresponding underground water management zones; or
 - c) 70% of the volume of water drained or discharged into a well during the recharge year where the well is completed in a Fractured Rock *aquifer type* and the corresponding underground water management zones.

Note: *Aquifer types* and the corresponding underground water management zones are shown in Table 5.2.
128. Recharge allocations are deemed to be taken in the order in which they accrue.
129. A *recharge allocation* may be granted to be taken in its recharge year, provided that a meter reading has been taken and recorded by the relevant authority that accurately reflects the drained or discharged volume for that year.¹³
130. Subject to principle 131, the Minister may make a determination to increase the specified number of years in respect of the confined limestone aquifer in the Angas Bremer Limestone and Currency Creek Limestone underground water management zones.
131. Before making a determination for the purposes of principle 130, the Minister must be satisfied that the storage of water in the aquifer for the period from the *date of adoption* has resulted in no adverse impacts to the aquifer, environment and other water users (including, but are not limited to, rising shallow watertables, increasing salinity and artesian conditions).

¹³ The applicant may request a special meter reading to be taken at any time. It should be noted that a fee may be payable for a meter reading that occurs outside normal readings.

Table 5.2 Aquifer type and corresponding underground water management zones and specified number of water use years

Aquifer Type	Underground water management zone	Specified number of water use years
Confined Limestone	Angas Bremer Limestone Currency Limestone Goolwa Limestone Sandergrove Limestone	4 years
Unconfined Limestone	Northern Limestone	2 years
Permian Sands	Currency Permian Finniss Permian 1–2 Tookayerta Permian	2 years
Quaternary	Angas Bremer Quaternary Currency Quaternary Goolwa Quaternary Sandergrove Quaternary	2 years
Fractured Rock	Angas Adelaidean Angas Kanmantoo Bremer Adelaidean Bremer Kanmantoo Currency Kanmantoo Finniss Kanmantoo 1–4 Finniss Adelaidean Northern Kanmantoo Tookayerta Kanmantoo 1–3	1 year

132. A *recharge allocation* shall only be allocated where the proposed point of extraction takes water from the same aquifer that the water was drained or discharged into and is:
 - a) the same point at which water is drained or discharged;
 - b) in all underground water management zones except the Angas Bremer Limestone *underground water management zone* — within 100 m of the well into which water is drained or discharged;
 - c) in the Angas Bremer Limestone underground water management zone — within 500 m of the well into which water is drained or discharged; or
 - d) at a greater distance if the proponent can provide hydrogeological evidence to demonstrate, to the Minister's satisfaction, that the water drained or discharged is available for extraction at the proposed extraction point.
133. *Well buffer zones* will be assigned to the proposed point of extraction of the *recharge allocation* in accordance with principle 98–101 and Table 5.1.
134. A *recharge allocation* will not be granted where the *well buffer zone* around the proposed point of extraction overlaps an *environmental buffer zone* of a *significant environmental asset* linked to the same aquifer, determined in accordance with principle 102.

5.4 VARIATION OF WATER ALLOCATIONS AND LICENCES

The following principles apply to the variation of all water allocations and licences in the Eastern Mount Lofty Ranges PWRA.

135. Subject to principle 139, a variation in the quantity of water specified on a water licence, the location of the point of taking and/or use, and/or the conditions endorsed on a water licence or attached to an allocation, must be consistent with the relevant objectives and principles in sections 5 and 6 of the Plan.

Variations under the Plan during the existing user allocation process and reservation

136. The Minister may refuse to vary a licence and/or allocation if:
- a) the assessment of that proposed variation against the relevant principles in the Plan may be affected by an *existing user allocation* (or allocations) for which the *existing user allocation process* is not complete; and/or
 - b) excess water has been reserved from allocation within the Eastern Mount Lofty Ranges PWRA, pursuant to section 166 of the NRM Act.
137. For the purposes of sections 5–7 of the Plan:
- a) an *existing user allocation* means an allocation granted, or proposed to be granted, in accordance with section 164N of the NRM Act.
 - b) the *existing user allocation process* means the processes associated with allocating water to existing users under section 164N of the NRM Act, including licence issue, allocation reduction and appeals.

Variations between water resources

138. A water licence or allocation must not be varied to allow:
- a) a *roof runoff allocation* to be taken from surface water or watercourse water that is not *roof runoff*;
 - b) an *urban runoff allocation* to be taken from surface water or watercourse water that is not *urban runoff*;
 - c) a water allocation made from surface water or watercourse water that is not roof runoff to be taken as a roof runoff allocation; or
 - d) a water allocation made from surface water or watercourse water that is not urban runoff to be taken as an urban runoff allocation.

Emergency water use

139. Despite principle 135, the Minister may, in emergency circumstances, vary an allocation or licence on application by the licensee to allow a limited volume of an existing allocation to be taken from a source that is not endorsed on the licence (the 'emergency source') without consideration of the relevant objectives and principles in sections 5 and 6 of the Plan, in the following circumstances:
- a) all of the following conditions are met:
 - i) there is structural or mechanical failure in the licensed water source such that water can't practically be taken from it; or the water is to be taken from the emergency source to replace water used from the licensed source by emergency services (such as the Country Fire Service) in an emergency situation;
 - ii) not taking water from the emergency source would result (or be likely to result) in significant financial loss or breach of legislative requirements;
 - iii) it is not reasonably practical to obtain the required water from elsewhere;
 - iv) the emergency source was in existence at the *date of adoption*;
 - v) a maximum of 500 kL is taken from the emergency source; and
 - vi) water may only be taken from the emergency source for up to two months;
 - or
 - b) other such circumstances as the Minister considers appropriate.

Recharge allocations

140. A *recharge allocation* may be varied to alter the allocation volume as a different percentage of the volume of water drained or discharged into a well during the *recharge year*, compared to the percentage allocated in accordance with principle 127. The varied percentage, not exceeding 100%, is that determined by the Minister that, in the Minister's opinion, will not have the potential to have an adverse impact on the aquifer, water-dependent ecosystems and other water users (including, but not limited to, undesirable rises in water levels and/or pressures, or damage to an aquifer confining layer).

Threshold flow rates

141. If the whole or part of a water allocation is taken from or by a dam, or from a watercourse, the Minister may vary the relevant water licence by imposing a condition on the water licence that requires that:
- a) subject to principles 57 and 68, any water present in a surface water *flow path* or watercourse at or below the *threshold flow rate*:
 - i) must not be taken; or
 - ii) if taken, must re-enter the same watercourse or surface water flow path immediately downstream of the *diversion structure* as soon as reasonably practical (and no longer than 24 hours after diversion), and must not be of poorer quality than the water that was diverted.
 - b) subject to principles 57 and 68, when water is flowing over land or in watercourses at or above the threshold flow rate, water must not be taken in a manner that causes the flow rate to decrease below the threshold flow rate, unless flow at or below the threshold flow rate re-enters the same surface water flow path or watercourse in accordance with principle 53 b).

6 TRANSFER CRITERIA

The following objectives apply to the transfer of water licences and/or allocations for all prescribed water resources in the Eastern Mount Lofty Ranges PWRA.

Objectives

- a) Enable the transfers of water allocations in a sustainable manner.
- b) Maintain the quantity and quality of water resources.
- c) Maintain and where possible restore water-dependent ecosystems by providing their water needs.
- d) Minimise impacts of taking and using water on the environment, prescribed water resources, other water resources and water users.

6.1 GENERAL TRANSFER CRITERIA

The following principles apply to the transfer of water licences and/or allocations for all prescribed water resources in the Eastern Mount Lofty Ranges PWRA.

General

- 142. Subject to principle 143, allocations may only be transferred if the transfer complies with the allocation criteria provided in section 5 of the Plan and the transfer criteria provided in section 6 of the Plan that relate to that type of allocation or water resource.
- 143. Despite principle 142, water allocations may be transferred without consideration of the relevant allocation criteria in section 5 of the Plan where there is no increase in the volume of water to be allocated, and there is no change to the location of the point of taking and to the conditions relating to the allocation.
- 144. The Minister may refuse to grant approval for the transfer of a water licence and/or allocation if:
 - a) the assessment of that proposed transfer against the relevant principles in the Plan may be affected by an *existing user allocation* (or allocations) for which the *existing user allocation process* is not complete; and/or
 - b) excess water has been reserved from allocation within the Eastern Mount Lofty Ranges PWRA, pursuant to section 166 of the NRM Act.
- 145. The following applies to transfer of water licences and allocations:
 - a) a *roof runoff allocation* is not to be transferred to be taken from surface water or watercourse water that is not *roof runoff*;
 - b) an *urban runoff allocation* is not to be transferred to be taken from surface water or watercourse water that is not *urban runoff*;
 - c) surface water or watercourse water that is not roof runoff is not to be transferred to be taken as a roof runoff allocation; and
 - d) surface water or watercourse water that is not urban runoff is not to be transferred to be taken as an urban runoff allocation.

146. If the taking of an allocation is not metered to the Minister's satisfaction then that allocation shall not be transferred, except if:
- a) there is no increase in the volume of water to be allocated, and there is no change to the location of the point of taking and to the conditions relating to the allocation; or
 - b) the entire allocation is transferred on, or as soon as practical after, 1 July.

Transfer between the Eastern Mount Lofty Ranges and other prescribed water resources

147. Subject to principle 149, an allocation from a prescribed water resource within the Eastern Mount Lofty Ranges PWRA shall not be transferred to be taken from any other prescribed water resource that is not within the Eastern Mount Lofty Ranges PWRA.
148. Subject to principle 149, an allocation from a prescribed water resource that is not within the Eastern Mount Lofty Ranges PWRA shall not be transferred to be taken from a prescribed water resource within the Eastern Mount Lofty Ranges PWRA.
149. Despite principles 147 and 148, an allocation may be transferred between a prescribed water resource that is within the Eastern Mount Lofty Ranges PWRA and another prescribed water resource if:
- a) the allocation will only be transferred within the boundaries of a single *property* that lies within both the Eastern Mount Lofty Ranges PWRA and the other prescribed water resource;
 - b) the water allocation plan for the other prescribed water resource allows for transfers between that prescribed water resource and the Eastern Mount Lofty Ranges PWRA; and
 - c) the proposed transfer complies with the relevant allocation and transfer principles in the water allocation plan for the prescribed water resource that the water allocation would be transferred to.
150. An allocation transferred in accordance with principle 149 shall not be subsequently transferred, except if:
- a) there are no changes to the location of taking, the volume of water allocated and any of the conditions associated with the allocation; or
 - b) the allocation is transferred back to the *source* or sources on the same property that allocation originally came from (pursuant to principle 149), provided that the proposed transfer complies with the relevant allocation and transfer principles in the water allocation plan for the prescribed water resource that the water allocation would be transferred to.

Temporary transfer of allocations

151. In the case of a temporary transfer, the allocation is to be accounted for at both the originating and receiving *sources* for the duration of the temporary transfer.

Transfer of allocations used for flood irrigation

152. A transfer will not be permitted for a water allocation used for the practice of *flood irrigation* where that allocation directly or indirectly provided water to red gum swamps as identified in Figure 4.11, unless there are no changes to:
- a) the location of taking;
 - b) the volume of water allocated; or
 - c) any of the conditions associated with the allocation.

Transfer of ecosystem allocations from the system provisions

153. *Ecosystem allocations (system provisions)* cannot be transferred, except if allocated in accordance with principle 15 b) and there are no changes to:
- a) the location of taking;
 - b) the volume of water allocated; or
 - c) any of the conditions associated with the allocation.

Transfer of rollover allocations

154. A *rollover allocation* can only be transferred if:
- a) it is transferred together with the entire associated *base allocation*; and
 - b) there is no change to the location of taking, the volume of water allocated or any of the conditions associated with the allocation.

6.2 SURFACE WATER AND WATERCOURSE WATER TRANSFER CRITERIA

6.2.1 Transfer criteria for surface water and watercourse water that is not roof runoff or urban runoff

The following principles apply to the transfer of surface water and watercourse water only, excluding *roof runoff* and *urban runoff*. They are in addition to the general objectives and principles outlined in section 6.1 of the Plan.

Catchment scale

155. A water allocation may be transferred from one *surface water catchment* to another surface water catchment, provided that the proposed transfer is consistent with the objectives and principles in sections 5.1, 5.2.1, 6.1 and 6.2.1 of the Plan.

Surface water management zone scale

156. A water allocation may be transferred within and between *surface water management zones*, provided that the proposed transfer is consistent with the objectives and principles in sections 5.1, 5.2.1, 6.1 and 6.2.1 of the Plan.

Transfer of lower Angas Bremer allocations

157. Despite principles 155–156, *lower Angas Bremer allocations* must not be transferred to be taken from a different *surface water management zone*.

6.2.2 Roof runoff transfer criteria

The following principles apply to the transfer of *roof runoff allocations* granted under the Plan only. They are in addition to the general objectives and principles outlined in section 6.1 of the Plan.

158. A *roof runoff allocation* shall not be transferred to become surface water or watercourse water that is not *roof runoff*.
159. A *roof runoff allocation* shall not be transferred, except if there is no change to the location of taking or any of the conditions relating to the allocation, and no increase in the volume of water allocated.

6.2.3 Urban runoff transfer criteria

The following principles apply to the transfer of *urban runoff allocations* granted under the Plan only. They are in addition to the general objectives and principles outlined in section 6.1 of the Plan.

160. An *urban runoff allocation* shall not be transferred to become surface water or watercourse water that is not *urban runoff*.
161. An *urban runoff allocation* shall not be transferred, except if there is no change to the location of taking or any of the conditions relating to the allocation, and no increase in the volume of water allocated.

6.3 UNDERGROUND WATER TRANSFER CRITERIA

6.3.1 Underground water

The following principles apply to the transfer of underground water only, excluding *recharge allocations*. They are in addition to the general objectives and principles outlined in section 6.1 of the Plan.

Underground water management zones and limits

162. An allocation may be transferred from one *underground water management zone* to another underground water management zone, or within an underground water management zone, provided that the proposed transfer is consistent with the objectives and principles in sections 5.1, 5.3.1, 6.1 and 6.3.1 of the Plan.

High intensity use zones

163. A water allocation shall not be transferred:
- a) into an area identified as a *high intensity use zone* if the allocation results in an increase in the total volume allocated in the high intensity use zone; or
 - b) if a new high intensity use zone will be created as a result of the transfer.
164. A water allocation may be transferred within a high intensity use zone.
165. A water allocation may be transferred out of a high intensity use zone.

Buffers

166. Where part or all of an allocation is permanently transferred, the radius of the *well buffer zone* around the well(s) that the transferred allocation was formerly taken from shall be reduced (where necessary) in order to maintain compliance with Table 5.1.
167. Principle 166 does not apply in the case of temporary transfers.

Salinity

168. In the Angas Bremer Limestone and Currency Creek Limestone *underground water management zones*, an allocation may not be transferred from a well where the salinity is greater than 1,600 mg/L Total Dissolved Solids (TDS):
- a) to a well where the salinity is less than 1,400 mg/L TDS; or
 - b) to any proposed point of taking where the nearest *operational well* demonstrates salinity is less than 1,400 mg/L TDS.

6.3.2 Recharge allocation transfer criteria

The following principle applies to the transfer of *recharge allocations* only. It is in addition to the general objectives and principles outlined in section 6.1 of the Plan.

169. Recharge allocations shall only be transferred where the point of taking does not alter as a result of the transfer.

7 PERMITS

The objectives and principles for assessing water affecting activities set out in the Plan operate in conjunction with the principles and objectives set out in the Natural Resources Management Plan for the South Australian Murray-Darling Basin Natural Resources Management Region ('Regional NRM Plan'). As set out in the section of the Regional NRM Plan relating to water affecting activities:

'A water allocation plan may set out additional policies [in relation to water affecting activities] that the Board will take into account when considering an application for a permit. The policies in a water allocation plan may be different to the policies in the Regional NRM Plan. To the extent that a water allocation plan includes different policies, the policies in the Regional NRM Plan will not apply to that prescribed water resource.'

A person may only undertake any of the activities listed in Table 7.1 if:

1. the relevant authority shown in Table 7.1 has granted a permit to authorise the activity; and
2. the activity is performed in accordance with the permit and the relevant objectives and principles set out in this section;

or if section 129 of the NRM Act authorises the activity to be performed without a permit.

In some cases, where development approval is required under the *Development Act 1993* for an activity that would otherwise require a permit, the development approval process will generally involve referral of the development application for assessment against the principles for managing that activity in the Plan. That is, a separate water affecting activity permit application under the NRM Act will not be required.

Table 7.1 Water affecting activities relevant authority reference table

Plan section	General description of water affecting activity	Section of the NRM Act	Relevant authority
7.2.1	Water diversion and storage	127 (3)(d)	The Board
7.2.2	Building or structure in a watercourse, lake or floodplain	127 (5)(b)	The Board
7.2.3	Drainage or discharge of water into a watercourse or lake	127 (5)(c)	The Board
7.2.4	Object or solid material in a watercourse or lake	127 (5)(d)	The Board
7.2.5	Excavation or removal of rock, sand or soil	127 (5)(h)	The Board
7.2.6	Use of imported water and effluent	127 (5)(i) & 127 (5)(j)	The Minister
7.2.7	Wells (drilling, plugging, backfilling, or sealing a well; and repairing, replacing or altering the casing, lining or screen)	127 (3)(a) & 127 (3)(b)	The Minister
7.2.8	Draining or discharging water into a well (artificial recharge)	127 (3)(c)	The Minister
7.2.9	Commercial forests	127 (5)(ja)	The Minister

Other approvals may also be required for an activity in addition to a water affecting activity permit. In accordance with the *Native Title Act 1993* (Cth), applications for permits on land where native title has not been extinguished will require the Minister to consider the application of the *Native Title Act 1993* (Cth) or where modified by an ILUA process prior to the grant of a permit.

Landholders and/or those undertaking works related to any of the activities listed in Table 7.1 should also be aware of their legal obligation under the *Aboriginal Heritage Act 1988*, which provides for the protection and preservation of Aboriginal sites, objects and remains within South Australia.

Owners or occupiers of a parcel of land, and agents of these (including staff, contractors and subcontractors), have legal responsibilities under the *Aboriginal Heritage Act 1988* when Aboriginal sites, objects or remains are discovered or where they may be at risk of damage, disturbance or interference.

Further information for landholders, contractors and grant recipients on what to do, who to contact and about divulging information about Aboriginal sites, objects and remains contrary to the *Aboriginal Heritage Act 1988* is available from the Board and the Aboriginal Affairs and Reconciliation agency within the Department of State Development.

Other approvals outside of the *Aboriginal Heritage Act 1988* and *Native Title Act 1993* (Cth) may also be needed.

7.1 GENERAL POLICIES

The following objectives and principles apply to all types of water affecting activities identified in Table 7.1. They are in addition to the objectives and principles expressed for specific water affecting activities in section 7.2. Thus for any given activity, both the general policies and the activity specific policies will apply.

Objectives

- a) Maintain and where possible restore water-dependent ecosystems, by providing their water needs and addressing detrimental impacts from water affecting activities.
- b) Protect aquifer structure and geomorphology of drainage paths, watercourses, lakes and floodplains.
- c) Provide for equitable and sustainable sharing of water resources.
- d) Protect water quality from deterioration.
- e) Maintain hydrological and hydrogeological systems, including natural discharge and recharge between water resources.
- f) Minimise interference between water users.
- g) Minimise adverse impacts of water affecting activities on the environment, water resources and water users.

Principles

- 170. A water affecting activity must be conducted in such a way that, in both the short term and the long term, it ensures:
 - a) maintenance of acceptable water quality;
 - b) equitable sharing of the water available for consumptive use;
 - c) maintenance of natural hydrological and hydrogeological systems;
 - d) maintenance and where possible rehabilitation of water-dependent ecosystems;
 - e) protection against the risk of harm to public and private assets and public safety from flooding; and
 - f) monitoring of potential impacts from the activity where appropriate.

171. A water affecting activity must not:
- a) cause soil erosion or bank destabilisation of a watercourse or lake, or erosion of a floodplain;
 - b) be located in ecologically sensitive areas (including *significant environmental assets*) where this will cause or be likely to cause significant detrimental impacts;
 - c) have adverse impacts on water resources (including quantity, water pressure and level, and water regime), other natural resources, or communities at both local and regional levels;
 - d) cause damage to the integrity of an aquifer or aquifers;
 - e) cause significant detrimental impacts on the ability of other users to lawfully take water;
 - f) cause a significant decrease in the amount and duration of discharge from underground water to surface water or watercourses and vice versa, or between aquifers;
 - g) have adverse impacts on water-dependent ecosystems, biodiversity and habitat preservation (including, but not limited to, adverse impacts on environmentally important components of the water regime and migration of aquatic biota);
 - h) cause or exacerbate unnatural waterlogging, rising watertables, erosion and/or unacceptable increases in soil salinity;
 - i) cause unacceptable deterioration in the quality of surface water, underground water or water in a watercourse or lake;
 - j) create or exacerbate the incidence or intensity of local or regional flooding or increase the flood risk to public or private assets, communities or individuals unless the activity is associated with licensed flood irrigation and does not cause adverse impacts to other assets, communities or individuals; or
 - k) impact on authorised devices or activities for scientific purposes.
172. The relevant authority may refuse to grant an application for a permit if:
- a) the assessment of that permit application against the relevant principles in the Plan may be affected by an *existing user allocation* (or allocations) for which the *existing user allocation process* is not complete; and/or
 - b) excess water has been reserved from allocation within the Eastern Mount Lofty Ranges PWRA, pursuant to section 166 of the NRM Act.

7.2 ACTIVITY SPECIFIC POLICIES

The following objectives and principles apply to the specific types of water affecting activities identified in Table 7.1. They are in addition to the general objectives and principles expressed for all water affecting activities in section 7.1. Thus for any given activity, both the general policies and the activity specific policies will apply.

7.2.1 Water diversion and storage

The following principles apply to the activity under section 127 (3)(d) of the NRM Act, comprising the erection, construction, modification, enlargement or removal of a dam, wall, or other structure that will collect or divert, or collects or diverts:

- water flowing in a watercourse in the Eastern Mount Lofty Ranges PWRA; or
- surface water flowing over land in the Eastern Mount Lofty Ranges PWRA.

These types of structures are referred to as '*diversion structures*'. These principles are in addition to those general objectives and principles expressed for all water affecting activities in section 7.1 of the Plan.

Siting and construction

173. *Diversion structures* shall be designed and constructed in accordance with best practice standards as determined by the relevant authority at the time of assessment.
174. A *diversion structure* for the storage, collection or diversion of water:
 - a) must not be enlarged or constructed within ecologically sensitive areas, including but not limited to *significant environmental assets*, where this will cause or be likely to cause significant detrimental impacts;
 - b) must not be enlarged or constructed in areas prone to erosion; and
 - c) must not contribute to dryland salinity or intrusions of saline underground water into watercourses.
175. *On-stream dams* must not be enlarged or constructed, unless it can be demonstrated to the relevant authority's satisfaction that there is no suitable location available on the property for it to be constructed as an *off-stream dam*.
176. For the purposes of the Plan:
 - a) an *on-stream dam* is a dam, wall, or other structure placed on, or constructed across, a watercourse or *flow path* for the purpose of holding back and storing the flow of that watercourse or the surface water runoff flowing along that flow path.
 - b) an *off-stream dam* is a dam, wall, or other structure that is not constructed across a watercourse and is primarily designed to hold water diverted or pumped from another source such as a watercourse, a drainage path, or an aquifer.
Off-stream dams may capture a limited volume of surface water from the catchment upstream of the dam (up to 5% of its total capacity, determined on the basis of mean annual adjusted runoff from the catchment area upstream of the dam).
177. The erection, construction, modification or enlargement of a diversion structure should not be undertaken if it is likely to cause:
 - a) significant movement of soil from the site through erosion or siltation; or
 - b) removal or destruction of riparian or in-stream vegetation (including through inappropriate inundation).
178. Erection, construction, modification, enlargement, removal or maintenance of a diversion structure:
 - a) must be undertaken in a manner that prevents silt or sediments from entering the watercourse; and
 - b) should include, but not be limited to, the use of erosion and sediment control measures such as diversion drains, revegetation, hay bale barriers, filter fences, sediment traps and detention basins.

179. Dams shall be constructed in such a manner as to prevent seepage.
180. New or enlarged dams shall be designed to include adequate freeboard to minimise the risk of water flowing over the dam during periods of heavy rainfall.

Dam design features – on-stream dams

181. *On-stream dams*, including on-stream stormwater basins and wetlands, must be designed and constructed to incorporate features to improve water quality and enhance ecological values. Such features may include, but are not limited to:
 - a) an irregular edge;
 - b) a variety of depths to increase habitat for a variety of plants and animals;
 - c) well vegetated edges;
 - d) minimal stock access;
 - e) an upstream silt trap (one-tenth the size of the dam);
 - f) provision for aquatic biota migration where appropriate;
 - g) provision of an island at least 0.5 metres above the maximum dam water level, for dams where water is more than 0.5 metres deep.

Maximum allowable dam capacity

182. Subject to principles 202–205, a dam must not be constructed or enlarged if that activity would cause any of the following limits to be exceeded¹⁴:
 - a) the evaporation and consumptive use limit at the regional scale (principle 184);
 - b) the evaporation and consumptive use limit at the catchment scale (principle 186);
 - c) the evaporation and consumptive use limits at the surface water management zone scale (principle 187);
 - d) the interception limit at the catchment scale (principle 188);
 - e) the interception limit at the surface water management zone scale (principle 190);
 - f) the dam capacity limit at the local area scale (principle 192);
 - g) the evaporation and consumptive use limit at the significant environmental asset scale (principle 193);
 - h) the dam capacity limits at the property scale (principles 195–198);
 - i) the limit on net increases in taking in the Angas River and Bremer River surface water catchments (principle 199);
 - j) the joint Tookayerta limit (principle 200);
 - k) the limit on net increases in taking in the Tookayerta Creek surface water catchment if applicable (principle 201).

¹⁴ Note that some of these limits place a limit on evaporation plus consumptive use, rather than on dam capacity (e.g. 182 a)–c), g), and i)–k)). However, the use from the dam is determined in part or in full by the dam capacity (e.g. non-licensed use is estimated to be 30% of dam capacity), and the evaporation is generally determined by the dam capacity. Hence these principles would be assessed by determining whether the evaporation and use from a dam of the proposed capacity will lead to the relevant limit being exceeded.

183. The principles referred to in principle 182 a) – k) are subject to principles 202–205.

Regional scale – evaporation and consumptive use limit

184. A dam must not be constructed or enlarged if the volume of *evaporation* plus *dam use* from the proposed dam would cause the total volume of *evaporation* plus *consumptive use from surface water and watercourses* in the Eastern Mount Lofty Ranges PWRA to exceed (or further exceed) the *regional evaporation and consumptive use limit* (given in Table 4.4).
185. For the purposes of the Plan, *dam use* is the volume of water taken, or estimated to be taken, from a dam. It is determined as:
- a) the allocation volume deemed to be taken from the dam (in ML); or
 - b) when the dam is a *non-licensed dam*: 30% of the volumetric dam capacity (in ML).

Catchment scale – evaporation and consumptive use limit

186. A dam must not be constructed or enlarged if the volume of *evaporation* plus *dam use* from the proposed dam would cause the total volume of *evaporation* plus *consumptive use from surface water and watercourses* in a *surface water catchment* to exceed (or further exceed) the *catchment evaporation and consumptive use limit* (given in Table 4.3).

Surface water management zone scale – evaporation and consumptive use limit

187. A dam must not be constructed or enlarged if the volume of *evaporation* plus *dam use* from the proposed dam would cause:
- a) the total volume of *evaporation* plus *consumptive use from surface water and watercourses* taken from outside the *main watercourse* in a *surface water management zone* to exceed (or further exceed) the *runoff evaporation and consumptive use limit* (given in Table 4.5) for the zone that the activity would occur in; or
 - b) the total volume of *cumulative evaporation plus consumptive use* (determined in accordance with principle 41 c)) to exceed (or further exceed) the *main watercourse evaporation and consumptive use limit* (given in Table 4.5) for:
 - i) the surface water management zone that the activity would occur in; or
 - ii) any surface water management zone affected by the proposed dam.

Catchment scale – interception limit

188. A dam must not be constructed or enlarged if that activity would cause the total volume of *interception* in a *surface water catchment* to exceed (or further exceed) the *catchment interception limit* for the surface water catchment that the activity would occur in.
189. For the purposes of sections 5–7 of the Plan:
- a) *interception* means the sum of the total volume of dam capacity and *forestry use from surface water by commercial forests* in an area or location, including a surface water catchment, surface water management zone, catchment area or property (in ML), where:
 - i) dam capacity includes those used for licensed purposes as well as *non-licensed dams*; and
 - ii) *forestry use from surface water* is determined in accordance with principle 267 a).

When determining interception as above, particular dams may be excluded from the calculation where the Minister determines that this is appropriate for the purposes of proper accounting against the water balance for the specific calculation being made. For example, in appropriate

cases, the capacity of dams which have been approved in accordance with principle 204 may be excluded when determining interception.

- b) the *catchment interception limit* for each surface water catchment is given in Table 4.3.

Surface water management zone scale – interception limit

190. A dam must not be constructed or enlarged if that activity would cause the total volume of *interception* in a surface water management zone to exceed (or further exceed) the *surface water management zone interception limit* for the surface water management zone that the activity would occur in.
191. For the purposes of the Plan, the *surface water management zone interception limit* for each surface water management zone is given in Table 4.5.

Local area scale – minimising downstream impacts

192. A dam must not be constructed or enlarged if that activity would cause the total potential demand for water in the catchment area of an affected downstream *diversion point* to exceed (or further exceed) the average supply of runoff to that point.

Total potential demand in a catchment area is the sum of (1) dam capacity; (2) *base allocations* taken from surface water or watercourses by diversion structures that are not dams (including *lower Angas Bremer allocations*); (3) *ecosystem allocations (system provisions)* that are taken from surface water or watercourses by diversion structures that are not dams; and (4) *forestry use from surface water*, occurring in that catchment area (all in ML).

For the purposes of this principle, the capacity of the new or enlarged dam (D1) shall not exceed the smallest volume returned by calculating the following equation at each diversion point 'x' (Dx) downstream of D1 within the Eastern Mount Lofty Ranges PWRA that may be affected by the activity:

$$TDC = [(A_{Dx} \times R_{Dx}) - (DC_{BDx} + allocation_{ND,BDx} + SP_{ND,BDx} + FU_{SW,BDx})] + DC_{D1}$$

where:

TDC	Total dam capacity: the total volume of dam capacity of dam D1 that must not be exceeded (in ML). TDC includes the proposed dam capacity as well as any existing dam capacity at D1 (for example when a dam is enlarged).
A_{Dx}	Area upstream of Dx: size of the catchment area upstream of diversion point Dx (in km ²).
R_{Dx}	Runoff at Dx: the <i>mean annual adjusted runoff depth</i> for the catchment area upstream of diversion point Dx, determined in accordance with principle 34 d) (in mm).
DC_{BDx}	Dam capacity both at and upstream of Dx: the total volume of dam capacity at diversion point Dx (if relevant) and in the catchment area upstream of diversion structure Dx, at the date of application (in ML).
$allocation_{ND,BDx}$	Total <i>base allocation</i> volume taken from surface water or watercourses by diversion structures that are not dams (including <i>lower Angas Bremer allocations</i>), both at and in the upstream catchment area of Dx, at the date of application (in ML).
$SP_{ND,BDx}$	Total volume of <i>ecosystem allocations (system provisions)</i> that are taken from surface water or watercourses by diversion structures that are not dams, both at and in the upstream catchment area of Dx (where relevant), at the date of application (in ML).
$FU_{SW,BDx}$	Total volume of <i>forestry use from surface water for commercial forests</i> both at and in the upstream catchment area of Dx at the date of application, where <i>forestry use from surface water</i> is determined in accordance with principle 267 a) (in ML).

DC_{D1} Dam capacity of D1: the existing dam capacity of dam D1 at the date of application, if any (in ML). Where dam D1 is a new dam, then DC_{D1} = 0 ML.

When calculating DC_{BDx} as above, particular dams may be excluded from the calculation where the Minister determines that this is appropriate for the purposes of proper accounting against the water balance for the specific calculation being made. For example, in appropriate cases, the capacity of dams which have been approved in accordance with principle 204 may be excluded when calculating DC_{BDx}.

Where the equation returns a negative value, TDC for D1 will be 0 ML.

Significant environmental asset scale – local evaporation and consumptive use limit

193. A dam must not be constructed or enlarged if the volume of *evaporation plus dam use* from the proposed dam would cause the total volume of *evaporation plus consumptive use from surface water and watercourses* in the catchment area of any *significant environmental asset* that may be affected by the proposed dam to exceed (or further exceed) the *local evaporation and consumptive use limit* for that catchment area.
194. For the purposes of principle 193 and 279, the *local evaporation and consumptive use limit* for the catchment area of a *significant environmental asset* is calculated as follows:

$$LECUL_{SEA} = A_{SEA} \times R_{SEA} \times 0.2$$

where:

LECUL _{SEA}	Local evaporation and consumptive use limit for the catchment area of a significant environmental asset (in ML).
A _{SEA}	Area: size of the catchment area of the significant environmental asset (in km ²).
R _{SEA}	Runoff: the <i>mean annual adjusted runoff depth</i> for the catchment area of the significant environmental asset, determined in accordance with principle 34 d) (in mm). A different value may be used for R _{SEA} where the proponent can demonstrate a different value based on adequate data, to the Minister's satisfaction.
0.2	Multiplication factor to determine local evaporation and consumptive use limit (20% of runoff).

Property-scale dam capacity limits – property size

195. Subject to principle 197, a dam must not be constructed or enlarged if that activity would cause the total volume of *interception* on a property to exceed (or further exceed) 30% of the mean annual adjusted runoff volume from the property.
196. For the purposes of principle 195, 30% of the mean annual adjusted runoff volume from a property is determined as follows:

$$RV_{0.3} = (A_{prop} \times R_{prop}) \times 0.3$$

where:

RV _{0.3}	30% of the mean annual adjusted runoff volume from a property (in ML).
A _{prop}	Area of the property (in km ²).
R _{prop}	Mean annual adjusted runoff depth for the property, determined as the <i>mean annual adjusted runoff depth</i> for the surface water management zone that the majority of the property lies within, given in Table 4.5 (in mm).
0.3	Multiplication factor to determine 30%.

197. If a proposed new or enlarged dam is to be constructed as an *off-stream dam*, then the maximum allowable dam capacity is 1.5 times the allowable volume derived from the application of principle 195–196.

Property-scale dam capacity limits – reasonable requirements for use

198. A dam must not be constructed or enlarged if that activity would cause the total volume of dam capacity on the property to exceed (or further exceed) twice the reasonable water requirements of the property from dams.

For the purposes of this principle, the capacity of the new or enlarged dam (D1) shall not exceed the following:

$$\text{TDC} = \{[2 \times (\text{allocation} + \text{RPR})] - \text{DC}_{\text{prop}}\} + \text{DC}_{\text{D1}}$$

where:

TDC Total dam capacity of dam D1 that must not be exceeded (in ML).

2 Multiplier to determine twice property-scale requirements.

allocation *Base allocations* taken from dams on the property (if any) (in ML).

RPR The reasonable property-scale requirement for dam capacity that the relevant authority considers to be appropriate to supply the reasonable non-licensed annual water needs of the property that is to include dam D1 (in ML). When determining this reasonable property-scale dam capacity, elements to be considered may include, but are not limited to:

- stock watering requirements related to the carrying capacity of the land and property management practices;
- property size;
- local climate;
- net evaporative loss from the dam; and
- domestic requirements (nominally 1 ML);

where appropriate, but excludes provision for storage of more than one year of supply.

DC_{prop} Dam capacity on the property: the total capacity of existing dams at the property for which dam D1 is proposed, at the date of application (if any) (in ML).

DC_{D1} Dam capacity at D1: the existing dam capacity of dam D1 at the date of application (if any) (in ML). Where dam D1 is a new dam, then DC_{D1} = 0 ML.

No net increase in taking in the Angas and Bremer catchments

199. A dam must not be constructed or enlarged in the Angas River *surface water catchment* or the Bremer River *surface water catchment* (as shown in Figure 4.2) if the volume of *evaporation plus dam use* from the proposed dam would cause a net increase in the total volume of *evaporation plus consumptive use from surface water and watercourses plus lower Angas Bremer allocations* in that *surface water catchment*, compared with *initial evaporation plus consumptive use* in that catchment (determined in accordance with principle 48).

Joint Tookayerta limit

200. A dam must not be constructed or enlarged in the Tookayerta Creek *surface water catchment* if the volume of *evaporation plus dam use* from the proposed dam would cause *joint Tookayerta demand* to exceed (or further exceed) the *joint Tookayerta limit*.

No net increase in taking in the Tookayerta catchment in some circumstances

201. This principle only applies if *joint Tookayerta demand* exceeds the *joint Tookayerta limit*.

A dam must not be constructed or enlarged in the Tookayerta Creek *surface water catchment* where the volume of *evaporation* plus *dam use* from the proposed dam would cause a net increase in the total volume of *evaporation* plus *consumptive use from surface water and watercourses* in that catchment, compared to that total volume immediately prior to the proposed dam.

Exceptions to dam capacity limits

202. Principles 182–201 may not apply if dam consolidation (a combined program of dam capacity removal and dam capacity construction by a proponent or proponents) results in an improvement over current conditions. An improvement over current conditions occurs where the value assessed against the limit for each of the principles 184, 186, 187, 188, 190, 192, 193, 195, 198, 199, 200 and 201 (where relevant) would be no higher as a result of the dam consolidation compared to the value immediately prior to the date of application, and at least one of those values is at least 20% lower than the value immediately prior to the date of application.
If the improvement over current conditions is smaller than 20% as outlined above, principles 182–201 still may not apply provided that the relevant authority is of the opinion that there is sufficient improvement over current conditions, including consideration of benefits to *significant environmental assets* arising from the proposed dam consolidation.
203. Principles 182–201 do not apply where:
- a) the proposed structure is authorised by the Minister or the Board for the specific purpose of measuring streamflow;
 - b) the proposed structure is a device to be constructed only for the purpose of meeting the requirements of principles 52–59 or 207–209; or
 - c) the proposed *diversion structure* is only for the purpose of improving water quality and/or mitigating flooding, prior to returning the diverted water to the same watercourse or *flow path* within three days of diversion or collection, with loss of water volume only allowed via minimised seepage and evaporation from the waterbody. The proponent must demonstrate the intended operation, maintenance and monitoring of the proposed diversion structure to the satisfaction of the relevant authority as part of such a permit application.
204. New dam capacity in addition to the limits set out in principles 182–201 may be allowed in the case where additional runoff is generated from an area as a result of *designated urban land use development*. Such new dam capacity may only be allowed where:
- a) the maximum volume of dam capacity for an area of designated urban land use development is *urban runoff* minus *pre-development runoff and recharge* from the area of the designated urban land use development;
 - b) the pre-development runoff and recharge from the site is returned to the environment:
 - i) as close as reasonably practical to the natural flow path;
 - ii) as soon as reasonably practical following precipitation, unless detained on-site for water quality remediation and/or mitigation of flooding, in which case the pre-development runoff and recharge must be returned to the environment within three days of collection or diversion;
 - iii) in a manner that maintains the natural flow regime and aquifer recharge; and
 - iv) in a manner that does not cause significant detrimental impacts to the environment, including but not limited to erosion and detrimental impacts to stream bed and bank

stability, demonstrated to the satisfaction of the relevant authority by a suitably qualified environmental engineer;

- c) the *time to peak flow* matches that of the pre-development case, as far as reasonably practical, for up to the five year *average recurrence interval* event, provided this does not exacerbate downstream flooding (demonstrated to the satisfaction of the relevant authority by a suitably qualified hydrologist or engineer); and
- d) the time to peak flow matches that of the pre-development case for the 5 year up to the 100 year average recurrence interval events, unless catchment wide benefits can be demonstrated, provided this does not exacerbate downstream flooding (demonstrated to the satisfaction of the relevant authority by a suitably qualified hydrologist or engineer).

Replacement dams

205. Where a dam (the 'original dam') has been washed away, a permit may be granted to construct a replacement dam of the same capacity as the original dam despite principles 182–201, provided that:
- a) the capacities of the original and replacement dams are demonstrated by a licensed surveyor to the relevant authority's satisfaction;
 - b) the replacement dam is constructed in the same location as the original dam or on a part of the same property that is *hydrologically continuous* with the original dam within the property; and
 - c) if the original dam was constructed on a *main watercourse*, the replacement dam may be constructed on a segment of that watercourse with a *stream order* that is the same or less than the stream order of the segment of watercourse that the original dam was constructed on.

Demonstration of dam capacity

206. If dam capacity is removed in order to allow new dam capacity to be constructed within the limits in the Plan, then the removed and reconstructed dam capacities must be demonstrated, using a licensed surveyor, to the relevant authority's satisfaction.

Flow regime

207. A dam, wall or other structure that collects or diverts surface water flowing over land or water from a watercourse must include a device that ensures that any water present in a surface water *flow path* or watercourse at or below the *threshold flow rate* (determined in accordance with principle 55):
- a) will not be taken; or
 - b) if taken, must re-enter the same watercourse or surface water flow path immediately downstream of the diversion structure as soon as reasonably practical (and no longer than 24 hours after diversion), and must not be of poorer quality than the water that was diverted.
208. A device that will achieve the outcomes required by principle 207:
- a) shall be designed and constructed to ensure its correct operation is automated and cannot be manually overridden;
 - b) shall be designed and constructed so that its correct operation minimises the risk of erosion and damage to infrastructure;
 - c) shall not increase the area that directs water to the diversion structure beyond the natural size of the catchment area upstream of the diversion structure;
 - d) shall be maintained in such a condition that it continues to be effective in meeting principle 207; and
 - e) must not be obstructed or tampered with in any way.

209. The design of the device that will achieve the outcomes required by principle 207 must be approved by the relevant authority prior to the granting of a permit for construction or enlargement of a diversion structure. Evidence that the device has been constructed as designed must be provided to the satisfaction of the relevant authority within one month of construction or enlargement of the diversion structure.
210. Principles 207–209 do not apply to structures authorised by the Minister or the relevant authority for the specific purpose of measuring streamflow.

Dam maintenance

211. Desilting of a dam (including detention basins and other water-sensitive urban design features that are dams) does not require a permit, provided that:
- a) desilting only involves the removal of unconsolidated material deposited since construction of the dam or since the dam was previously desilted;
 - b) desilting does not enlarge the dam capacity or increase the dam wall height beyond their original dimensions;
 - c) the excavated material is not placed in or near a watercourse, floodplain or lake;
 - d) the excavated material does not:
 - i) adversely impact native vegetation;
 - ii) impede the natural flow of surface water;
 - iii) re-enter any water body; or
 - iv) facilitate the spread of pest plants or pathogenic material; and
 - e) appropriate measures are undertaken to minimise water quality impacts during desilting. The use of a silt curtain, coffer dam or similar may assist in complying with this principle.

7.2.2 Building or structure in a watercourse, lake or floodplain

The principles that follow apply specifically to an activity under section 127 (5)(b) of the NRM Act, comprising the erection, construction or placement of any building or structure in a watercourse or lake or on the floodplain of a watercourse. They are in addition to the general objectives and principles expressed for all water affecting activities in section 7.1 of the Plan.

212. A building or structure should not be located where it is likely to adversely affect the migration of aquatic biota.
213. The design and construction of a building and the design, construction and operation of a structure should not alter the hydrology of a stream in such a way as to have the potential to adversely affect the ecology.
214. Structures that impede the flow of water must be designed to not capture or otherwise return flows at or below the *threshold flow rate* in accordance with principles 207–209, excluding those structures authorised by the Minister or relevant authority for the purpose of:
- a) measuring streamflow; or
 - b) managing water flow to assist with maintenance, rehabilitation or restoration of locally indigenous water-dependent ecosystems, habitats, communities or species, for a purpose and in a manner accredited by the Minister or relevant authority.
215. Buildings and structures must be maintained in an appropriate condition to perform their intended function.

7.2.3 Drainage or discharge of water into a watercourse or lake

The objectives and principles that follow apply specifically to an activity under section 127 (5)(c) of the NRM Act, comprising draining or discharging water directly or indirectly into a watercourse or lake. They are in addition to those general objectives and principles expressed for all water affecting activities in section 7.1 of the Plan.

Objectives

- a) To ensure that drainage or discharge water is managed so that:
 - i) contaminants in drainage or discharge water are contained and managed on-site to minimise the conveyance of contaminants into watercourses, lakes, or underground water resources; and
 - ii) the quality of water drained or discharged into a watercourse or lake is of a quality similar to, or better than, that of the receiving water environment.

Principles

- 216. Drainage or discharge of water into a watercourse or lake should only be undertaken where protective measures have been provided to minimise erosion and degradation in the quality of the receiving water. Suitable protective measures may include, but are not limited to:
 - a) detention basins to regulate the rate, volume and quality of water discharged;
 - b) re-use of drainage or discharge water under conditions that would not present a risk to public or environmental health;
 - c) litter traps;
 - d) pre-treatment of the water before discharge;
 - e) draining or discharging water of similar quality or better than that of the receiving water environment; and
 - f) discharge into the receiving watercourse at times of naturally high flow.
- 217. All treatment devices must be appropriately managed to ensure that they continue to function according to their design, particularly in the removal of accumulated sediment and rubbish.
- 218. Storage of any contaminated water must only be undertaken in off-stream storages with no natural catchment to prevent leakage or overflow of any contaminated water.

7.2.4 Object or solid material in a watercourse or lake

The objectives and principles that follow apply specifically to an activity under section 127 (5)(d) of the NRM Act, comprising depositing or placing an object or solid material in a watercourse or lake. They are in addition to those general objectives and principles expressed for all water affecting activities in section 7.1 of the Plan.

Objectives

- a) To ensure watercourses and lakes are free from obstructions that may impede natural streamflow.

Principles

- 219. Depositing or placing an object or solid material in a watercourse or lake may only occur where it includes:

- a) the construction of an erosion control structure, for example, but not limited to, a rock chute or rip rap;
 - b) an authorised activity for scientific purposes (including, but not limited to flow measuring devices);
 - c) an authorised device or structure used to regulate water flowing in a watercourse; or
 - d) an authorised structure, object or solid material for the purposes of maintenance, rehabilitation or restoration of locally indigenous water-dependent ecosystems, habitats, communities or species, for a purpose and in a manner accredited by the Minister or relevant authority.
220. For the purpose of principle 219, 'authorised' means authorised by a Local Government Authority, the Board or the Minister.
221. Any object or solid material used in the control or prevention of watercourse erosion must be designed with consideration of the local-scale and catchment-scale landscape and hydrological processes, and must not cause either of the following:
- a) increased erosion upstream or downstream; or
 - b) detrimental off-site impacts (including, but not limited to, flooding).
222. Objects or solid materials that impede the flow of water must be designed to not capture or otherwise return flows below the *threshold flow rate* in accordance with principles 207–209, excluding those structures authorised by the Minister or relevant authority for the purpose of:
- a) measuring streamflow; or
 - b) managing water flow to assist with maintenance, rehabilitation or restoration of locally indigenous water-dependent ecosystems, habitats, communities or species, for a purpose and in a manner accredited by the Minister or relevant authority.

7.2.5 Excavation or removal of rock, sand or soil

The objectives and principles that follow apply specifically to an activity under section 127 (5)(h) of the NRM Act, comprising excavating or removing rock, sand or soil from a watercourse or lake or the floodplain of a watercourse; or an area near to the banks of a lake so as to damage, or create the likelihood of damage to, the banks of the lake. They are in addition to those general objectives and principles expressed for all water affecting activities in section 7.1 of the Plan.

Objectives

- a) To ensure the excavation or removal of rock, sand or soil is undertaken in a manner that protects the geomorphology and ecology of a watercourse, lake or floodplain.

Principles

223. Alteration to the alignment of a watercourse may only occur where it is for the protection of existing development and infrastructure, or rehabilitation of a watercourse, and the realignment does not result in any of the following:
- a) increased erosion;
 - b) increased flooding;
 - c) bed and bank instability;
 - d) downstream sedimentation;

- e) loss of riparian vegetation;
- f) decline in water quality; or
- g) alteration to the natural flow regime of a watercourse.

7.2.6 Use of imported water and effluent

The objectives and principles that follow apply specifically to:

- an activity under section 127 (5)(i) of the NRM Act, comprising using water in the course of carrying on a business in the region at a rate that exceeds 1 ML/y or 1 ML/irrigated ha/y, if the water has been brought into the region by means of a pipe or other channel ('imported water'); and
- an activity under section 127 (5)(j) of the NRM Act, comprising using effluent in the course of carrying on a business in the region at a rate that exceeds 0.5 ML/y or 0.5 ML/irrigated ha/y.

They are in addition to those general objectives and principles expressed for all water affecting activities in section 7.1 of the Plan.

Objectives

- a) Ensure that the use of effluent is undertaken in a manner such that there is no risk to public health.
- b) Protect the productive capacity of the land.
- c) Protect against the risk of detrimental impacts to public and private assets by rising watertables.

Principles

- 224. Subject to principle 226, a permit is required for the use of imported water or *effluent* where the imported water or effluent is used on the land at a rate that exceeds:
 - a) for imported water — 1 ML/y or 1 ML/irrigated ha/y; or
 - b) for effluent — 0.5 ML/y or 0.5 ML/irrigated ha/y.
- 225. Where *effluent* is imported to an area, the prescribed rate will be that stipulated for the use of effluent in accordance with principle 224.
- 226. A permit for use of *effluent* or imported water may not be required where a person or business is legally obliged to comply with a mandatory code of practice for the use of imported water or effluent that is consistent with these principles (for example, but not limited to, the Environment Protection Authority (EPA) Code of Practice for Milking Shed Effluent 2003 or its successors).
- 227. A permit for use of imported water is not required where:
 - a) a licence holder owns and/or occupies a property that lies in both the Eastern Mount Lofty Ranges PWRA and another prescribed water resource (such as the Western Mount Lofty Ranges PWRA, the Marne Saunders PWRA or the River Murray PWC); and
 - b) that licensee has water allocated to be taken from a *source* on that property in the other prescribed water resource, and uses that water on that property in the Eastern Mount Lofty Ranges PWRA.
- 228. The use of *effluent* should not have the potential to pose a risk to human health.
- 229. The use of imported water and/or *effluent* must not:
 - a) cause a rise in underground water levels that adversely affects land, public or private assets, other water resources or natural resources and their beneficial uses;

- b) adversely affect the natural flow of water or the ambient quality of receiving waters;
 - c) adversely affect the productive capacity of the land by increasing salinity, waterlogging, sodicity, toxicity, nutrient concentrations or watertables; and
 - d) adversely affect the condition, biodiversity or extent of water-dependent ecosystems.
230. Any dams constructed for the storage of chlorine-treated imported water or *effluent* must be constructed so as to prevent:
- a) leakage from the dam through the soil;
 - b) overflows from the dam onto the surface of the land surrounding the dam; and
 - c) overflow from the dam into a watercourse or lake.
231. Any dams constructed for the storage of chlorine-treated imported water or *effluent* must not be located in a watercourse or drainage path, to minimise the risk of contamination of watercourses or drainage paths during high flow events.
232. Chlorine-treated imported water or *effluent* must not be discharged directly or indirectly into a watercourse.
233. The use of imported water and *effluent* will not be permitted within the *environmental buffer zone* of a *significant environmental asset*, unless the practice occurred prior to the *date of adoption*.

7.2.7 Wells

The objectives and principles that follow apply specifically to:

- an activity under section 127 (3)(a) of the NRM Act, comprising drilling, plugging, back filling or sealing of a well; and
- an activity under section 127 (3)(b) of the NRM Act, comprising repairing, replacing or altering the casing, lining or screen of a well,

which for the purposes of section 7.2.7 of the Plan will be referred to as the 'activity' or 'activities'. These objectives and principles are in addition to those objectives and principles expressed for all water affecting activities in section 7.1 of the Plan.

Objectives

- a) Protect and maintain the quantity and quality of underground water resources.
- b) Minimise interference between wells.
- c) Protect existing underground water users.
- d) Maintain and where possible restore water-dependent ecosystems by providing their water needs and addressing detrimental impacts from water affecting activities.

Principles

General works

- 234. The equipment, materials and method used for the activity shall not adversely affect the quality of the underground water resource.
- 235. Aquifers shall be protected during the activity to prevent adverse impacts on the integrity of an aquifer.
- 236. Where a well passes through two or more aquifers, an impervious seal must be made and maintained between the aquifers to prevent leakage between aquifers.
- 237. Wells constructed for the purpose of draining or discharging water into the well must be pressure cemented along the full length of the casing.
- 238. The headworks of wells constructed for licensed purposes must allow water extraction from the well to be metered without interference.
- 239. The headworks of wells constructed for the purpose of draining or discharging water into the aquifer must be constructed to allow discharge and recovery operations to be metered without interference.

Location of wells

- 240. A well intended to be used for the purpose of draining or discharging water into the well must not be constructed within:
 - a) 50 m of a domestic supply well regardless of aquifer type; and/or
 - b) 200 m of a watercourse in a Fractured Rock, Permian Sands, Quaternary or Unconfined Limestone aquifer type, where the underground water management zones corresponding to aquifer types are given in Table 5.2.

A minimum distance is not required to be maintained between a watercourse and a proposed well intended to be used for the purpose of draining or discharging water into the well, where the aquifer type is Confined Limestone and there is no known connectivity between the aquifer and watercourse.

Where there is uncertainty on the existence, location, status and/or purpose of use of a well, it shall be the responsibility of the proponent to determine the relevant information to the satisfaction of the relevant authority.

- 241. Subject to principles 242, 243, 245, 246 and 250, a permit for construction of a well will not be granted if the *well buffer zone* that would be assigned to the proposed well overlaps:
 - a) an *environmental buffer zone* linked to the same aquifer; or
 - b) a well buffer zone linked to the same aquifer around an *operational well* owned by another landholder;where well buffer zones are determined in accordance with principles 98–101 and environmental buffer zones are determined in accordance with principle 102.
- 242. Despite principle 241, a permit for construction of a well used for licensed purposes may be granted where its *well buffer zone* will overlap another well buffer zone if:
 - a) the overlapping *well buffer zones* are situated exclusively on the well owner's property; or
 - b) there is minimal well buffer zone overlap.
- 243. Despite principle 241, a permit for construction of a well only used for non-licensed purposes may be granted where its *well buffer zone* will overlap another well buffer zone if:

- a) a property is completely or almost completely covered by an existing *well buffer zone* or zones; or
 - b) it is impractical to locate the well elsewhere; or
 - c) there is minimal well buffer zone overlap.
244. Principles 242 and 243 do not apply where the *well buffer zone* of the proposed well would overlap an *environmental buffer zone* linked to the same aquifer.

Replacement wells

245. Despite principle 241, a replacement well may be permitted if:
- a) the original well is backfilled in accordance with a permit issued pursuant to section 127 (3)(a) of the NRM Act;
 - b) the original well is being replaced due to an operational problem, including but not limited to structural failure;
 - c) the replacement well takes water only from the same aquifer as the original well; and
 - d) the replacement well is within 50 m of the original well.

Deepening wells

246. Despite principle 241:
- a) an application to deepen an existing well in a Fractured Rock *aquifer type* may be permitted, regardless of any overlapping *well buffer zones*, if the volume of water to be extracted from the well will not increase;
 - b) an application to deepen an existing well in a Confined Limestone, Unconfined Limestone, Permian Sands or Quaternary *aquifer type* may be permitted, regardless of overlapping *well buffer zones*, provided that the well is not deepened to the extent that it penetrates a different aquifer.

Watertable monitoring wells in the Angas Bremer Limestone underground water management zone.

247. Principles 248–249 apply to the construction of watertable monitoring wells where these wells are required by principles 26–27.
248. A permit may only be granted for the construction of a watertable monitoring well to meet the requirements of principles 26–27 where:
- a) the proposed well is completed to two metres below the current standing watertable to a maximum depth of six metres;
 - b) the proposed well is cased with 75 mm ID (internal diameter) Class 12 UPVC with three metres of slots directly above the bottom of the well, and a PVC bottom-cap;
 - c) the casing of the proposed well extends one metre above the natural surface of the land;
 - d) the slotted section of the proposed well is covered with fabric made of an appropriate geotextile;
 - e) the bottom four metres of the annulus (area outside the casing) of the proposed well is backfilled with 1.5 mm diameter graded sand;
 - f) the annulus of the proposed well is backfilled with cement from the top of the graded sand to the surface; and

- g) the casing of the proposed well that extends above the natural surface of the land is protected by an outer sleeve of galvanized pipe 1.5 m in length, with a wall thickness of 4 mm, a screw-on top cap, and set into cement at the ground surface.
249. A permit may only be granted for the construction of a watertable monitoring well to meet the requirements of principles 26–27 where the proposed location of the monitoring well is:
- a) within the property or area of land where allocated water is used for irrigation purposes; and
 - b) at the lowest practicable point on that property or area of land.
250. A well constructed for the purpose of underground water monitoring only is exempt from principle 241.

7.2.8 Draining or discharging water into a well

The objectives and principles that follow apply specifically to an activity under section 127 (3)(c) of the NRM Act, comprising draining or discharging water directly or indirectly into a well (*'artificial recharge'*). These objectives and principles are in addition to those objectives and principles expressed for all water affecting activities in section 7.1 of the Plan.

In addition to the requirements outlined below for drainage or discharge into a well, a managed aquifer recovery scheme may also require a water licence for the recovery component of the scheme, which must be in accordance with the principles for the allocation of *recharge allocations* outlined in section 5.3.2 of the Plan.

Objectives

- a) Sustainable operation and management of artificial recharge schemes.
- b) Reasonable and practicable measures are taken to avoid the discharge of waste to the receiving underground water resource during the draining or discharging of water into a well.
- c) Drainage or discharge into a well does not cause environmental harm.
- d) Drainage or discharge of water directly or indirectly into the aquifer does not adversely affect:
 - i) the quality of underground water;
 - ii) the integrity of the aquifer, for example, but not limited to, the aquifer's confining layer and the ability of the aquifer to transmit water;
 - iii) watertables, for example, but not limited to, rising shallow watertables, waterlogging, land salinisation and damage to infrastructure (roads, buildings, foundations etc.);
 - iv) any underground water-dependent ecosystem or ecologically sensitive area that depends on or is affected by the underground water resource;
 - v) the ability of other persons to lawfully take from that underground water; or
 - vi) the longevity of operations.
- e) The activity of *artificial recharge* should not be at variance with the National Water Quality Management Strategy – Australian Guidelines for Water Recycling: Managing Health & Environmental Risks, Phase 1 (2006) or its successors, and (where applicable) the associated guidelines.

Principles

251. Water may be drained or discharged into a well where the *source water* will not contravene the water quality criteria in Schedule 2 of the *Environment Protection (Water Quality) Policy 2003*.
252. Where a person has been granted an exemption by the Environment Protection Authority from clause 13 of the *Environment Protection (Water Quality) Policy 2003* on the basis of use of an *attenuation zone* in accordance with clause 15 of that policy, a permit to drain or discharge water into a well ('the subject well') —
- a) may only be granted if:
 - i) subject to principle 253, the attenuation zone does not overlap an *environmental buffer zone* or a *well buffer zone* around another well (other than a well into which the water will be drained or discharged and a well from which the water will subsequently be taken); and
 - ii) the applicant can demonstrate to the satisfaction of the relevant authority that appropriate measures will be taken to monitor pollution within the attenuation zone and to detect any pollution outside of the attenuation zone; and
 - b) will be subject to a condition requiring the holder of the permit to take the measures referred to in principle 252 a) ii) above.
253. Principle 252 does not apply if water was being drained or discharged into the subject well prior to the *date of adoption*.

Hydrogeological assessment

254. A hydrogeological assessment is not required to undertake *artificial recharge* in the Confined Limestone *aquifer type* if a permit has previously been obtained for artificial recharge and:
- a) the annual volume of water to be artificially recharged to the aquifer is 20 ML or less; or
 - b) the water is to be artificially recharged to the aquifer under gravity.
255. Hydrogeological assessment is required as part of the permit application process to undertake *artificial recharge* in all other aquifers or circumstances regardless of proposed volumes and recharge methods, unless the proposed risk to the resource is considered negligible (for example, but not limited to, the discharge of roof runoff) in the opinion of the relevant authority.
256. Hydrogeological assessments must be conducted by a suitably qualified person, and must detail:
- a) water levels and salinity of local underground water;
 - b) transmissivity and storage co-efficient of the aquifer from pump testing, and whether pump testing has shown any effect of extractions on other water users;
 - c) the capacity of the aquifer to accept water;
 - d) the recommended injection pressure that protects the integrity of the aquifer;
 - e) the recommended recovery volume;
 - f) proximity of other users (including licensed and non-licensed users), their well and pump depths, and the aquifer they are accessing;
 - g) advice on how either low or high underground water levels may affect nearby landowners and water users and the environment; and
 - h) any other information considered necessary by the relevant authority.

Monitoring prior to commencement of operations

257. For the purposes of principle 251, the following samples must be taken prior to the commencement of *artificial recharge* and reported as required by the relevant authority:

- a) one sample (unless otherwise specified by the relevant authority) of the *ambient underground water*; and
- b) one or more samples of the *source water*, at a time to adequately represent the water that will be injected (e.g. winter runoff for surface water) and the potential variability of water quality within the source water.

All samples must be collected by a suitably qualified person in accordance with Australian Standard AS5667, Water quality–sampling; and must be analysed by a National Association of Testing Authorities (NATA) accredited laboratory.

258. For the purposes of principle 257, the *ambient underground water* sample should be collected from the proposed point of injection, or as near as possible to the proposed point of injection, and from the same aquifer as that in which storage is proposed, as recommended by the relevant authority. The following parameters in the ambient underground water (at a minimum) must be sampled, analysed and reported to the relevant authority:

- a) pH, TDS, turbidity, ammonia, nitrate, nitrite, total phosphorus, sodium, chloride, sulphate, calcium, magnesium, bicarbonate, iron, total arsenic, total boron, total cadmium, total chromium, total lead, total manganese, total zinc, total coliforms and faecal coliforms; and
- b) additional parameters as may be required following discussions with the relevant authority.

259. For the purposes of principle 257, the following parameters in the *source water* (at a minimum) must be sampled, analysed and reported to the relevant authority:

- a) in the case of surface water and watercourse water (e.g. dam, lake, imported water that has been held in a catchment dam, water directly pumped from a watercourse or roof runoff):
 - i) parameters as per principle 258 a);
 - ii) where the water to be drained or discharged comes from a source likely to contain pesticides, herbicides, *Giardia*, *Cryptosporidium*, volatile organic compounds and petroleum hydrocarbons (including but not limited to water from land used for intensive agriculture or industrial purposes): those substances, materials and characteristics; and
 - iii) any additional parameters required by the relevant authority.
- b) in the case of imported water¹⁵:
 - i) parameters as per principle 258 a);
 - ii) if the water has been treated by chlorination, sufficient representative samples must be taken and analysed for trihalomethanes; and
 - iii) any additional parameters required by the relevant authority.

If the water provider can supply analysis results for the parameters outlined in principle 259 b) i) ii) & iii), no additional monitoring is required prior to the commencement of drainage or discharge.

¹⁵ Artificial recharge of treated wastewater / effluent into a well currently requires an authorisation under the *Environment Protection Act 1993*, and so doesn't require a water affecting activity permit. If a water affecting activity permit is required for artificial recharge of effluent into a well in the future, then the principles in this Plan relating to artificial recharge of imported water will also apply to artificial recharge of effluent.

Ongoing monitoring

260. One sample (unless otherwise directed by the relevant authority) must be taken of the ambient underground water annually before recovery of artificially recharged water commences, and the analysis results reported as directed by the relevant authority, as follows:
- a) Where there is no *attenuation zone* (under principle 252), samples of underground water should be collected at the point of injection.
 - b) Where an attenuation zone has been used (under principle 252), samples of underground water should be collected from the point of injection and from the end of the attenuation zone, down gradient of the flow direction of the underground water, from the same aquifer as that in which storage has occurred (at appropriate monitoring wells identified in accordance with principle 252).
 - c) Samples should be analysed for the parameters outlined in principle 258.
 - d) All samples must be collected by a suitably qualified person in accordance with Australian Standard AS5667, Water quality–sampling.
 - e) All samples must be analysed by a NATA accredited laboratory.
261. Ongoing sampling of *source water* from roof runoff, surface water or watercourse water will not be required annually unless otherwise specified by the relevant authority.
262. Ongoing sampling of *source water* from imported water must be undertaken on an ongoing basis, and the analysis results reported as directed by the relevant authority, unless the supplier of the water:
- a) ensures the water quality will be maintained at a consistent level year round; or
 - b) provides regular water quality analysis to the relevant authority.
263. If a review of monitoring results over consecutive periods indicates that concentrations of a parameter are absent or below detection limits, that parameter does not need to continue to be monitored on an ongoing basis, unless otherwise specified by the relevant authority.
264. When specifying conditions for a permit to drain or discharge water into a well, the relevant authority may wish to give consideration to specifying a condition requiring the holder of the permit to:
- a) take the measures referred to in principles 257–262; and
 - b) take specified action where the drainage or discharge of water into a well results in any specified adverse impacts (including, but not limited to, increased water levels or pressure, deterioration in the quality of water in the aquifer, damage to the integrity of the aquifer, and/or impacts to other water users or environmental assets).

7.2.9 Commercial forestry

A permit is required to undertake commercial forestry, pursuant to section 127 (5)(ja) of the NRM Act.

The following objectives and principles apply in addition to those expressed for all water affecting activities in section 7.1 of the Plan.

Objectives

- a) Allow for the expansion of *commercial forests* within sustainable limits.
- b) Minimise the adverse impacts of the water use of commercial forests on other water users and the environment.

Principles

Permit not required

265. For the purposes of the Plan, a permit is not required to either fell or replant a *commercial forest*, provided that there is no increase in the area, or a change in the location of the forest.
266. A permit is not required to plant non-irrigated vegetation in the *Angas Bremer Irrigation Management Zone* in order to meet the requirements of principles 28–32.

Deemed volumes of water used or intercepted

267. For the purposes of the Plan, the volume of water deemed to be used and/or intercepted by a given area of *commercial forest* is determined as follows:

- a) from surface water ('*forestry use from surface water*') is 85% of the mean annual adjusted runoff of the relevant *surface water management zone* for the given area, calculated as follows:

$$FU_{SW} = A_F \times R \times 0.85$$

where

FU_{SW} *Forestry use from surface water* for a given area of commercial forest (in ML).

A_F Area of commercial forest (in km²).

R Runoff: *mean annual adjusted runoff depth* for the surface water management zone that the majority of the area of the commercial forest lies within, given in Table 4.5 (in mm).

0.85 Multiplication factor to determine 85% of runoff.

- b) from underground water ('*forestry use from underground water*') is:

- i) 85% of the mean annual recharge for the given area minus 85% of the baseflow from the given area, calculated as follows:

$$FU_{UGW} = (A_F \times RR \times 0.85) - [A_F \times (BF \div A_z) \times 0.85]$$

where

FU_{UGW} Forestry reduction of underground water recharge for a given area of commercial forest (in ML).

A_F Area of commercial forest (in km²).

RR Recharge rate for the underground water management zone that the majority of the area of commercial forest lies within, given in Table 4.7 (in mm).

BF Baseflow volume for the underground water management zone that the majority of the area of commercial forest lies within, given in Table 4.7 (in ML).

A_z Area of the underground water management zone that the majority of the area of commercial forest lies within, given in Table 4.7 (in km²).

0.85 Multiplication factor to determine 85% of recharge or baseflow.

- ii) plus in addition to principle 267 b) i), where the watertable is 6 metres or less below ground level:

I. 1.82 ML/ha/y for a hardwood commercial forest; or

II. 1.66 ML/ha/y for a softwood commercial forest.

268. Where the depth to the watertable is unknown, a permit for a *commercial forest* will not be granted unless the applicant provides information relevant to the depth to the watertable as required by the relevant authority.

Maximum allowable plantation area

269. A commercial forest must not be planted if it would cause any of the following limits to be exceeded¹⁶:
- a) the evaporation and consumptive use limit at the regional scale (principle 270);
 - b) the evaporation and consumptive use limit at the catchment scale (principle 271);
 - c) the interception limit at the catchment scale (principle 272);
 - d) the evaporation and consumptive use limits at the surface water management zone scale (principle 273);
 - e) the interception limit at the surface water management zone scale (principle 274);
 - f) the underground water consumptive use limit at the regional scale (principle 275);
 - g) the underground water consumptive use limit at the underground water management zone scale (principle 276)
 - h) the limits at the local catchment area scale (principles 277–278);
 - i) the evaporation and consumptive use limit at the significant environmental asset scale (principle 279);
 - j) the limit on net increases in taking in the Angas River and Bremer River surface water catchments (principle 280);
 - k) the joint Tookayerta limit (principle 281); or
 - l) the limits on net increases in taking in the Tookayerta Creek surface water catchment and Tookayerta Permian underground water management zone if applicable (principles 282 and 283).

Regional scale – evaporation and consumptive use limit

270. A *commercial forest* must not be planted if would cause the total volume of *evaporation* plus *consumptive use from surface water and watercourses* in the Eastern Mount Lofty Ranges PWRA to exceed (or further exceed) the *regional evaporation and consumptive use limit* (given in Table 4.4).

Catchment scale – evaporation and consumptive use limit

271. A *commercial forest* must not be planted if it would cause the total volume of *evaporation* plus *consumptive use from surface water and watercourses* in a *surface water catchment* to exceed (or further exceed) the *catchment evaporation and consumptive use limit* for the surface water catchment that the forest would lie within (given in Table 4.3).

¹⁶The limits referred to in these principles essentially calculate the maximum allowable volume of *forestry use from surface water*, which can be translated to the maximum allowable new commercial forest area through use of the equation in principle 267 a) (where the maximum allowable new commercial forest area equates to the value of A_F).

Catchment scale – interception limit

272. A commercial forest must not be planted if it would cause the total volume of *interception* in a *surface water catchment* to exceed (or further exceed) the *catchment interception limit* for the *surface water catchment* that the forest would lie within (given in Table 4.3).

Surface water management zone scale – evaporation and consumptive use limit

273. A commercial forest must not be planted if it would cause:
- a) the total volume of *evaporation* plus *consumptive use* from *surface water* and *watercourses* taken from outside the *main watercourse* in a *surface water management zone* to exceed (or further exceed) the *runoff evaporation and consumptive use limit* for the *surface water management zone* that the forest would lie within (given in Table 4.5); or
 - b) the total volume of *cumulative evaporation plus consumptive use* (determined in accordance with principle 41 c)) to exceed (or further exceed) the *main watercourse evaporation and consumptive use limit* (given in Table 4.5) for:
 - i) the *surface water management zone* that the forest would lie within; or
 - ii) any *surface water management zone* affected by the proposed forest.

Surface water management zone scale – interception limit

274. A commercial forest must not be planted if it would cause the total volume of *interception* in a *surface water management zone* to exceed (or further exceed) the *surface water management zone interception limit* for the *surface water management zone* that the forest would lie within (given in Table 4.5).

Regional scale – underground water consumptive use limit

275. A commercial forest must not be planted if would cause the total volume of *consumptive use* from *underground water* from all *underground water management zones* in the Eastern Mount Lofty Ranges PWRA to exceed (or further exceed) the *regional underground water consumptive use limit* (given in Table 4.4).

Underground water management zone scale – underground water consumptive use limit

276. A commercial forest must not be planted if it would cause the total volume of *consumptive use* from *underground water* in an *underground water management zone* to exceed (or further exceed) the *underground water consumptive use limit* for the *underground water management zone* that the forest would lie within (given in Table 4.7).

Local catchment area scale – available runoff

277. A commercial forest must not be planted if it would cause the total volume of *consumptive use from surface water and watercourses, ecosystem allocations (system provisions) allocated from surface water and watercourses, lower Angas Bremer allocations, and evaporation* from the catchment area upstream of the forest to exceed (or further exceed) the mean annual adjusted runoff from the catchment area upstream of the forest.

For the purposes of this principle, the allowable volume of *forestry use from surface water* for a commercial forest (F1) shall not exceed the following:

$$TV_{\max} = (A_{F1} \times R_{F1}) - (CU_{SW,UF1} + SP_{SW,UF1} + LAB_{UF1} + E_{UF1})$$

where:

TV_{\max}	Maximum allowable total volume of forestry use from surface water for commercial forest F1 (in ML).
A_{F1}	Area: size of the catchment area upstream of commercial forest F1 (in km ²).
R_{F1}	Runoff: <i>mean annual adjusted runoff depth</i> for the catchment area upstream of forest F1 (in mm), determined in accordance with principle 34 d). A different value may be used for R_{F1} where the proponent can demonstrate a different value based on adequate data, to the Minister's satisfaction.
$CU_{SW,UF1}$	Consumptive use upstream of F1: determined as the volume of <i>consumptive use from surface water and watercourses</i> in the catchment area upstream of forest F1, immediately prior to the application (in ML).
$SP_{SW,UF1}$	<i>Ecosystem allocations (system provisions)</i> taken from surface water and watercourses in the catchment area upstream of forest F1 (in ML).
LAB_{UF1}	<i>Lower Angas Bremer allocations</i> taken in the catchment area upstream of forest F1 (in ML).
E_{UF1}	<i>Evaporation</i> upstream of F1: the total volume of mean net annual evaporation from dams in the catchment area upstream of forest F1 (in ML), determined in accordance with principle 34.

Local catchment area scale – minimising downstream impact

278. A *commercial forest* must not be planted if it would cause the total demand for water from surface water and watercourses in the catchment area of an affected downstream *diversion point* to exceed (or further exceed) the average supply of runoff to that point. Total demand includes (1) *consumptive use from surface water and watercourses*, (2) *ecosystem allocations (system provisions)* allocated from surface water and watercourses, (3) *lower Angas Bremer allocations*, and (4) *evaporation*.

For the purposes of this principle, the allowable volume of *forestry use from surface water* for a commercial forest (F1) must not exceed the smallest volume returned by calculating the following at each diversion point x (Dx) downstream of F1 within the Eastern Mount Lofty Ranges PWRA that may be affected by the planting.

$$TV_{\max} = (A_{Dx} \times R_{Dx}) - (CU_{SW,BDx} + SP_{SW,BDx} + LAB_{BDx} + E_{BDx})$$

where:

TV_{\max}	Maximum allowable volume of <i>forestry use from surface water</i> for commercial forest F1 (in ML).
A_{Dx}	Area: size of the catchment area upstream of diversion point Dx (in km ²).
R_{Dx}	Runoff: <i>mean annual adjusted runoff depth</i> for the catchment area upstream of diversion point Dx (in mm), determined in accordance with principle 34 d).
$CU_{SW,BDx}$	Consumptive use both at and in the catchment area upstream of diversion point x: the total volume of <i>consumptive use from surface water and watercourses</i> both at and in the catchment area upstream of diversion point Dx, at the date of application (in ML).
$SP_{SW,BDx}$	<i>Ecosystem allocations (system provisions)</i> taken from surface water and watercourses both at and in the catchment area upstream of diversion point Dx at the date of application (in ML).
LAB_{BDx}	<i>Lower Angas Bremer allocations</i> both at and in the catchment area upstream of diversion point Dx at the date of application (in ML).
E_{BDx}	<i>Evaporation</i> both at and upstream of Dx: the total volume of mean net annual evaporation from dams both at and in the catchment area upstream of diversion point Dx at the date of application (in ML), determined in accordance with principle 34.

Where the equation returns a negative value, TV_{\max} will be zero.

Note that this calculation determines the maximum allowable volume of forestry use from surface water by new commercial forests. This maximum allowable volume is in addition to forestry use from surface water by existing commercial forests at F1 (if any).

Protection of significant environmental assets – water-taking limit

279. A *commercial forest* must not be planted if it would cause the total volume of *evaporation* plus *consumptive use from surface water and watercourses* in the catchment area of any *significant environmental asset* that may be affected by the commercial forest to exceed (or further exceed) the *local evaporation and consumptive use limit* for that catchment area. The local evaporation and consumptive use limit for the catchment area of a significant environmental asset is determined in accordance with principle 194.

No net increase in taking in the Angas and Bremer catchments

280. A *commercial forest* must not be planted in the Angas River *surface water catchment* or the Bremer River *surface water catchment* (as shown in Figure 4.2) if it would cause a net increase in the total volume of *evaporation plus consumptive use from surface water and watercourses plus lower Angas Bremer allocations* in that *surface water catchment*, compared with *initial evaporation plus consumptive use* from that catchment (determined in accordance with principle 48).

Joint Tookayerta limit

281. A *commercial forest* must not be planted in the Tookayerta Creek *surface water catchment* or the Tookayerta *Permian underground water management zone* if it would cause *joint Tookayerta demand* to exceed (or further exceed) the *joint Tookayerta limit*.

No net increase in taking in the Tookayerta catchment in some circumstances

282. This principle only applies if *joint Tookayerta demand* exceeds the *joint Tookayerta limit*.
A *commercial forest* must not be planted in the Tookayerta Creek *surface water catchment* if it would cause a net increase in the total volume of *evaporation plus consumptive use from surface water and watercourses* in that *surface water catchment*, compared to that total volume immediately prior to the proposed forest.

No net increase in taking in the Tookayerta Permian in some circumstances

283. This principle only applies if *joint Tookayerta demand* exceeds the *joint Tookayerta limit*.
A *commercial forest* must not be planted in the Tookayerta *Permian underground water management zone* if it would cause a net increase in the total volume of *consumptive use from underground water* in that *underground water management zone*, compared to that total volume immediately prior to the proposed forest.

Location of commercial forests

284. The outermost stump line of a *commercial forest* shall not be planted within 5 metres of the edge of a *drainage path*, which for the purposes of the Plan is a fold, depression or contour in land or a path along which surface water may flow.
285. Where the watertable is more than 6 metres below ground level, the outermost stump line of a *commercial forest* shall not be planted within 20 metres of the centreline of a watercourse or the edge of an *environmental asset* or *significant environmental asset*.
286. Where the watertable is 6 metres or less below ground level, the outermost stump line of a *commercial forest* shall not be planted within the specified buffer distance of the centreline of a watercourse or the edge of an *environmental asset* or *significant environmental asset*.
287. For the purposes of principle 286, the specified buffer distance is:
- 200 metres where the area of the proposed *commercial forest* plus the area of any adjacent existing commercial forest areas on the property is 20 hectares or more;
 - 50 metres where the area of the proposed commercial forest plus the area of any adjacent existing commercial forest areas on the property is five hectares or less; or
 - in all other cases, the value, in metres, calculated by:
$$[\text{the area of the proposed commercial forest} + \text{the area of any adjacent existing commercial forest areas on the property (in hectares)}] \times 10$$

For the purposes of this principle, two proposed or actual forest areas are considered to be adjacent when the average distance between the areas is less than the sum of the specified

buffer distances that would be assigned to each area in accordance with this principle, if each commercial forest area was considered in isolation.

8 MONITORING, EVALUATION, REPORTING AND IMPROVEMENT

8.1 INTRODUCTION

Section 76 (4)(d) of the NRM Act sets out that a water allocation plan must provide for regular monitoring of the capacity of the water resources to meet demands for water.

Monitoring and evaluation of water resources, water use and water-dependent ecosystems provides a mechanism for assessing whether the Plan's objectives are being met, helps to identify actions that need to be taken to protect the resource and dependent users, and improves knowledge. Together, this information allows informed improvements in water management, including changes to the Plan over time.

This chapter outlines key parts of a monitoring and evaluation program that aims to:

- assess the effectiveness of the consumptive use limits and other policies contained within the Plan in meeting the Plan's objectives;
- collect data to assist accurate assessment of permit, allocation and transfer applications;
- enable adequate resource assessment with a reasonable to high level of confidence on a continuing basis;
- enable trends analysis of water flow regime, water level and pressure, and water quality;
- enable adequate determination of cause and effects in relation to water resource management;
- effectively assess and report on changes to water-dependent ecosystems on a continuing basis;
- inform and underpin future water management decisions;
- provide information to all water users relevant to the condition of the water resources in their region; and
- improve understanding of resource behaviour and response, including interactions between underground water and surface water/watercourse water.

8.2 APPROACH

The Board's planning approach includes a Monitoring, Evaluation, Reporting and Improvement (MERI) framework. Key components of a MERI program for the Plan are outlined below.

8.2.1 Monitoring

Section 8.3.1 sets out monitoring (and reporting) requirements for licensees and some permit holders that are designed to collect information about water demand and use, and potential impacts of water taking, use and water affecting activities on the water resources and environment at a local scale.

Section 8.3.2 focuses on regional-scale monitoring, largely led by agencies such as the Board and the Department, working with other bodies and the community. The 'Monitoring requirements' column of Table 8.1 sets out the key monitoring required to assess the capacity of the resource to meet demands, by monitoring consumptive water demand and management, water resource behaviour, and environmental responses over time. These water resource monitoring requirements focus on aspects that the principles in the Plan aim to help manage, such as water regime and availability (e.g. flow pattern, underground water level/pressure over time), and indicators of effects of water taking on water quality (e.g. salinity).

The Board will work with the Department and others to develop an adaptive operational MERI plan to underpin the program set out in section 8.3.2, and update it over time. The operational detail of the

monitoring program needs to be refined and optimised to ensure monitoring is targeted to areas of likely high risk (e.g. high water demand in areas with high environmental value) as they develop and change over time. It will also be important for the operational plan to integrate existing monitoring programs as they evolve over time, identify gaps to be filled, and to identify roles and responsibilities for different aspects of the monitoring program.

Monitoring more intensively, over more sites and over a wider range of parameters, will provide a more complete picture of water resource behaviour and environmental responses, including responses to broader land use issues that are outside the scope of the Plan to manage. As part of the Board's broader regional NRM planning program, the Board will draw on other monitoring and assessment programs (such as the Environment Protection Authority's aquatic ecosystem condition reporting, and community monitoring programs), and will continue to work with other bodies and the community to develop and implement suitable monitoring and research programs to complement the Plan's key monitoring requirements, including the monitoring and evaluation desires of Aboriginal nations described in section 1.3.4.2. Resources and reviews such as Kawalec and Roberts (2005), Cottingham et al. (2005) and Murdoch (2009) will help to refine and direct further monitoring actions.

8.2.2 Evaluation and reporting

It is important to evaluate the effectiveness of the Plan, and of the assumptions, knowledge and modelling of water resources, demand and environmental responses that underpin the Plan. Such evaluation generally needs to occur over a reasonable period to allow for time for implementation and response, and to capture variability in factors such as climate and markets. The Plan needs to be reviewed within ten years of adoption, and it is expected that these factors will be assessed at Plan review, based on the information collected and evaluations made during the life of the Plan.

The 'Condition indicator' column of Table 8.1 sets out a number of indicators that provide a basis for evaluation of monitoring data for identification of potential issues. As outlined above, for some indicators it will take at least the anticipated ten year life of the Plan to collect sufficient data to make a meaningful evaluation.

It is intended that evaluation and reporting of monitoring outcomes during the life of the Plan will generally occur through existing mechanisms. At the date of adoption of the Plan, these include:

- Annual water resource status reporting program by the Department. The current purpose of the Groundwater Status Reports is to report on the trends in underground water levels and salinity, and provide an explanation of the potential drivers of the trends if possible. The report also assigns a status to the resource based on the trend observed over the last 12 months only (not the previous 5 or 10 years of record). The status report does not seek to evaluate the sustainable limits of the resource, nor does it make any recommendations on management or monitoring of the resource. These actions are important, but occur through separate processes such as the steps outlined in principles 300–301 (discussed below). Surface water status reports are also being produced, reporting on stream flow levels, salinity and metered water use.
- Regional NRM Plan reporting. The Board's regional Monitoring, Evaluation and Reporting Plan includes reporting at several different scales and frequencies, including:
 - Information on the state and condition of natural resources in the SAMDB region included as part of the SAMDB Regional NRM Plan. The Regional NRM Plan must be reviewed every ten years.
 - Regional Outcomes Report – the Regional NRM Plan includes a set of Management Action Targets, which are a measure to assess the Board's success in implementing the Regional NRM Plan. The purpose of the Regional Outcomes Report is to report on progress towards achieving the Management Action Targets. To date, the regional outcomes reporting process has been undertaken twice within the former five-year Regional NRM Plan review period.

- The regular preparation and review of a Business Plan are statutory obligations under the NRM Act. The review brings together information on Board activities and success of implementation to inform the development of the Business Plan.

The Board will also, to the best of its endeavours, work with other agencies and the community to provide annual evaluation and reporting of water use data and environmental data collected under this section, via the Board's website.

Monitoring data and status reports are available on a number of websites. The Board will include links to these sites on its website.

8.2.3 Improvement

Table 8.1 sets out condition indicators such that if evaluation of monitoring data shows an indicator has been met, the response steps set out in principle 300 will be triggered. These steps include identification of appropriate remedial actions if required. If regulatory actions are identified as the most appropriate response, the NRM Act sets out a range of possible tools that may be used. These may include temporary restrictions on how water is taken or the amount taken, permanent allocation reductions, notices specifying actions to be taken, and amendment of the water allocation plan. Principle 301 also sets out responses for particular issues.

Improvement of the Plan will occur through the review and amendment processes set out in the NRM Act. A water allocation plan can be reviewed at any time, but must be reviewed within ten years of adoption. The review may, or may not, recommend amendment of the Plan. Significant amendment of a water allocation plan generally must follow the same steps as plan development, including extensive consultation.

8.3 MONITORING

8.3.1 Water use monitoring and annual reporting

Principles

Water use monitoring by licensees and permit holders

288. An annual water use report is to be completed by all licensees and permit holders (using imported water or effluent, or draining and discharging water into a well) on or before 31 July each year.
289. For the purpose of principle 288, the annual water use report will include the following data (where relevant):
- a) licensee name, address and contact details;
 - b) licence and permit numbers;
 - c) the volume of water allocated on the licence;
 - d) the volume of water actually used by the licensee during the water use year (where measured);
 - e) meter numbers, meter readings and source identifier (where relevant);
 - f) where water is used for irrigation:
 - i) the type of crop(s) irrigated;
 - ii) the area of each crop;
 - iii) the date of planting of a crop, or crop age
 - iv) the volume or proportion of water applied to each crop type (where relevant); and
 - v) the type of irrigation system;
 - g) where water is used for other licensed purposes:
 - i) the nature and size(s) of each purpose(s); and
 - ii) the volume or proportion of water applied to each purpose (where relevant); and
 - h) other information as required by the Board.
290. In addition to the requirements of principle 288, the annual water use report for licensees and permit holders in the Angas Bremer Limestone *underground water management zone* will also include the following data:
- a) where watertable monitoring wells have been constructed in accordance with principles 26–27 (or equivalent principles in the Water Allocation Plan for the River Murray Prescribed Watercourse or the Water Allocation Plan for the Angas Bremer Prescribed Wells Area) — the level of the watertable below the natural surface level of the land upon which the water endorsed on the licence is used, measured in those watertable monitoring wells in September, December, March and June of every *water use year*;
 - b) area and duration of any flooding (whether natural and artificial);
 - c) where appropriate, vegetation health in accordance with the Watercourse Diversion Best Management Practice guidelines (ABWMC 2005) unless advised otherwise; and
 - d) the nature of any soil moisture monitoring devices used.

The information shall be submitted to the Board through the Angas Bremer Water Management Committee Inc. on the 31st of July of each water use year, or directly to the Board in the absence of the Angas Bremer Water Management Committee Inc.

Artificial recharge

291. In addition to the requirements of principle 289–290, licensees and permit holders who undertake *artificial recharge* must provide information on the total metered amount of water artificially recharged in a given water use year.
292. Licensees and permit holders who undertake *artificial recharge* must maintain a log book of the following:
- a) the date and time of start of drainage or discharge;
 - b) the date and time of finish of drainage or discharge; and
 - c) the volume of water drained or discharged during that time.

Log books are to be submitted to the relevant authority if requested.

293. Principles 260, 261 and 262 outline water quality monitoring requirements for *artificial recharge*. The outcomes of this monitoring are to be reported as directed by the relevant authority.

Allocations not actively taken

294. Where an allocation is not actively taken and used, an annual water use report is still to be completed indicating nil taking and use, but does not need to provide further information on water taking and use as set out in principles 288–290.

Licensee underground water salinity monitoring program

295. In addition to the requirements of principles 288–290, licensees are to collect a sample of water from well(s) used for licensed purpose during the water use year and provide it to the Board for salinity testing as required. Samples are required as follows:
- a) for Angas Bremer Limestone and Currency Creek Limestone *underground water management zones* (where wells penetrate the confined limestone aquifer):
 - i) at the start, or as close as reasonably practicable to the start of the irrigation season (September); and
 - ii) at the end, or as close as reasonably practicable to the end of the irrigation season (March);
 - b) for all other underground water management zones:
 - i) at, or as close as reasonably practicable to the end of irrigation season (March) unless otherwise specified by the Board.

Environmental use, monitoring and reporting

296. Where:
- a) an allocation is granted for the purpose of environmental use or as an *ecosystem allocation*; and
 - b) the allocation is used actively;
- the licensee must implement a monitoring and reporting program designed to the Minister's satisfaction to assess achievement against objectives for that use, and report to the Minister as required by that program.
297. If a licensee does not report the following information through the requirements of principle 290, where an *ecosystem allocation (system provisions)* is granted in accordance with principle 15 b), the licensee must provide an annual report to the Minister describing:
- a) area and duration of watering of red gum swamps that are the subject of that allocation, noting whether the watering was natural or artificial; and
 - b) vegetation health in the red gum swamps that are the subject of that allocation (as per principle 290 c)).

8.3.2 Regional monitoring

298. Table 8.1 outlines the basic monitoring considered to be required to provide for regular monitoring of the capacity of the water resources to meet demands for water.
299. Monitoring undertaken in accordance with Table 8.1 shall be undertaken in a manner that is consistent with best practice and with sufficient documentation to demonstrate to the Minister's satisfaction that representative samples were collected and sufficient quality assurance has been achieved.

8.4 CONDITION INDICATORS AND RESPONSES

300. When monitoring shows that a condition indicator given in Table 8.1 has been met in the area that the indicator applies to, the following steps will be taken by the Board and the Department:
- a) Identify the cause of the indicator being met.
 - b) Determine if there are likely to be negative impacts to the water resource, water-dependent ecosystems and/or water users as a result of the indicator being met.
 - c) If necessary, assess what options are available for remedial action. These remedial actions may include, but are not limited to, reductions in allocations or application of other legislative instruments.
 - d) Report to stakeholders including licensees, the Board and the Minister.
 - e) Implement remedial actions as required.

301. If the Minister is satisfied that:

- a) the condition of a red gum swamp that is the subject of an *ecosystem allocation (system provisions)* granted in accordance with principle 15 b) is poor or declining (due to condition indicator 8 from Table 8.1 being met, or for some other reason); and
- b) the manner of taking and/or use of the *ecosystem allocation (system provisions)* is contributing to the poor or declining condition of the red gum swamp;

the Minister may, subject to sections 149 and 156 of the NRM Act, and without limiting section 164P of the NRM Act:

- c) vary the conditions of the relevant water licence or water allocation to ensure that the taking and/or use of water is consistent with the purpose of the allocation; and/or
- d) vary the water allocation or the quantity of water included on the relevant water licence.

Table 8.1 Condition indicators and monitoring requirements.

No.	Water resource / asset	Condition indicator	Monitoring requirements
1	Surface water and watercourses in the Eastern Mount Lofty Ranges PWRA.	Significant variation in the rainfall-runoff relationships underpinning the Plan. Long-term increase in salt load.	Continuous monitoring of flow/water level and salinity at the existing gauging station and water level detector network (at a minimum). Appendix E lists key flow gauging stations.
2	The parts of the Angas Bremer Limestone underground water management zone where the underground water salinity is 2,500 mg/L or less, as at identified in figure 7 of Zulfic and Barnett (2007) (reproduced in Figure 8.1).	An increase in underground water salinity of 1.5% or more per year for 3 consecutive years across at least 50% of representative monitoring wells identified by the Minister.	Twice yearly monitoring of underground water salinity in the observation wells network (at a minimum) in the Angas Bremer Limestone underground water management zone; , at or as close as reasonably practicable to the start and end of the irrigation season (September and March).
3	Underground water in the Eastern Mount Lofty Ranges PWRA.	An increase in underground water salinity of 1.5% or more per year for 3 consecutive years across at least 50% of representative monitoring wells identified by the Minister.	Monitoring of underground water salinity level in the observation wells (at a minimum) at the frequency as follows: <ul style="list-style-type: none"> • in the Angas Bremer Limestone, Currency Limestone and Finniss Permian underground water management zones — at least twice yearly, at or as close as reasonably practicable to the start and end of the irrigation season (September and March); • in all other underground water management zones — at least annually, at or as close as reasonably practicable to the end of the irrigation season (March).

No.	Water resource / asset	Condition indicator	Monitoring requirements
4	Underground water in the Eastern Mount Lofty Ranges PWRA.	For underground water level — a 10% decline in standing water level each year for two consecutive years across at least 50% of representative monitoring wells identified by the Minister in an underground water management zone.	<p>Monitoring of underground water level in the observation wells network (at a minimum) at the frequency as follows:</p> <ul style="list-style-type: none"> in the Angas Bremer Limestone, Currency Limestone and Finniss Permian underground water management zones — at least quarterly in all other underground water management zones — at least twice yearly. <p>Expansion of the existing observation wells network is required to achieve the objectives identified in the Plan. It is proposed that the expansion uses existing wells (where appropriate) and focuses on key areas identified through risk assessment (areas with high demand and high likelihood of impacts to the resource or users including the environment).</p>
5	Eastern Mount Lofty Ranges PWRA.	Fish recruitment is marginal or poor in 30% or more of years at any sites, assessed over at least four years of data.	Continue long-term monitoring of native fish in accordance with the recommendations detailed in Hammer (2007).
6	Eastern Mount Lofty Ranges PWRA.	Macroinvertebrate community condition is worse than moderate over 2 consecutive years.	Establish and monitor integrated monitoring sites examining underground water, surface water/watercourse water and water-dependent ecosystem interactions (including fish, vegetation and macroinvertebrates).
7	Eastern Mount Lofty Ranges PWRA.	Condition indicators defined for identified vulnerable environmental assets ¹⁷ .	<p>Establish and monitor key water regime components at identified vulnerable environmental asset sites.</p> <p>Establish and monitor integrated monitoring sites examining underground water, surface water/watercourse water and water-dependent ecosystem interactions (including fish, vegetation and macroinvertebrates).</p>

¹⁷ It is planned that, through the operational MERI plan for the Plan, a selection of vulnerable environmental assets will be identified and condition indicators set based on key parts of the water regime for that site (e.g. minimum pool depth, refreshing rates, frequency and duration presence of different types of flow habitats, salinity).

No.	Water resource / asset	Condition indicator	Monitoring requirements
8	Red gum swamps on the floodplains of the lower Angas and Bremer Rivers, as shown in Figure 4.11.	An overall decline in condition over 2 or more years in red gum swamp communities.	Establish and monitor long-term sites to monitor the condition of red gum swamps on the floodplains of the lower Angas and Bremer Rivers (as shown in Figure 4.11).
9	Surface water management zones 426AR026 and 426BR062.	An overall decline in condition over 2 or more years in in-stream ecological communities.	Establish and monitor long-term sites to monitor the condition in-stream ecological communities in surface water management zones 426AR026 and 426BR062.
10	Surface water management zones 426AR026 and 426BR062.	An overall decline in condition over 2 or more years in end-of-catchment ecological communities.	Establish and monitor long-term sites to monitor the condition of end-of-catchment ecological communities in surface water management zones 426AR026 and 426BR062.
11	Eastern Mount Lofty Ranges PWRA.	Return of low flows to meet the provisions set out in the Plan does not begin within three years of plan adoption.	Track implementation of program to return low flows.

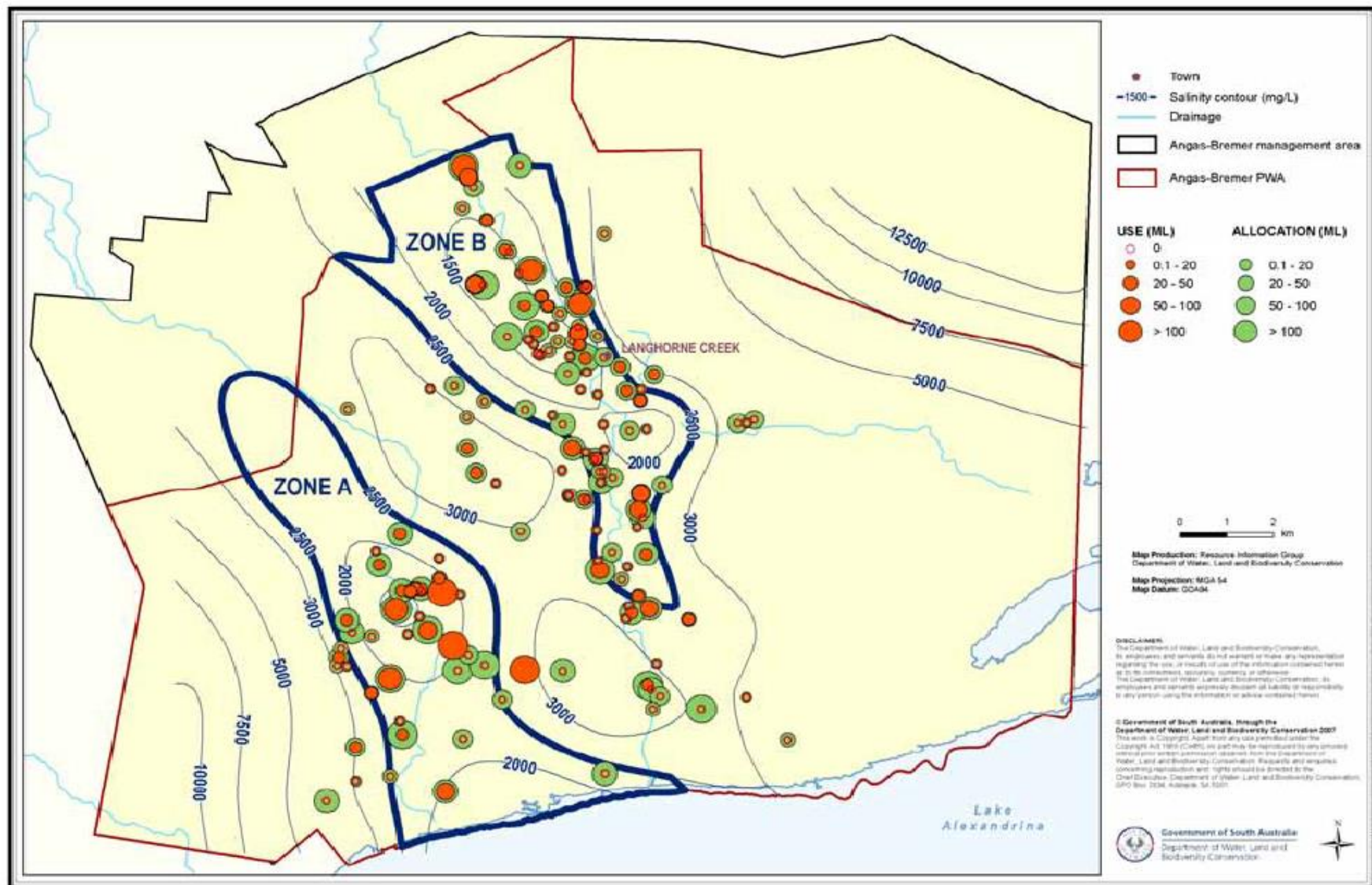


Figure 8.1 Angas Bremer Limestone underground water management zone (labelled as Angas-Bremer PWA in the figure), showing areas with a salinity of 2,500 mg/L or less (labelled Zone A and Zone B) (from Zulfic and Barnett 2007).

APPENDIX A

SURFACE WATER ZONES USED FOR THE DETERMINATION OF STOCK AND DOMESTIC DEMAND ESTIMATES.



APPENDIX B

WATER REQUIREMENTS OF FUNCTIONAL GROUPS

The information in this appendix is taken from VanLaarhoven and van der Wielen (2009).

Tables are given outlining the environmental water requirements of fish, aquatic macroinvertebrates and vegetation in the Eastern Mount Lofty Ranges. Environmental water requirements are grouped by flow season and flow component (see section 2.2.1.2), showing the ecological process that each requirement supports.

Environmental water requirements for functional groups of freshwater fish in the Eastern Mount Lofty Ranges

Fish are reliant on other biotic groups and so the environmental water requirements for these other groups are also part of the requirements for fish. For example, many fish are reliant on macroinvertebrates as a food source (e.g. Lloyd 1987). Aquatic, in-stream, riparian and floodplain vegetation provide shade and habitat for fish survival, sources of terrestrial and aquatic macroinvertebrates (food), shelter during floods, and sites for spawning and recruitment (including indirectly through input of woody debris and leaf litter).

Some groups have species with specific requirements, identified in the table for river blackfish (RB), southern pygmy perch (SPP), mountain galaxias (MG), common galaxias (CG) and Yarra pygmy perch (YPP). Requirements for diadromous and potamodromous fish are grouped together in the 'diadromous/migratory' column.

Flow season	Flow component	Ecological process supported by environmental water requirement				
		Freshwater obligate (stream specialist)	Freshwater obligate (wetland specialist)	Freshwater obligate (generalist)	Diadromous/migratory	Fleurieu wetland
Low Flow Season	Zero flow	Maintain persistent aquatic conditions through combination of zero flows, low flows and channel shape				
		Discourage exotic fish		Discourage exotic fish	Discourage exotic fish	
	Low flow	Persistent water in pools throughout season (base flow ideal); cool and well oxygenated (RB), well vegetated (SPP) Maintain shallower sub-optimal habitats and pool margins when exotic predatory fishes occur Maintain shallows (larval habitat) for spawning and recruitment (RB, SPP)	Persistent cool, well-oxygenated, tolerable salinity water in wetlands, channels, riffles, anabranches and refuges (pools, billabongs) throughout season (base flow ideal); tannin-rich, clearer water (YPP) Promote successful spawning events Continuously flowing cool water discourages exotic fish in these habitats	Persistent water in pools throughout season (base flow ideal) Maintain shallower sub-optimal habitats and pool margins when exotic predatory fishes occur Promote successful spawning events	Persistent water in pools throughout season (base flow ideal) Maintain shallower sub-optimal habitats and pool margins when exotic predatory fishes occur Sustained flow to allow upstream migration	Persistent water in wetlands throughout season (base flow ideal) Cool flowing conditions discourage exotic fish Access to shallows (larval habitat) for spawning and recruitment

Flow season	Flow component	Ecological process supported by environmental water requirement				
		Freshwater obligate (stream specialist)	Freshwater obligate (wetland specialist)	Freshwater obligate (generalist)	Diadromous/migratory	Fleurieu wetland
Low Flow Season (cont.)	Fresh	Refill pools, maintain water quality Prevent vegetation encroachment Clean substrates for egg deposition (MG, RB) and feeding (RB) Allow movement between pools Maintain submerged aquatic vegetation habitat (SPP) Variable flows discourage exotic fish	Refill pools, maintain water quality Prevent vegetation encroachment Maintain water in a range of habitats at different elevations to allow co-existence of species with different requirements Variable flows discourage exotic fish	Refill pools, maintain water quality. Prevent vegetation encroachment Variable flows discourage exotic fish	Refill pools, maintain water quality (particularly pools and migration barriers) Prevent vegetation encroachment Variable flows discourage exotic fish	Low-energy freshes that refill wetlands and maintain water quality Allow localised movement between wetlands Variable flows discourage exotic fish
Transitional Flow Season 1 (T1)	Zero flow	Maintain persistent aquatic conditions through combination of zero flows, low flows and channel shape				
		Discourage exotic fish		Discourage exotic fish	Discourage exotic fish	
	Low flow	Persistent water in pools; cool and well oxygenated (RB), well vegetated (SPP) Trigger spawning, oxygenate riffles and allow access to new habitats (spawning sites) (MG) Localised movement between pools (RB, SPP) Maintain water quality Maintain shallower sub-optimal habitats and pool margins when exotic predatory fishes occur Maintain shallows for juveniles and young fish (RB) Promote successful spawning	Persistent cool, well oxygenated, tolerable salinity water in wetlands, channels, riffles, anabranches and refuges (pools, billabongs); tannin-rich, clearer water (YPP) Continuously flowing cool water discourages exotic fish in these habitats	Persistent water in pools Maintain shallower sub-optimal habitats and pool margins when exotic predatory fishes occur	Persistent water in pools Maintenance of permanent water in slow flow areas (larval lampreys) Maintain shallower sub-optimal habitats and pool margins when exotic predatory fishes occur Sustained flow to allow upstream and downstream migration	Persistent water in wetlands throughout the season (base flow ideal) Cool flowing conditions discourage exotic fish Allow localised movement between wetlands Access to shallows for juveniles and young fish

Flow season	Flow component	Ecological process supported by environmental water requirement				
		Freshwater obligate (stream specialist)	Freshwater obligate (wetland specialist)	Freshwater obligate (generalist)	Diadromous/migratory	Fleurieu wetland
Transitional Flow Season 1 (T1) (cont.)	Fresh	Trigger spawning, oxygenate riffles and allow access to new habitats (spawning sites) (MG) Allow movement between pools Variable flows discourage exotic fish	Allow fish movement to recolonise vacant habitats Variable flows discourage exotic fish	Allow fish movement to recolonise vacant habitats Variable flows discourage exotic fish	Promote spawning success (raise water levels to allow access to emergent vegetation (e.g. common galaxias spawning lower stream reaches), appropriate water quality, permanence and access where species congregate) Trigger spawning, oxygenate riffles (CG) and successive access to riparian spawning habitat Allow fish movement to recolonise vacant habitats Variable flows discourage exotic fish	Allow movement between wetlands Variable flows discourage exotic fish
High Flow Season	Zero flow	Maintain persistent aquatic conditions through combination of zero flows, low flows and channel shape				
		Discourage exotic fish		Discourage exotic fish	Discourage exotic fish	

Flow season	Flow component	Ecological process supported by environmental water requirement				
		Freshwater obligate (stream specialist)	Freshwater obligate (wetland specialist)	Freshwater obligate (generalist)	Diadromous/migratory	Fleurieu wetland
High Flow Season (cont.)	Low flow	<p>Persistent water in pools; cool and well oxygenated (RB), well vegetated (SPP)</p> <p>Allow movement between pools over local and relatively long distances</p> <p>Maintain shallower sub-optimal habitats and pool margins when exotic predatory fishes occur</p> <p>Maintain water quality</p> <p>Maintain shallows, hollows and cavities (larval habitat) with low salinity water for spawning and recruitment (RB)</p> <p>Access to emergent and edge vegetation for spawning and recruitment (SPP)</p>	<p>Persistent cool, well-oxygenated, tolerable salinity water in wetlands, channels, riffles, anabranches and refuges (pools, billabongs); tannin-rich, clearer water (YPP)</p> <p>Sustain flows to provide access to off-channel habitat for adult conditioning, spawning sites and larval habitat</p> <p>Continuously flowing cool water discourages exotic fish in these habitats</p>	<p>Persistent water in pools</p> <p>Maintain shallower sub-optimal habitats and pool margins when exotic predatory fishes occur</p> <p>Allow fish movement to recolonise vacant habitats</p> <p>Sustain flows to provide access to off-channel habitat for larger species (e.g. Murray cod, golden perch) for adult conditioning, spawning sites and larval habitat in lowland/floodplain reaches</p>	<p>Persistent water in pools</p> <p>Maintain shallower sub-optimal habitats and pool margins when exotic predatory fishes occur</p> <p>Sustain flow to allow upstream and downstream migration</p> <p>Allow fish movement to recolonise vacant habitats</p>	<p>Persistent water in wetlands throughout season (base flow ideal)</p> <p>Cool flowing conditions discourage exotic fish</p> <p>Increase seasonal flow to prevent vegetation encroachment of open water</p> <p>Allow movement between wetlands</p> <p>Sustained flow between wetlands to allow connectivity with stream reaches for colonisation by climbing galaxias</p> <p>Access to shallows for spawning and recruitment</p>

Flow season	Flow component	Ecological process supported by environmental water requirement				
		Freshwater obligate (stream specialist)	Freshwater obligate (wetland specialist)	Freshwater obligate (generalist)	Diadromous/migratory	Fleurieu wetland
High Flow Season (cont.)	Fresh	<p>Allow movement between pools over relatively long distances</p> <p>Maintain water quality</p> <p>Access to emergent and edge vegetation for spawning and recruitment (SPP)</p> <p>Variable flows discourage exotic fish</p>	<p>Flows to provide access to off-channel habitat for adult conditioning, spawning sites and larval habitat</p> <p>Variable flows discourage exotic fish</p>	<p>Allow fish movement to recolonise vacant habitats</p> <p>Flows to provide access to off-channel habitat for larger species (e.g. Murray cod, golden perch) for adult conditioning, spawning sites and larval habitat in lowland/ floodplain reaches</p> <p>Variable flows discourage exotic fish</p>	<p>Promote spawning success (raise water levels to allow access to emergent vegetation (e.g. common galaxias spawning lower stream reaches), appropriate water quality, permanence and access where species congregate)</p> <p>Attractant flow to trigger upstream migration</p> <p>Trigger spawning, and successive access to riparian spawning habitat</p> <p>Variable flows discourage exotic fish</p>	<p>Increase seasonal flow to prevent vegetation encroachment of open water</p> <p>Allow movement between wetlands</p> <p>Sustain flow between wetlands to allow connectivity with stream reaches for colonisation by climbing galaxias</p> <p>Flow related disturbance to maintain a mosaic of habitats to allow species co-existence</p> <p>Access to shallows for spawning and recruitment</p> <p>Variable flows discourage exotic fish</p>
Transitional Flow Season 2 (T2)	Zero flow	Maintain persistent aquatic conditions through combination of zero flows, low flows and channel shape				
		Discourage exotic fish		Discourage exotic fish	Discourage exotic fish	

Flow season	Flow component	Ecological process supported by environmental water requirement				
		Freshwater obligate (stream specialist)	Freshwater obligate (wetland specialist)	Freshwater obligate (generalist)	Diadromous/migratory	Fleurieu wetland
Transitional Flow Season 2 (T2) (cont.)	Low flow	<p>Persistent water in pools; cool and well oxygenated (RB), well vegetated (SPP)</p> <p>Localised movement between pools (RB, SPP)</p> <p>Maintain shallower sub-optimal habitats and pool margins when exotic predatory fishes occur</p> <p>Maintain water quality</p> <p>Maintain shallows, hollows and cavities (larval habitat) with low salinity water for spawning and recruitment (RB)</p> <p>Access to emergent and edge vegetation for spawning and recruitment (SPP)</p>	<p>Persistent cool, well oxygenated, tolerable salinity water in wetlands, channels, riffles, anabranches and refuges (pools, billabongs); tannin-rich, clearer water (YPP)</p> <p>Sustain flows to provide access to off-channel habitat for adult conditioning, spawning sites and larval habitat</p> <p>Continuously flowing cool water discourages exotic fish in these habitats</p>	<p>Persistent water in pools</p> <p>Maintain shallower sub-optimal habitats and pool margins when exotic predatory fishes occur</p> <p>Allow fish movement to recolonise vacant habitats</p> <p>Sustain flows to provide access to off-channel habitat for larger species (e.g. Murray cod, golden perch) for adult conditioning, spawning sites and larval habitat in lowland / floodplain reaches</p>	<p>Persistent water in pools</p> <p>Maintain shallower sub-optimal habitats and pool margins when exotic predatory fishes occur</p> <p>Sustained flow to allow upstream and downstream migration</p> <p>Allow fish movement to recolonise vacant habitats</p>	<p>Persistent water in wetlands throughout the season (base flow ideal)</p> <p>Cool flowing conditions discourage exotic fish</p> <p>Seasonal flow increase to prevent vegetation encroachment of open water</p> <p>Sustain flow between wetlands to allow connectivity with stream reaches for colonisation by climbing galaxias</p> <p>Access to shallows for spawning and recruitment</p>
	Fresh	<p>Allow movement between pools</p> <p>Maintain water quality</p> <p>Variable flows discourage exotic fish</p>	<p>Flows to provide access to off-channel habitat for adult conditioning, spawning sites and larval habitat</p> <p>Variable flows discourage exotic fish</p>	<p>Flows to provide access to off-channel habitat for larger species (e.g. Murray cod, golden perch) for adult conditioning, spawning sites and larval habitat in lowland / floodplain reaches</p> <p>Variable flows discourage exotic fish</p>	<p>Promote spawning success (raises water levels to allow access to emergent vegetation (e.g. common galaxias spawning lower stream reaches), appropriate water quality, permanence and access where species congregate)</p> <p>Flow to allow upstream and downstream migration</p> <p>Variable flows discourage exotic fish</p>	<p>Seasonal flow increase to prevent vegetation encroachment of open water</p> <p>Allow movement between wetlands</p> <p>Sustained flow between wetlands to allow connectivity with stream reaches for colonisation by climbing galaxias</p> <p>Variable flows discourage exotic fish</p>

Flow season	Flow component	Ecological process supported by environmental water requirement				
		Freshwater obligate (stream specialist)	Freshwater obligate (wetland specialist)	Freshwater obligate (generalist)	Diadromous/migratory	Fleurieu wetland
Transitional Flow Season 2 (T2) (cont.)	Bankfull / over-bank	Maintain shallows (larval habitat) for spawning and recruitment	Flows to provide access to off-channel habitat for larger species (e.g. Murray cod, golden perch) for adult conditioning, spawning sites and larval habitat	Flows to provide access to off-channel habitat for larger species (e.g. Murray cod, golden perch) for adult conditioning, spawning sites and larval habitat in lowland/ floodplain reaches		
Any season	Bankfull / over-bank	Maintain deep pool structure (scour sediment, prevent vegetation encroachment) Channel forming flows to maintain habitat diversity Discourage exotic fish (flushing)	Channel forming flows to maintain wide range of habitat diversity (regional-scale mosaic), including physical habitat and vegetation Maintain deep pool structure (scour sediment, prevent vegetation encroachment) Discourage exotic fish (flushing)	Maintain deep pool structure (scour sediment, prevent vegetation encroachment) Channel forming flows to maintain habitat diversity Discourage exotic fish (flushing)	Maintain deep pool structure (scour sediment, prevent vegetation encroachment) Scour in-channel cease-to-flow points to improve connectivity Channel forming flows to maintain habitat diversity Discourage exotic fish (flushing)	

Environmental water requirements for functional groups of aquatic macroinvertebrates in the Eastern Mount Lofty Ranges

Flow season	Flow component	Ecological process supported by environmental water requirement				
		Flowing water, cascade	Flowing water, riffle	Still water, persistent pools and ponds	Still water, lowland streams	Still water, temporary pools
Low Flow Season	Zero flow					Maintain habitat quality (determines conditions for temporary water specialists)
	Low flow	Maintain persistent aquatic habitat conditions	Maintain persistent aquatic habitat conditions	Maintain persistent aquatic habitat conditions (pool habitat)	Maintain persistent aquatic habitat conditions (pool habitat)	Maintain persistent aquatic habitat conditions (pool habitat)
	Fresh	Maintain habitat quality (clean surface habitats)	Maintain habitat quality (clean surface habitats)	Refill pools, maintain water quality	Maintain habitat quality (flush pools – water quality)	Maintain habitat quality (flush pools – water quality)
Transitional Flow Season 1 (T1)	Zero flow					Maintain habitat quality (determines conditions for temporary water specialists)
	Low flow	Maintain persistent aquatic habitat conditions Allow movement to recolonise vacant habitats	Maintain persistent aquatic habitat conditions Allow movement to recolonise vacant habitats	Maintain persistent aquatic habitat conditions (pool habitat) Allow movement to recolonise vacant habitats	Maintain persistent aquatic habitat conditions (pool habitat) Allow movement to recolonise vacant habitats	Maintain persistent aquatic habitat conditions (pool habitat) Allow movement to recolonise vacant habitats
	Fresh			Maintain habitat quality (flush pools – water quality)	Maintain habitat quality (flush pools – water quality)	Maintain habitat quality (flush pools – water quality)
High Flow Season	Zero flow					Maintain habitat quality (determines conditions for temporary water specialists)

Flow season	Flow component	Ecological process supported by environmental water requirement				
		Flowing water, cascade	Flowing water, riffle	Still water, persistent pools and ponds	Still water, lowland streams	Still water, temporary pools
High Flow Season (cont.)	Low flow	Maintain persistent aquatic habitat conditions Allow movement to recolonise vacant habitats	Maintain persistent aquatic habitat conditions Allow movement to recolonise vacant habitats	Maintain persistent aquatic habitat conditions (pool habitat) Allow movement to recolonise vacant habitats	Maintain persistent aquatic habitat conditions (pool habitat) Allow movement to recolonise vacant habitats	Maintain persistent aquatic habitat conditions (pool habitat) Allow movement to recolonise vacant habitats
	Fresh	Maintain habitat quality (overturn cobbles and clean riffles)	Maintain habitat quality (overturn cobbles and clean riffles) Entrain organic material from banks	Entrain organic material from banks	Entrain organic material from banks	
Transitional Flow Season 2 (T2)	Zero flow					Maintain habitat quality (determines conditions for temporary water specialists)
	Low flow	Maintain persistent aquatic habitat conditions Allow movement to recolonise vacant habitats	Maintain persistent aquatic habitat conditions Allow movement to recolonise vacant habitats	Maintain persistent aquatic habitat conditions (pool habitat) Allow movement to recolonise vacant habitats	Maintain persistent aquatic habitat conditions (pool habitat) Allow movement to recolonise vacant habitats	Maintain persistent aquatic habitat conditions (pool habitat) Allow movement to recolonise vacant habitats
	Fresh	Maintain habitat quality (overturn cobbles and clean riffles)	Maintain habitat quality (overturn cobbles and clean riffles)			
Any season	Bankfull	Maintain channel morphology – habitat resetting	Maintain channel morphology – habitat resetting Entrain organic material from banks	Maintain channel morphology – habitat resetting Maintain pool habitat – scour sediments Entrain organic material from banks	Maintain channel morphology – habitat resetting Maintain pool habitat – scour sediments Entrain organic material from banks	Maintain channel morphology – habitat resetting Maintain pool habitat – scour sediments

Flow season	Flow component	Ecological process supported by environmental water requirement				
		Flowing water, cascade	Flowing water, riffle	Still water, persistent pools and ponds	Still water, lowland streams	Still water, temporary pools
Any season	Overbank					Maintain persistent aquatic habitat conditions (pool habitat for still water floodplain wetland species)

Environmental water requirements for functional groups of water-dependent vegetation in the Eastern Mount Lofty Ranges

The flow component associated with a particular ecological process for a vegetation functional group can vary depending on which habitat the plant is found in. For example, water for germination of river red gums on a floodplain would need to be an overbank flow, while the same process on an in-stream bench would require a fresh. The tables below refer broadly to habitats as aquatic (wetted at cease-to-flow to low flow in a season); in-stream (from edge of pools to top of bank, including riffles, runs, benches, bars and stream bank); riparian (top of bank); and floodplain.

The particular water requirements between species in a group are variable in preferred timing, depth, duration and frequency of wetting. Maintaining a naturally variable water regime will help promote a diversity of species over time and space, including at different heights from the stream bed up to the floodplain. The tables below provide the environmental water requirements for plants based on the most common seasonal patterns for plant groups in the Mount Lofty Ranges, although some species may germinate and reproduce at different times or opportunistically when the appropriate flow regime occurs.

Part 1 – Tda = terrestrial damp; ATI = amphibious fluctuation tolerator, low growing; ATe = amphibious fluctuation tolerator, emergent; ATw = amphibious fluctuation tolerator, woody

Flow season	Flow component	Ecological process supported by environmental water requirement			
		Tda	ATI	ATe	ATw
Low Flow Season	Zero flow		Reproduction – needs to be exposed – gradual seasonal decline in water level (in-stream)		
	Low flow		Establishment and growth (damp soil to shallow water – in-stream) Reproduction – gradual seasonal decline in water level (in-stream)	Establishment and growth (damp soil to shallow water – in-stream)	Establishment and growth (damp soil to shallow water – in-stream)
	Fresh	Establishment (damp soil – in-stream and riparian) Preferred time for dispersal of newly produced propagules late in season	Establishment and growth (damp soil to shallow water – in-stream) Preferred time for dispersal of newly produced propagules late in season	Establishment and growth (damp soil to shallow water – in-stream) Preferred time for dispersal of newly produced propagules late in season	Establishment and growth (damp soil to shallow water – in-stream) Preferred time for dispersal of newly produced propagules late in season

Flow season	Flow component	Ecological process supported by environmental water requirement			
		Tda	ATI	ATe	ATw
Low Flow Season (cont.)	Bankfull/ overbank	Establishment (dampen soil – riparian and floodplain)	Establishment and growth (dampen soil – riparian and floodplain)	Establishment and growth (dampen soil – riparian and floodplain)	Establishment and growth (dampen soil for pairs of years – riparian and floodplain)
Transitional Flow Season 1 (T1)	Zero flow				
	Low flow		Growth (damp soil to shallow water – in-stream)	Growth (damp soil to shallow water – aquatic and low in-stream)	Growth (damp soil to shallow water – aquatic and low in-stream)
	Fresh		Growth (damp soil to shallow water – in-stream)	Growth (damp soil to shallow water – in-stream)	Growth (damp soil to shallow water – in-stream)
	Bankfull/ overbank		Growth (damp soil – riparian and floodplain)	Growth (damp soil to shallow water – riparian and floodplain)	Growth (damp soil to shallow water – riparian and floodplain)
High Flow Season	Zero flow				
	Low flow		Germination, establishment and growth (saturated soil to shallow water – aquatic and in-stream)	Germination, establishment and growth (saturated soil to shallow water – aquatic and in-stream)	Germination, establishment and growth (saturated soil to shallow water – aquatic and in-stream)

Flow season	Flow component	Ecological process supported by environmental water requirement			
		Tda	ATI	ATe	ATw
High Flow Season (cont.)	Fresh	Germination, establishment and growth (damp soil – in-stream and riparian) Promote community diversity over time by maintaining diversity of habitats (e.g. scour pools, shape in-channel features)	Germination, establishment and growth (saturated soil to shallow water – in-stream and riparian) Promote community diversity over time by removal of competitive dominants and terrestrial competitors through high flow disturbance Promote community diversity over time by maintaining diversity of habitats (e.g. scour pools, shape in-channel features)	Germination, establishment and growth (saturated soil to shallow water – in-stream and riparian) Regulates distribution of shorter species by inundating photosynthetic parts that need to remain emergent Promote community diversity over time by removal of competitive dominants and terrestrial competitors through high flow disturbance Promote community diversity over time by maintaining diversity of habitats (e.g. scour pools, shape in-channel features)	Germination, establishment and growth (saturated soil to shallow water – in-stream and riparian) Promote community diversity over time by removal of competitive dominants and terrestrial competitors through high flow disturbance Promote community diversity over time by maintaining diversity of habitats (e.g. scour pools, shape in-channel features)
	Bankfull/ overbank	Germination, establishment and growth (damp soil – riparian and floodplain)	Germination, establishment and growth (saturated soil to shallow water – riparian and floodplain) Reproduction – exposed on recession of overbank flows	Germination, establishment and growth (saturated soil to shallow water – riparian and floodplain)	Germination, establishment and growth (saturated soil to shallow water – riparian and floodplain)
Transitional Flow Season 2 (T2)	Zero flow		Reproduction – needs to be exposed – gradual seasonal decline in water level (aquatic and in-stream)		

Flow season	Flow component	Ecological process supported by environmental water requirement			
		Tda	ATI	ATe	ATw
Transitional Flow Season 2 (T2) (cont.)	Low flow		Germination, establishment and growth (saturated soil to shallow water – aquatic and in-stream) Reproduction – needs to be exposed – gradual seasonal decline in water level (aquatic and in-stream)	Germination, establishment and growth (saturated soil to shallow water – aquatic and in-stream)	Germination, establishment and growth (saturated soil to shallow water – aquatic and in-stream)
	Fresh	Germination, establishment and growth (damp soil – in-stream and riparian)	Germination, establishment and growth (saturated soil to shallow water – in-stream and riparian) Reproduction – needs to be exposed – gradual seasonal decline in water level (aquatic and in-stream)	Germination, establishment and growth (saturated soil to shallow water – in-stream and riparian)	Germination, establishment and growth (saturated soil to shallow water – in-stream and riparian)
	Bankfull/overbank	Germination, establishment and growth (damp soil – riparian and floodplain)	Germination, establishment and growth (saturated soil to shallow water – riparian and floodplain) Reproduction – exposed on recession of overbank flows	Germination, establishment and growth (saturated soil to shallow water – riparian and floodplain)	Germination, establishment and growth (saturated soil to shallow water – riparian and floodplain)
All seasons	All	Promote community diversity over time by retaining flow variability to provide a variety of depth/duration/frequency over time and space to meet requirements of different species (within and between functional groups)			
	Low flow	Prevent terrestrial invasion of aquatic habitat (where appropriate)			
Any time	Fresh	Dispersal of propagules			
	Bankfull/overbank	Dispersal of propagules Promote community diversity over time by maintaining diversity of habitats (e.g. shape in-channel and floodplain features) and by removing competitive dominants and terrestrial (dry) competitors through high flow disturbance			

Part 2 – ARp = amphibious fluctuation responder, plastic; ARf = amphibious fluctuation responder, floating; Sr = submerged r-selected; Se = submerged emergent; Sk = submerged k-selected

Flow season	Flow component	Ecological process supported by environmental water requirement				
		ARp	ARf	Sr	Se	Sk
Low Flow Season	Zero flow		Maintain persistent aquatic conditions through combination of low flows, zero flows and channel morphology Commonly reproduce on gradually declining seasonal water level (aquatic and in-stream)	Maintain persistent aquatic conditions through combination of low flows, zero flows and channel morphology Drying stimulates germination for some species Commonly reproduce on gradually declining seasonal water level (aquatic and in-stream)	Maintain persistent saturated or aquatic conditions through combination of low flows, zero flows and channel morphology	Maintain persistent aquatic conditions through combination of low flows, zero flows and channel morphology Commonly reproduce on gradually declining seasonal water level (aquatic and in-stream)
	Low flow	Establishment and growth (damp soil to shallow water – in-stream)	Establishment and growth (saturated soil to shallow water – aquatic) Commonly reproduce on gradually declining seasonal water level (aquatic)	Establishment and growth (surface water – aquatic) Drying by seasonal decline in water level stimulates germination in some species Commonly reproduce on gradually declining seasonal water level (surface water – aquatic)	Establishment and growth (saturated soil to shallow water – aquatic)	Establishment and growth (surface water – aquatic) Commonly reproduce on gradually declining seasonal water level (surface water – aquatic)

Flow season	Flow component	Ecological process supported by environmental water requirement				
		ARp	ARf	Sr	Se	Sk
Low Flow Season (cont.)	Fresh	Establishment and growth (damp soil to shallow water – in-stream) Preferred time for dispersal of newly produced propagules late in season	Maintain water in aquatic habitats Preferred time for dispersal of newly produced propagules late in season Maintain water quality (aquatic habitats)	Maintain water in aquatic habitats Preferred time for dispersal of newly produced propagules late in season Maintain water quality (aquatic habitats)	Maintain water in aquatic habitats Preferred time for dispersal of newly produced propagules late in season Maintain water quality (aquatic habitats)	Maintain water in aquatic habitats Preferred time for dispersal of newly produced propagules late in season Maintain water quality (aquatic habitats)
	Bankfull/overbank	Establishment and growth (dampen soil – floodplain wetlands)	Establishment and growth (saturated soil to shallow water – floodplain wetlands)	Establishment and growth (surface water – floodplain wetlands)	Establishment and growth (saturated soil to shallow water – floodplain wetlands)	Establishment and growth (surface water – permanent floodplain wetlands)
Transitional Flow Season 1 (T1)	Zero flow		Maintenance of persistent aquatic conditions through combination of low and zero flows		Maintenance of persistent saturated or aquatic conditions through combination of low flows, zero flows and channel morphology	Maintenance of persistent saturated or aquatic conditions through combination of low flows, zero flows and channel morphology
	Low flow	Growth (damp soil to shallow water – aquatic and low in-stream)	Growth (saturated soil to shallow water – aquatic)		Growth (saturated soil to shallow water – aquatic)	Growth (surface water – aquatic)
	Fresh	Growth (damp soil to shallow water – in-stream)				
	Bankfull/overbank	Growth (damp soil to shallow water – floodplain wetlands)	Growth (saturated soil to shallow water – floodplain wetlands)		Growth (saturated soil to shallow water – floodplain wetlands)	Growth (surface water – permanent floodplain wetlands)

Flow season	Flow component	Ecological process supported by environmental water requirement				
		ARp	ARf	Sr	Se	Sk
High Flow Season	Zero flow		Maintenance of persistent aquatic conditions through combination of low flows, zero flows and channel morphology	Maintenance of persistent aquatic conditions through combination of low flows, zero flows and channel morphology	Maintenance of persistent saturated or aquatic conditions through combination of low flows, zero flows and channel morphology	Maintenance of persistent aquatic conditions through combination of low flows, zero flows and channel morphology
	Low flow	Germination, establishment and growth (saturated soil to shallow water – aquatic and in-stream)	Germination, establishment and growth (saturated soil to shallow water – aquatic)	Germination, establishment and growth (surface water – aquatic)	Germination, establishment and growth (saturated soil to shallow water – aquatic)	Germination, establishment and growth (surface water – aquatic)
	Fresh	Germination, establishment and growth (saturated soil to shallow water – in-stream) Promote community diversity over time by removal of competitive dominants and terrestrial competitors through high flow disturbance Promote community diversity over time by maintaining diversity of habitats (scour pools, create undercut banks, deposit bars and benches, etc.)	Promote community diversity over time by removal of competitive dominants and terrestrial competitors through high flow disturbance Promote community diversity over time by maintaining diversity of habitats (scour pools, create undercut banks, deposit bars and benches, etc.)	Germination, establishment and growth (surface water – in-stream habitats that stay inundated for at least 4 months) Promote community diversity over time by removal of competitive dominants and terrestrial competitors through high flow disturbance Promote community diversity over time by maintaining diversity of habitats (scour pools, create undercut banks, deposit bars and benches, etc.)	Promote community diversity over time by removal of competitive dominants and terrestrial competitors through high flow disturbance Promote community diversity over time by maintaining diversity of habitats (scour pools, create undercut banks, deposit bars and benches, etc.)	Promote community diversity over time by removal of competitive dominants and terrestrial competitors through high flow disturbance Promote community diversity over time by maintaining diversity of habitats (scour pools, create undercut banks, deposit bars and benches, etc.)

Flow season	Flow component	Ecological process supported by environmental water requirement				
		ARp	ARf	Sr	Se	Sk
High Flow Season (cont.)	Bankfull/ overbank	Germination, establishment and growth (saturated soil to shallow water – floodplain wetlands)	Germination, establishment and growth (saturated soil to shallow water – floodplain wetlands)	Germination, establishment and growth (surface water – floodplain wetlands)	Germination, establishment and growth (saturated soil to shallow water – floodplain wetlands)	Germination, establishment and growth (surface water – permanent floodplain wetlands)
Transitional Flow Season 2 (T2)	Zero flow		Maintenance of persistent aquatic conditions through combination of low flows, zero flows and channel morphology Commonly reproduce on gradually declining seasonal water level (aquatic)	Maintenance of persistent aquatic conditions through combination of low flows, zero flows and channel morphology Commonly reproduce on gradually declining seasonal water level (aquatic)	Maintenance of persistent saturated or aquatic conditions through combination of low flows, zero flows and channel morphology	Maintenance of persistent aquatic conditions through combination of low flows, zero flows and channel morphology Commonly reproduce on gradually declining seasonal water level (aquatic)
	Low flow	Germination, establishment and growth (saturated soil to shallow water – aquatic and in-stream) Commonly reproduce on gradually declining seasonal water level (aquatic and in-stream)	Germination, establishment and growth (saturated soil to shallow water – aquatic) Commonly reproduce on gradually declining seasonal water level (aquatic)	Germination, establishment and growth (surface water – aquatic) Drying by seasonal decline in water level stimulates germination in some species Commonly reproduce on gradually declining seasonal water level (aquatic)	Germination, establishment and growth (saturated soil to shallow water – aquatic)	Germination, establishment and growth (surface water – aquatic) Commonly reproduce on gradually declining seasonal water level (aquatic)

Flow season	Flow component	Ecological process supported by environmental water requirement				
		ARp	ARf	Sr	Se	Sk
Transitional Flow Season 2 (T2) (cont.)	Fresh	Germination, establishment and growth (saturated soil to shallow water – in-stream) Commonly reproduce on gradually declining seasonal water level (in-stream)		Germination, establishment and growth (surface water – in-stream habitats that stay inundated for at least 4 months)		
	Bankfull/overbank	Germination, establishment and growth (saturated soil to shallow water – floodplain wetlands) Commonly reproduce on gradually declining seasonal water level (flood recession in floodplain wetlands)	Germination, establishment and growth (saturated soil to shallow water – floodplain wetlands) Commonly reproduce on gradually declining seasonal water level (flood recession in floodplain wetlands)	Germination, establishment and growth (surface water – floodplain wetlands) Commonly reproduce on gradually declining seasonal water level (flood recession in floodplain wetlands)	Germination, establishment and growth (saturated soil to shallow water – floodplain wetlands)	Germination, establishment and growth (surface water – permanent floodplain wetlands) Commonly reproduce on gradually declining seasonal water level (flood recession in floodplain wetlands)
All seasons	All	Promote community diversity over time by retaining flow variability to provide a variety of depth/duration/frequency over time and space to meet requirements of different species (within and between functional groups)				
	Low flow	Prevent terrestrial invasion of aquatic habitat (where appropriate)				
Any time	Fresh	Dispersal of propagules				
	Bankfull/overbank	Dispersal of propagules Promote community diversity over time by maintaining diversity of habitats (scour pools, create undercut banks, deposit bars and benches, etc.) Promote community diversity over time by removal of competitive dominants and terrestrial competitors through high flow disturbance				

APPENDIX C

ENVIRONMENTAL WATER REQUIREMENTS METRICS TABLE

Season & flow component	Environmental water requirements metric	Measurement unit	Reach type	Flow purpose	Priority group
Low Flow Season					
Low flows	Average daily LFS flow	ML/day	All	<ul style="list-style-type: none"> Correlated with macroinvertebrate health General measure of seasonal discharge – indicator of habitat persistence, recharge to underground water where relevant 	3
	80th percentile exceedance non-zero flow	ML/day	All	<ul style="list-style-type: none"> Maintenance of core aquatic habitat (refugia) Flows to prepare climbing galaxias (fish) breeding Promote flowering and seed set of some aquatic plant species 	1
Zero flows	Number of years with LFS zero flow spells	# years	All	<ul style="list-style-type: none"> Correlated with the viability of core aquatic habitat (refugia) Promote flowering and seed set of some aquatic plant species Discourage exotic fish species 	1
	Average number of LFS zero flow spells per year	events/ season	All	<ul style="list-style-type: none"> Can cause 'false start' breeding events for plants Determines habitat quality for temporary still water macroinvertebrate species 	2
	Average duration of LFS zero flow spells	days/spell	All	<ul style="list-style-type: none"> Correlated with the viability of core aquatic habitat (refugia) Promote flowering and seed set of some aquatic plant species Discourage exotic fish species 	1 ^A
Low flow freshes	Number of years with one or more LFS freshes	# years	All	<ul style="list-style-type: none"> Flush mountain galaxias (fish) spawning sites Maintain damp conditions on banks for plant establishment Transport plant propagules 	1

Season & flow component	Environmental water requirements metric	Measurement unit	Reach type	Flow purpose	Priority group
Low Flow Season (cont.)					
Low flow freshes (cont.)	Average number of LFS freshes per year	events/ season	All	<ul style="list-style-type: none"> • Maintenance of core aquatic habitat (refugia) • Flush mountain galaxias spawning sites • Allow localised fish movement • Transport plant propagules • Refresh pool water quality 	1
	Average total duration of LFS freshes per year	days/season	All	<ul style="list-style-type: none"> • Maintenance of core aquatic habitat (refugia) • Flush mountain galaxias spawning sites • Allow localised fish movement • Transport plant propagules 	2
Transitional Flow Season 1 (T1)					
Low flows	Average daily T1 flow	ML/day	All	<ul style="list-style-type: none"> • General measure of seasonal discharge – indicator of habitat persistence, recharge to underground water where relevant 	3
	80th percentile exceedance non-zero flow	ML/day	All	<ul style="list-style-type: none"> • Maintain core aquatic habitat (refugia) • Stimulate mountain galaxias breeding • Prepare climbing galaxias breeding • Open common galaxias migration to sea • Allow localised fish movement • Extend habitat to riffles for macroinvertebrates 	1
	Current month reaching median flow of natural T1 median (delay in onset)	# years	Upper pool-riffle only	<ul style="list-style-type: none"> • Delayed onset of T1 means longer low flow stress for refuges and shorter flow period • Important for fish survival • Ensure sufficient duration of habitat availability for plants 	1
Zero flows	Number of years with T1 zero flow spells	# years	All	<ul style="list-style-type: none"> • Correlated with the viability of core aquatic habitat (refugia) • Discourage exotic fish species 	1

Season & flow component	Environmental water requirements metric	Measurement unit	Reach type	Flow purpose	Priority group
Transitional Flow Season 1 (T1) (cont.)					
Zero flows (cont.)	Average number of T1 zero flow spells per year	events/ season	All	<ul style="list-style-type: none"> Determines habitat quality for temporary still water macroinvertebrate species 	2
	Average duration of T1 zero flow spells	days/spell	All	<ul style="list-style-type: none"> Correlated with the viability of core aquatic habitat (refugia) Discourage exotic fish species 	1 ^A
T1 freshes	Number of years with one or more T1 freshes	# years	All	<ul style="list-style-type: none"> Enhance movement of common galaxias to sea Transport plant propagules 	1
	Average number of T1 freshes per year	events/ season	All	<ul style="list-style-type: none"> Enhance movement of common galaxias to sea 	1
	Average total duration of T1 freshes per year	days/season	All	<ul style="list-style-type: none"> Maintain core aquatic habitat (refugia) Enhance movement of common galaxias to sea Transport plant propagules 	2
	Number of years with 2 or more T1 freshes	# years	n.a. for upper pool-riffle dry	<ul style="list-style-type: none"> Promote successful climbing galaxias breeding 	2
	Frequency of spells higher than LFS fresh level	events/ season	Lowland only (not ephemeral)	<ul style="list-style-type: none"> Localised fish movement 	2
High Flow Season					
Low flows	Average daily HFS flow	ML/day	All	<ul style="list-style-type: none"> Correlated with macroinvertebrate health General measure of seasonal discharge – indicator of habitat persistence, recharge to underground water where relevant 	3

Season & flow component	Environmental water requirements metric	Measurement unit	Reach type	Flow purpose	Priority group
High Flow Season (cont.)					
Low flows (cont.)	80th percentile exceedance non-zero flow	ML/day	All	<ul style="list-style-type: none"> • Maintenance of core aquatic habitat (refugia) • Localised movement of macroinvertebrate and fish species (recolonise vacant habitats) • Breeding and movement for diadromous fish • Regulate terrestrial and amphibious plant distribution • Extend habitat availability for plants (MPR), including amphibious (lowland & MPR) 	1
Zero flows	Number of years with HFS zero flow spells	# years	All	<ul style="list-style-type: none"> • Correlated with the viability of core aquatic habitat (refugia) • Discourage exotic fish species 	1
	Average number of HFS zero flow spells per year	events/season	All	<ul style="list-style-type: none"> • Determines habitat quality for temporary still water macroinvertebrate species 	2
	Average duration of HFS zero flow spells	days/spell	All	<ul style="list-style-type: none"> • Correlated with the viability of core aquatic habitat (refugia) • Discourage exotic fish species 	1 ^A
HFS freshes	Number of years with one or more HFS freshes	# years	All	<ul style="list-style-type: none"> • Promote fish spawning success • Promote large-scale fish movement • Trigger upstream fish migration • Transport plant propagules • Dampen bank soils for plant germination and establishment • Maintain habitat (overturn substrates and scour pools) • Regulate terrestrial/amphibious plant distribution • Entrain organic material from banks 	1

Season & flow component	Environmental water requirements metric	Measurement unit	Reach type	Flow purpose	Priority group
High Flow Season (cont.)					
HFS freshes (cont.)	Average number of HFS freshes per year	events/ season	All	<ul style="list-style-type: none"> • Discourage exotic fish (Gambusia) • Promote fish spawning success • Promote large-scale fish movement • Trigger upstream fish migration • Transport plant propagules • Dampen bank soils for plant germination and establishment • Habitat maintenance (overturn substrates and scour pools) • Regulate terrestrial/amphibious plant distribution • Entrain organic material from banks • Expand riffles for macroinvertebrates 	1
	Average total duration of HFS freshes per year	days/season	All	<ul style="list-style-type: none"> • Discourage exotic fish (Gambusia) • Promote fish spawning success • Promote large-scale fish movement • Trigger upstream fish migration • Transport plant propagules • Dampen bank soils for plant germination and establishment • Maintain habitat (overturn substrates and scour pools) • Regulate terrestrial/amphibious plant distribution • Entrain organic material from banks • Expand riffles for macroinvertebrates 	2
	Number of years with 1 or more spell greater than the annual 5th percentile exceedance flow in HFS	# years	Upper pool-riffle wet only	<ul style="list-style-type: none"> • Correlate with large-scale fish movement 	2
	Number of years with 2 or more freshes early in the season (Jul, Aug)	# years	All but upper pool-riffle and lowland ephemeral	<ul style="list-style-type: none"> • Stimulate successful climbing galaxias breeding 	2

Season & flow component	Environmental water requirements metric	Measurement unit	Reach type	Flow purpose	Priority group
Transitional Flow Season 2 (T2)					
Low flows	Average daily T2 flow	ML/day	All	<ul style="list-style-type: none"> General measure of seasonal discharge – indicator of habitat persistence, recharge to underground water where relevant 	3
	Median non-zero daily T2 flow	ML/day	All but upper pool-riffle dry	<ul style="list-style-type: none"> Promote resilience in fish populations leading into the subsequent LFS Access to spawning habitats for southern pygmy perch (fish) Prime gudgeon (fish) spawning 	2
	80th percentile exceedance non-zero flow	ML/day	All	<ul style="list-style-type: none"> Maintenance of core aquatic habitat (refugia) Localised movement of macroinvertebrate and fish species (recolonise vacant habitats) Breeding and movement for diadromous fish Promote plant reproduction for some species 	1
	Current month reaching median flow of natural T2 median (early onset)	# years	All	<ul style="list-style-type: none"> Early onset of Low Flow Season means longer low flow stress for refuges and shorter flow period Promote survival of fish Support gudgeon spawning Support reproduction of some amphibious plants 	1
Zero flows	Number of years with T2 zero flow spells	# years	All	<ul style="list-style-type: none"> Correlate with the viability of core aquatic habitat (refugia) Discourage exotic fish species Promote germination of some amphibious plants 	1
	Average number of T2 zero flow spells per year	events/ season	All	<ul style="list-style-type: none"> Determine habitat quality for temporary still water macroinvertebrate species 	2
	Average duration of T2 zero flow spells	days/spell	All	<ul style="list-style-type: none"> Correlate with viability of core aquatic habitat (refugia) Discourage exotic fish species Promote germination of some amphibious plants 	1 ^A

Season & flow component	Environmental water requirements metric	Measurement unit	Reach type	Flow purpose	Priority group
Transitional Flow Season 2 (T2) (cont.)					
T2 freshes	Number of years with one or more T2 freshes	# years	All	<ul style="list-style-type: none"> • Maintain core aquatic habitat (refugia) • Maintain habitat (overturn substrates, scour algae for macroinvertebrates) • Provide fish edge habitat (esp. southern pygmy perch) • Scour algae to provide macroinvertebrate habitat and food • Transport plant propagules • Promote establishment of in-stream vegetation 	1
	Average number of T2 freshes per year	events/ season	All	<ul style="list-style-type: none"> • Maintain core aquatic habitat (refugia) • Amount of flow related edge habitat for southern pygmy perch • Attractant flow for migratory fish 	1
	Average total duration of T2 freshes per year	days/season	All	<ul style="list-style-type: none"> • Maintain core aquatic habitat (refugia) • Maintain habitat (overturn substrates) • Amount of flow related edge habitat for southern pygmy perch • Transport plant propagules • Promote establishment of in-stream vegetation 	2
	Frequency of spells higher than LFS fresh level	events/ season	Lowland only (not ephemeral)	<ul style="list-style-type: none"> • Enhance localised fish movement (pool to pool) 	2
	Number of years with 1 or more spell greater than the annual 5th percentile exceedance flow	# years	Upper pool-riffle only	<ul style="list-style-type: none"> • Large-scale fish movement 	2
	Number of consecutive years with no T2 fresh	# years	Upper pool riffle dry only	<ul style="list-style-type: none"> • Maintain core aquatic habitat (refugia) 	1

Season & flow component	Environmental water requirements metric	Measurement unit	Reach type	Flow purpose	Priority group
Any time of year					
Bankfull	Number of years with 1 or more bankfull flows	# years	All	<ul style="list-style-type: none"> • Maintain floodplain vegetation (recruitment and survivorship – pairs of years) • Fill floodplain wetlands • Regulate distribution of terrestrial plant competitors • Regulate plant distribution • Maintain channel morphology 	2
	Average duration of bankfull flow spells	days	All	<ul style="list-style-type: none"> • Fill floodplain wetlands • Promote fish recruitment (access to flood-runners) • Correlate fish recruitment (dry upper pool-riffle) 	See note B
	Average total duration of bankfull flow per year	days/year	All	<ul style="list-style-type: none"> • Fill floodplain wetlands • Promote fish recruitment (access to flood-runners) • Correlate to fish recruitment (dry upper pool-riffle) 	See note B

Table notes for Appendix C

A If the number of years with zero flow spells in the relevant flow season is four or less (both current and natural conditions) then the priority group is 3 instead of 1.

B If value is less than 2 for current and 'natural', priority group is:

1 – Lowland

2 – all other zones

If value is greater than 2 for current or 'natural', priority group is:

3

APPENDIX D

ANGAS BREMER IRRIGATION REGION REVEGETATION BOOKLET

Angas - Bremer Irrigation Region

Revegetation Booklet

*Commissioned by
The Angas-Bremer Water Management Committee
August 2000*



Produced by Environmental Regeneration Australia

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HOW TO USE THIS GUIDE

Re-establishing vegetation requires a reasonable understanding of what the land is capable of supporting. In order to assess this and to give an indication of what may formerly have been present on the land throughout the Angas-Bremer Irrigation region, this guide has been put together.

Because of the range of vegetation associations and soil types it has been necessary to tackle this in a number of stages. This revegetation guide has divided the Angas-Bremer Irrigation area into five common soil types. A brief description of each of these is given in the main body of the text.

In each of the soil types a description of the site is given, a list of weeds and plants likely to be around on such a site and photos to help identify the site type.

If the site description matches the sort of revegetation project you wish to undertake, it is worthwhile checking the former vegetation list and even visiting some remnant vegetation areas or revegetation sites to provide a realistic insight into what you are trying to achieve.

The former vegetation lists are by no means exhaustive and merely try to pick out some indicator species that help show the differences between sites and include species likely to be useful in revegetation projects.

General revegetation information is gathered together at the front of the booklet because most of this information is common to any revegetation project in this area. This is probably the most important information because it really is dealing with the basic requirements of good revegetation planning.

Obviously, all sites are different and historical management practices have had impacts on all sites. A couple of the significant factors likely to make it difficult to re-establish vegetation are also dealt with in the front section of the booklet.

Good luck with your planting!

EASY STEPS TO REVEGETATION

WOODY WEED CONTROL

Woody weed control needs to be done as far in advance of revegetation as possible. For example, 2-5 years of follow up control may be required on species such as Bridal Creeper and Boxthorn, however this will become more difficult in among newly planted trees. Swamp areas will have significant ongoing weed control issues with a broad range of woody weeds including Olives, Caster Oil Plant etc.

FENCING

Fencing should be carried out well in advance of planting time. Under no circumstances should planting go ahead without fencing in place. All likely grazing animals need to be excluded from the revegetation area. If machine planting and weed control is likely, fencing will need to allow for access. For example,

- Wide end of rows to allow for machinery to turn around.
- Fencing far enough back from steep banks to allow for machinery access.
- Openable panels or drop fences if fences are too close to allow for turning.

OTHER GRAZING CONTROL

Grazing by pest and other species may need to be considered:

- RABBITS need to be controlled prior to planting – contact Animal and Plant Control Board
- Ideally, HARE numbers need to be low for successful revegetation.
- RED LEGGED EARTH MITE can be a significant problem but are usually only a nuisance. If huge numbers are present and spraying is an acceptable option this is possible but will need to extend into adjacent paddocks and be repeated regularly.
- KANGAROOS grazing can be a problem. Exclusion fencing or individual tree guards may be possible in some cases. Otherwise plant species selection and planting methods and layout may be adjusted to accommodate the extra grazing pressure. These measures will only be necessary if kangaroos occur in large numbers.

WEED CONTROL

Woody and perennial weeds will need to be dealt with in the year prior to planting as a minimum.

Some weeds, eg Couch, Kikuyu, Horehound etc. need to be controlled during active growth in the spring and early summer in the season prior to planting.

Annual weeds can be controlled with a 2-litre/ha glyphosate spray before planting. In wetter seasons with an early season break and in later sowing areas 2 weed control sprays will be necessary – one soon after initial germination and one in the fortnight before planting. (This strategy will need to be adjusted for individual sites, eg if erosion is a concern 2 sprays may be inadvisable).

It is very important to only use Glyphosate for weed control if direct seeding, unless your contractor advises otherwise. Particularly avoid residuals as these can affect germination in direct seeding.

TIMING

This will be dealt with under the individual soil types. As all the Angas Bremer Water Management Committee area is under 500mm rainfall, unirrigated planting will generally take place between May and August.

If possible, get advice from someone who has seen your site and has experience with tree planting in your area. Irrigated planting needs more planning but planting can be carried out into spring and summer.

SPECIES SELECTION

Species to be planted need to be determined well in advance of planting. The species mix under each soil type will assist in compiling a list. Sourcing seed from local areas is important. There will be sites that have been seriously altered eg increased salinity or waterlogging. These site changes will mean that the planting lists will also need to be changed. Again seek advice on any tricky sites.

SEED AND SEEDLINGS

A complete order for seed and seedlings required for the job needs to be organised by October the previous year at the latest. This allows for local seed collection and growing of tubestock.

If any harder to grow species are to be included in the tubestock order, an extra 12 months time may be required to supply because some of these plants need to germinate over winter. Similarly some plants only set seed biannually, or even less, so some species will be unavailable unless collectors have a couple of season's notice.

PLANTING

This is the simplest part of the job if all preparation has been done effectively. Organise plants to be on site well in advance of planting. Organise a demonstration of appropriate planting technique on site if possible.

If direct seeding, the direct seeding contractor should be contacted regularly to ensure they understand the status of the job and preparations. Ensure all preparations are complete and if possible be on site on the day of sowing.

POST PLANTING

Watch out for unexpected grazing and deal with it. Watch out for serious weed competition and discuss with the contractor if concerned. Relax about germination if it is direct seeded. It may take 6 – 10 weeks before you see anything and you will need to put your nose in the trench to see anything at all.

Tubestock will need similar vigilance. Weed competition is the greatest threat to survival so wet spring or summer conditions will probably mean follow up weed control around each plant will be necessary.

PLANTS FOR MODIFIED SITE CONDITIONS

Some sites will have experienced changes since clearing that will make it impossible to replace the former vegetation. The two commonest problems in this regard are salinity and waterlogging. These problems are often linked and due to the wide range of ways they affect a site it is impossible to give specific treatments for all cases. Below are some general statements on the way these problems impact on plants. Before investing time and effort in planting such sites get advice from experienced people who have seen your situation.

SALINITY

High salinity levels significantly impact on plants. Re-establishing deep-rooted perennial vegetation may be very difficult on seriously saline sites.

Also, salinity may not be the only issue on some sites that are very salt affected. In order to establish what may be possible; identify what is currently surviving on site.

- 1) Bare soil, salt crusting on surface, no vegetation cover.
Action: Fence well beyond bared area. Trees will not grow in these conditions. Mounding of bared site and allowing two winters prior to planting may establish some highly tolerant species. Focus efforts on areas that have grass cover around the perimeter of the bared areas. Also, revegetation anywhere in the catchment zone for these areas will be beneficial.
- 2) Samphire, occasional mounds with taller vegetation or grasses.
Samphire is your best bet on these sites. Exclude stock and plant perimeter areas with highly tolerant species.
- 3) Saltwater Barley Grass, Saltwater Couch etc
Exclude stock, mound if possible, plant with salt tolerant species.

It is important to note that most of the species native to this area have reasonable salt tolerance due to their exposure to saline soils and the historical coastal influence. However, changes in water tables and other changes mean some areas are too salty even for these species. Incredibly salt hardy plants such as the samphires, *Melaleuca halmaturorum* and *Melaleuca brevifolia* mean most areas can support some sort of plant life.

Areas that are currently supporting salt tolerant grasses will grow trees and as the range of plants increases so will the possible revegetation species. It is important to realise that part of the cost of salt tolerance is growth rate. *Melaleuca halmaturorum* is one of the most salt tolerant trees around but it will not grow fast and it will not grow large. In seriously salty situations it will grow even slower!

WATER USE

Ironically in low rainfall areas such as the Angas Bremer irrigation area there are occasions where high water use plants are desirable. Such plants are used to reduce recharge, planting in wet areas or to utilise wastewater.

1. Reducing recharge

Local vegetation is probably the most effective plant association at surviving on local rainfall and yet being able to reduce recharge flow through the root zone. It manages this by relying on a wide species range all competing for water and each responding to different situations. For instance, native grasses will grow when there is plenty of water and the big mallees have deep roots that grab any moisture that gets past all the other plants' root zones.

2. Wet Areas

If planting into a recognised wet spot or an area with a water table that the plants can access it may be necessary to incorporate some higher water using species. If local species are appropriate for this use the former swamp vegetation list found in the 'Black Cracking Soils' section. However, if some sort of woodlot plantation is considered, seek advice. Information that will assist in these decisions should still be gathered. Soil type, existing vegetation, water table depths (summer and winter) salinity level, irrigation potential during establishment will all be helpful.

3 Waste Water Use

Again this is a specialised area and needs to be tailor made to your project. It is however safe to generalise by saying that usually bigger plants use more water than smaller plants and faster growers use more water than slower growers do! Water quality and volume available as well as the specific pollutant information will also be necessary for planning. Do not overlook local species as we do have some species that do very well in irrigated situations.

REVEGETATING HEAVY RED SOILS

1. SITE TYPE. Heavy Red Soils

2. SITE DESCRIPTION {including indicator species likely to be on site}

These sites are characteristically flat to gently sloping areas with deep clay to sandy clay soil overlying calcareous subsoil. Currently they are rapidly being planted to vines. They are obviously very fertile sites capable of supporting large Peppermint Box trees and associated vegetation. Few areas of this vegetation are left in the district because of the ability of these sites to produce good cereal crops, etc and a long history of clearing.

Characteristic weed species on these sites are:

Soursob
Salvation jane

Native species that persist on these sites:

Eucalyptus odorata	Peppermint Box
Acacia microcarpa	Manna Wattle
Acacia brachybotra	Grey Wattle

3. FORMER VEGETATION TYPE ON THESE SITES

Acacia acainacea	Round Leaved Wattle
Acacia brachybotra	Grey Mulga
Acacia microcarpa	Manna Wattle
Acacia paradoxa	Kangaroo Thorn
Acacia pycnantha	Golden Wattle
Carpobrotus sp	Pigface
Callitris preissii	Native Pine
Danthonia sp	Wallaby Grasses
Dianella revoluta	Flax Lillie
Dodonaea viscosa	Hop Bush
Einadia nutans	Creeping Salt Bush
Enchylaena tomentosa	Ruby Salt Bush
Eucalyptus odorata	Peppermint Box
Eutaxia microphylla	Mallee Bush Pea
Maireana sp	Bluebush
Melaleuca lanceolata	Dryland Tea Tree
Myoporum platycarpum	Sugarwood
Pittosporum phylliraeoides	Native Apricot
Vittadinia sp	

4. CONSIDERATIONS FOR REVEGETATION

These red soils have been the prime agricultural production areas in the region. Consequently they have nearly always been cultivated extensively causing significant changes in fertility and soil structure. Where cropping has been carried out in recent seasons there is also the complication of herbicide effects. As much information on the chemical history as possible should be gathered to help in planning. If regular pre-emergent herbicide applications have been made it is probably going to impact on direct seeding results.

Excellent results have been achieved on these sites, particularly in wetter years, but weed competition is always a major issue. A strategy for controlling weeds along seeding rows and immediately around seedlings to ease the competition if necessary should be considered in the planning stages.



Plate 1: Langhorne Ck Cemetery, showing former heavy red soil vegetation type



Plate 2: Successful revegetation site on land adjoining the Langhorne Creek Cemetery, planted in 1991

5. RE-ESTABLISHING NATIVE VEGETATION ON THESE SITES

Species selection

A good number of the species listed lend themselves to revegetation projects because they grow well as either seedlings or direct seeding. Seed collection from mallee vegetation is usually easy because all except the tallest mallees are usually reachable and the mallee vegetation tends to seed prolifically in their efforts to reproduce. So collect a lot of seed and do so opportunistically because not all species will seed each year.

Wattles need to be a strong component in these revegetation areas because they will tend to alter the site in favour of tree cover again. Their rapid growth matches it with many weedy competitors and their nitrogen fixing roots redistribute the nutrients in the soil to a deeper level favouring deeper-rooted perennial vegetation.

Seeding rates

A typical direct seeding mix would consist of:

<u>Species</u>	<u>Percentage of mix</u>
Peppermint box and other mallees	25
Melaleuca species	15
Wattles (acacias), & others	40
Native pine	10
Dodonea, Enchylaena, etc	5
Grasses or other	5

Seeding rates overall need to be fairly high due to the potential difficulty of seasonal conditions. Recommended rate would be at least 500g per km for single row planting machines or approximately 2.5kg per ha at the minimum for other machines.

Timing

Direct seeding can be carried out as late as mid August. Earlier sowing is often desirable but if a wet spring is experienced extra weed control will be required.

Tubestock will need to be planted by August unless watering is intended.

Site preparation

Ideally couch can be controlled in the seasons prior to revegetation. Again, stock exclusion for a season or more is desirable to allow things to stabilise after a long history of cultivation. Glyphosate at 2 litres a hectare is suggested as a knockdown spray to control annual weeds – once as soon as possible after the season breaks.

Sowing techniques

Direct seeding is generally effective on these sites.

Tubestock enable a broader range of species to be established but will be more expensive. Seedling plantings are often used in narrow strip plantings or small areas or where irrigation is being used. Often tubestock are used to broaden out species range and fill in gaps in the seasons following a large direct seeding job.

Planting of tubestock can be carried out during the winter months as long as effective weed control has been done. Early winter plantings will probably require follow up weed control as will irrigated plantings.

Barerooted plants and seedlings are options for fodder plantings.

Post sowing management

Red-legged earthmite may need controlling in the weeks after sowing if direct seeding.

Weed competition will be an issue. If spraying is necessary in the first spring shielded spraying will be the only option. After the seedlings have survived a summer overspray options are available but specific advice on chemical, rate, timing and species to be oversprayed should be sought.

Long term site management strategies

Subsequent plantings and spot spraying of problem weeds should be carried out as seasonal conditions dictate.

6. OTHER MANAGEMENT OPTIONS

Agroforestry

There are really no options for commercial forestry on these sites on natural rainfall. Irrigated woodlots may be a good option where wastewater etc is available. Also high water tables may offer adequate water supply within the reach of plant roots in a few locations. In both these cases high water use, rapid growth species are required.

Private use woodlots are obviously a potential use of such sites. In other states (and Kangaroo Island) mallee areas are used to grow Eucalyptus oil successfully.

Fodder shrub

These heavier soils will suit saltbush growing very well. However, current returns from other crops probably make this potential unattractive unless salinity is an issue.

REVEGETATING RED SANDY SOILS

1. SITE TYPE. Red Sandy Soils

2. SITE DESCRIPTION {including indicator species likely to be on site}

These sites are closely associated with the heavier red soil sites. There are many species that grow on both sites and the main differences are the needs of the plants growing on these sites to be able to cope with drier conditions. Often lighter sandy ridges cross a plain of heavier soil meaning that revegetation sites often cover both of these soil types.

Characteristic weed species on these sites are:

Veldt Grass is the main weed species present on nearly all of these sites

Native species that persist on these sites:

Callitris preissii	Native Pine
Allocasuarina verticillata	Drooping sheoak
Mallee Eucalypts	

3. FORMER VEGETATION TYPE ON THESE SITES

Acacia calamifolia	Sandhill Wattle
Acacia pycnantha	Golden Wattle
Acacia paradoxa	Kangaroo Thorn
Acacia brachybotra	Grey Mulga
Acacia acinacea	Round Leaf Wattle
Allocasuarina verticillata	Drooping Sheoak
Bursaria spinosa	Christmas Bush
Callitris preissii	Native Pine
Dianella revoluta	Flax Lillie
Eucalyptus fasciculosa	Pink Gum
Eucalyptus spp.	Mallee species
Lomandra spp	Iron Grass, Tussocks
Melaleuca uncinata	Broom Bush

4. CONSIDERATIONS FOR REVEGETATION

These sandy sites are generally located adjacent to heavier soil types, and in planning revegetation it is necessary to allow for these variations.

Throughout the district there is evidence of historical movement of this sand in the deposits that have been left along roadsides and in other less disturbed areas. Roadsides and fencelines are often targeted for revegetation areas, so it is likely many trees will be planted into these windblown deposits. It is worth remembering that if they blew around once they could easily be eroded again.

All sandy sites need to be treated with care during any change of land use. Potential for erosion needs to be assessed before on site work commences, and steps to reduce the risk taken. These would include using cover crops, delaying planting to allow site consolidation, spraying narrow bands rather than blanket areas, mulching or spot spraying and planting tubestock.

These sites vary greatly in what grows on them so locate the nearest remnant to your planting area to give some clues. Also seek advice from locals who may remember some of the former Sheoak or Native Pine patches that are common on these sandy sites.



Plate 3: Native vegetation on red sandy soils along Sheoak Road



Plate 4: Successful revegetation on roadside

5. RE-ESTABLISHING NATIVE VEGETATION ON THESE SITES

Species selection

On sandy areas it is important to get plants established rapidly to reduce the risk of erosion. The initial planting needs to focus on pioneering species with the capability of establishing strongly. If seed is available other plants can be utilised but generally it is better to look at broadening the species range in later seasons once the site is more stable.

Seeding rates

A typical direct seeding mix would consist of:

<u>Species</u>	<u>Percentage of mix</u>
Eucalypts	15
Melaleuca species	10
Wattles (acacias), & others	35
Native pine	15
Allocasuarina (sheoak)	15
Grasses or other (eg. enchylaena)	10

Seeding rates overall need to be fairly high due to the potential difficulty of seasonal conditions. Recommended rate would be at least 500g per km for single row planting machines or approximately 2.5kg per ha at the minimum for other machines.

Seedling planting

Seedling planting is very easy on these soils. Species mixes can closely resemble those recommended for direct seeding although seedlings allow for trickier to grow plants to be included. Propagating cuttings can also be used to grow plants not germinated by seed.

Weed competition needs to be controlled for about 1 metre from each plant.

Planting can commence at the same time as seeding or even up to a couple of months earlier if follow up weed control can be carried out if necessary.

Timing

Seeding times on these sites is determined more by site preparation than some other low rainfall sites. Late July to early August is reasonable because they allow for later weed control in the season of sowing. Cover crop establishment is also necessary on some sites and this also may require an early August sowing time.

Site preparation

Veldt grass is usually the major weed problem on these sites. Weed control should commence as soon as practical after there is enough cover on the site to hold it together. It is also a good idea to prevent any soil disturbance, including grazing, for at least the twelve months prior to sowing. Other annual weeds should be controlled in the same operation. Perennial weeds such as Bridal Creeper will need to be controlled in the year prior to planting and followed up as required.

It is occasionally necessary to secure a site with a cover crop to prevent blowing and this is another operation that will impact on both timing and planting layout so needs to be considered in the early planning stages.

Sowing techniques

Direct seeding is quite effective on red sandy sites but is variable depending on seasonal conditions.

Tubestock enable a broader range of species to be established but will be more expensive. Often tubestock are used to broaden out species range and fill in gaps in the seasons following a large direct seeding job.

Barerooted and seedlings are options for fodder plantings.

Post sowing management

Red-legged earthmite may need controlling in the week's post sowing if direct seeding.

Weed competition will be an issue. If spraying is necessary in the first spring shielded spraying will be the only option. After the seedlings have survived a summer overspray options are available but specific advice on chemical, rate, timing and species to be oversprayed should be sought.

Long term site management strategies

Subsequent plantings and spot spraying of problem weeds should be carried out as seasonal conditions dictate.

6. OTHER MANAGEMENT OPTIONS

Agroforestry

There are really no options for Forestry on these sites on natural rainfall.

Fodder shrub

Other

With irrigation a broad range of species can be grown on these sites. Horticultural possibilities with native flowers may be an option in these areas.

REVEGETATING BLACK CRACKING SOILS

1. SITE TYPE. Black Cracking Soils

2. SITE DESCRIPTION {including indicator species likely to be on site}

These are the former swamp sites along the watercourses and lakefront. There is a number of standing swamps still to be found in the area, particularly south of Langhorne Creek, along the lower stretch of the Angas and the flood out areas adjacent to these areas. The swamps are very different to any other landscape in the district and immediately identified by the huge redgum overstorey. Former locations of these sites can also be readily identified by the blackish coloured; deeply cracking soils that that become sloppy grey mud when wet. The original swamps also experienced regular inundation that may no longer occur due to changed drainage patterns.

Lakefront revegetation has had mixed results. Revegetation efforts are complicated by the serious changes these areas have suffered over the last 60-70 years. Total clearing, long term grazing, rising lake levels after the building of the barrages (and resulting groundwater changes) and increased salinity mean these are highly altered sites with a reduced range of appropriate species for revegetation. The highly exposed lakefront means only highly salt tolerant, coastal type species are likely to withstand the elements and weed competition is aggressive. Good results have been achieved only slightly inland from the lake's edge where weed competition is still a major issue.

Characteristic weed species on these sites are:

Boxthorn
Salvation jane
Olives
Castor oil plant
Fennell
Dock
Marshmallow
Briar rose
Nightshade
Myrsiphyllum

Native species that persist on these sites:

Eucalyptus camaldulensis	Redgum
Muehlenbeckia cunninghamii	Lignum

3. FORMER VEGETATION TYPES ON THESE SITES

Former Swamp Areas

Acacia retinodes	Swamp Wattle
Acacia melanoxylon	Blackwood
Muehlenbaekia cunninghamii	Lignum
Eucalyptus camaldulensis	Redgum
Eucalyptus largiflorens	River box
Phragmites australis	Common reed
Cyperus spp	Sedges
Isolepis spp	Sedges
Juncus spp	Sedges

Lake Front Areas

Acacia brachybotra	Grey Mulga
Acacia cupularis	Coastal Umbrella Bush
Acacia microcarpa	Manna Wattle
Acacia pycnantha	Golden Wattle
Allocasuarina verticillata	Drooping Sheoak
Disphyma sp	Small Pigface
Enchhylaena tomentosa	Ruby salt bush

Eucalyptus fasciculosa	Pink Gum
Eucalyptus leucoxylon	SA Blue Gume
Melaleuca halmaturorum	Salt Water Paper Bark
Nitraria billardierei	Nitre Bush
Acacia retinodes	Swamp Wattle
Muehlenbaekia cunninghamii	Lignum
Eucalyptus camaldulensis	Redgum
Eucalyptus largiflorens	River box
Phragmites australis	Common reed
Cyperus spp	Sedges
Isolepis spp	Sedges
Juncus spp	Sedges

4. CONSIDERATIONS FOR REVEGETATION

Black cracking soils are very difficult revegetation targets. Access difficulties, occasional flooding, weed competition, soil cracking and exposed sites all contribute to make plant establishment difficult. If high salinity levels are present it becomes even more complex.

5. RE-ESTABLISHING NATIVE VEGETATION ON THESE SITES

Species selection

There is only a narrow range of plants suited to revegetation on these sites. Lignum for instance is not usually grown from seed so is only available in smaller numbers from cuttings.

The revegetation of these areas is really hard due to weed competition and so tubestock are often a good option making both species range broader and weed control easier.

If direct seeding is being used Redgum and Wattles will dominate the mix.

Seeding rates

A typical direct seeding mix would consist of:

<u>Species</u>	<u>Percentage of mix</u>
Eucalypts	30
Acacia (wattles)	60
Melaleuca (if appropriate)	
Sedges	5 (seedlings ?)
Lignum	5 (seedlings)

Seeding rates overall need to be fairly high due to the potential difficulty of seasonal conditions. Recommended rate would be at least 500g per km for single row planting machines or approximately 2.5kg per ha at the minimum for other machines.

Timing

Seeding times on these sites is determined by access as much as anything is. Given that they often go underwater in winter and spring it is a bit of guesswork to try to time planting before the sites dry out. Late July in drier seasons to early spring are the likely planting times.

If it is a site not likely to get inundated access can still be difficult. This is less of an issue for tubestock planting but even this can be difficult in sticky wet conditions. Planting times on these sites should be much earlier, eg June to August.

Site preparation

Woody weeds are a significant problem on the swamp sites. They need to be controlled well in advance of planting. Weed control can start in the season prior to sowing to reduce seed set on annual weeds as well. Two sprays prior to sowing are a good idea if possible. Exclude stock.



Plate 5: Redgum swamp on Bremer River (black cracking soils)



Plate 6: Direct seeding on lakefront black soil site



Plate 7: Successful revegetation on a site not far from Plate 6.

Sowing techniques

In larger plantings direct seeding is still worth using but may require extra follow up. Progress is often slow for the first few seasons after planting.

Tubestock enable a broader range of species to be established but will be more expensive. Often tubestock are used to broaden out species range and fill in gaps in the seasons following a large direct seeding job.

Barerooted and seedlings are options for fodder plantings.

Post sowing management

Red-legged earthmite may need controlling in the week's post sowing if direct seeding.

Weed competition will be an issue. If spraying is necessary in the first spring shielded spraying will be the only option. After the seedlings have survived a summer overspray options are available but specific advice on chemical, rate, timing and species to be oversprayed should be sought.

Long term site management strategies

Subsequent plantings and spot spraying of problem weeds should be carried out as seasonal conditions dictate.

6. OTHER MANAGEMENT OPTIONS**Agroforestry**

These are the best big tree growing areas around. If ground water is good quality good growth can be expected.

Redgums are ideal as can be seen in any of the surviving swamps. Other forest species could be used in specific situations. Seek advice.

Fodder shrub

Salt bush would do very well on these sites.

REVEGETATING WHITE SANDY SITES

1. SITE TYPE. Sandy Sites – White non-wetting sand dune systems

2. SITE DESCRIPTION {including indicator species likely to be on site}

These sites are common on the western edge of the Angas floodplain area as well as other isolated pockets scattered through the irrigation area. Historically they have posed serious management problems as they are prone to rabbit infestation and wind erosion. Consequently they have often been neglected and may have been left with some remnant mallee for shelter or just allowed to become barren stock campsites.

Characteristically non-wetting dunes bared off over summer. Plants that are likely to occur on these sites are:

Couch Grass
Silver Grass
Evening Primrose
Nut Grass
Veldt Grass

Native species that often persist on these sites:

Danthonia species	Wallaby Grass
Stipa species	Spear Grass
Eucalyptus incrassata	Ridge Fruited Mallee
Melaleuca uncinata	Broombush

3. FORMER VEGETATION TYPE ON THESE SITES

Acacia calamifolia	Sandhill Wattle
Acacia pycnantha	Golden Wattle
Acacia spinescens	Spiney Wattle
Baekea behrii	Silver Baekea
Banksia marginata	Silver Banksia
Banksia ornata	Desert Banksia
Billardia cymosa	Sweet Appleberry
Callitris preissii	Southern Cypress Pine
Callitris verrucosa	Mallee Cypress Pine
Calytrix tetragona	Fringe Myrtle
Clematis microphylla	Old Mans Beard
Danthonia species	Wallaby Grass
Dianella revoluta	Flax Lily
Dodonea viscosa	Sticky Hop Bush
Enchylaena tomentosa	Ruby Salt Bush
Eucalyptus fasciculosa	Pink Gum
Eucalyptus incrassata	Ridge Fruited Mallee
Eutaxia microphylla	Mallee Bush Pea
Grevillea ilicifolia	Holly Leaved Grevillea
Hakea muelleriana	Desert Hakea
Kennedia prostrata	Running Postman
Kunzea pomifera	Muntries
Lasiopetalum behrii	Pink Velvet Bush
Leptospermum coriacium	Mallee Tea Tree
Lomandra species	Iron Grass
Maireana species	Blue Bush
Melaleuca acuminata	Mallee Honey Myrtle
Melaleuca uncinata	Broom Bush
Pultenea tenuifolia	Sand Dune Bush Pea
Rhagodia candolleana	Seaberry Saltbush
Stipa species	Spear Grass

4. CONSIDERATIONS FOR REVEGETATION

All sandy sites pose definite difficulties for management. This is highlighted in areas of rainfall below about 450mm. This is because of the instability of these sites and the difficulty of controlling this during a major land use change. Revegetation relies on removing competition to allow desirable vegetation cover to establish.

These white sands also suffer the effects of historical management practices which have broken down any soil structure that existed and seriously increased soil acidity. Major weed infestations are often tolerated purely because this prevents the risk of erosion.

One interesting feature of these dunes is their ability to hold significant moisture below the surface. This probably indicates that they contribute to ground water recharge. Deep-rooted perennial plants are greatly advantaged by this moisture reserve and will often display rapid growth. This is also the reason why large pink gums often fringe the edges of these dunal systems.

The linear pattern of these dunes in some areas makes farm planning around them quite difficult and a range of options will be used to deal with them. Revegetation with native and fodder species remains important options for management.

5. RE-ESTABLISHING NATIVE VEGETATION ON THESE SITES

Species selection

These sites have suffered significant alterations over time. Therefore it is not likely that all species that formerly occurred will be successful if planted {in the short term at least}. Initial planting mixes should contain higher rates of pioneering species. If direct seeding is the chosen establishment method, seed availability will also determine the species mix. It is essential that species to be planted should be sourced from as close as possible to the planting location.

Seeding rates

A typical direct seeding mix would consist of:

<u>Species</u>	<u>Percentage of mix</u>
Mallee eucalypts	25
Melaleuca species	15
Wattles (acacias), & others	40
Native pine	10
Allocasuarina (sheoak)	5
Grasses or other	5

Seeding rates overall need to be fairly high due to the potential difficulty of seasonal conditions. Recommended rate would be at least 500g per km for single row planting machines or approximately 2.5kg per ha at the minimum for other machines.

Timing

Seeding times on these sites is determined more by site preparation than some other low rainfall sites. Late July to early August is reasonable because they allow for later weed control in the season of sowing. Cover crop establishment is also necessary on some sites and this also may require an early August sowing time.

Site preparation

Ideally couch can be controlled in the seasons prior to revegetation. Otherwise weed control should commence as soon as practical after there is enough cover on the site to hold it together. It is also a good idea to prevent any soil disturbance, including grazing, for at least the twelve months prior to sowing.

It is occasionally necessary to secure a site with a cover crop to prevent blowing and this is another operation that will impact on both timing and planting layout so needs to be considered in the early planning stages.

Sowing techniques

Direct seeding is quite effective on white acid sand but is highly reliant on seasonal conditions. Note that the non-wetting nature of these sites can be a problem. Wetting agents may be required.

Tubestock enable a broader range of species to be established but will be more expensive. Often tubestock are used to broaden out species range and fill in gaps in the seasons following a large direct seeding job.

Barerooted and seedlings are options for fodder plantings.

Post sowing management

Red-legged earthmite may need controlling in the week's post sowing if direct seeding.

Weed competition will be an issue. If spraying is necessary in the first spring shielded spraying will be the only option. After the seedlings have survived a summer overspray options are available but specific advice on chemical, rate, timing and species to be oversprayed should be sought.

Long term site management strategies

Subsequent plantings and spot spraying of problem weeds should be carried out as seasonal conditions dictate.



Plate 8: Typical presentation of the white non-wetting sand dunes in the Angas-Bremer region.



Plate 9: Good growth rates can be achieved with the right vegetation mix on these formerly infertile sites.

6. OTHER MANAGEMENT OPTIONS

Agroforestry

There are really no options for Forestry on these sites on natural rainfall.

Fodder shrub

The most common fodder shrub used on these sites is Tagasaste (Tree Lucerne). It does extremely well on these acid sands. It can provide good fodder reserves in autumn and good shelter paddocks. Tagasaste requires tight management to get the best results. Grazing control is critical. Establishment is by direct seeding or seedlings with a number of growers or contractors available. Advice on layout and management should be sought from both suppliers and other farmers with experience.

Management for this plant includes not permitting any seed escape, as it is a potentially serious weed in scrub areas.

Pasture

In some areas of SA acid sands such as this are extensively modified by clay spreading enabling a wider range of cropping and pasture options. This would possibly also extend the options for fodder shrubs and revegetation. Specific advice should be sought.

Other

With irrigation, a broad range of acid loving species is able to be grown on these sites. Horticultural possibilities with native flowers may be an option in these areas.

REVEGETATING GRADATIONAL SOILS

1. SITE TYPE. Gradational soils



Plate 10: Roadside showing typical low mallee found on these soils

2. SITE DESCRIPTION {including indicator species likely to be on site}

These are the typical hard mallee soils. Usually grey to brown in colour with textures ranging from loamy clay to sandy. These sites often overly limestone and may have significant limestone scattered on the surface. The plants associated with them are also varied but can be described as typical mallee. On some of the drier parts of the Angas-Bremer area, to the north and east, where these soils are common, the mallee is relatively short and stunted. One of the typical features of these associations is the very large range of mallee eucalypts present (usually 3 or 4). If grazing has been allowed in these associations only larger shrubs will be left in the understorey. This often leaves these patches looking dry and uninviting. Mallee with an intact understorey is less common but worth a visit during the wetter months.

Characteristic weed species on these sites are:

Horehound
Scabious
Wild Turnip
Wild Radish
Capeweed
Wire Weed
Ryegrass
Barley grass

Native species that persist on these sites:

A range of Mallee Eucalypts
Melaleuca lanceolata

3. FORMER VEGETATION TYPE ON THESE SITES

Acacia pycnantha	Golden Wattle
Acacia brachybotra	Grey Mulga
Allocasuarina verticillata	Drooping Sheoak
Dianella revoluta	Flax Lillie
Enchylaena tomentosa	Ruby Salt Bush
Eucalyptus calycagona	Square Fruited Mallee
Eucalyptus gracilis	Yorrell
Eucalyptus incrassata	Ridge Fruited Mallee
Eucalyptus leptophylla	Slender Leaved Red Mallee
Eucalyptus socialis	Red Mallee
Eucalyptus spp	Other Mallees
Hakea muelleriana	Desert Hakea
Lomandra spp	Tussocks, Irongrass
Melaleuca acuminata	
Melaleuca lanceolata	Dryland Tea Tree
Melaleuca uncinata	Broom Bush
Pittosporum phylliraeoides	Native Apricot
Santalum acuminatum	Quandong

4. CONSIDERATIONS FOR REVEGETATION

A lot of the sites that are being considered for revegetation on this soil type will be quite degraded. If there has been significant wind erosion, a long history of cultivation, significant weed infestation or serious limestone, growth rates may be slow. This is even more likely on sites that originally only supported low vegetation anyway.

Well prepared sites can get excellent results in good seasons because these sites are less hospitable to weeds, and once the site is clean most resources are available for the newly established plants.

Extra site preparation in the form of ripping and rolling may be required in rocky areas. There are good examples of these mallee areas persisting along roadsides.

5. RE-ESTABLISHING NATIVE VEGETATION ON THESE SITES

Species selection

Use a good range of species from the list. Look at local stands to identify more accurately the species you want for your project. Collect seed from as local as possible.

Seeding rates

A typical direct seeding mix would consist of:

<u>Species</u>	<u>Percentage of mix</u>
Mallee eucalypts	25
Melaleuca species	15
Wattles (acacias), & others	40
Native pine	10
Allocasuarina (sheoak)	5
Grasses or other	5

Seeding rates overall need to be fairly high due to the potential difficulty of seasonal conditions. Recommended rate would be at least 500g per km for single row planting machines or approximately 2.5kg per ha at the minimum for other machines.

Timing

Direct seeding and tubes need to be planted as early as practical in most of these sites. Weed control needs to be carried out early and sowing carried out by July.

Site preparation

Ideally couch can be controlled in the seasons prior to revegetation. Otherwise weed control should commence as soon as practical. It is also a good idea to prevent any soil disturbance, including grazing, for at least the twelve months prior to sowing.

If ripping is required it should be done by May.

Sowing techniques

Direct seeding is quite effective on these sites. Seasonal variation can be an issue but given the fact some of these sites are large and results are often as good or better than tubestock planting direct seeding is an obvious choice.

Often tubestock are used to broaden out species range and fill in gaps in the seasons following a large direct seeding job or they lend themselves to smaller jobs on these sites.

Barerooted and seedlings are options for fodder plantings.

Post sowing management

Red-legged earthmite may need controlling in the week's post sowing if direct seeding.

Weed competition can be an issue. If spraying is necessary in the first spring shielded spraying will be the only option. After the seedlings have survived a summer overspray options are available but specific advice on chemical, rate, timing and species to be oversprayed should be sought.

Long term site management strategies

Subsequent plantings and spot spraying of problem weeds should be carried out as seasonal conditions dictate.

6. OTHER MANAGEMENT OPTIONS**Agroforestry**

There are really no options for Forestry on these sites on natural rainfall.

APPENDIX E

KEY FLOW GAUGING STATIONS

Existing stations from which data has been used for development of the Plan

- A4260503 (Angas River at Angas Weir)
- A4261074 (Angas River at Cheriton Road)
- A4260533 (Bremer River at Hartley)
- A4260557 (Mt Barker Creek downstream of Mt Barker)
- A4260558 (Dawesley Creek at Dawesley)
- A4260679 (Mt Barker Creek upstream of Bremer River confluence)
- A4260688 (Bremer River upstream of confluence)
- A4261018 (Western Flat Creek, Mt Barker)
- A4260530 (Currency Creek at Higgins)
- A4261099 (Currency Ck Cemetery)
- A4260504 (Finniss River east of Yundi)
- A4261075 (Finniss River at Ford Road)
- A4261103 (Giles Creek downstream of Signal Flat Road)

Note that this list doesn't include sites that will be replaced by sites listed below.

Stations required for principles in the Plan

- A4261220 (Angas River at Ballandown Road)
- A4261219 (Bremer River at Ballandown Road)

Future stations required (at a minimum)

- Base station in Tookayerta Creek catchment
- If appropriate, other high priority sites identified through a risk assessment process (e.g. sites with high demand, high potential for impact on resources or users, and limited data)

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ABBREVIATIONS, ACRONYMS AND SYMBOLS

AHD	Australian height datum
AS	Australian Standard
Board, the	South Australian Murray-Darling Basin Natural Resources Management Board
Department, the	The Department responsible for the administration of the NRM Act
DEW	Department for Environment and Water
DEWNR	Department of Environment, Water and Natural Resources (former)
DFW	Department for Water (former)
DWLBC	Department of Water, Land and Biodiversity Conservation (former)
EA	Environmental asset
EMLR	Eastern Mount Lofty Ranges
EPA	Environment Protection Authority
EPBC Act	<i>Environment Protection and Biodiversity Conservation Act 1999</i> (Cth)
GL	Gigalitre (1,000,000,000 litres)
GL/y	Gigalitres per year
GRO	General Registry Office
ha	Hectare
ILUA	Indigenous Land Use Agreement
kL	Kilolitre (1,000 litres)
kL/y	Kilolitres per year
km	Kilometre
km ²	Square kilometre
KNY Agreement	Kungun Ngarrindjeri Yunnan Agreement
L	Litre
L/s	Litres per second
L/s/km ²	Litres per second per square kilometre
m	Metre
m ²	Square metre
m ³ /s	Cubic metres per second
MACAI	Mannum Aboriginal Community Association
mAHD	metres above the Australian height datum
MERI	Monitoring, evaluation, reporting and improvement
MGL	Murray Group Limestone
mg/L	Milligrams per litre
Minister	The Minister responsible for the administration of the NRM Act
ML	Megalitre (1,000,000 litres)
NATA	National Association of Testing Authorities
NRA	Ngarrindjeri Regional Authority
NRM	Natural resources management
NRM Act	<i>Natural Resources Management Act 2004</i>
PIRSA	Primary Industries and Regions South Australia

Plan, the	Water Allocation Plan for the Eastern Mount Lofty Ranges
PWA	Prescribed Wells Area
PWC	Prescribed Watercourse
PWRA	Prescribed Water Resources Area
Regional NRM Plan	Natural Resources Management Plan for the South Australian Murray-Darling Basin Natural Resources Management Region
s	Second
SA Water	South Australian Water Corporation
SAMDB NRM Board	South Australian Murray-Darling Basin Natural Resources Management Board
SEA	Significant environmental asset
SOC	Statement of Commitment
SW	Surface water
SWL	Standing water level
SWMZ	Surface water management zone
S&D	Stock and domestic
TDS	Total dissolved solids
UGW	Underground water
WC	Watercourse water
y	Year

GLOSSARY

Aboriginal — the term “Aboriginal” is used throughout this Plan instead of “Indigenous” as endorsed by the former SA Aboriginal State-wide Advisory Committee.

“Aboriginal nations” or “nation” is used throughout the Plan and is defined for the purposes of the Plan as a group or community of Aboriginal people who identify as descendants of the original inhabitants of the Plan area and may share a single common territory, or it may be located as a nation within another larger nation. The Aboriginal nation may include the native title holder or claimant body. All decisions and consultations about native title matters that impact on the Plan must be done with the native title body. An ILUA may provide that the native title holder or claimant is acknowledged as representing the nation on all matters dealt within the ILUA over all land and water within the ILUA area. Otherwise the representative body of the nation will be a body that demonstrates that it represents the members of the nation that hold the authority and responsibility with respect to Aboriginal culture and heritage for the specified area.

Aboriginal Cultural Heritage — means Aboriginal objects, Aboriginal remains and Aboriginal sites that are protected under the *Aboriginal Heritage Act 1988*. It is an offence to damage, disturb or interfere with Aboriginal sites, objects or remains without the authorisation of the Minister or agreement of the Registered Aboriginal Representative Body.

An Aboriginal object: means an object—

(a) of significance according to Aboriginal tradition; or

(b) of significance to Aboriginal archaeology, anthropology or history,

and includes an object or an object of a class declared by regulation to be an Aboriginal object but does not include an object or an object of a class excluded by regulation from the ambit of this definition.

Aboriginal remains: means the whole or part of the skeletal remains of an Aboriginal person but does not include remains that have been buried in accordance with the law of the state.

An Aboriginal site: means an area of land—

(a) that is of significance according to Aboriginal tradition; or

(b) that is of significance to Aboriginal archaeology, anthropology or history

and includes an area or an area of a class declared by regulation to be an Aboriginal site but does not include an area or an area of a class excluded by regulation from the ambit of this definition.

Aboriginal Water Interests — is used to describe native title rights and interests or other uses of water that are currently permitted under the NRM Act as described below. It also includes aspirations to other legal interests in water that are not currently permitted under existing law including to the “cultural flow” as a separate and distinct entitlement. The term also describes the outcomes and objectives to the use and management of water that accords with the social, cultural and spiritual values of Aboriginal people as expressed by them.

Notice of authorisation to take water for native title purposes, pursuant to section 128 of the NRM Act 2004. *Authorise the taking of water from any prescribed watercourse, lake or well, or surface water prescribed area within the State of South Australia by a person who is a native title holder in relation to the land or waters on or in which that watercourse, lake, well, or surface water prescribed area is situated and the taking is for the purpose of satisfying that person’s personal, domestic, cultural, spiritual or non-commercial communal needs where they are doing so in the exercise or enjoyment of their native title rights and interests, providing that the taking does not involve stopping, impeding or diverting the flow of water for the purpose of collecting the water or diverting the flow of water from a watercourse.*

This authorisation applies whether or not sub-section 124 (4) applies to the taking of water from a prescribed water resource or a prescribed surface water area.

In this Notice: 'native title holder' means the person or persons who hold, or claim to hold, the native title in relation to the lands and waters according to their traditional laws and customs. Dated 10 September 2012.

Adaptive management — a management approach that involves identifying actions, implementing the changes, monitoring the outcomes, investigating the assumptions, and regularly evaluating and reviewing the actions required. Consideration must be given to the temporal and spatial scale of monitoring and the evaluation processes that are appropriate to the natural resource being managed.

Allotment — has the same meaning as in the *Real Property Act 1886*.

Ambient — the background level of an environmental parameter (e.g. a measure of water quality such as salinity).

Ambient underground water — the underground water that is present in the relevant aquifer prior to the commencement of draining or discharging water into a well, and may be the native underground water or mixed underground water.

Angas Bremer Irrigation Management Zone — the area identified as the Angas Bremer Irrigation Management Zone in Figure 4.12.

Aquatic habitat — environments characterised by the presence of standing or flowing water.

Aquifer — an underground layer of rock or sediment that holds water and allows water to percolate through.

Aquifer test — a hydrological test performed on a well, aimed to increase the understanding of the aquifer properties, including any interference between wells, and to more accurately estimate the sustainable use of the water resources available for development from the well.

Aquifer type — a group of underground water management zones, grouped together as they have the same type of aquifer. Aquifer types and their corresponding underground water management zones are given in Table 5.2.

Aquifer, confined — an aquifer that is bound above and below by an impermeable confining bed. The pressure in a confined aquifer is usually greater than atmospheric pressure, resulting in water levels in wells rising above the top of the aquifer.

Aquifer, unconfined — an aquifer that has the watertable as its upper surface and that may be recharged directly by infiltration from the ground surface.

Aquifer, sedimentary — an aquifer where underground water is stored in and moves through pore spaces within sediments.

Aquifer, fractured rock — an aquifer where underground water is stored and moves through joints and fractures in rocks.

Aquitard — a layer that separates two aquifers and restricts the flow of water between them.

Artificial recharge — draining or discharging water directly or indirectly into a well.

Attenuation zone — an area in underground waters where waste is discharged and the concentration of pollutants is reduced by physico-chemical and microbiological processes, as provided for in clause 15 of the *Environment Protection (Water Quality) Policy 2003*.

Australian Height Datum (AHD) — the datum adopted for vertical control, measured in metres. Zero metres AHD is approximately mean sea level.

Average recurrence interval (ARI) — the average or expected value of the period between exceedances of a given discharge.

Base allocation — an allocation that is not a *roof runoff allocation, urban runoff allocation, rollover allocation, recharge allocation, or an ecosystem allocation (system provisions)*.

Baseflow — the water in a stream that results from underground water discharge to the stream; often maintains flows during seasonal dry periods and has important ecological functions.

Biodiversity — the variety of life forms represented by plants, animals and other organisms and micro-organisms, the genes that they contain, and the ecosystems and ecosystem processes of which they form a part.

Biota — all of the organisms at a particular locality.

Building — a structure with a roof and walls, or a portion of such a structure, whether temporary or permanent, moveable or immovable, including but not limited to, a boat or pontoon permanently moored or fixed to land, or a caravan permanently fixed to land; a shed, and a pump station.

Catchment area — the catchment area of a particular point means all of the land, determined by natural topographic features, from which runoff has potential to naturally drain to that point.

Catchment interception limit — the limit to the total volume of *interception* in a *surface water catchment* (given in Table 4.3).

Catchment evaporation and consumptive use limit — the limit to the total volume of *evaporation* plus *consumptive use from surface water and watercourses* in a *surface water catchment* (given in Table 4.3).

Code of practice — standards of management developed by industry and government, promoting techniques or methods of environmental management by which environmental objectives may be achieved.

Commercial forest — a forest plantation where the *forest vegetation* is grown or maintained so that it can be harvested or used for commercial purposes (including through the commercial exploitation of the carbon absorption capacity of the forest vegetation).

Confining layer — a rock unit impervious to water, which forms the upper bound of a confined aquifer; a body of impermeable material adjacent to an aquifer. See also 'aquifer, confined'.

Connected roof area — the area of roof that drains (through gutters, downpipes or other means) to water storage facilities. Where there are multiple connected roof areas on a property, the connected roof area for the property is the total of all connected roof areas for that property.

Consumptive use — in general, consumptive use is water taken for licensed and non-licensed consumptive purposes. For the purposes of section 5–7 of the Plan, a range of terms have been defined that capture different aspects of consumptive use, including, but not limited to 'consumptive use from surface water and watercourses', and 'consumptive use from underground water'.

Consumptive use from surface water and watercourses (CU_{sw}) — as per principle 34, the volume of surface water and watercourse water estimated to be taken for licensed and non-licensed consumptive purposes (including stock and domestic use and water intercepted by commercial forests) from a given area or location, including a surface water catchment, surface water management zone, catchment area, property or diversion point. Consumptive use from surface water and watercourses calculated in accordance with principle 34; and excludes *lower Angas Bremer allocations, rollover allocations, ecosystem allocations (system provisions), roof runoff allocations* and *urban runoff allocations*.

Consumptive use from underground water (CU_{ugw}) — as per principle 91 b), the volume of underground water estimated to be taken for licensed and non-licensed consumptive purposes (including stock and domestic use and water intercepted and directly extracted by commercial forests) from a given area or location, including an underground water management zone. Consumptive use from underground water is calculated in accordance with principle 91 b), and excludes *recharge allocations, rollover allocations* and *ecosystem allocations (system provisions)*.

Consumptive use limit (CUL) — is a collective term for the quantum of water which is available for consumptive purposes, including licensed and non-licensed purposes, after considering system and environmental provisions. In the case of surface water and watercourses, this is an evaporation and consumptive use limit that includes the evaporative loss from dams.

Note that for accounting purposes, the consumptive use limits do not apply to certain types of allocations that would be considered to represent consumptive use in the general sense of the word (see the definitions for the specific consumptive use limits – as listed below).

The Plan includes different consumptive use limits that apply to different resources and at different scales. The following are types of consumptive use limit: *local evaporation and consumptive use limit, main watercourse evaporation and consumptive use limit, runoff evaporation and consumptive use limit, catchment evaporation and consumptive use limit, regional evaporation and consumptive use limit, underground water consumptive use limit and regional underground water consumptive use limit.*

Contaminant — a material added by humans or natural activities that may, in sufficient concentrations, render the environment unacceptable for biota; the presence of these materials is not necessarily harmful.

Cultural flows — described in paragraphs 30-31 f schedule 1 of the Murray-Darling Basin Plan.

Indigenous uses includes use for cultural, social, environmental, spiritual and economic purposes. Many Indigenous people view water spiritually – people, land and rivers are inextricably connected. Indigenous economic interests include trading, hunting, gathering food and other items that alleviate the need to purchase similar items and the use of water to support businesses in industries such as pastoralism and horticulture. The environmental and cultural health of the Murray-Darling Basin is of paramount importance in serving these interests.

The concept of cultural flows helps translate the complex relationship described above into the language of water planning and management. The following definition of cultural flows is currently used by the Northern Murray-Darling Basin Aboriginal nations and the Murray Lower Darling Rivers Indigenous nations: — Water entitlements that are legally and beneficially owned by the Indigenous nations and are of sufficient and adequate quantity to improve the spiritual, cultural, environmental, social and economic conditions of those Indigenous nations. This is our inherent right. — The provision of cultural flows will benefit Indigenous people in improving health, wellbeing and provides empowerment to be able to care for their country and undertake cultural activities.

Cumulative evaporation plus consumptive use — as per principle 41 c), the sum of *evaporation plus consumptive use from surface water and watercourses* from (1) the surface water management zone being considered and (2) all surface water management zones that drain into that zone. Table 4.6 shows the surface water management zones that drain into each surface water management zone, where relevant.

Dam use — as per principle 185, the volume of water taken, or estimated to be taken, from a dam. It is determined in accordance with principle 185.

Dams, off-stream dam — see 'off-stream dam'.

Dams, on-stream dam — see 'on-stream dam'.

Date of adoption — the date that the Plan was adopted.

Designated urban land use development — as per principle 89 b), development that is:

- a) located in an area that the Minister considers to be urban, including, but not limited to, land zoned as residential zone, regional town centre zone, neighbourhood centre zone, local centre zone or home industry zone in a relevant Development Plan under the *Development Act 1993*; and
- b) either:
 - i) authorised by a development approval under the *Development Act 1993* after 16 October 2003 and commenced after 16 October 2003; or

- ii) located in any of the following *surface water catchments*: Angas Plains, Ferries-McDonald, Long Gully Group, Milendella Creek, Preamimma Creek, Rocky Gully Creek, Salt Creek, or Sandergrove Plains.

Diversion point — a diversion structure or an area of *commercial forestry*.

Diversion structure — A dam, wall or other structure, object or device that will collect or divert water in a watercourse or surface water flowing over land, including but not limited to a dam, weir, levee or pump.

Domestic purpose — in general, means the taking of water for ordinary household purposes. Has the same meaning as section 3 (1) of the NRM Act, where domestic purpose in relation to the taking of water does not include—

- a) taking water for the purpose of watering or irrigating land, other than land used solely in connection with a dwelling; or
- b) without limiting paragraph (a) – taking water for the purpose of watering or irrigating more than 0.4 of a hectare of land; or
- c) taking water to be used in carrying on a business (except for the personal use of persons employed in the business).

Domestic wastewater — has the same meaning as in section 3 (1) of the NRM Act, meaning water used in the disposal of human waste, for personal washing, for washing clothes or dishes, and in a swimming pool.

Drainage path — a fold, depression or contour in land or a path along which surface water may flow.

Dryland salinity — the process whereby salts stored below the surface of the ground are brought close to the surface by the rising watertable. The accumulation of salt degrades the upper soil profile, with impacts on agriculture, infrastructure and the environment.

Eastern Mount Lofty Ranges PWRA — means the following areas:

- Eastern Mount Lofty Ranges Water Resources Area (the area bounded by the bold red line in GRO Plan No 422/2003);
- Eastern Mount Lofty Ranges Prescribed Wells Area (the area bounded by the bold red line in GRO Plan No 423/2003);
- Angas Bremer Prescribed Wells Area (as described in the *Gazette* published on 23 October 1980 (page 1192) pursuant to the *Water Resources Act 1976*).

Ecological processes — all biological, physical or chemical processes that maintain an ecosystem.

Ecosystem — a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit.

Ecosystem allocation — an allocation granted in accordance with principles 9–10, for the purpose of maintenance, rehabilitation or restoration of locally indigenous water-dependent ecosystems, habitats, communities or species, for a purpose and in a manner accredited by the Minister. Ecosystem allocations can be allocated from the consumptive use limit (in accordance with principles 11–13), or from the *system provisions* (in accordance with principles 14–23 — see *Ecosystem allocation (system provisions)*).

Ecosystem allocation (system provisions) — an allocation granted in accordance with principles 9–10 and 14–23, for a purpose as given in principle 15. These allocations are counted against the *system provisions* rather than the *consumptive use limit*.

Effluent — *domestic wastewater* or *industrial wastewater*.

Electrical conductivity (EC) — commonly used as a measure of water salinity as it is quicker and easier to measure compared to measuring salinity as total dissolved solids. 1 EC unit = 1 micro-Siemen per centimetre ($\mu\text{S}/\text{cm}$) measured at 25°C.

Endangered species — any species in danger of extinction throughout all or a significant portion of its range.

End-of-system flow gauging station — means:

- flow gauging station A4261220 (Ballandown Road) where water will be taken from the Angas River surface water catchment; or
- flow gauging station A4261219 (Ballandown Road) where water will be taken from the Bremer River surface water catchment;

as appropriate, or their successors.

Engagement — Aboriginal ‘engagement’ is defined as any process that involves Aboriginal people in problem solving or decision making, and uses community input to make better decisions (Commonwealth of Australia, 2016)

Environmental asset — for the purposes of section 5–7 of the Plan means a permanent pool, red gum swamp or location identified as supporting an important underground water-dependent ecosystem (that is not a *significant environmental asset*). The locations of environmental assets used for the purposes of the Plan will be identified in a database. Indicative locations of environmental assets in the Eastern Mount Lofty Ranges PWRA identified to the date of map production are shown in Figure 4.11.

Environmental buffer zone — as per principle 102, an environmental buffer zone:

- a) is an area radiating from:
 - i) the outermost perimeter of an *environmental asset* or *significant environmental asset*, with a radius determined in accordance with Table 5.1; or
 - ii) the centreline of a *main watercourse*, with a radius determined in accordance with Table 5.1. Main watercourses are shown in Figure 4.3 to Figure 4.9, and the centreline is determined from the spatial database held by the Department that was used to define main watercourses for the Plan; and
- b) is linked to the aquifer that interacts with, or is likely to interact with, the environmental asset, significant environmental asset or main watercourse.

Environmental water provisions — those parts of environmental water requirements that can be met at any given time. This is what can be provided at that time with consideration of existing users’ rights, social and economic impacts.

Environmental water requirements — has the same meaning as in section 76 (9) of the NRM Act, meaning those water requirements that must be met in order to sustain the ecological values of ecosystems that depend on the water resource, including their processes and biological diversity, at a low level of risk.

Erosion — natural breakdown and movement of soil and rock by water, wind or ice; the process may be accelerated by human activities.

Evaporation (E) — for the purposes of section 5–7 of the Plan, means mean net annual evaporation from dams, determined in accordance with principle 34. The mean value has been determined for the period 1974–2006.

Existing user allocation — for the purposes of section 5–7 of the Plan, means an allocation granted, or proposed to be granted, in accordance with section 164N of the NRM Act.

Existing user allocation process — for the purposes of section 5–7 of the Plan, means the processes associated with allocating water to existing users under section 164N of the NRM Act, including licence issue, allocation reduction and appeals.

First flush trigger flow rate — the flow rate that must be reached or exceeded at the relevant *end-of-system flow gauging station* in order for a *flow event* to start in accordance with principle 67. The first flush trigger flow rate for relevant surface water management zones is given in principle 67 c). Relates to *lower Angas Bremer allocations*.

Flood irrigation — irrigation where water is pumped or directed onto an irrigation bay or land so that it flows across the bay or land without the aid of sprinklers, drippers or other irrigation infrastructure, but may include the use of pumps, weirs, sluice gates and similar to direct the flow of water.

Floodplain — has the same meaning as in section 3 (1) of the NRM Act, meaning any area of land adjacent to a watercourse, lake or estuary that is periodically inundated with water and includes any other area designated as a floodplain (a) by an NRM Plan; or (b) by a Development Plan under the *Development Act 1993*.

Flow bands — flows of different frequency, volume and duration.

Flow event — for the purposes of section 5–7 of the Plan, a flow event in relation to the taking of a *lower Angas Bremer allocation* sourced from surface water management zones 426AR026 and 426BR062 is described in principle 67. In summary:

- a) A flow event starts when the flow rate is first measured to reach or exceed the *first flush trigger flow rate* at the relevant *end-of-system flow gauging station*, after the previous flow event has ended.
- b) A flow event ends when the daily flow rate has been measured to be less than the threshold flow rate (in ML/day) for 20 consecutive days at the relevant end-of-system flow gauging station.

Flow path — the natural preferential path or direction of surface water flow, and includes a *drainage path*.

Flow regime — the character of the timing and amount of flow in a stream.

Forestry use from surface water — the volume of surface water deemed to be intercepted by *commercial forests*, determined in accordance with principle 267 a).

Forestry use from underground water — the volume of underground water deemed to be intercepted and directly extracted by *commercial forests*, determined in accordance with principle 267 b).

Forest vegetation — trees and other forms of forest vegetation including (a) roots or other parts of the trees or other forest vegetation that lie beneath the soil; and (b) leaves, branches or other parts or products of trees or other forest vegetation.

Fresh — a short duration, small volume pulse of streamflow generated by a rainfall event that temporarily, but noticeably, increases stream discharge above ambient levels.

Gazette — the South Australian Government Gazette.

Geological features — include geological monuments, landscape amenity and the substrate of land systems and ecosystems.

Geomorphology — the scientific study of the landforms on the Earth's surface and of the processes that have fashioned them.

Groundwater — water occurring naturally below ground level, generally referred to as 'underground water' in the Plan. See '*underground water*'.

High intensity use zone — as per principle 111, a high intensity use zone is a circular area centred on a licensed well with a radius of 600 metres where the total volume allocated in the area exceeds four times the mean annual recharge rate for the area, determined in accordance with principle 111.

Hydrogeology — the study of underground water, which includes its occurrence, recharge and discharge processes, and the properties of aquifers; see also 'hydrology'.

Hydrologically continuous — two or more points in the landscape directly connected by the same flow path or watercourse.

Hydrology — the study of the characteristics, occurrence, movement and utilisation of water on and below the Earth's surface and within its atmosphere; see also 'hydrogeology'.

Hydrometric — literally relating to water measurement of components of the hydrological cycle, from the Greek words hydro (water) and metrikos (measurement).

Indigenous Land Use Agreement (ILUA) — is a voluntary statutory agreement between a native title group or holder and the government made pursuant to Division 3 Subdivision of the *Native Title Act 1993* (Cth). Once registered an ILUA allows for the application of certain parts of the *Native Title Act 1993* (Cth) to be modified, for example the processes and effects of the future act provisions. It can also provide for compensation for extinguishment of native title and provide for the exercise of native title rights and interests.

Industrial wastewater — has the same meaning as in section 3 (1) of the NRM Act, meaning water (not being *domestic wastewater*) that has been used in the course of carrying on a business (including water used in the watering or irrigation of plants) that has been allowed to run to waste or has been disposed of or has been collected for disposal.

Infrastructure — has the same meaning as in section 3 (1) of the NRM Act, which includes artificial lakes; dams or reservoirs; embankments, walls, channels or other works or earthworks; bridges and culverts; buildings or structures; roads; or pipes, machinery or other plant or equipment; any device, any item or thing used in connection with testing, monitoring, protecting, enhancing or re-establishing any natural resource, or any aspect of a natural resource or with any other program or initiative associated with the management of a natural resource; and other items brought within the ambit of this definition (under the NRM Act) by the regulations.

Initial evaporation plus consumptive use — determined in accordance with principle 48.

Intensive farming — has the same meaning as in section 3 (1) of the NRM Act, meaning a method of keeping animals in the course of carrying on the business of primary production in which the animals are usually confined to a small space or area and are usually fed by hand or mechanical means.

Interception — calculated in accordance with principle 189 a) for the purposes of section 5–7 of the Plan, and in essence is the total dam capacity and *forestry use from surface water by commercial forests* in an area or location.

Irrigation — watering land by any means for the purpose of growing plants.

Irrigation season — the period in which major irrigation use occurs, usually starting in August–September and ending in April–May.

Joint Tookayerta demand — as per principle 50 a), the total consumptive demand for water (including *evaporation*) in the Tookayerta Creek *surface water catchment* and Tookayerta Permian *underground water management zone*, determined in accordance with principle 50 a).

Joint Tookayerta limit — the limit on *evaporation, consumptive use from surface water and watercourses* and *consumptive use from underground water* collectively over the Tookayerta Creek *surface water catchment* and Tookayerta Permian *underground water management zone*. The value of the joint Tookayerta limit is given in Table 4.4.

Kurna — Kurna people are the Aboriginal traditional owners of all land and water of the greater Adelaide region (ART, 2016). A native title determination has been made in favour of Aboriginal people within the Kurna nation on 21 March 2018.

Kungun Ngarrindjeri Yunnan Agreement 2009 — Agreement (Listen to Ngarrindjeri people talking) between three Ngarrindjeri representative corporations and the South Australia Government that was set in place to frame the Ngarrindjeri strategy for negotiating Ngarrindjeri interests in natural resource management.

Lake — has the same meaning as in section 3 (1) of the NRM Act, meaning a natural lake, pond, lagoon, wetland or spring (whether modified or not) and includes part of a lake; or a body of water designated as a lake by an NRM Plan, or by a Development Plan under the *Development Act 1993*.

Land — has the same meaning as in section 3 (1) of the NRM Act, meaning, according to the context, (a) land as a physical entity, including land under water; or (b) any legal estate or interest in, or right in respect of, land; and includes any building or structure fixed to the land.

Land capability — the ability of the land to accept a type and intensity of use without sustaining long-term damage.

Licence — see 'water licence'.

Licensed dam — a dam that takes water used for licensed purposes.

Licensee — a person who holds a water licence.

Local evaporation and consumptive use limit (LECU) — the limit on the total volume of *evaporation plus consumptive use from surface water and watercourses* in the catchment area of a *significant environmental asset*. For the purposes of principle 193 and 279, the local evaporation and consumptive use limit is determined in accordance with principle 194.

Lower Angas Bremer allocation — as per principle 60, an allocation granted to take water sourced from a watercourse in surface water management zones 426AR026 and/or 426BR062, or that flows from these zones, that must be taken in accordance with principles 61–68 in addition to the rest of the relevant principles in the Plan.

Lower Angas Bremer allocations are not accounted for against the *regional evaporation and consumptive use limit*, the *catchment evaporation and consumptive use limit*, the *runoff evaporation and consumptive use limit*, the *main watercourse evaporation and consumptive use limit* or the *local evaporation and consumptive use limit*.

Main watercourse — a watercourse that receives inflow from another surface water management zone. Main watercourses in the Eastern Mount Lofty Ranges PWRA are shown in Figure 4.3 to Figure 4.9.

Main watercourse evaporation and consumptive use limit — this is a cumulative limit that applies to *evaporation plus consumptive use from surface water and watercourses* (including from *main watercourses*) for the *surface water management zone* being considered as well as all surface water management zones that drain into it. It is given for each relevant surface water management zone in Table 4.5, and has been calculated as the sum of (1) the *runoff evaporation and consumptive use limit* from the surface water management zone being considered and (2) the runoff evaporation and consumptive use limit(s) of all surface water management zones that drain into it.

Managed aquifer recharge — the intentional artificial recharge of water to aquifers for subsequent recovery or environmental benefit.

Management zone — a surface water management zone (shown in Figure 4.3 to Figure 4.9) or an underground water management zone (identified in Table 4.7 and shown in Figure 4.10).

Mannum Aboriginal Community Association (MACAI) — a Ngarrindjeri Regional Authority member organisation and an incorporated body that represents descendants of the ancestors who comprise some or all of the traditional owners of the Peramangk nation. Whilst Peramangk area is not subject to a native title claim, should one be made in the future then both MACAI and the claimants or holders of native title will be entitled to be consulted and dealt with in the Peramangk area about their respective responsibilities within the Peramangk nation.

Mean annual adjusted runoff — the modelled long-term (1971–2006) mean annual runoff, adjusted to remove the impacts of dams, watercourse diversions, limited urban runoff and plantation forestry. Mean annual adjusted runoff may be expressed as a volume or depth as appropriate. The volume of mean annual adjusted runoff from a surface water management zone is given in the 'Resource capacity' column of Table 4.5. Also see *mean annual adjusted runoff depth*.

Mean annual adjusted runoff depth (R) — the mean annual adjusted depth of runoff that runs off an area, determined in accordance with principle 34 d).

Megalitre (ML) — one million litres. An Olympic size swimming pool contains approximately one and a half megalitres.

Metamorphism — change to the structure of rock by natural agencies such as pressure or heat or introduction of new chemical substances.

Minister — The Minister responsible for the administration of the NRM Act.

Ngarrindjeri — the Indigenous People of the Lower River Murray, Lakes and Coorong (Ngarrindjeri Tendi Incorporated, Ngarrindjeri Heritage Committee Incorporated, Ngarrindjeri Native Title Management Committee 2006). Some Aboriginal people within this nation are native title holders pursuant to a determination of native title made on 14 December 2017 in the Ngarrindjeri and Others native title claim.

Ngarrindjeri Regional Authority (NRA) — Ngarrindjeri governing organisation recognised by state and federal governments as the peak governing body for the Ngarrindjeri nation. The NRA Board includes representative from the Ngarrindjeri Native Title Holding Body, the Ngarrindjeri Heritage Committee and the Ngarrindjeri Tendi as well as representatives from MACAI.

Ngartjis – Ngarrindjeri term for special animals (Ngarrindjeri Tendi Incorporated, Ngarrindjeri Heritage Committee Incorporated, Ngarrindjeri Native Title Management Committee 2006).

Non-licensed dam — a dam that is not used for licensed purposes.

Notice of Prohibition — for the purposes of the Plan means any of the following notices:

- Notice of Prohibition on taking surface water and water from watercourses in the Eastern Mount Lofty Ranges Area, published in the *Gazette* on 16 October 2003, pages 3814–3815
- Notice of Prohibition on taking water from wells in the Eastern Mount Lofty Ranges Area published in the *Gazette* on 16 October 2003, pages 3815–3816
- Notice of variation to the Notice of Prohibition on taking surface water and water from watercourses in the Eastern Mount Lofty Ranges Area, published in the *Gazette* on 23 June 2005, page 1892
- Notice of variation to the Notice of Prohibition on taking water from wells in the Eastern Mount Lofty Ranges Area, published in the *Gazette* on 23 June 2005, page 1892
- Notice of Prohibition on taking surface water and water from watercourses in the Eastern Mount Lofty Ranges Area, published in the *Gazette* 15 September 2005, pages 3331–3332
- Notice of Prohibition on taking water from wells in the Eastern Mount Lofty Ranges Area, published in the *Gazette* 15 September 2005, pages 3330–3331
- Notice of Prohibition on taking surface water and water from watercourses in the Eastern Mount Lofty Ranges Area, published in the *Gazette* 13 September 2007, pages 3683–3684
- Notice of Prohibition on taking water from wells in the Eastern Mount Lofty Ranges Area, published in the *Gazette* 13 September 2007, pages 3682–3683
- Notice of Prohibition on taking surface water and water from watercourses in the Eastern Mount Lofty Ranges Area, published in the *Gazette* 17 September 2009, pages 4469–4470
- Notice of Prohibition on taking water from wells in the Eastern Mount Lofty Ranges Area, published in the *Gazette* 17 September 2009, pages 4468–4469
- Notice of Prohibition on taking surface water and water from watercourses and wells in the Eastern Mount Lofty Ranges, published in the *Gazette* 22 September 2011, pages 4053–4055.

Observation well — A narrow well or piezometer whose sole function is to permit water monitoring measurements.

Obswell — observation well network.

Occupier — has the same meaning as in section 3 (1) of the NRM Act, meaning a person who has, or is entitled to, possession or control of the land (other than a mortgagee in possession unless the mortgagee has assumed active management of the land), or who is entitled to use the land as the holder of native title in the land.

Off-stream dam — as per principle 176 b), means a dam, wall, or other structure that is not constructed across a watercourse and is primarily designed to hold water diverted or pumped from another source such as a watercourse, a drainage path, or an aquifer.

Off-stream dams may capture a limited volume of surface water from the catchment upstream of the dam (up to 5% of its total capacity, determined on the basis of mean annual adjusted runoff from the catchment area upstream of the dam).

On-stream dam — as per principle 176 a), means a dam, wall, or other structure placed on, or constructed across, a watercourse or *flow path* for the purpose of holding back and storing the flow of that watercourse or the surface water runoff flowing along that flow path.

Operational well — as per principle 99, means any water well listed on the SA Geodata database that is not an investigation, abandoned or backfilled well. Alternative information on the existence, location, status and/or purpose of use of water wells may also be considered by the Minister. Where there is uncertainty on the existence, location, status and/or purpose of use of an operational well in relation to an assessment under the Plan, it shall be the responsibility of the applicant to determine the relevant information to the satisfaction of the Minister.

Owner of land — has the same meaning as in section 3 (1) of the NRM Act, meaning:

- a) if the land is unalienated from the Crown—the Crown; or
- b) if the land is alienated from the Crown by grant in fee simple—the owner (at law or in equity) of the estate in fee simple; or
- c) if the land is held from the Crown by lease or licence—the lessee or licensee, or a person who has entered into an agreement to acquire the interest of the lessee or licensee; or
- d) if the land is held from the Crown under an agreement to purchase—the person who has the right to purchase; or
- e) a person who holds native title in the land; or
- f) a person who has arrogated to himself or herself (lawfully or unlawfully) the rights of an owner of the land;

and includes an occupier of the land and any other person of a prescribed class included within the ambit of this definition (under the NRM Act) by the regulations.

Peramangk — Aboriginal people who identify with the Country on the eastern side of the escarpment of the Mount Lofty Ranges. The Peramangk people share close relationships, culture and some language with the nations of the Kaurna to the west, Ngadjuri to the north, Ngarrindjeri to the south and meru to the east. Whilst the Peramangk area is not subject to a native title claim, should one be made in the future then both MACAI and the claimants or holders of native title will be entitled to be consulted and dealt with in the Peramangk area about their respective responsibilities within the Peramangk nation.

Percentile — a way of describing sets of data by ranking the dataset and establishing the value for each percentage of the total number of data records. For example, the 90th percentile of the distribution is the value such that 90% of the observations fall at or below it.

Phreatophytic vegetation — plants that draw water from the underground watertable to maintain vigour and function.

Point of injection — an *artificial recharge* well through which water is pumped or gravity-fed into an aquifer.

Potable water — water suitable for human consumption such as drinking or cooking water.

Pre-development runoff and recharge — the mean annual volume expected to return to water resources from a site under conditions prior to a *designated urban land use development*. The volume of *pre-development runoff and recharge* for a *designated urban land use development* is determined in accordance with principle 89 d).

Prescribed water resource — a water resource declared by the Governor to be prescribed under the NRM Act, and may include surface water, watercourses and underground water (to which access is obtained by prescribed wells). Prescription of a water resource requires that future management of the resource be regulated via a licensing system.

Prescribed watercourse — a watercourse declared to be a prescribed watercourse under the NRM Act.

Prescribed well — a well declared to be a prescribed well under the NRM Act.

Property — an allotment or contiguous allotments owned or occupied by the same person, persons or body and operated as a single unit. Allotments will be considered to be contiguous if they abut at any point, or are separated only by a road, street, lane, footway, court, alley, railway, thoroughfare, easement, right-of-way, watercourse, channel or a reserve or similar open space.

Ramsar Convention — an international treaty on wetlands titled *The Convention on Wetlands of International Importance Especially as Waterfowl Habitat*. It is administered by the International Union for Conservation of Nature and Natural Resources. It was signed in the town of Ramsar, Iran in 1971, hence its common name. The convention includes a list of wetlands of international importance and protocols regarding the management of these wetlands. Australia became a signatory in 1974.

Recharge — replenishment of water to an aquifer.

Recharge allocation — an allocation granted in accordance with section 5.3.2 of the Plan, to allow recovery of water that has been drained or discharged into a well.

Recharge year — the *water use year* in which water has been drained or discharged into a well to give rise to a *recharge allocation*.

Regional evaporation and consumptive use limit — this limit applies to *evaporation plus consumptive use from surface water and watercourses*, at the scale of the Eastern Mount Lofty Ranges PWRA (given in Table 4.4).

Regional underground water consumptive use limit — this limit applies to *consumptive use from underground water*, at the scale of the Eastern Mount Lofty Ranges PWRA (given in Table 4.4).

Relevant land — as per principle 29 c), for the purposes of principles 28–32, means land within the *Angas Bremer Irrigation Management Zone* (shown in Figure 4.12) that is:

- a) owned by the licensee; or
- b) owned by any other person, with the written consent of that person for the use of that land for activities in accordance with principle 28; or
- c) under the care, control and management of the relevant Local Council (under the *Local Government Act 1999*, the *Crown Land Management Act 2009* or other relevant legislation), the South Australian Murray-Darling Basin Natural Resources Management Board, or a Minister, instrumentality or agency of the Crown; with the written consent of that Council, Board, Minister, instrumentality or agency for the use of that land for activities in accordance with principle 28.

Resource capacity — in general, the total amount of water available to meet all water demands, including consumptive use and the needs of the environment, on a long-term average annual basis. For the Plan, it has been determined as the long-term mean annual volume or rate of water inflow to a water resource that is expected to occur in the current landscape in the absence of water resource development.

The resource capacity for surface water and watercourse water combined is equivalent to the *mean annual adjusted runoff*, and is given for each surface water catchment in Table 1.4, and for each surface water management zone in Table 4.5 (in ML).

The resource capacity for underground water is the mean annual recharge volume (or input via throughflow for aquifers with no/minimal current rainfall recharge), and is given in Table 1.5 (and also Table 4.7) for each underground water management zone (in ML).

Reticulated water — water supplied through a piped distribution system.

Riparian zone — that part of the landscape adjacent to a water body that influences and is influenced by watercourse processes. This can include landform, hydrological or vegetation definitions. It is commonly used to include the in-stream habitats, bed, banks and sometimes floodplains of watercourses.

Rollover allocation — an allocation granted in accordance with principles 71–79 or 113–123, allowing part of an unused water allocation to be taken in subsequent *water use years*.

Roof runoff — water that runs off a roof after having fallen as rain or hail or having precipitated in any other manner.

Roof runoff allocation — a surface water allocation of *roof runoff*, which is assigned to a *source* identified as roof runoff, granted in accordance with section 5.2.3 of the Plan.

Roof runoff Notice of Authorisation — the Notice of Authorisation to take water in the South Australian Government Gazette, 30 August 2012, pages 3921–3928, or its successors.

Runoff — water flowing over land or in a natural or man-made drain, after having fallen as rain or hail or having precipitated in any other manner.

Runoff evaporation and consumptive use limit — this limit applies to *evaporation plus consumptive use from surface water and watercourses* from outside of a *main watercourse*, within a *surface water management zone*. This limit is given for each surface water management zone in Table 4.5, and has been calculated as 20% of the mean annual adjusted runoff.

Ruwe / Ruwar — Ngarrindjeri Country: represents the interconnectedness between lands, waters, body, spirit and all living things.

SA Geodata — a collection of linked databases storing geological and hydrogeological data. The Department should be contacted for database extracts related to underground water.

Significant environmental asset — includes any wetland, watercourse or water-dependent ecosystem that contains:

- a) any water-dependent threatened ecological community listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act);
- b) any water-dependent species listed as threatened flora or threatened fauna under the EPBC Act;
- c) any water-dependent species listed in Schedules 7, 8 or 9 of the South Australian *National Parks and Wildlife Act 1972*; and/or
- d) any species protected under the South Australian *Fisheries Management Act 2007*.

The locations of significant environmental assets used for the purposes of the Plan will be identified in a database. Indicative locations of significant environmental assets identified to the date of map production are shown in Figure 4.11.

Source — a specific point at which water is taken and its associated water-taking infrastructure, such as a given well, *diversion structure* or roof.

Source water—water to be drained or discharged into a well.

Stock use — the taking of water for watering stock that are not subject to *intensive farming*.

Stream order — a method of classifying the size of a part of a watercourse, based on the hierarchy of connecting watercourse segments. The Strahler stream ordering system is used in the Plan. The most upstream part of a watercourse is a first order stream. Two first order watercourses join together to become a second order watercourse. Two second order watercourses join together to become a third order watercourse and so on. Arthur Strahler first proposed the approach in 1952 in an article in the Geological Society of America Bulletin.

Structure — something built or constructed, including, but not limited to, a ford, causeway, culvert, fence, jetty, boat mooring, weir or retaining wall.

Stygofauna — fauna that live within underground water systems, including caves and aquifers.

Surface water — has the same meaning as in section 3 (1) of the NRM Act, meaning:

- a) water flowing over land (except in a watercourse) —
 - i) after having fallen as rain or hail or having precipitated in any other manner; or
 - ii) after rising to the surface naturally from underground;
 - b) water of the kind referred to in paragraph a) that has been collected in a dam or reservoir;
 - c) water of the kind referred to in paragraph a) that is contained in any stormwater infrastructure;
 - d) water in a watercourse if the watercourse, or particular part of a watercourse, is declared by proclamation under subsection (13) (of the NRM Act) to constitute surface water for the purposes of the NRM Act.

Surface water catchment — a catchment in the Eastern Mount Lofty Ranges PWRA, as shown in Figure 4.2.

Surface water management zone (SWMZ) — a part of a surface water catchment as shown in Figure 4.3 to Figure 4.9, with key characteristics of each zone given in Table 4.5.

Surface water management zone interception limit — the volume of *interception* that should not be exceeded for each surface water management zone, given in Table 4.5.

System provisions — the system provisions (in its simplest form) is water that has been set aside from the resource capacity for system processes and environmental provisions, and is not available for allocation for consumptive purposes. For the purposes of section 5–7 of the Plan, *system provisions* of a surface water or underground water management zone are determined in accordance with principle 17.

Taxa — general term for a group identified by taxonomy, which is the science of describing, naming and classifying organisms.

Threshold flow rate — the flow rate at or below which water must not be taken, or if taken is to be returned to the same watercourse or surface water *flow path* immediately downstream of the *diversion structure* as soon as reasonably practical (in accordance with principles 53–59 and/or 207–210). The threshold flow rate is determined in accordance with principle 55. The threshold flow rate is also used to determine when a *flow event* has ended in relation to the taking of *lower Angas Bremer allocations*, as per principle 67.

Time to peak flow — the amount of time between the centre of mass of rainfall excess (the point at which half the rain that's running off has fallen) and the peak of the hydrograph (maximum flow rate generated by the runoff).

Total Dissolved Solids (TDS) — a measure of water salinity, measured in milligrams per litre (mg/L).

Traditional Country — is a non-Aboriginal term that recognises the connections, relationships, authority and responsibilities of particular Aboriginal nations (including native title holders and claimants where native title rights are concerned and or as described in an ILUA) to the living entities of land and sea. 'Sea Country' – the coasts and oceans – forms an integral part of 'Country' as the lands and seas are not considered separately. It has a markedly different meaning than the English language definition. For Aboriginal people, they are a part of the living body of their Country, they are Country. Country is capitalised when used. Country also refers to area(s) that an Aboriginal person has rights and responsibilities for (and where the Aboriginal person is a native title holder or claimant will include responsibilities according to the laws and customs that form the native title rights and interests). All parts of South Australia, the lands, waters, seas, sky and even metropolitan and townships are the Country of an Aboriginal nation.

Transmissivity — a parameter indicating the ease of underground water flow through a metre width of aquifer section.

Tributary — a river or creek that flows into a larger river.

Twentieth percentile exceedance non-zero flow — the daily flow rate that is equalled or exceeded for 20% of the time when water is flowing.

Underground water — has the same meaning as in section 3 (1) of the NRM Act, meaning (a) water occurring naturally below ground level; (b) water pumped, diverted or released into a well for storage underground.

Underground water consumptive use limit — this limit applies to *consumptive use from underground water* within an underground water management zone. This limit is given for each underground water management zone in Table 4.7, and has been calculated as resource capacity minus baseflow minus throughflow.

Underground water management zone — a defined zone for the purpose of underground water management, based on the predominant type of aquifer. Underground water management zones are identified in Table 4.7 and shown in Figure 4.10.

Unit threshold flow rate — used to determine the *threshold flow rate* in accordance with principle 55. Given in Table 4.5 for surface water management zones.

Urban runoff — as per principle 89 c), means the mean annual volume of water expected to run off a *designated urban land use development*, as determined to the satisfaction of the Minister by a suitably qualified hydrologist or engineer. The runoff from roofs that is already allocated as a *roof runoff allocation* in the designated urban land use development shall not be included in the calculation of urban runoff.

Urban runoff allocation — as per principle 89 a), means an allocation of water running off a *designated urban land use development*, granted in accordance with section 5.2.4 of the Plan.

Water affecting activities — activities referred to in section 127 of the NRM Act.

Water allocation — in respect of a water licence, has the same meaning as in section 3 (1) of the NRM Act, and means an allocation under the terms of a licence in accordance with chapter 7, part 3, division 2 of the NRM Act.

Water allocation plan (WAP) — a plan prepared by a NRM Board and adopted by the Minister in accordance with requirements of the NRM Act in relation to water allocation plans.

Water licence — has the same meaning as in section 3(1) of the NRM Act and means a licence granted by the Minister under section 146 of the NRM Act.

Water quality criteria — has the same meaning as in the *Environment Protection Act 1993* and any associated policy.

Water use efficiency — relates to the application of water. The application of water should not exceed the industry or theoretical enterprise requirement and associated management factors, taking into consideration local and recent climatic data, by greater than 20% per year for a maximum of three consecutive years.

Water use year — the period between 1 July in any given calendar year and 30 June in the following calendar year.

Watercourse — has the same meaning as in section 3 (1) of the NRM Act, meaning a river, creek or other natural watercourse (whether modified or not) in which water is contained or flows whether permanently or from time to time and includes:

- a) a dam or reservoir that collects water flowing in a watercourse;
- b) a lake through which water flows;

- c) a channel (but not a channel declared by regulation to be excluded from the ambit of this definition (under the NRM Act)) into which the water of a watercourse has been diverted;
- d) part of a watercourse;
- e) an estuary through which water flows; and
- f) any other natural resource, or class of natural resource, designated as a watercourse for the purposes of the NRM Act by an NRM plan.

Water-dependent ecosystems — those parts of the environment, the species composition and natural ecological processes, that are determined by the permanent or temporary presence of flowing or standing water, above or below ground. The in-stream areas of rivers, riparian vegetation, springs, wetlands, floodplains, estuaries, lakes and aquifer ecosystems are all water-dependent ecosystems.

Well — has the same meaning as in section 3 (1) of the NRM Act, meaning:

- a) an opening in the ground excavated for the purpose of obtaining access to underground water;
- b) an opening in the ground excavated for some other purpose but that gives access to underground water;
- c) a natural opening in the ground that gives access to underground water.

Well buffer zone — as per principle 98, a well buffer zone is a circular area centred on an *operational well*. The well buffer zone is linked to the aquifer that the well takes water from. The radius of the well buffer zone is determined in accordance with Table 5.1 and principles 100 and 101.

Wetland — has the same meaning as in section 3 (1) of the NRM Act, meaning an area that comprises land that is permanently or periodically inundated with water (whether through a natural or artificial process) where the water may be static or flowing and may range from fresh water to saline water and where the inundation with water influences the biota or ecological processes (whether permanently or from time to time) and includes any other area designated as a wetland—

- a) by an NRM Plan; or
 - b) by a Development Plan under the *Development Act 1993*,
- but does not include—
- c) a dam or reservoir that has been constructed by a person wholly or predominantly for the provision of water for primary production or human consumption; or
 - d) an area within an estuary or within any part of the sea; or
 - e) an area excluded from the ambit of this definition (under the NRM Act) by the regulations.

Aboriginal nations refer to freshwater wetlands as ‘nurseries’ in recognition of the important role these areas play in providing food and shelter for many types of animals, birds and fish (ngartjis). Submerged plants in these nursery areas are critical for food and shelter for animals and their young) (DEWNR, 2017). The nurseries are regarded as the lungs of the system that cleanse the body (land).

Yarluwar-Ruwe — Ngarrindjeri ‘Sea Country’: represents the interconnectedness between what western traditions understand as sea and land, fresh water and salt. The Eastern Mount Lofty Ranges PWRA forms part of Ngarrindjeri Yarluwar-Ruwe.



Natural Resources
SA Murray-Darling Basin



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