Eastern Mount Lofty Ranges Prescribed Water Resources Area – Water Allocations for Management Zones Risk Assessment

DEWNR Technical report 2015/12

Government of South Australia
Department of Environment, Water and Natural Resources

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Preface

This report is the first of two that together describe how the risk caused by high demand for water in the Eastern Mount Lofty Ranges (EMLR) was categorised and then how specific zones were assigned to risk categories.

Initial studies completed during the EMLR water allocation planning process indicated the volumes of water needed for the existing user allocation process[1] are potentially greater than the resource can support for some underground water and surface water management zones.

The risk assessment documented in this report identifies, analyses and evaluates potential risks to EMLR water resources caused by high demand. It determines the level of risk for each underground and surface water management zone if all licence holders use their full proposed water allocations. It also presents recommendations regarding the priority for treatment to reduce the risk level.

A second report, *Methodology for assigning management zones in the Eastern Mount Lofty Ranges Prescribed Water Resources Area to high demand categories (categorisation report)* (DEWNR, 2015) establishes a method for categorising water resource management zones based on priority for risk treatment. It builds on the risk assessment report by considering additional information about specific management zones and water demand.

The categorisation report assigns water resource management zones into one of four categories (i.e. low demand, category 1, category 2, and category 3). These categories informed the issuing and management of licences through the existing user process[2]. These categories have been renamed to show priority for risk treatment:

- Low demand = Low
- Category 1 = Medium
- Category 2 = High
- Category 3 = Very high

The definitions for each of these categories are as follows:

> ***Low –*** *water sources are located in an area where the water demand is within the sustainable limit. The best available science suggests there is a negligible risk that the water resources and/or water users would be negatively impacted if every licence holder in these zones used their full water allocation. In these management zones, water resource condition will be monitored and evaluated as part of the base regional program.*
>
> ***Medium –*** *water sources are located in an area where water demand is higher than the sustainable limit. However, best available science suggests there is a low risk that the water resources and/or water users would be negatively impacted if every licence holder in these zones used their full water allocation.*

[1] Existing users are people who either took water from the Eastern Mount Lofty Ranges Prescribed Water Resources during the establishment period (1 July 2000 to 16 October 2003) or who committed significant financial, legal or other resources to a project within this period that would require access to water and applied for a water licence within the statutory application period. This is in accordance with section 164N of the *Natural Resources Management Act 2004*.

[2] Water allocations initially granted to existing users were based on the scale and type of water use declared during the establishment period, including any significant commitment (see footnote 1). This means the allocations initially granted to existing users were not changed to consider scientific evidence on the risk of damage to the water resource.

In these management zones, water resource condition will be monitored and evaluated, allowing assessment of whether further action is required.

High – *water sources are located in an area where water demand is higher than the sustainable limit. The best available science suggests there is a medium to high risk that the water resource and/or water users would be negatively impacted if every licence holder in these zones used their full water allocation. In these management zones, there will be targeted water resource condition monitoring and evaluation, and licensed water use will be measured more frequently. Action may be taken to address the risk to the water resource if negative impacts come to light or there is an ongoing risk of negative impacts. Water users will be consulted prior to the implementation of any strategy to manage high water demand.*

Very high – *water resources are located in an area where water demand is higher than the sustainable limit. The best available science suggest that the water resources, water users and/or dependent ecosystems are being negatively impacted, or that there is a serious risk that they will be, particularly if every licence holder in these management zones used their full water allocation. In order to sustainably manage the resource in the long term for all users in these areas, there is a need to reduce the demand for water.*

The Department of Environment, Water and Natural Resources and the South Australian Murray-Darling Basin Natural Resources Management Board will actively partner with the community to find solutions to manage water demand.

For further information on the Managing High Water Demand project, please visit the following website http://www.naturalresources.sa.gov.au/samurraydarlingbasin/water

Executive summary

Following prescription of the Eastern Mount Lofty Ranges (EMLR) Prescribed Water Resources Area (PWRA) in 2005, a water allocation plan (the WAP) (SAMDB NRM Board, 2013) has been developed through a process of community engagement to define the objectives and principles governing use of water resources in the EMLR. Section 164N of the Natural Resources Management Act 2004 (the Act) requires that existing water users are provided with water allocations based on their reasonable requirements. This process, known as the existing user process, occurs in parallel with the WAP development process and is not bound by the principles of the WAP including extraction limits.

Initial investigations determined that water allocations proposed through the existing user process potentially exceed extraction limits defined by the WAP for a number of surface and underground water management zones. These high allocations could lead to unanticipated and/or undesirable changes in water resource condition which, in turn, could cause degraded water dependent ecosystems and/or reduced beneficial use values in the EMLR PWRA. A risk assessment has been undertaken to identify, analyse, evaluate and make generic treatment recommendations for water resource risks caused by these proposed water allocations.

This risk assessment was undertaken in 2012 in accordance with the *Risk Management Framework for Water Planning and Management* (DEWNR, 2012a) and is consistent with the *AS/NZS ISO 31000:2009 Risk management – Principles and guidelines* (Joint Technical Committee OB-007, Risk Management, 2009) (AS/NZS ISO 31000:2009). The risk assessment process involved participation of multiple stakeholders having a role in the planning and management of water resources in EMLR region. The assessment drew on relevant surface water, ground water and ecology knowledge and data.

In accordance with the AS/NZS ISO 31000:2009 risk management guidelines, this risk assessment involved the following steps:

- Establishing the context for the risk assessment and determination of the risk assessment criteria (i.e. metrics by which risks will be assessed)
- The risk assessment, involving
    - Risk identification
    - Risk analysis (i.e. measurement of likelihood, consequence and risk level)
    - Risk evaluation (i.e. determination of risk tolerability)
- Generic recommendations regarding treatment of risks

The following risk statement was identified describing the circumstances of the risk, including sources of risk, water resource events and potential consequences to be investigated:

> *There is the potential that water allocations given to existing users at a rate exceeding the allocation and consumptive use limits will lead to significant decline/alteration in the condition of water resources and/or water dependent ecosystems within a management zone*

Risk was rated on the basis of the likelihood and consequence of changes in water resource condition. Development of all risk criteria drew on the scientific knowledge and data regarding resource and ecosystem response which underpins many of the objectives and principles of the EMLR WAP.

Likelihood criteria for both surface and underground water are based on the extent to which the extraction limits established by the WAP could be exceeded by the proposed allocations. In addition to this factor, the likelihood analysis for SWMZs considered the potential effects on surface water flows caused by groundwater allocations that are greater than extraction limits for those zones having gaining streams.

Consequence criteria for surface water were based on quantification of potential loss of environmental values at the surface water management zone (SWMZ) scale. Determination of the potential severity of consequences drew on

data including observations of fish species, macroinvertebrates and the presence of significant wetlands/habitat. Determination of consequence severity for UWMZs addressed potential degradation of groundwater quantity and quality affecting beneficial use values, and local (i.e. within zone) impacts to groundwater dependent ecosystems (GDEs).

Evaluation of risk tolerability and determination of generic treatment recommendations considered the outcomes of the risk analysis (i.e. risk level as a function of likelihood and consequence) and confidence ratings for the risk analysis process. Confidence was rated for each risk according to availability of data and knowledge and level of agreement on assessments among risk assessment participants. In accordance with the precautionary principle, lower confidence is correlated with reduced risk tolerability and more proactive recommendations regarding treatment of risks.

To keep the risk assessment process manageable, risks were assessed only for those SWMZs and UWMZs where existing user allocations exceeded the consumptive use limit set by the EMLR WAP. These included 53 out of a total of 193 SWMZs and six out of a total of 23 UWMZs. The assessment did not consider four Quaternary aquifer UWMZs from which there is no current demand for licensed water use..

The SWMZ risk analysis identified one extreme risk, 28 high risks, 20 moderate risks and four low risk zones. Of these, the following generic recommendations were made for SWMZs on the basis of the risk evaluation criteria:

- One SWMZ (426AR026) has an extreme level of risk requiring high priority treatment to reduce risk.
- Thirteen additional SWMZs have an intolerable level of risk due in part to lower confidence in the information supporting the assessment. In these cases an acceptable course of action may be to improve the confidence in the risk assessment within a reasonable timeframe before making decisions regarding treatment
- Twenty eight SWMZs have a level of risk that is tolerable subject to being as low as reasonably practicable (ALARP). No action to reduce risk is required if it can be demonstrated that the costs of treatment significantly outweigh the benefits
- Eight additional SWMZs also have a level of risk that is tolerable subject to ALARP. However in these cases it is a lack of confidence in the risk assessment that precludes the risk level from being deemed acceptable. It is appropriate that further investigations to improve confidence for these risks should have lower priority than investigations to address intolerable risks.
- Three SWMZs have a risk level that is acceptable and thus require no treatment to reduce risk apart from an appropriate level of monitoring

Any treatment options to reduce risk level within a SWMZ should consider action to address the source of risk both within the zone and in connected upstream zones, and in underground water management zones providing baseflow.

The analysis of risks to beneficial use values of UWMZs identified two extreme risks, one high risk, three moderate risks and zero low risks. Of these, the following recommendations are made for the UWMZs assessed:

- Two UWMZs (Currency Limestone and Tookayerta Permian) have an extreme level of risk and should be treated to reduce risk
- Four UWMZs have a level of risk tolerable subject to ALARP. No action to reduce risk is required if it can be demonstrated that the costs of treatment significantly outweigh the benefits

The UWMZ 'impact on GDEs' risk analysis identified one extreme risk, three high risks, one moderate risk and one low risk. Of these, the following recommendations are made for the UWMZs assessed:

- One UWMZs (Tookayerta Permian) has an extreme level of risk and should be treated to reduce risk
- Four UWMZs have a level of risk that is tolerable subject to ALARP. No action to reduce risk is required if it can be demonstrated that the costs of treatment significantly outweigh the benefits

- One UWMZ (Currency Limestone) has a low level of risk for this consequence category. It is a confined aquifer having no groundwater dependent ecosystems.

The risk treatment recommendations produced from the risk are intended to be generic in nature. They do not outline specific controls to address the likelihood or consequence of an identified risk. Instead they provide a guide regarding the *minimum level of action* that is warranted given the tolerability of risks and the level of confidence in the analysis of risks.

1. Background and context

1.1. Introduction and purpose

The Eastern Mount Lofty Ranges (EMLR) Prescribed Water Resources Area (PWRA) was proclaimed on 8 September 2005 under the *Natural Resources Management Act 2004* (the NRM Act). This triggered development of the EMLR Water Allocation Plan (WAP) (SAMDB, 2014) which establishes the objectives and principles governing use of surface and underground water resources of the PWRA.

In accordance with the section 164N of the NRM Act, existing users in the EMLR PWRA are to be provided with water allocations based on their reasonable requirements. Determination of these allocations takes into consideration economic, social and environmental factors through an approach known as the existing user process. The existing user process is separate to the water allocation planning process meaning that existing user water allocations are not bound by the objectives and principles of the WAP including the extraction limits.

Initial investigations identified that the proposed existing user water allocations were likely to lead to the extraction limits defined by the WAP being exceeded for a number of surface and underground water management zones (SWMZ and UWMZ respectively). Therefore, a risk assessment was undertaken in 2012 to identify, analyse and evaluate potential risks to the water resources and water dependent ecosystems of the EMLR PWRA caused by extraction resulting from these proposed allocations.

It is anticipated the outcomes of this risk assessment will contribute to decisions regarding i) implementation of the existing user allocation process, ii) implementation of the EMLR WAP and iii) deployment of additional measures available under existing legislation and policy frameworks.

Risk has been analysed and reported at the spatial scale of surface and underground water management zones established by the EMLR WAP. These are delineated in the maps presented in Figure 2 and Figure 3. Note that zone names in all SWMZ maps 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.

The risk assessment approach adopts the principles and processes of DEWNR's *Risk Management Framework for Water Planning and Management* (DEWNR, 2012a), which is consistent with the *AS/NZS ISO 31000:2009 Risk management – Principles and guidelines* (Joint Technical Committee OB-007, Risk Management, 2009) (AS/NZS ISO 31000:2009).

1.2. Eastern Mount Lofty Ranges water allocation plan (EMLR WAP)

The water resources of the EMLR PWRA were prescribed in 2005 due to concerns regarding existing and potential environmental impacts caused by development of these resources.

The EMLR WAP aims to maintain and/or restore self-sustaining populations of aquatic and riparian flora and fauna which are resilient in times of drought. The approach to achieving this objective has been to define environmental water provisions (EWPs) which fulfil key components of the environmental water requirements (EWRs) of the PWRA while having the least possible impact on the social and economic objectives for regional stakeholders.

Accordingly, the WAP outlines the following objectives for regional EWPs:

- Pass 85% of EWR metrics defined for the majority (i.e. at least 50%) of sites in the EMLR PWRA, and
- Ensure that baseflow is protected.

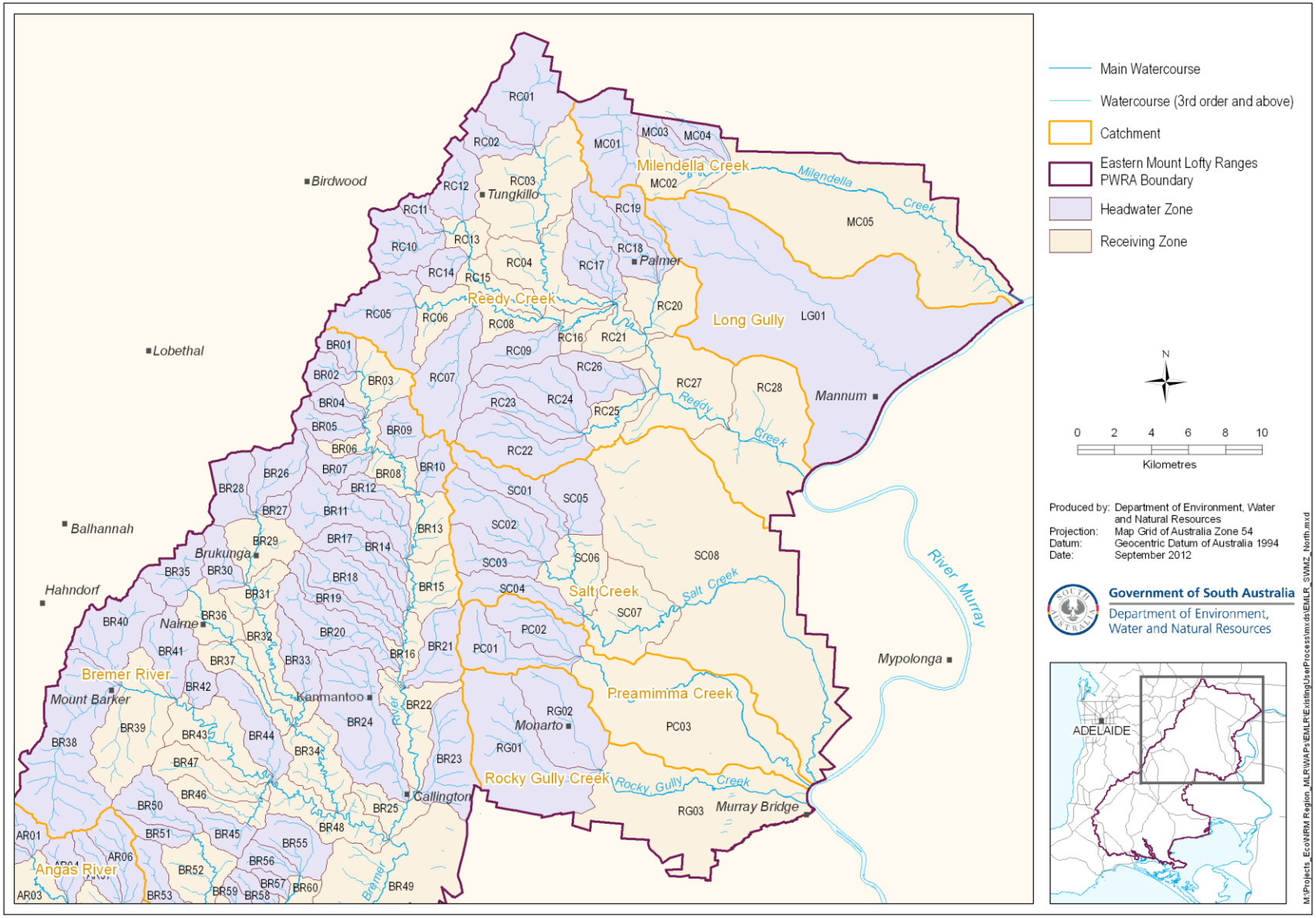
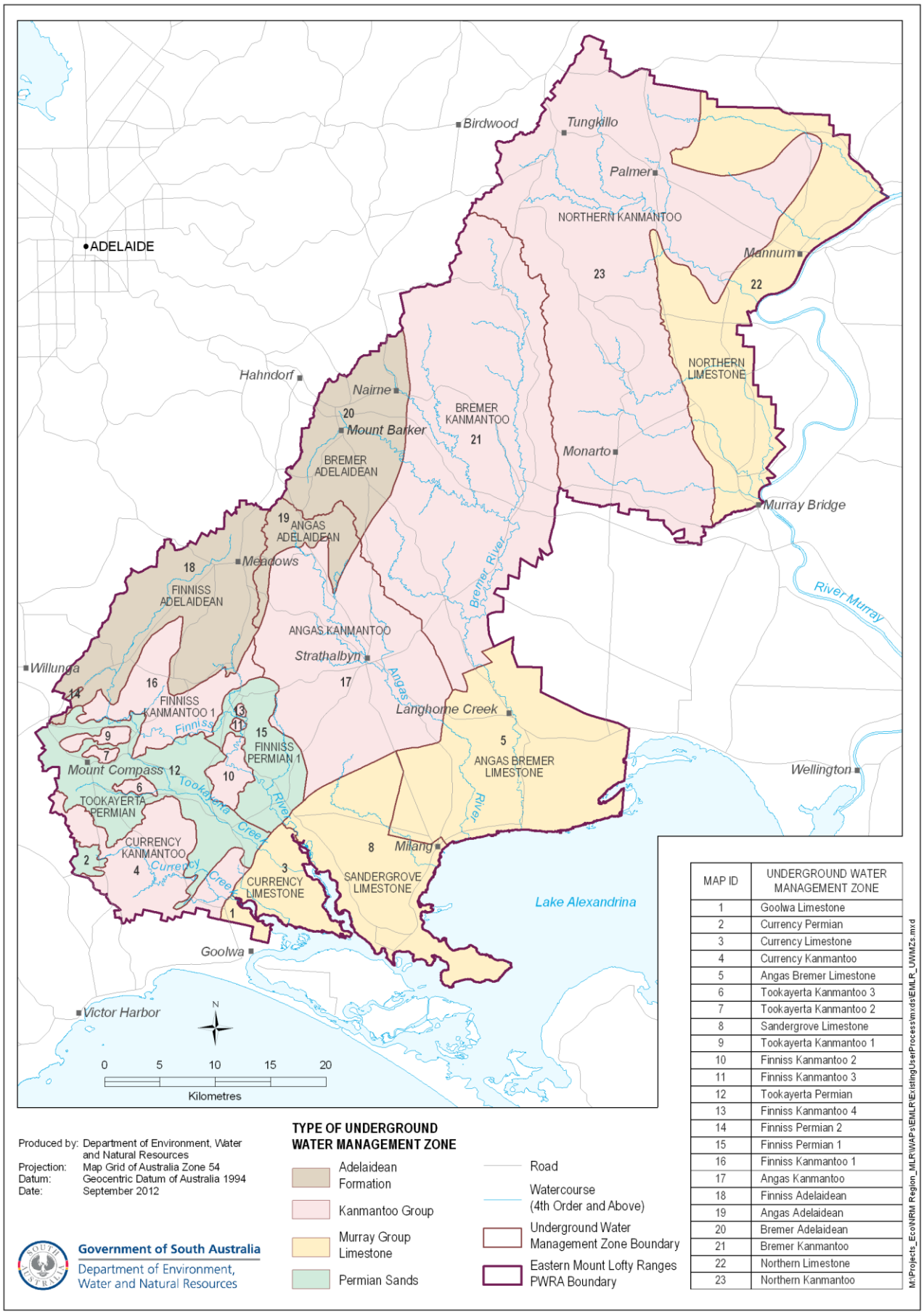


Figure 1. Eastern Mount Lofty Ranges Prescribed Water Resources Area Surface Water Management Zones (North)

Figure 2. Eastern Mount Lofty Ranges Prescribed Water Resources Area Surface Water Management Zones (South)



MAP ID	UNDERGROUND WATER MANAGEMENT ZONE
1	Goolwa Limestone
2	Currency Permian
3	Currency Limestone
4	Currency Kanmantoo
5	Angas Bremer Limestone
6	Tookayerta Kanmantoo 3
7	Tookayerta Kanmantoo 2
8	Sandergrove Limestone
9	Tookayerta Kanmantoo 1
10	Finniss Kanmantoo 2
11	Finniss Kanmantoo 3
12	Tookayerta Permian
13	Finniss Kanmantoo 4
14	Finniss Permian 2
15	Finniss Permian 1
16	Finniss Kanmantoo 1
17	Angas Kanmantoo
18	Finniss Adelaidean
19	Angas Adelaidean
20	Bremer Adelaidean
21	Bremer Kanmantoo
22	Northern Limestone
23	Northern Kanmantoo

Figure 3. Eastern Mount Lofty Ranges Prescribed Water Resources Area Underground Water Management Zones

Key mechanisms outlined by the WAP for achieving these provision objectives include:

- An evaporation and consumptive use limit of 20% of upstream mean annual adjusted runoff
- Return of flows at or below the threshold flow rate around licensed dams and diversion structures and dams used for non-licensed purposes with a capacity of 5 ML or greater
- An interception limit of 30% of the upstream mean annual adjusted runoff

For underground water resources, the WAP requires:

- Water is allocated sustainably
- Natural flow through aquifers be maintained
- Environmental buffer zones are placed around all environmental assets and main watercourses

Since the rights of existing users must be recognised based on their reasonable requirements, allocations to those users are not subject to limits established by the WAP. However, the Act also requires that the Minister assess the needs of water dependent ecosystems (section 164N (4)), and take these needs into account when making decisions based on the quantity of water available or the periods of availability (section 170).

This risk assessment considers the likelihood and consequences of events over the life of the current WAP – i.e. ten years.

1.3. Stakeholders

Stakeholders are people or organisations that can affect, be affected by, or perceive themselves to be affected by a decision or activity. For the purposes of this risk assessment, stakeholders are classified as follows:

- *Stakeholders impacted by risk*, including;
    - Existing and prospective water users in the EMLR
    - Landholders
    - Relevant industry associations
    - Relevant NGOs
    - Community groups
    - Aboriginal groups
    - SA Water
- *Stakeholders with jurisdictional authority over elements of water resource risk,* including
    - The Minister for Sustainability, Environment and Conservation
    - SA Murray-Darling Basin NRM Board
    - Department of Environment, Water and Natural Resources (DEWNR) (in particular, the water licensing function)
    - Environment Protection Authority (EPA)
    - Murray-Darling Basin Authority (MDBA)
    - Local Government
    - Primary industry and Regions SA (PIRSA)
    - SA Water

- *Stakeholders who contribute specialist knowledge to the risk assessment process*, including
    - DEWNR (in particular, the science, monitoring and water licensing functions)
    - SA MDB NRM Board
    - EPA

1.4. Outputs of risk assessment

In accordance with the AS/NZS ISO 31000:2009 risk management standard, this report documents the following process:

- Definition of risk statements which describe the chain of circumstances giving rise to risk including the source of risk, water resources events, and consequences arising from events
- Analysis of the level of risk for surface and groundwater resources caused by proposed allocations to existing users, where
    - Surface water risks are analysed at the surface water management zone (SWMZ) scale, and
    - Underground water risks are analysed at the underground water management zone (UWMZ) scale
- Evaluation of the risk level to determine the acceptability or tolerability of risk for each management zone
- A recommendation for each surface and underground water management zone regarding the minimum level of treatment appropriate for each risk that has been assessed.

Note that specific treatment recommendations for assessed risks are out of the scope of this report. Where treatment is recommended, management actions to reduce risk will likely depend on the level of risk and the feasibility of different treatment options.

Water licences within relevant limits of the EMLR WAP had already been issued within the Angas Bremer Prescribed Wells Area (coincides with the Angas Bremer Limestone and Angas Bremer Quaternary zones of the EMLR PWRA). Therefore these zones are not considered by this assessment.

1.4.1. Caveats

Estimates of reasonable requirements for existing licensed users continued to be refined up until the point at which licenses were issued. The estimated allocations underpinning this assessment are based on data received prior to the finalisation of licenses. This means that for some management zones there may be discrepancies between the proposed and actual allocations. It is therefore recommended that policy decisions made on the basis of this assessment should consider the most up to date data regarding allocations.

Furthermore it should be recognised that an existing user's requirements are estimated on the basis of the type and size of the water-using enterprise(s) that an existing user operated during the establishment period (1 July 2000–16 October 2003 in the EMLR) and development that the user made significant commitment towards before the end of the establishment period. This means that the volumes to be allocated to existing licensed users may not necessarily reflect current or historical use. For example water may be allocated for commitments not yet developed, or the user may use water at a different rate to the theoretical requirements.

A key assumption underpinning this risk assessment is that water users will use their full entitlements, and hence this work considers the maximum potential risk. If users are not currently using their full entitlements, then the potential risk may not be manifest.

2. Risk assessment method and criteria

2.1. Risk assessment method

The risk assessment methodology has been derived from the framework presented in DEWNR (DEWNR, 2012 a) which is consistent with AS/NZS ISO 31000:2009 (Joint Technical Committee OB-007, Risk Management, 2009). The risk management process is comprised of the following steps:

1) *Establishing context*, which involves determining the internal and external parameters to be taken into account when managing risk and setting the risk criteria
2) *Risk assessment*, involving:
    a. *Risk identification*, whereby risks are identified, recognised and described
    b. *Risk analysis*, which involves comprehending the risk and determining the risk level, and
    c. *Risk evaluation*, whereby the results of the risk analysis are compared with criteria to determine the acceptability or tolerability of the risk level
3) *Risk treatment*, whereby actions are taken to modify the risks.

This report describes the context and risk assessment process, but not risk treatment (i.e. steps 1 and 2, but not 3). It is intended that the risk assessment documented by this report informs decisions regarding the treatment of intolerable risks.

The level of risk is correlated with the likelihood and consequences of an event, where an event relates to some unanticipated or undesirable change in the status of the water resource. For the purposes of this assessment it was decided that determination of likelihood and consequence draw principally on scientific data, information and knowledge used to inform the development of the WAP.

Examples of the considerations and data used for a SWMZ and UWMZ risk assessment are shown in the Appendix.

2.2. Risk identification

In accordance with DEWNR (DEWNR, 2012b), a risk statement can be expressed in a generic form that articulates a timeline or chain of circumstances as follows:

'There is the potential for *risk source* to lead to *event* which in turn leads to *consequence*'

Elements of the risk statement were defined as follows:

Risk Source: Water allocations given to existing users at a rate exceeding the allocation and consumptive use limits

Event: Declines in water availability and/or quality and/or alteration of water availability pattern

Consequence: Significant decline and/or alteration in condition of water resources and/or water dependent ecosystems

The following generic risk statement for surface water and underground water management zones was identified given these elements of risk:

There is the potential that water allocations given to existing users at a rate exceeding the allocation and consumptive use limits will lead to significant decline/alteration in the condition of water resources and/or water dependent ecosystems within a management zone

This risk statement covers the scope of the analysis documented by this report.

For SWMZs the risk assessment addresses the potential for degradation of environmental values including fish species, macro-invertebrates and habitat values. It is assumed that risks to beneficial use of these resources (i.e. to social and economic values) are correlated with environmental risks for SWMZs.

For UWMZs, the risk assessment considers two classes of consequence, including

- Altered condition of groundwater resources, and
- Impacts on Groundwater Dependent Ecosystems (GDEs)

The first of these consequence classes considers the potential for groundwater events (i.e. changes in water quantity and/or quality) to impact the beneficial use values of the resource (i.e. consumptive use for irrigation, stock, domestic, industrial use etc). The second consequence class is concerned with the potential for local impacts (i.e. within-zone) of groundwater use on GDEs caused by use within the UWMZ.

It was recognised that proposed water allocations are a source of risk for both the management zone in which the allocation is made and for other connected management zones of the PWRA (e.g. downstream zones or zones linked through surface-groundwater interactions). Therefore an important principle governing the development of risk criteria is that calculation of risk level should accumulate both the internal and upstream sources of risk for a given management zone.

2.3. Risk analysis – Surface water management zones

2.3.1. Likelihood criteria

Likelihood criteria for the surface water management zone risk assessment are based on the scientific investigations underpinning the environmental water provisions for the WAP.

The WAP established the following environmental water provision to support the ecological objectives of the PWRA:

At least 85% of environmental water requirements are 'passed' for the majority (i.e. at least 50%) of sites

Scientific investigations, including hydrological modelling, were used to configure a number of policies to support this environmental water provision (Section 1.2). A key policy is the evaporation and consumptive use limit of 20% of upstream mean annual adjusted runoff. Modelling demonstrated that use above this limit, even when all other policies are implemented, causes the proportion of sites at which 85% or more metrics are passed to decline below 50%.

Table 1 presents the likelihood and confidence criteria. Likelihood categories are based on the relationship observed between use as a percentage of resource capacity and the proportion of sites at which 85% of environmental water requirement (EWR) metrics are passed. As this relationship was observed to be non-linear and inconsistent above 20% use, it was elected to apply a 'confidence modifier' for certain ranges of use when undertaking the risk evaluation component of this risk assessment.

The confidence modifier was assigned where percentage use was determined to be within 5% of the threshold between the 'possible' and 'likely', and 'likely' and 'almost certain' categories. In these cases the confidence rating is reduced by one level (i.e. from high to 'moderate' or from 'moderate' to 'low'). This approach accounts for the observation that, while the data do not clearly support distinct likelihood categories above 20% demand, the data is generally distributed (i.e. there was a lack of clearly defined clusters separating the data into the categories of 'likely' or 'almost certain') such that as demand increases above the 20% consumptive use limit, the number of sites where at least 85% of EWRs are passed tends to decrease.

Table 1: Likelihood criteria – surface water management zone risk assessment

Likelihood	% Demand	Confidence modifier[3]
Rare	0-4.99%	None
Unlikely	5.00-20.00%	None
Possible	20.01-30.00%	None
	25.01-30.00%	-1 category
Likely	30.01-50.00%	None
	45.01-50.00%	-1 category
Almost certain	> 50.00%	None

As noted in Section 2.2, the risk assessment considers sources of risk internal and external to a SWMZ. Thus the likelihood assessment for a zone accumulates the impact of existing user allocations in all hydrologically connected surface and groundwater management zones as follows:

- Comparison between the total upstream consumptive use limit to total upstream demand, where 'upstream' refers to the entire catchment area at and above the zone being assessed, and
- Consideration of the impact of allocations above environmental sustainable extraction limits (i.e. overallocation) of groundwater on baseflow that flows into the SWMZ being assessed and all upstream zones.

Given this methodology, it is possible that overallocated SWMZs (i.e. high demand relative to consumptive use limit for a specific SWMZ) do not attract a high likelihood score because upstream demand may be low relative to upstream consumptive use limit. Conversely, SWMZs where allocations are within limits may become high risk zones where upstream demand is high relative to the upstream consumptive use limit.

The criteria assume that overallocation of groundwater for some UWMZs could impact baseflow, which in turn could impact some SWMZs. In these cases, the overallocation of groundwater can be considered an additional demand on the water resources available in relevant downstream SWMZs.

Overallocation of groundwater was determined to be a relevant source of risk for SWMZs in the EMLR PWA where significant interactions between surface and groundwater are likely to occur (e.g. gaining streams). However, there is limited data available to quantify these impacts for the purposes of this risk assessment. Therefore, the risk assessment team formulated the following assumptions to inform assessment of this risk factor:

- It is assumed that groundwater extraction has an even or linear impact across the UWMZ
- The relationship between throughflow and baseflow is considered linear throughout the catchments in the SWMZs
- The entire area of a UWMZ contributes equally to baseflow
- Groundwater allocations only impact surface water flow regimes where existing user groundwater allocations are above allocation limits determined for the relevant UWMZs.

Table 2 outlines the method used to incorporate the proposed water allocations of overallocated UWMZs into the total demand on a SWMZ where baseflow is a known contributor to flow regimes.

[3] Table 11 provides criteria regarding assessment of confidence.

Table 2: Steps for calculation of UWMZ allocations on SWMZ demand

Step	Description	Calculation/action
1	Calculate UW impact coefficient for surface water in streams	For each overallocated UWMZ, impact coefficient = baseflow (ML)/recharge (ML)
2	Determine volume of UWMZ overallocation (ML) to be considered in SWMZ allocations	Overallocation (ML) = impact coefficient * overallocation of UWMZ (ML)
3	Convert from ML to mm	overallocation (mm) = overallocation (ML) / UWMZ area (km^2)
4	Transfer overallocation (mm) to SWMZs located inside overallocated UWMZs	Enter overallocation (mm) to SW Zones data layer for each SWMZ inside an overallocated UWMZ
5	Calculate ML impact on each SWMZ	Impact per SWMZ (ML) = impact (mm) * SWMZ area (km^2)
6	Calculate total surface water (SW) and groundwater (GW) impact for each SWMZ	Total SW & GW impact (ML) = SWMZ demand (ML) + Impact per SWMZ (ML)
7	Calculate upstream accumulation of SW/UW demand	For each SWMZ, enter result of step 6 into risk assessment spreadsheet and run accumulation macro

Note that the likelihood criteria are subject to the assumption that all the policies of the WAP designed to support the environmental water provisions, such as restoration of low flows, are implemented.

2.3.2. Consequence criteria

The key philosophy driving the consequence criteria is quantification of potential loss of environmental values at the management zone scale as a result of changes to water quantity/quality or water regimes caused allocations to existing users. In accordance with this principle, consequence criteria are based on the environmental values being put at risk by water use. Table 3 outlines a generic framework for the SWMZ consequence criteria.

Table 3: SWMZ Consequence criteria – environmental values

Rating		Value	Description
5	Catastrophic	Presence of a very high value asset.	Sensitive flow responder with high conservation value (endangered), or for a vulnerable high value asset (e.g. declining condition, particular significance)
4	Major	Presence of high value asset	Sensitive flow responder with moderate conservation value (e.g. a rating of vulnerable or uncommon)
3	Moderate	Presence of asset of value	Moderate flow responder but more common, or species with conservation significance that may not be flow responders
2	Minor	Presence of an asset	Degraded, or has a broader flow tolerance or 'just a pool'
1	Insignificant	No asset	Highly degraded or exotic species only

It was determined that given the availability of data and knowledge, environmental values could be appropriately represented by the following attributes:

- Fish
- Macroinvertebrates
- Presence of permanent pools and wetlands

Table 4 presents examples of how the framework outlined by Table 3 is implemented for fish.

Table 4: SWMZ Consequence criteria - fish examples

Rating		Examples
5	Catastrophic	Blackfish, Pygmy Perch
4	Major	Mountain galaxias, Diadromous species with conservation status above rare (lampreys, congollis)
3	Moderate	Freshwater generalist species (carp gudgeon, flathead gudgeon). Diadromous species (shortfinned eel, common galaxias, climbing galaxias). Other migratory species (Murray-Darling golden perch). Wetland species with conservation status (Murray hardyhead, Yarra pygmy perch, chanda perch, silver perch, freshwater catfish, purple spotted gudgeon, Murray cod)
2	Minor	Euryhaline species (smallmouth hardyhead, gobies). Wetland species (unspecked hardyhead, murray rainbow, bony herring, smelt)
1	Insignificant	Exotics only

The overall consequence level reported for each management zone is based on the maximum value of the three attributes assessed (i.e. fish, macroinvertebrates and habitat). For example, a SWMZ where Blackfish have been recently observed will be scored the highest possible consequence rating regardless of observations with respect to macroinvertebrates or habitat. This approach was adopted because it reflects the attitudes to environmental risk held by key stakeholders and the relevant objectives determined for the water resources of the PWRA.

Note that the consequence level determined for a given SWMZ has no impact on consequence assessments of upstream zones. Thus the risk assessment only reports the likelihood and consequences of an event within a management zone.

2.4. Risk analysis – Underground Water Management Zones

As noted in Section 2.2, the UWMZ risk assessment considers the potential for impacts to both beneficial use and environmental values. The risk assessment team determined that it was appropriate to apply similar likelihood criteria in each case (i.e. the potential for water resource degradation). However the risk level is reported for each consequence class independently.

2.4.1. Likelihood

Likelihood criteria are based on the allocation limits determined during the development of the EMLR WAP. These limits were based on scientific investigations undertaken to determine the rate at which water can be extracted from the resource without causing unacceptable impact to the beneficial use or environmental values of that resource. It is therefore assumed that extraction at a rate higher than the allocation limits leads to a risk of significant degradation of the resource.

The allocation limit values used as the basis for likelihood criteria by this assessment were determined as follows:

Allocation Limit = Consumptive Use Limit – (Stock and Domestic Use + Forestry Use)

Table 5 outlines likelihood criteria based on the ratio of demand to the allocation limit. Note that the 'rare' and 'unlikely' categories outlined in Table 5 correspond to allocations less than the allocation limit for each UWMZ – zones falling in these two low likelihood categories have not been considered by this risk assessment as it is deemed that the risks for these zones are effectively managed by the policies of the WAP.

Table 5: Likelihood criteria - underground water management zone risk assessment

Likelihood	Likelihood score	Demand : Allocation Limit ratio (after accounting for effects of throughflow)
Rare	1	< 0.8 : 1
Unlikely	2	0.8-1.0 : 1
Possible	3	1.0-1.4 : 1
Likely	4	1.4-1.8: 1
Almost certain	5	> 1.8:1

As with the SWMZ risk assessment, assessment of likelihood considers sources of risk both internal and external to a given UWMZ. Thus, the assessment accounts for:

- Allocations within the management zone being assessed, and
- Allocations made in other management zones where the groundwater resources are known to be connected to the resources of the management zone being assessed by means of throughflow.

Connected zones are considered in the likelihood calculation for zones that:

- Are known to be 'donor zones' (i.e. from which throughflow accounts for a significant inflow to an adjacent zone), and
- Have demand to allocation limit ratios greater than 1:1 (Table 5).

In these cases, the portion of the allocation above the allocation limit in the donor zone that would contribute to throughflow is added to the allocated volume of the recipient zone under assessment (with the total throughflow volume as the maximum volume that can be added). The portion of the allocation in the donor zone that would contribute to throughflow is determined by splitting the overallocated volume (i.e. the volume in excess of the allocation limit) between throughflow and baseflow according to the known ratio of throughflow to baseflow of that zone (Figure 4).

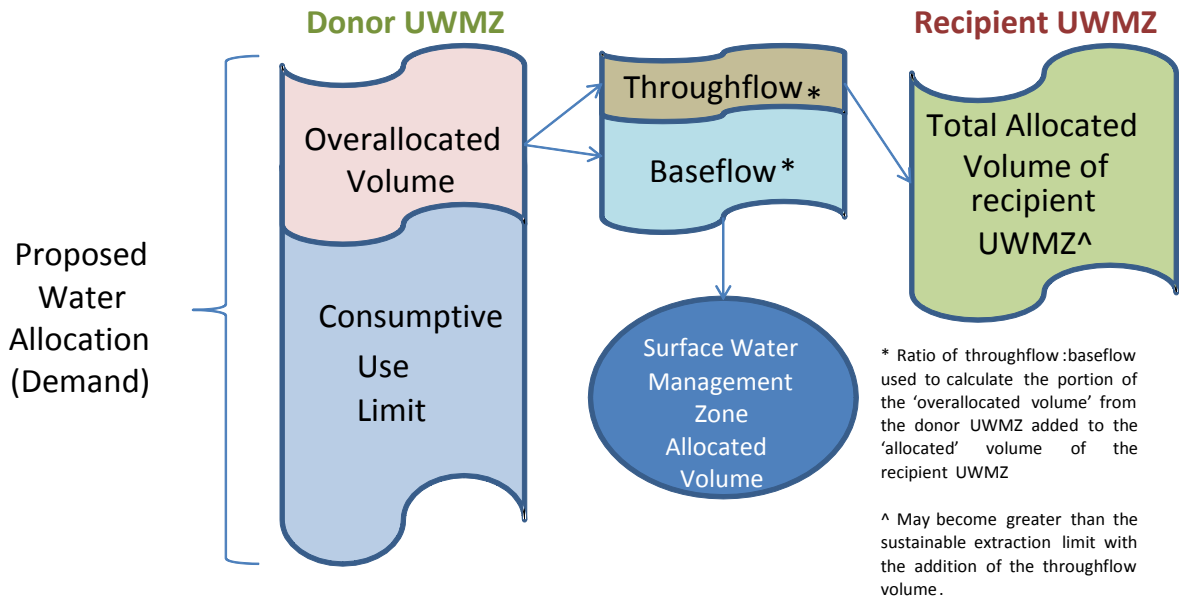


Figure 4. Method for accounting for throughflow and baseflow

With the throughflow volume taken into consideration in the allocated volume of the relevant zones, the final ratios of demand compared to the allocation limit are calculated for the purposes of the likelihood assessment.

2.4.2. Consequence criteria – Altered UWMZ resource condition

The assessment of consequences to beneficial use values does not directly address the economic and social values of the UWMZs. Instead the criteria can be considered an indicator of the vulnerability of social and economic values that are dependent on the groundwater resource.

Table 6 shows that the consequence rating for risks to the UWMZ resource condition is a function of indicators relating to the potential timeframe over which a decline in resource condition may occur and the type of resource degradation as a function of water level, salinity and potential for recovery.

Table 6: Consequence attributes - underground water management zone risk assessment

#	Consequence indicators	Comment
1	**Time to adverse impact**	Criteria for the potential timescale of resource decline. Onset of any decline within a short timeframe is undesirable and thus is correlated with high risk (see Table 7).
2	**Resource response**	Criteria for the extent of degradation that may occur in terms of salinity and water level. For example, a decline in water level coupled with an increase in salinity for a non-renewable low salinity resource is correlated with high risk (see Table 8).

These consequence indicators are scored independently for each UWMZ according to criteria outlined in Table 7 and Table 8 below. Following this assessment, the scores are summed to arrive at the total consequence rating for the risk statement being assessed. Thus a non-renewable, high quality resource that is expected to experience undesirable resource condition trends leading to degradation over a short period of time is correlated with an overall high consequence rating.

Note that the scoring system outlined in Table 7 and 8 produces ordinal risk indices indicating rank or priority according to arbitrary criteria rather than real values quantifying the extent of groundwater impact according to some measurable indicator. While the use of ordinal risk indices is recognised as an acceptable method to inform risk assessments, in general it is not recommended that ordinal values be aggregated because there is no fundamental model to determine the linearity or otherwise of the individual scores. In this case however, the risk assessment team determined that aggregation of these two indices would produce risk assessment outcomes within the confidence bounds required in this context.

2.4.2.1. Time to adverse impact

The assessment of 'time to adverse impact' (Table 7) takes into consideration current trends in the state and condition of the groundwater resource in the UWMZ and the degree to which the resource is nominally over-allocated given the proposed existing user allocations.

Where adverse trends of the resource are already clearly apparent in the monitoring data, time to adverse impact is considered to be immediate. Where there is insufficient monitoring data or adverse trends are not clearly apparent, time to adverse impact is assessed based on expert judgement informed by data regarding the extent to which the resource is nominally over-allocated.

For example, according to these criteria, a high demand to allocation limit ratio combined with monitoring data showing a declining trend is correlated with high risk.

Table 7: Groundwater consequence criteria: attribute #1 - time to adverse impact

Time to adverse impact	Score
Immediate	5
< 5 years	4
5-10 years	3
10-30 years	2
> 30 years	1

2.4.2.2. Resource response

The resource response component of the consequence score is a function of the following factors:

- Changes in water level
- Changes in salinity
- Existing salinity levels relative to economically important salinity thresholds, and
- The extent to which the groundwater resource is renewable (i.e. whether the resource attain a new equilibrium, in which extractions and natural outflows are equivalent to recharge).

Table 8 outlines criteria showing how these factors are addressed to determine the resource response score for a UWMZ. The assessment process drew on expert knowledge and scientific investigations supporting the development of the WAP coupled with available monitoring data for salinity and water level accessed from the Obswell database and/or the Drillhole Enquiry Database.

Table 8: Groundwater consequence criteria: attribute #2 - resource response

Resource response	Score
Decline in level + increase in salinity in low salinity resource (< 1500 mg/L)	4
Decline in level + increase in salinity in moderate salinity resource (1500-3000 mg/L)	3
Decline in level only or increase in salinity only	2
If non-renewable groundwater resource	+1

2.4.3. Consequence criteria – Impacts on groundwater dependent ecosystems (GDEs)

The potential for impacts to GDEs within a UWMZ was determined to be a function of indicators of GDE 'vulnerability' and 'value' as follows:

Consequence rating (GDEs inside UWMZ) = Vulnerability of the GDEs + Value of the GDEs

The vulnerability component describes the extent to which GDEs within an UWMZ are potentially impacted by the local effects of groundwater extraction through wells[4]. An indicator of local effects was determined to be the extent of interference observed between the 50 metre environmental buffer zone (a buffer applied to environmental assets defined by the WAP) and the relevant well buffer zone per square kilometre of environmental asset (including the 50 metre buffer). Thus, high vulnerability is correlated with a large number of existing wells within or in close proximity to a given area of environmental asset including the buffer.

A vulnerability index based on the above concept considered the following observations for each UWMZ assessed:

- Number of wells located inside the 50 metre buffer of environmental assets
- Number of wells located outside environmental assets buffers where the 50 metre buffer of the well overlaps the 50 metre buffer of the asset
- Square kilometres of asset buffer in the UWMZ

The following calculation was used to derive the value of the index:

$$\textit{Vulnerability of GDEs in the UWMZ} = \frac{\textit{(Number of wells in 50 m Environmental Asset buffer x 2) + Number of well buffers intersecting Environmental Asset buffer}}{\textit{Total Area of Environmental Assets including the 50m buffer within the UWMZ (km2)}}$$

Note that the index applies a weighting to the number of wells within asset buffers to account for the effects of their relative proximity to the asset compared to wells outside buffers.

[4] Regional scale impacts on GDEs through impacts of groundwater extraction on baseflow have been accounted for in the SWMZ risk assessment as described on pages 19 to 20.

The analysis was undertaken using ArcGIS mapping layers of the groundwater well data (dated March 2012) and the 'Aquatic Assets' layer (dated August 2012), which represents environmental assets, such as wetlands, persistent pools and stream sections supported by baseflow. The protection buffer of 50 metres was applied to all features in the Aquatic Assets layer.

To classify vulnerability into one of five ratings on the basis of the vulnerability index, a 'relative risk' assessment approach was used, whereby the score for a given zone depends on its rank within the distribution of scores derived for all UWMZs of the EMLR PWRA. Calculation of the vulnerability index for all zones yielded scores ranging from 0 (four zones) to 38.6 (for one zone, Finniss Kanmantoo–2). Table 9 presents the distribution of vulnerability scores calculated for all relevant UWMZs on the basis of thresholds (bins) and assigns an appropriate vulnerability rating.

Table 9: UWMZ risk assessment - GDE vulnerability criteria

Bin	Frequency	Vulnerability rating
0	4	1
0.1- 5	6	2
5-15	4	3
15-25	3	4
>25	2	5

Only 22 of the 25 UWMZs were assessed using the GDE vulnerability criteria as three zones represent confined aquifer systems with no connections to GDEs within the UWMZ (Currency Limestone, Goolwa Limestone and Sandergrove Limestone). As such it is appropriate to assign the lowest consequence rating for these zones.

Assessment of the 'value' of the GDEs was determined through consideration of existing biological datasets and expert knowledge in accordance with the consequence framework and criteria determined for the SWMZ, as described on pages 16 to 18.

2.5. Determining risk level – the risk matrix

Table 10 presents criteria for risk level for surface and underground water management zones. This table is typical of other risk frameworks in that high likelihood combined with high consequence scores leads to high or extreme risk. In this table, red represents extreme, orange high, yellow 'Moderate' and green 'Low'.

Table 10: Surface and underground water management zone risk level based on likelihood and consequence

		Consequence				
Likelihood		**1**	**2**	**3**	**4**	**5**
Almost Certain	**5**	**M** (5)	**M** (10)	**H** (15)	**E** (20)	**E** (25)
Likely	**4**	**L** (4)	**M** (8)	**H** (12)	**H** (16)	**E** (20)
Possible	**3**	**L** (3)	**M** (6)	**M** (9)	**H** (12)	**H** (15)
Unlikely	**2**	**L** (2)	**L** (4)	**M** (6)	**M** (8)	**M** (10)
Rare	**1**	**L** (1)	**L** (2)	**L** (3)	**L** (4)	**M** (5)

2.6. Risk evaluation criteria

2.6.1. Concepts – risk tolerability

Following risk analysis, risks are evaluated to determine the tolerability of the risk level. Risk tolerability informs decisions regarding the need to treat risks to reduce the risk to an acceptable or tolerable level. For the purposes of this assessment, risks are assigned one of the following three categories of tolerability:

- Acceptable
- Tolerable subject to being as low as reasonably practicable (ALARP)
- Intolerable

Acceptable risks are those that that are negligible or sufficiently small that they are managed by existing systems. They require no further action regarding treatment or further analysis.

Intolerable risks on the other hand are those that must be treated in a timely manner to reduce the risk level.

Risks that fall in between the intolerable and acceptable ratings are, in effect 'conditionally tolerable'; they may be tolerated providing it can be demonstrated that they are as low as reasonably practicable (ALARP). A risk is deemed ALARP where the resources and/or actions required to treat the risk are grossly disproportionate to the potential benefit to be gained from reducing the level of risk.

2.6.2. Tolerability criteria – confidence in the risk assessment process

For this assessment, risk tolerability is rated according to risk likelihood, consequence and the level of confidence in the risk assessment process. In general, the lower the confidence in the risk assessment, the less likely it is that risks will be acceptable as opposed to tolerable or intolerable. In essence, low confidence in the conclusions of a risk assessment calls for a more precautionary approach to the management of risks since there is a reasonable probability that the risk level might actually be higher.

Table 11 provides general criteria applied for assessing confidence in the outputs of the risk assessment process (after DEWNR, 2012b).

Table 11: General criteria for assessment of confidence in risk analysis outcomes (after DEWNR, 2012b)

Criteria	Low confidence	Moderate confidence	High confidence
Data/information	Not location specific; Anecdotal evidence only; Not tested	Location specific (regional scale); Validated historical or scientific evidence	Location specific (local scale); validated historical or scientific evidence based on specific hypothesis testing
Team knowledge	Not specific to the risk source, risk assessment or location	Risk source or process and location specific	Risk source and process and location specific
Agreement	Not on interpretations or risk levels	On interpretations or risk levels	On interpretations and risk levels

2.6.3. Confidence assessment – SWMZ risk assessment

For the SWMZ risk assessment confidence was assessed in two stages.

A provisional confidence rating was obtained through assessing the confidence in the consequence assessments. In general it was found that the 'team knowledge' and 'agreement' attributes of the confidence criteria supported a rating of high confidence. The overall confidence rating therefore hinged on the availability of data which was considered on a zone by zone basis according to criteria outlined by Table 12.

Final confidence was determined by applying a modifier to the provisional confidence rating based on consideration of the likelihood assessment according to the criteria outlined in Table 1 (Section 2.3.1).

Table 12: Criteria for confidence assessment - SWMZ

Confidence level	Data availability
Low	No relevant zone or region data to inform assessment (e.g. closest fish monitoring site at least one zone distant OR physical features invalidate extrapolation of ratings from connected zones OR zone specific data is available but is more that 10 to 15 years old)
Moderate	No relevant zone data, but is reasonable to make extrapolations from regional data (e.g. monitoring sites of connected zones or zones that are judged to be biophysically similar)
High	Sufficiently current data (i.e. up to 10 years old) is available from monitoring sites within zone

2.6.4. Confidence assessment – UWMZ risk assessment

Confidence in the UWMZ assessment was rated for both the likelihood and consequence components of risk (based on the criteria of Table 11) with overall confidence being the average of these two ratings.

As with the SWMZ assessment, it was determined that the 'Team knowledge' and 'agreement' attributes warranted a rating of high confidence, meaning that the final rating hinged on 'data availability'. Table 13 presents the criteria used to rate this attribute of confidence. With respect to the 'impacts on GDEs' consequence class, confidence was rating using the same confidence criteria as was used for the SWMZ assessment.

Table 13: Criteria for confidence assessment - UWMZ

Confidence level	Data availability
Low	No Obswell database information available, only 'snapshot' data from the Drillhole Enquiry System database.
Moderate	Data is available for the zone, but has only a 5 to 10 year record Inherent uncertainty exists in the calculations undertaken to obtain the data (this is applicable to any assessments that used the allocation limits and/or the proposed water allocations)
High	Data exists for at least the last 10 years, with evidence of consistent data collection

2.7. Risk treatment - criteria for recommendations

Figure 5 outlines a flowchart for making generic recommendations on the basis of the risk evaluation (i.e. risk tolerability) and the level of confidence determined for the risk assessment. According to this decision framework, where effort to increase confidence in the assessment of a risk (e.g. obtain data that is location specific (local scale); validated historical or scientific evidence based on specific hypothesis testing, see Table 11) is likely to change the tolerability rating, which, in turn, is likely to lead to a different management decision, further risk analysis may be considered as a treatment option.

Table 14 presents the recommendations that may be made given the decision framework of Figure 5, while Table 15, Table 16, and Table 17 show the criteria for the recommendations on the basis of likelihood and consequence given confidence assessments of high, 'moderate' and 'low' respectively. The recommendations presented by Table 14 are generic in nature; they do not outline specific controls to address the likelihood or consequence of an identified risk. Instead they provide a guide regarding the *minimum level of action* that is warranted given the tolerability of risks and the level of confidence in the analysis of risks.

It can be observed from the criteria of Table 15 to Table 17 that the option of further risk analysis is available for those risks sitting at the boundaries of different regions of tolerability where confidence is less than high.

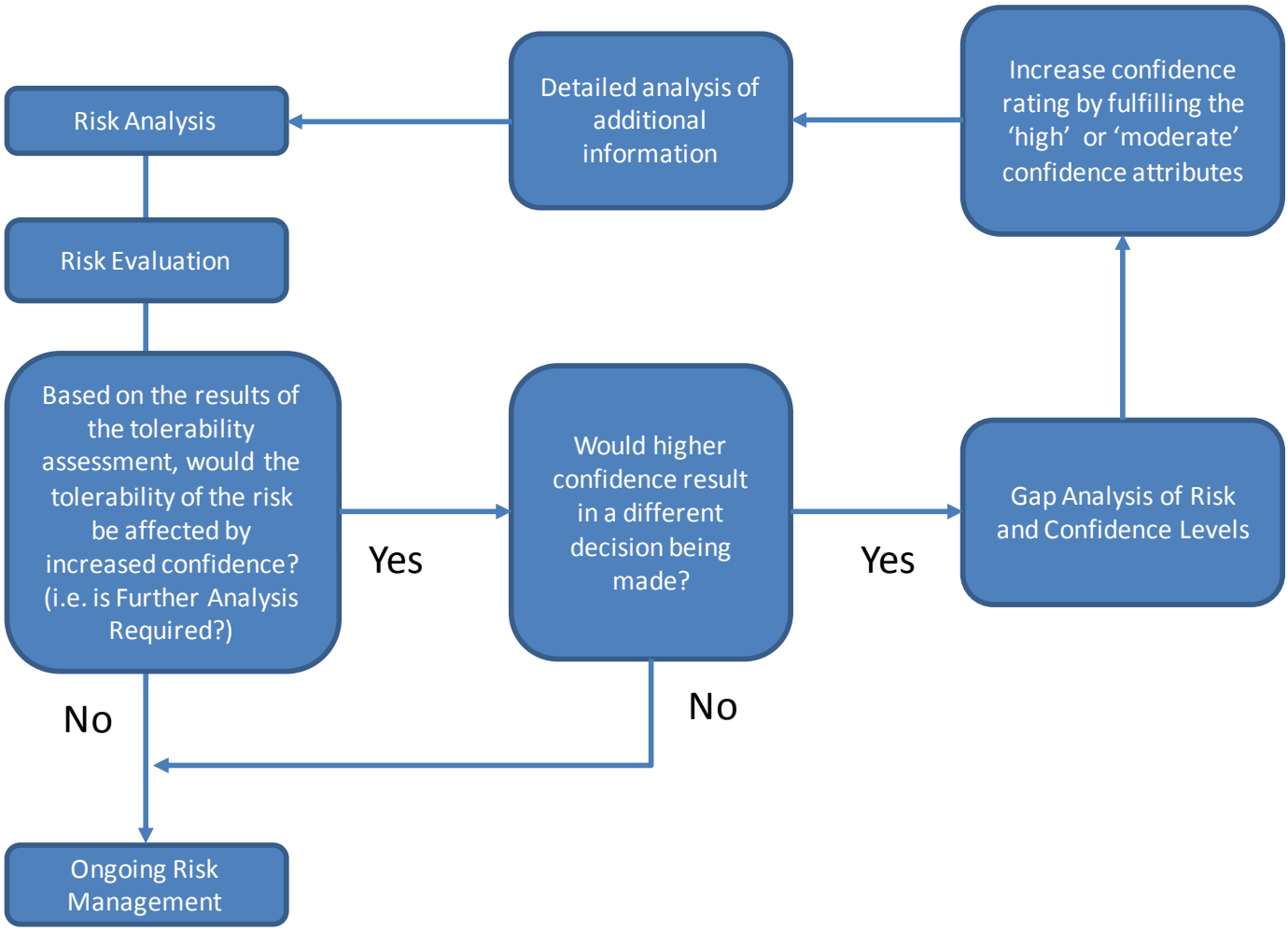


Figure 5: Flowchart demonstrating risk evaluation decision points (after Australian Emergency Management Committee 2010)

The intent of the evaluation criteria and the decision framework is to achieve the following outcomes:

i) Encourage that a more precautionary approach to risk treatment is taken where confidence is less than high; and

ii) Clarify the circumstances under which more analysis is justified as a short term option for treating unacceptable levels of risk.

As an example, consider the scenario where confidence is low, likelihood has been rated as 'possible' and consequence has been rated as 'major' (see table 17). In this case, given low confidence, there is a very real possibility that likelihood and consequence could in fact be higher than the analysis suggests meaning that the overall risk level could be higher. Therefore, in accordance with the framework presented in Table 14, it is appropriate to rate the risk as intolerable but to consider further risk analysis as a short term treatment option to improve confidence.

Table 14: Generic risk treatment recommendations

	Tolerability	Recommendation	Minimum requirements
	Intolerable	Unconditional treat	Commitment to reduce likelihood and/or consequence of risk
	Intolerable	Further analysis (high priority)	Commitment to re-evaluation of risk informed by additional monitoring/analysis as appropriate (i.e. increase confidence through fulfilling high confidence attributes in Table 11)
	Tolerable subject to ALARP	Conditional treat	Commitment to: 1) Determine if risk is as low as reasonably practicable 2) Reduce likelihood and/or consequence of risks that are not as low as reasonably practicable
	Tolerable subject to ALARP	Further analysis (low priority)	Commitment to re-evaluation of risk informed by additional monitoring/analysis as appropriate (i.e. increase confidence through fulfilling high confidence attributes in Table 11)
	Acceptable	Monitor	Commitment to monitoring of risk as appropriate

Table 15: Recommendation criteria - high risk assessment confidence

	Consequence level				
Likelihood level	Insignificant	Minor	Moderate	Major	Catastrophic
Almost certain					
Likely					
Possible					
Unlikely					
Rare					

Table 16: Recommendation criteria – moderate risk assessment confidence

	Consequence level				
Likelihood level	Insignificant	Minor	Moderate	Major	Catastrophic
Almost certain					
Likely					
Possible					
Unlikely					
Rare					

Table 17: Recommendation criteria – low risk assessment confidence

	Consequence level				
Likelihood level	**Insignificant**	**Minor**	**Moderate**	**Major**	**Catastrophic**
Almost certain					
Likely					
Possible					
Unlikely					
Rare					

3. Risk assessment results

3.1. Surface Water Management Zones

There are 53 SWMZs in the EMLR PWRA where the percentage of upstream water use exceeds the consumptive use limit set by the WAP (i.e. use greater than 20% of resource capacity). Thus the risk assessment and evaluation was undertaken for these nominally overallocated management zones.

Table 25 presents the results of the analysis and evaluation of the risk statement for these zones. Results are ordered according to risk rating and within these ranges, by alphanumeric order of the SWMZ names. Each row presents the results of the risk analysis as likelihood, certainty and risk level ratings, and the results of the risk evaluation as tolerability and recommended action.

3.1.1. Likelihood

Table 18 summarises the likelihood scores for the EMLR PWRA. Since the risk analysis excludes those zones having percentage upstream use level below 20%, no risks were rated 'rare' or 'unlikely'. Thus the risk assessment specifically addresses those SWMZ for which there is likely to be significant risk that is not controlled by the water allocation plan.

Most SWMZs fell in the 'possible' category, while the 'likely' and 'almost certain' ratings accounted for 17 and two SWMZs respectively. Two SWMZs (426AR006 and 426AR020) have demand greater than 50% of the consumptive use limit taking into consideration the demand of upstream resources and impacts from baseflow (groundwater use). These headwater zones are adjacent to each other and both located in the Angas River catchment (Table 25 and Figure 2).

Table 18: SWMZ risk analysis summary – likelihood

Likelihood level [5]	Criteria	Count
Almost certain	> 50.00% consumptive use limit	2
Likely	30.01 – 50.00% consumptive use limit	17
Possible	20.01 – 30.00% consumptive use limit	34

3.1.2. Consequence

Table 19 summarises the consequence scores for the SWMZs considered in this risk assessment (i.e. having estimated demand greater than 20% of the consumptive use limit). There are nine zones with a potentially 'catastrophic' consequence, 17 with a potentially 'major' consequence and four with a potentially 'moderate' consequence should an event occur. Minor and insignificant ratings accounted for 19 and four SWMZs respectively.

As shown in Table 25, the SWMZs attracting the highest consequence rating are:

- 426TC005
- 426BR048
- 426AR019
- 426AR014
- 426TC006
- 426BR054
- 426AR025
- 426AR009

[5] The consequence assessment was only undertaken for zones with 'possible' or higher likelihood, as such only the results for these categories are shown.

- 426AR026

Of these, five are located in the Angas River catchment, two are in the Bremer River catchment and two are the Tookayerta Creek catchment area (Table 25 and Figure 2).

Table 19: SWMZ risk analysis summary - consequence

Consequence level	Count
Catastrophic	9
Major	17
Moderate	4
Minor	19
Insignificant (or unknown)	4

3.2. Risk level

Table 20, Figure 6 and Figure 7 summarise the risk level distribution for the 53 SWMZs considered by this risk assessment according to the likelihood and consequence ratings. One zone is at extreme risk, 28 have high risk, 20 have moderate risk and 4 zones attract a low risk rating.

Table 25 shows that the zone having extreme risks (426AR026) is located in the Angas River catchment, as are 11 of the high risk zones. The remaining high zones are located in the Bremer River, Deep Creek, Finniss River and Tookayerta Creek catchments.

Table 20: SWMZ risk analysis summary - risk level

Risk level	Count
Extreme	1
High	28
Moderate	20
Low	4

3.3. Risk tolerability and treatment recommendations

As proposed in Section 0, tolerability of risk is rated according to risk likelihood, consequence and the confidence that may be placed in the risk assessment process. As such, the confidence placed in a risk analysis has a bearing on risk evaluation and treatment recommendations. This is because a more precautionary approach to management is justified when confidence in the assessed risk level is low.

Based on the criteria of Table 12, most SWMZ consequence ratings were determined to be of moderate or high confidence (Table 25). Using the appropriate confidence modifier for the likelihood analysis (Table 1) the final confidence score was determined for each risk. This confidence rating was used to determine which of the risk evaluation matrices should be applied (i.e. Table 15 to Table 17) to arrive at the final risk tolerability rating (Table 25).

Table 21 shows that 36 zones have a risk level that is tolerable subject to being as low as reasonably practicable (ALARP), which means that the risk may be tolerated provided it can be demonstrated that the benefits of treatment are grossly outweighed by the costs. 14 zones have been rated as having an intolerable level of risk, with one of these zones requiring unconditional treatment and the remaining 13 requiring further analysis with high priority to determine the extent to which they too may require treatment (Table 22). 28 zones were deemed to require conditional treatment. These recommendations are presented on maps of the EMLR PWRA (Figure 8 and Figure 9).

Table 21: SWMZ risk evaluation summary - risk tolerability

Tolerability	Count
Intolerable	14
ALARP	36
Acceptable	3

Table 22: Summary of generic treatment recommendations – SWMZs

Treatment recommendation	Count
Unconditional treat	1
Further analysis (high priority)	13
Conditional treat	28
Further analysis (low priority)	8
Monitor	3

Zone 426AR026 requires 'unconditional treatment' (Figure 9 and Table 25). It can be assumed that treatment for this zone may involve measures in upstream zones to address the source of risk (i.e. demand higher than the sustainable limit). Further details regarding the assessment of this zone are presented in the Appendix.

3.3.1. Surface water management zones

Figure 6 and Figure 7 map risk levels for the North and South SWMZs respectively. Figure 8 and Figure 9 present the generic treatment recommendations for these SWMZs based on the risk evaluation methodology and criteria described in Section 0.

Table 25 lists the risk assessment results for all SWMZs having likelihood rating of greater than 'unlikely'.

3.3.1.1. Impact of surface and groundwater interactions on risk level

As outlined in Section 2.3.1, the analysis of SWMZ risks considered potential impacts of UWMZ overallocation. Tables 24, 25 and 26 summarise the impact of UWMZ overallocation on the overall distribution of risk levels, risk tolerability and treatment recommendations respectively by comparing the risk assessment results with those that would have been achieved had surface water/groundwater interactions not been considered as a source of risk. Of particular note is that consideration of UWMZ overallocation has caused 16 additional SWMZs to have allocation to resource capacity ratios raised to higher than 0.2, which has led to an elevation of the likelihood rating to at least 'possible' for those zones.

Table 23: SWMZ Risk level with and without UWMZ overallocation

Risk Level	Risk level	No UWMZ overallocation	Difference
Extreme	1	0	1
High	28	18	10
Moderate	20	16	4
Low	4	3	1
Total	**53**	**37**	**16**

Table 24: SWMZ Risk tolerability ratings with and without UWMZ overallocation

Tolerability	Risk Level	No UWMZ overallocation	Difference
Intolerable	14	9	5
ALARP	36	27	9
Acceptable	3	1	2
Total	**53**	**37**	**16**

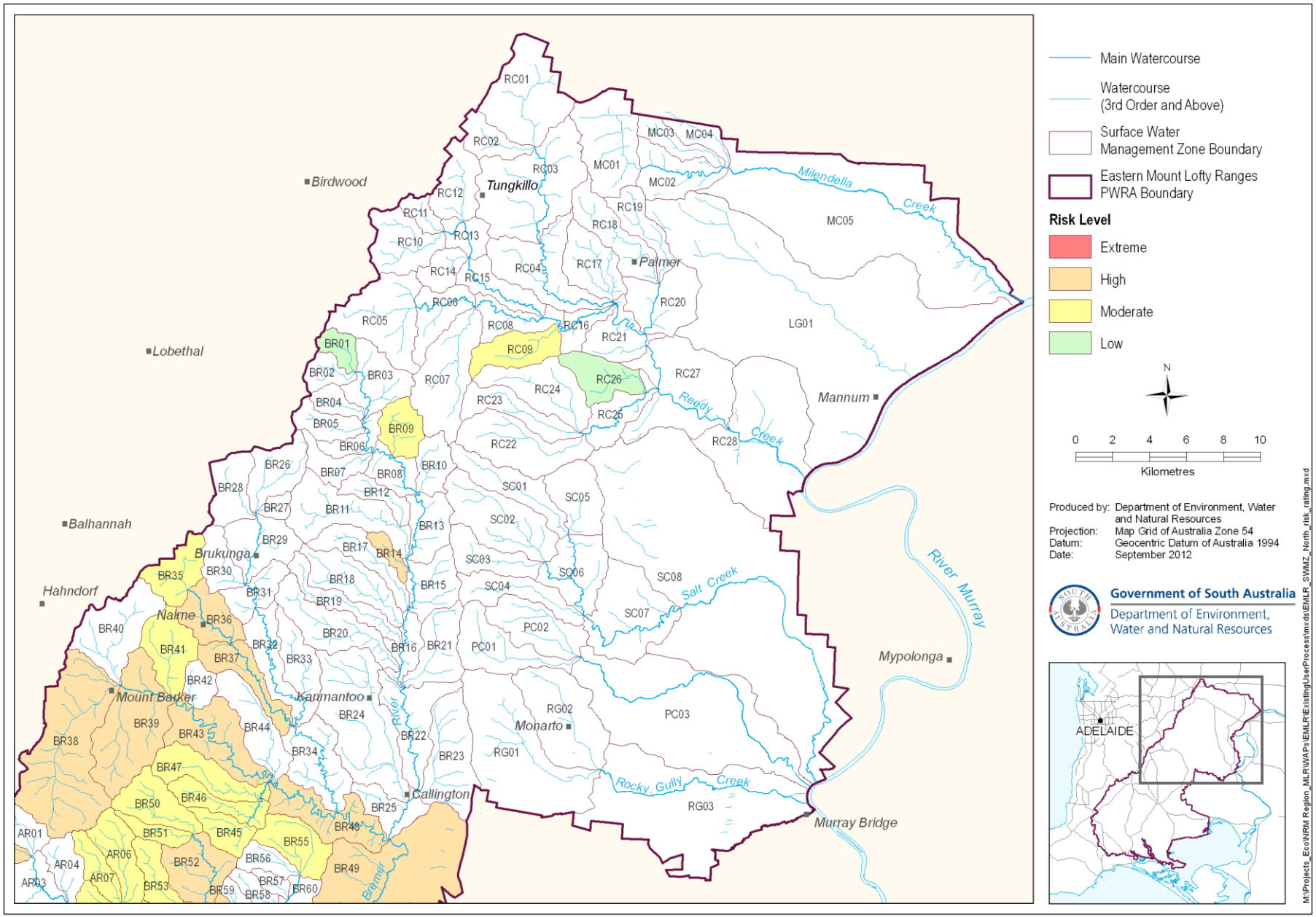


Figure 6. Risk levels – SWMZs (North)

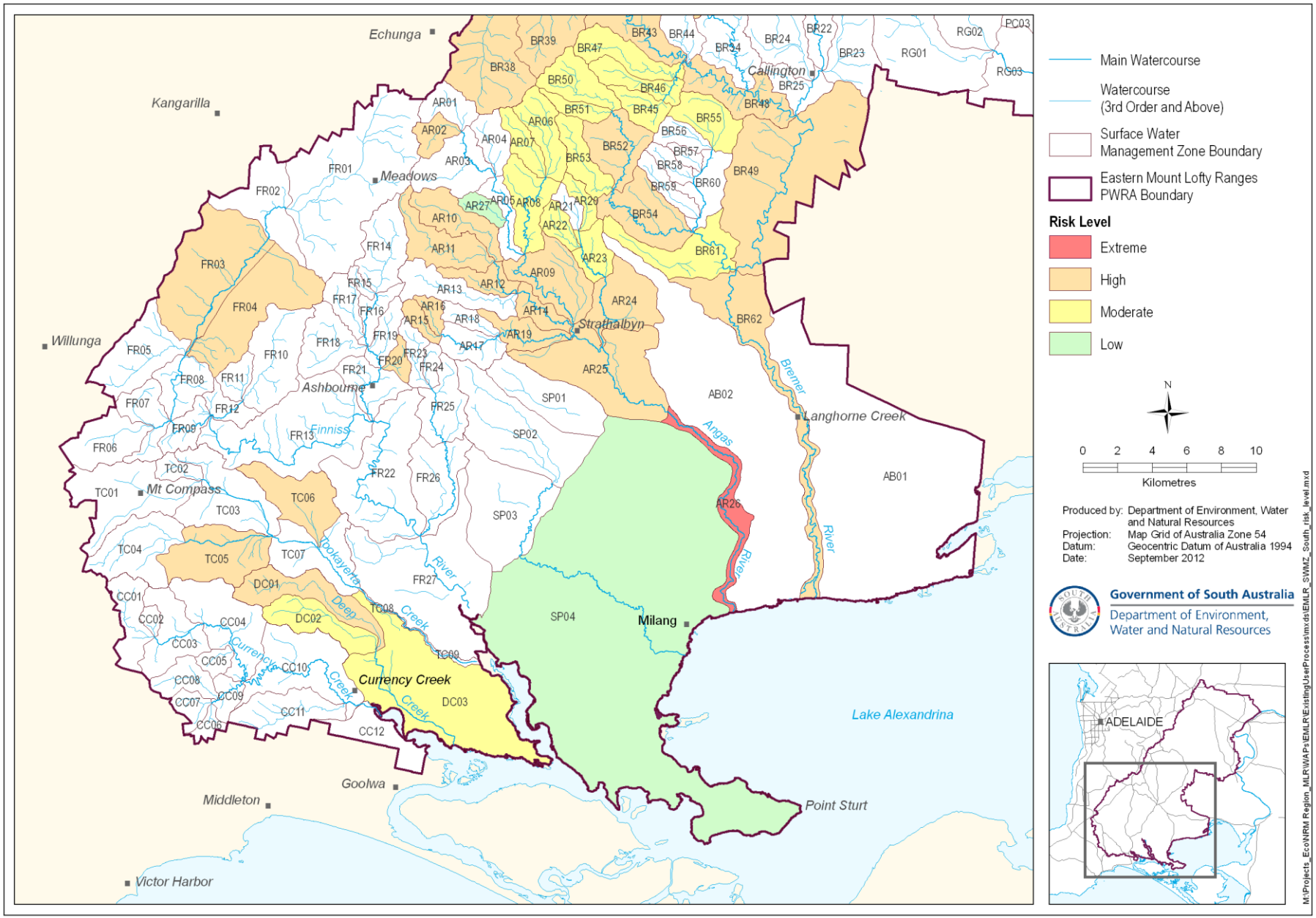


Figure 7. Risk level – SWMZs (South)

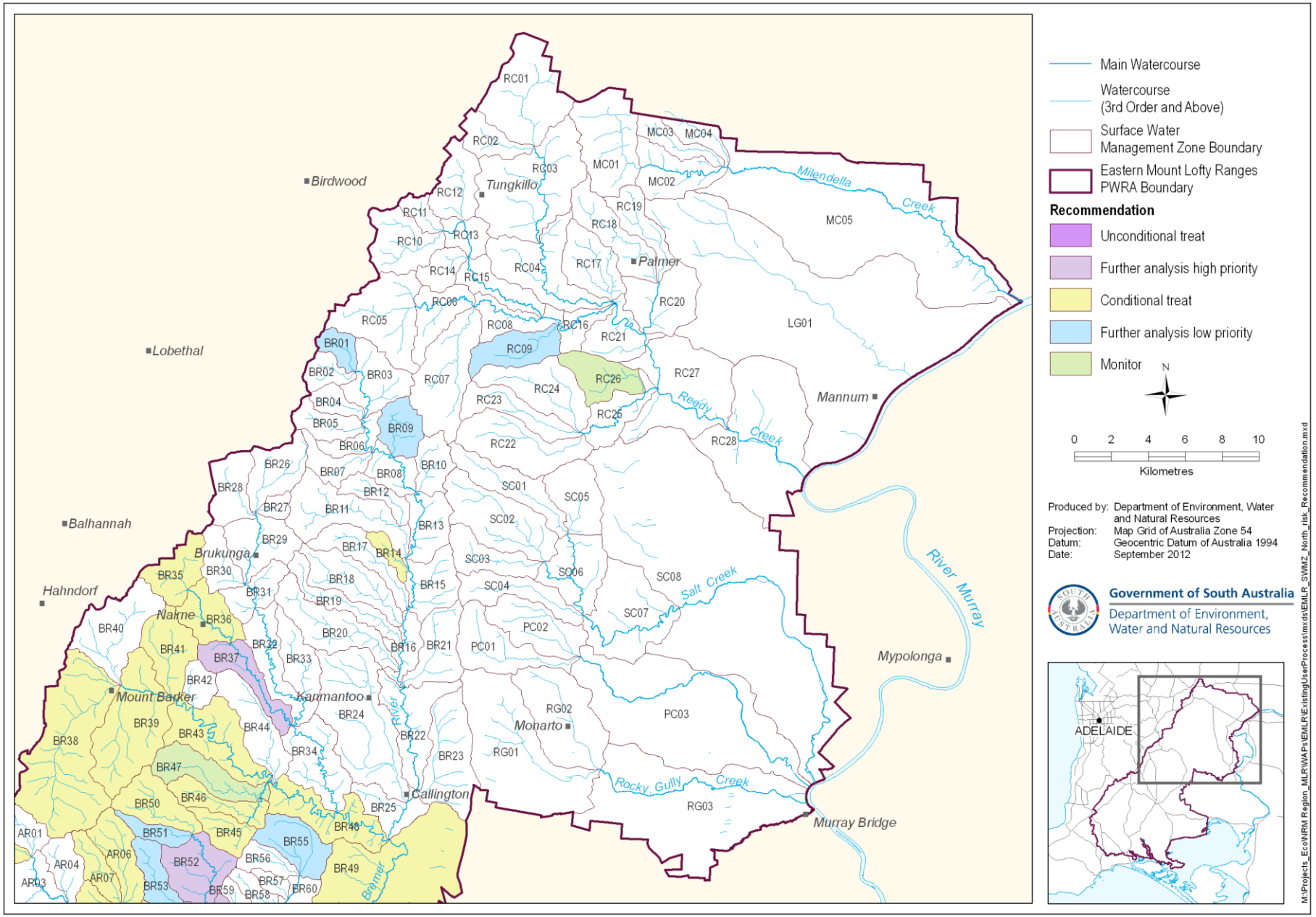


Figure 8. Risk treatment recommendations – SWMZs (North)

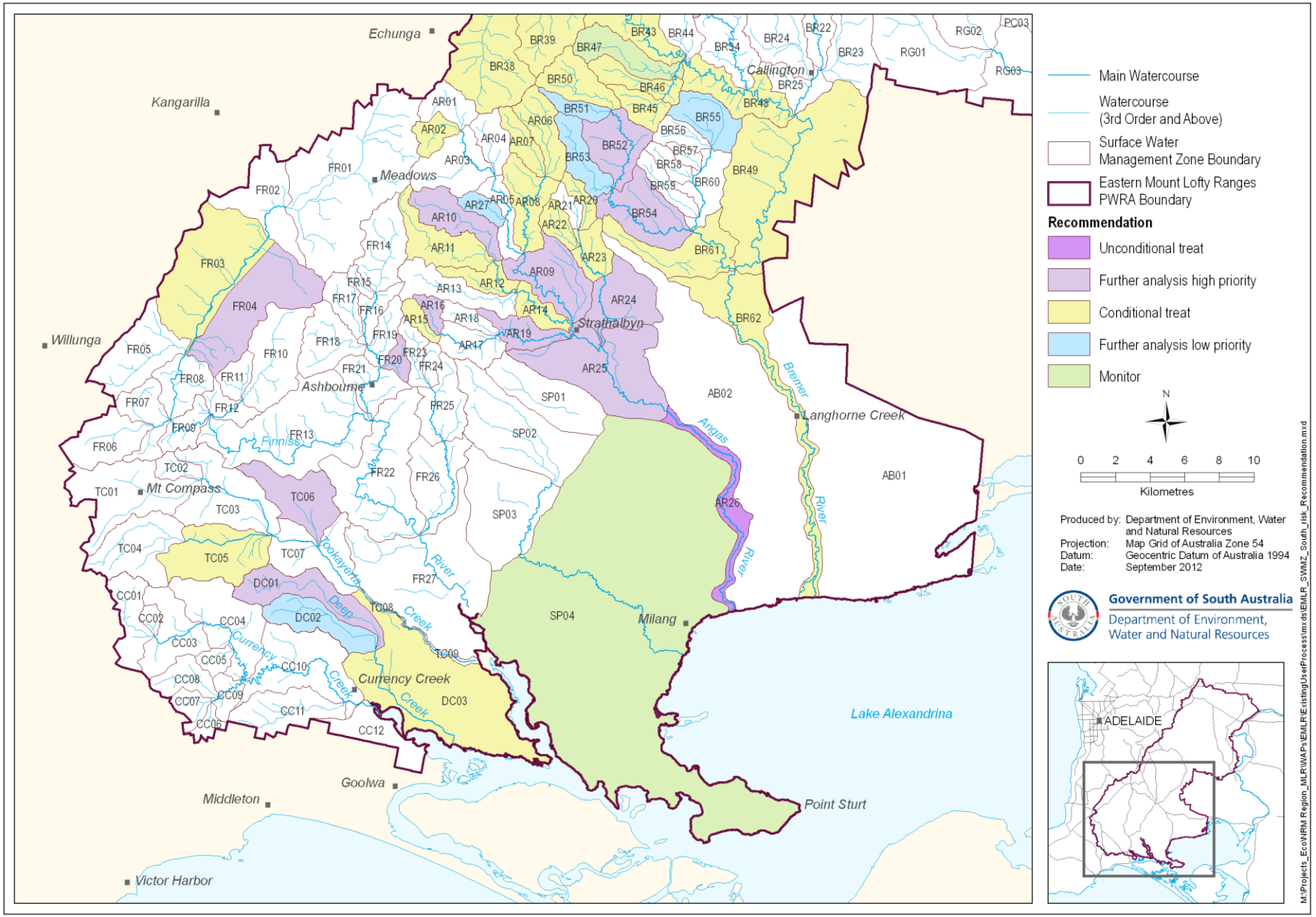


Figure 9. Risk treatment recommendations – SWMZs (South)

Table 25: EMLR SWMZ Risk assessment summary - all zones having likelihood > unlikely

SWMZ	Catchment (SWMZ nomenclature)	Risk Level	Demand:Resource Capacity Ratio	Likelihood	Consequence	Confidence	Tolerability	Recommendation
426AR026	Angas River	Extreme	0.301	Likely	Catastrophic	high	Intolerable	Unconditional treat
426AR002	Angas River	High	0.244	Possible	Major	moderate	ALARP	Conditional treat
426AR009	Angas River	High	0.293	Possible	Catastrophic	moderate	Intolerable	Further analysis (high priority)
426AR010	Angas River	High	0.252	Possible	Major	low	Intolerable	Further analysis (high priority)
426AR011	Angas River	High	0.267	Possible	Major	moderate	ALARP	Conditional treat
426AR012	Angas River	High	0.248	Possible	Major	moderate	ALARP	Conditional treat
426AR014	Angas River	High	0.222	Possible	Catastrophic	high	ALARP	Conditional treat
426AR015	Angas River	High	0.212	Possible	Major	moderate	ALARP	Conditional treat
426AR016	Angas River	High	0.232	Possible	Major	low	Intolerable	Further analysis (high priority)
426AR019	Angas River	High	0.221	Possible	Catastrophic	moderate	Intolerable	Further analysis (high priority)
426AR024	Angas River	High	0.458	Likely	Moderate	low	Intolerable	Further analysis (high priority)
426AR025	Angas River	High	0.292	Possible	Catastrophic	moderate	Intolerable	Further analysis (high priority)
426BR014	Bremer River	High	0.326	Likely	Moderate	high	ALARP	Conditional treat
426BR036	Bremer River	High	0.220	Possible	Major	moderate	ALARP	Conditional treat
426BR037	Bremer River	High	0.226	Possible	Major	low	Intolerable	Further analysis (high priority)
426BR038	Bremer River	High	0.255	Possible	Major	moderate	ALARP	Conditional treat
426BR039	Bremer River	High	0.225	Possible	Major	high	ALARP	Conditional treat
426BR043	Bremer River	High	0.229	Possible	Major	moderate	ALARP	Conditional treat
426BR048	Bremer River	High	0.219	Possible	Catastrophic	high	ALARP	Conditional treat
426BR049	Bremer River	High	0.210	Possible	Major	high	ALARP	Conditional treat
426BR052	Bremer River	High	0.347	Likely	Moderate	low	Intolerable	Further analysis (high priority)
426BR054	Bremer River	High	0.284	Possible	Catastrophic	moderate	Intolerable	Further analysis (high priority)
426BR062	Bremer River	High	0.283	Possible	Major	moderate	ALARP	Conditional treat

SWMZ	Catchment (SWMZ nomenclature)	Risk Level	Demand:Resource Capacity Ratio	Likelihood	Consequence	Confidence	Tolerability	Recommendation
426DC001	Deep Creek	High	0.447	Likely	Major	low	Intolerable	Further analysis (high priority)
426FR003	Finniss River	High	0.212	Possible	Major	high	ALARP	Conditional treat
426FR004	Finniss River	High	0.426	Likely	Major	low	Intolerable	Further analysis (high priority)
426FR020	Finniss River	High	0.212	Possible	Major	low	Intolerable	Further analysis (high priority)
426TC005	Tookayerta Creek	High	0.202	Possible	Catastrophic	high	ALARP	Conditional treat
426TC006	Tookayerta Creek	High	0.262	Possible	Catastrophic	moderate	Intolerable	Further analysis (high priority)
426AR006	Angas River	Moderate	0.533	Almost Certain	Minor	moderate	ALARP	Conditional treat
426AR007	Angas River	Moderate	0.338	Likely	Minor	moderate	ALARP	Conditional treat
426AR008	Angas River	Moderate	0.437	Likely	Minor	moderate	ALARP	Conditional treat
426AR020	Angas River	Moderate	0.669	Almost Certain	Minor	moderate	ALARP	Conditional treat
426AR022	Angas River	Moderate	0.497	Likely	Minor	low	ALARP	Conditional treat
426AR023	Angas River	Moderate	0.406	Likely	Minor	moderate	ALARP	Conditional treat
426BR009	Bremer River	Moderate	0.265	Possible	Minor	low	ALARP	Further analysis (low priority)
426BR035	Bremer River	Moderate	0.317	Likely	Minor	moderate	ALARP	Conditional treat
426BR041	Bremer River	Moderate	0.341	Likely	Minor	moderate	ALARP	Conditional treat
426BR045	Bremer River	Moderate	0.383	Likely	Minor	moderate	ALARP	Conditional treat
426BR046	Bremer River	Moderate	0.311	Likely	Minor	moderate	ALARP	Conditional treat
426BR047	Bremer River	Moderate	0.242	Possible	Minor	high	Acceptable	Monitor
426BR050	Bremer River	Moderate	0.426	Likely	Minor	moderate	ALARP	Conditional treat
426BR051	Bremer River	Moderate	0.265	Possible	Minor	low	ALARP	Further analysis (low priority)
426BR053	Bremer River	Moderate	0.209	Possible	Minor	moderate	ALARP	Further analysis (low priority)
426BR055	Bremer River	Moderate	0.261	Possible	Minor	low	ALARP	Further analysis (low priority)

SWMZ	Catchment (SWMZ nomenclature)	Risk Level	Demand:Resource Capacity Ratio	Likelihood	Consequence	Confidence	Tolerability	Recommendation
426BR061	Bremer River	Moderate	0.236	Possible	Moderate	high	ALARP	Conditional treat
426DC002	Deep Creek	Moderate	0.280	Possible	Minor	low	ALARP	Further analysis (low priority)
426DC003	Deep Creek	Moderate	0.336	Likely	Minor	moderate	ALARP	Conditional treat
426RC009	Reedy Creek	Moderate	0.213	Possible	Minor	moderate	ALARP	Further analysis (low priority)
426AR027	Angas River	Low	0.419	Likely	Insignificant	low	ALARP	Further analysis (low priority)
426BR001	Bremer River	Low	0.298	Possible	Insignificant	low	ALARP	Further analysis (low priority)
426RC026	Reedy Creek	Low	0.224	Possible	Insignificant	moderate	Acceptable	Monitor
426SP004	Sandergrove Plains	Low	0.261	Possible	Insignificant	moderate	Acceptable	Monitor

Table 26: SWMZ Recommend treatments with and without UWMZ overallocation

Recommendation	Treatment	No UMZ overallocation	Difference
Unconditional Treat	1	0	1
Further analysis (high priority)	13	9	4
Conditional treat	28	18	10
Further analysis (low priority)	8	9	-1
Monitor	3	1	2
Total	**53**	**37**	**16**

Table 27 lists all the SWMZs for which risk level ratings, risk tolerability and/or treatment recommendation have been affected by overallocation of UWMZs. This table is presented to inform decisions regarding the treatments options available for these risks. It highlights that treating overallocation of unconfined UWMZs could reduce the risk level for a number of SWMZs.

Table 27: SWMZs results comparison with 'likelihood' unlikely and UWMZ overallocation considered

SWMZ	Catchment (SWMZ nomenclature)	Risk Level	Risk Level (without UWMZ overallocation)	Tolerability	Tolerability (without UWMZ overallocation)	Recommendation	Recommendation (without UWMZ overallocation)
426AR026	Angas River	Extreme	High	Intolerable	Intolerable	Unconditional treat	Further analysis (high priority)
426AR010	Angas River	High	High	Intolerable	ALARP	Further analysis (high priority)	Conditional treat
426AR014	Angas River	High	Moderate	ALARP	ALARP	Conditional treat	Conditional treat
426AR015	Angas River	High	Moderate	ALARP	ALARP	Conditional treat	Conditional treat
426AR019	Angas River	High	Moderate	Intolerable	ALARP	Further analysis (high priority)	Conditional treat
426BR036	Bremer River	High	Moderate	ALARP	ALARP	Conditional treat	Conditional treat
426BR037	Bremer River	High	Moderate	Intolerable	ALARP	Further analysis (high priority)	Conditional treat
426BR039	Bremer River	High	Moderate	ALARP	ALARP	Conditional treat	Conditional treat
426BR043	Bremer River	High	Moderate	ALARP	ALARP	Conditional treat	Conditional treat
426BR048	Bremer River	High	Moderate	ALARP	ALARP	Conditional treat	Conditional treat
426BR049	Bremer River	High	Moderate	ALARP	ALARP	Conditional treat	Conditional treat
426BR054	Bremer River	High	High	Intolerable	ALARP	Further analysis (high priority)	Conditional treat
426TC005	Tookayerta Creek	High	Moderate	ALARP	ALARP	Conditional treat	Conditional treat
426TC006	Tookayerta Creek	High	Moderate	Intolerable	ALARP	Further analysis (high priority)	Conditional treat
426BR035	Bremer River	Moderate	Moderate	ALARP	ALARP	Conditional treat	Further analysis (low priority)
426BR041	Bremer River	Moderate	Moderate	ALARP	ALARP	Conditional treat	Further analysis (low priority)
426BR046	Bremer River	Moderate	Moderate	ALARP	ALARP	Conditional treat	Further analysis (low priority)
426BR047	Bremer River	Moderate	Low	Acceptable	Acceptable	Monitor	Monitor
426BR053	Bremer River	Moderate	Low	ALARP	Acceptable	Further analysis (low priority)	Monitor
426DC002	Deep Creek	Moderate	Low	ALARP	Acceptable	Further analysis (low priority)	Monitor
426DC003	Deep Creek	Moderate	Low	ALARP	Acceptable	Conditional treat	Monitor

3.3.2. Underground water management zones

There are six UWMZs in the EMLR PWRA where total proposed water allocations exceed the allocation limit (Table 28). Results are ordered according to the extent to which the extraction limit is exceeded by existing water use. Consequence assessments have been undertaken for the top six likelihood ratings.

Table 28: EMLR UWMZ – all zones Likelihood

UWMZ Name	Demand: Allocation Limit ratio (after accounting for effects of throughflow)	Likelihood level	Likelihood
Currency Limestone	3.79	5	Almost certain
Tookayerta Permian	2.67	5	Almost certain
Angas Kanmantoo	1.55	4	Likely
Bremer Adelaidean	1.35	3	Possible
Tookayerta Kanmantoo - 2	1.33	3	Possible
Finniss Adelaidean	1.02	3	Possible
Angas Adelaidean	0.91	2	Unlikely
Finniss Kanmantoo - 2	0.91	2	Unlikely
Currency Permian	0.83	2	Unlikely
Finniss Permian - 1	0.76	1	Rare
Bremer Kanmantoo	0.71	1	Rare
Currency Kanmantoo	0.58	1	Rare
Tookayerta Kanmantoo - 1	0.34	1	Rare
Northern Limestone	0.13	1	Rare
Northern Kanmantoo	0.10	1	Rare
Finniss Kanmantoo - 1	0.10	1	Rare
Angas Bremer Limestone	0.03	1	Rare
Sandergrove Limestone	0.02	1	Rare
Finniss Kanmantoo - 3	0.00	1	Rare
Finniss Kanmantoo - 4	0.00	1	Rare
Finniss Permian - 2	0.00	1	Rare
Goolwa Limestone	0.00	1	Rare
Tookayerta Kanmantoo - 3	0.00	1	Rare

The six UWMZs having higher demand than the allocation limit were assessed against the consequence criteria (Section 2.4.2). The two consequence classes were analysed separately to ensure an inappropriately low level of risk was not reported.

3.3.2.1. Altered UWMZ resource condition

The assessment of risks due to altered condition of groundwater resources considers the potential for significant degradation of groundwater quantity and quality impacting the beneficial use values of the resource. The results of this analysis are reported in Table 29 and presented in maps of the EMLR PWRA (Figure 10 and Figure 11).

Table 29: EMLR UWMZ risk assessment summary - risks to UWMZ resource condition

UWMZ Name	Risk level	Likelihood	Time to adverse impact (out of 5)	Resource response (out of 5)	Consequence	Confidence	Tolerability	Recommendation
Currency Limestone	Extreme	Almost certain	5	5	Catastrophic	High	Intolerable	Unconditional treat
Tookayerta Permian	Extreme	Almost certain	4	4	Major	High	Intolerable	Unconditional treat
Angas Kanmantoo	High	Likely	3	4	Moderate	High	ALARP	Conditional treat
Bremer Adelaidean	Moderate	Possible	3	4	Moderate	High	ALARP	Conditional treat
Tookayerta Kanmantoo - 2	Moderate	Possible	2	4	Moderate	Moderate	ALARP	Conditional treat
Finniss Adelaidean	Moderate	Possible	2	4	Moderate	Moderate	ALARP	Conditional treat

The Currency Limestone UWMZ has the highest consequence rating (catastrophic) of the six zones assessed. Tookayerta Permian (shown on Figure 10 and Figure 11 as 'Map ID' 12) has the next highest consequence score (major). The remaining UWMZs (Angas Kanmantoo, Bremer Adelaidean, Tookayerta Kanmantoo–2 and Finniss Adelaidean) were all rated as having moderate consequence. The Currency Limestone and Tookayerta Permian UWMZs both attract extreme risk ratings. Angaus Kanmantoo is rated high risk, with the remaining three zones having moderate risk (Table 29).

The Currency Limestone zone represents the confined Murray Group Limestone aquifer within the Currency Creek catchment area and is identified by Map ID 3 on Figure 10 and Figure 11. It is known to support a range of agricultural enterprises including vineyards, olives and pasture (DWLBC, 2008). The majority of the monitoring wells in the highly transmissive aquifer originally had or still have a salinity of less than 1500 mg/L (i.e. typical threshold for irrigation of crops), which enhances the value of this groundwater resource.

This lens of fresh groundwater is judged to have been recharged between 5000 and 8000 years ago during a time when the climate in the area was wetter than today. This aquifer is now mostly recharged via lateral throughflow from the Permian Sands aquifer at its western boundary, although it also receives some throughflow from the Kanmantoo Group aquifer and downward leakage from the overlying Quaternary aquifer. Recharge of this resource with low salinity water occurs at a low rate meaning that any increases in salinity are likely to be irreversible. On this basis it is deemed to be a non-renewable resource (DWLBC, 2008), with higher extraction rates likely to lead to increased salinity over the long term. Similarly, water levels in this aquifer will likely decline if extraction occurs above the allocation limit, with adverse impacts due to extraction having already being observed.

The Tookayerta Permian UWMZ represents the Permian Sands aquifer in the Tookayerta Creek catchment area. Analysis undertaken through risk assessment is presented in the Appendix. This aquifer is generally permeable allowing high recharge rates from rainfall typically resulting in low groundwater salinity (DWLBC, 2008). Six observation wells monitoring the salinity of this UWMZ show salinity values of less than 700 mg/L. Based on the Obswell database and linear trend analysis, the majority of the 33 water level monitoring wells indicate that there has been a slow but steady decline in water level (i.e. 0.02 to 0.28 m/y) over the last 8–20 years. Over the five years prior to 2012 water levels appear to have stabilised, with only three observation wells (out of 27) showing gradually declining levels and the remaining 24 showing a stable or slightly increasing trend. It is expected that if the proposed water allocation volumes, which are approximately 270% of the allocation limit, were extracted then the declining trend will likely recommence.

There was a moderate level of confidence for all 'time to adverse impact' ratings, as uncertainty is inherent in the extraction limits determined for each zone. This level of confidence also applied to all likelihood ratings because the likelihood evaluation also drew upon this data. Thus all UWMZs attracted final confidence score of moderate/high given the high confidence in the data supplied regarding the proposed water allocations.

The confidence rating for the resource response attribute of risk was deemed to be high for most UWMZs. This determination was made on the basis of the quality of the data used and the length of time over which this data has been collected (i.e. 10 years or greater). Overall confidence ratings considering all relevant attributes were determined

to be high for all but two UWMZs. On this basis it is recommended that the Currency Limestone and Tookayerta Permian UWMZs require unconditional treatment. The remaining UWMZs are all rated as tolerable subject to ALARP and therefore attract a recommendation of conditional treatment (Table 29).

3.3.2.2. Risk assessment – Impact on GDEs

The assessment of UWMZ risks to GDEs is concerned with the local, within-zone impacts of groundwater use on GDEs. A summary of the results regarding the risk associated with impacts on GDEs is reported in Table 30 and mapped in Figure 12 and Figure 13.

As shown in Table 30 the Tookayerta Permian and Bremer Adelaidean zones have the highest consequence scores of all the UWMZs assessed (i.e. major). According to the vulnerability attribute of consequence (i.e. presence of intersecting wells/well buffers per environmental buffer area) Tookayerta Permian was ranked in the 3rd bin and 'Bremer Adelaidean' ranked in the 4th bin (Table 9). However, Tookayerta Permian has environmental assets of greater value scoring a five for this component of the criteria (see Appendix for more information on this zone).

Table 30: EMLR UWMZ risk assessment summary - risks to GDEs

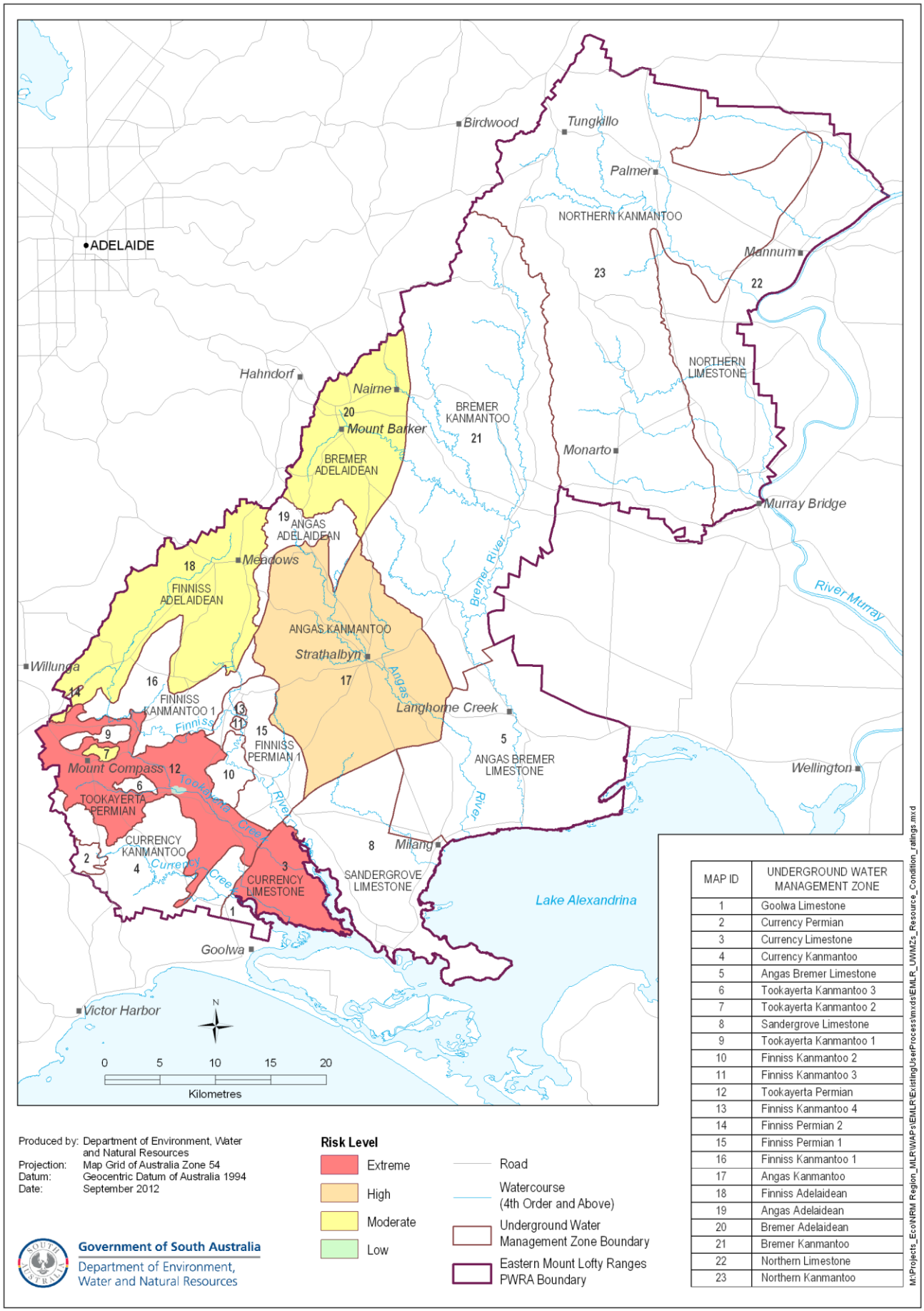
UWMZ Name	Risk level	Likelihood	GDE Vulnerability (out of 5)	GDE Value (out of 5)	Consequence	Confidence	Tolerability	Recommendation
Tookayerta Permian	Extreme	Almost certain	3	5	Major	High	Intolerable	Unconditional treat
Angas Kanmantoo	High	Likely	2	5	Moderate	High	ALARP	Conditional treat
Bremer Adelaidean	High	Possible	4	4	Major	High	ALARP	Conditional treat
Finniss Adelaidean	High	Possible	3	4	Moderate	High	ALARP	Conditional treat
Tookayerta Kanmantoo - 2	Moderate	Possible	4	2	Moderate	High	ALARP	Conditional treat
Currency Limestone[6]	Low	Almost certain	N/A	N/A	Insignificant	High	Tolerable	N/A

The Tookayerta Permian zone was rated as having extreme risk. Of the remaining UWMZs, three returned a risk rating of high (Angas Kanmantoo, Bremer Adelaidean, Finniss Adelaidean), one was rated as moderate (Tookayerta Kanmantoo -2) and Currency Limestone rated as low risk. In this case it was deemed that, being a confined aquifer at significant depth, this resource does not interact with GDEs (reflected by the consequence scores of GDE Vulnerability and GDE Value in Table 30).

As with the other assessments, confidence was rated as high for the team knowledge and agreement attributes (Table 11). The likelihood ratings were all given a moderate/high confidence rating, due to i) the inherent uncertainty in the extraction limits (moderate confidence) ii) high confidence in the data supplied regarding proposed water allocations and iii) high confidence in data regarding extraction wells (i.e. location and allocation values) and iv) high confidence in data regarding ecosystem values for these zones. As such the overall average confidence ratings of likelihood and consequence scores for all assessments are considered high.

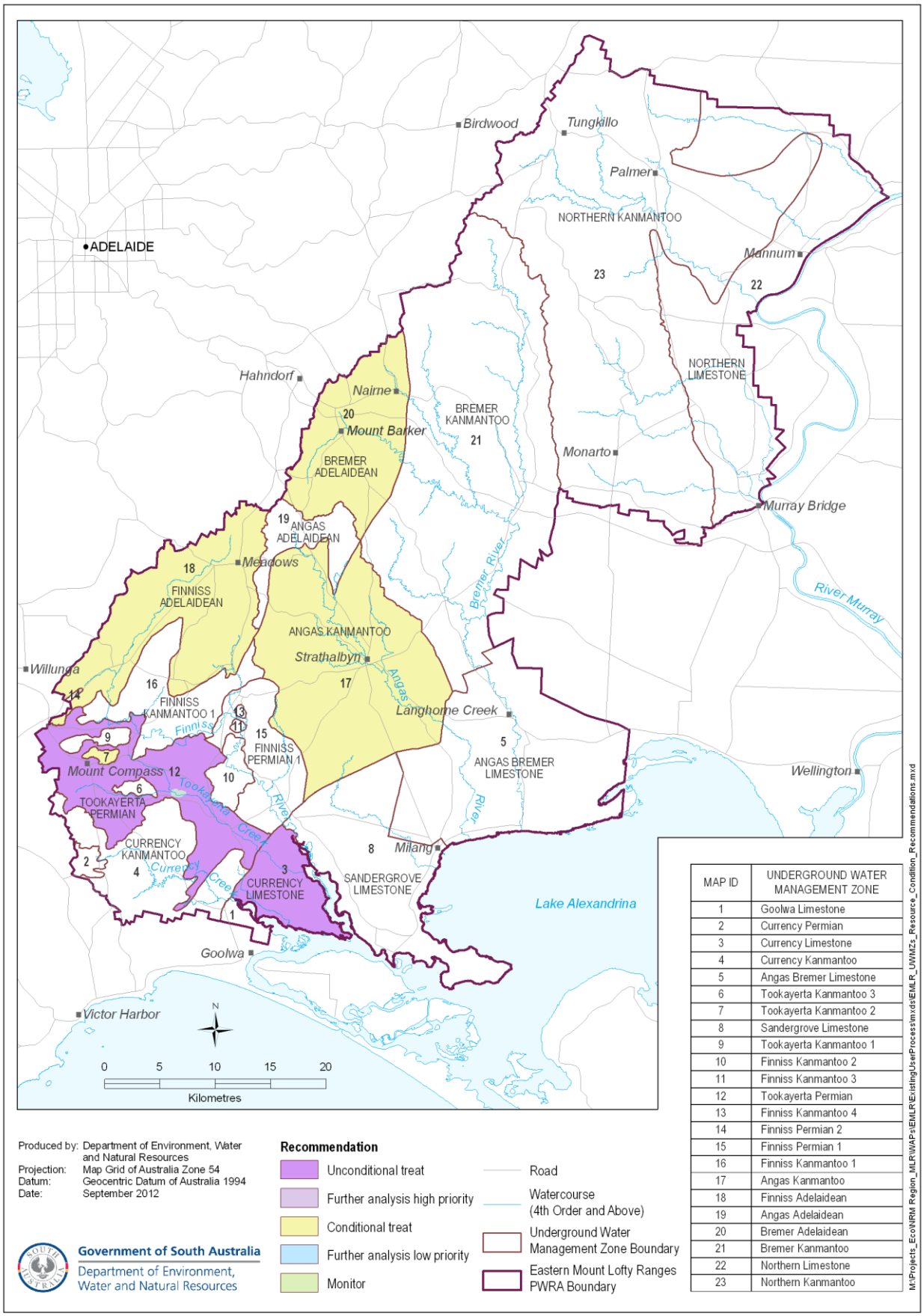
With respect to potential local impacts on GDEs caused by water allocations, this assessment returned one intolerable risk requiring unconditional treatment (i.e. for Tookayerta Permian UWMZ).

[6] Currency Limestone UWMZ represents a confined aquifer and as such is assigned a consequence rating of Insignificant. While typically the recommendation would be 'Monitor' with this combination of rating results this is not applicable in this circumstance.



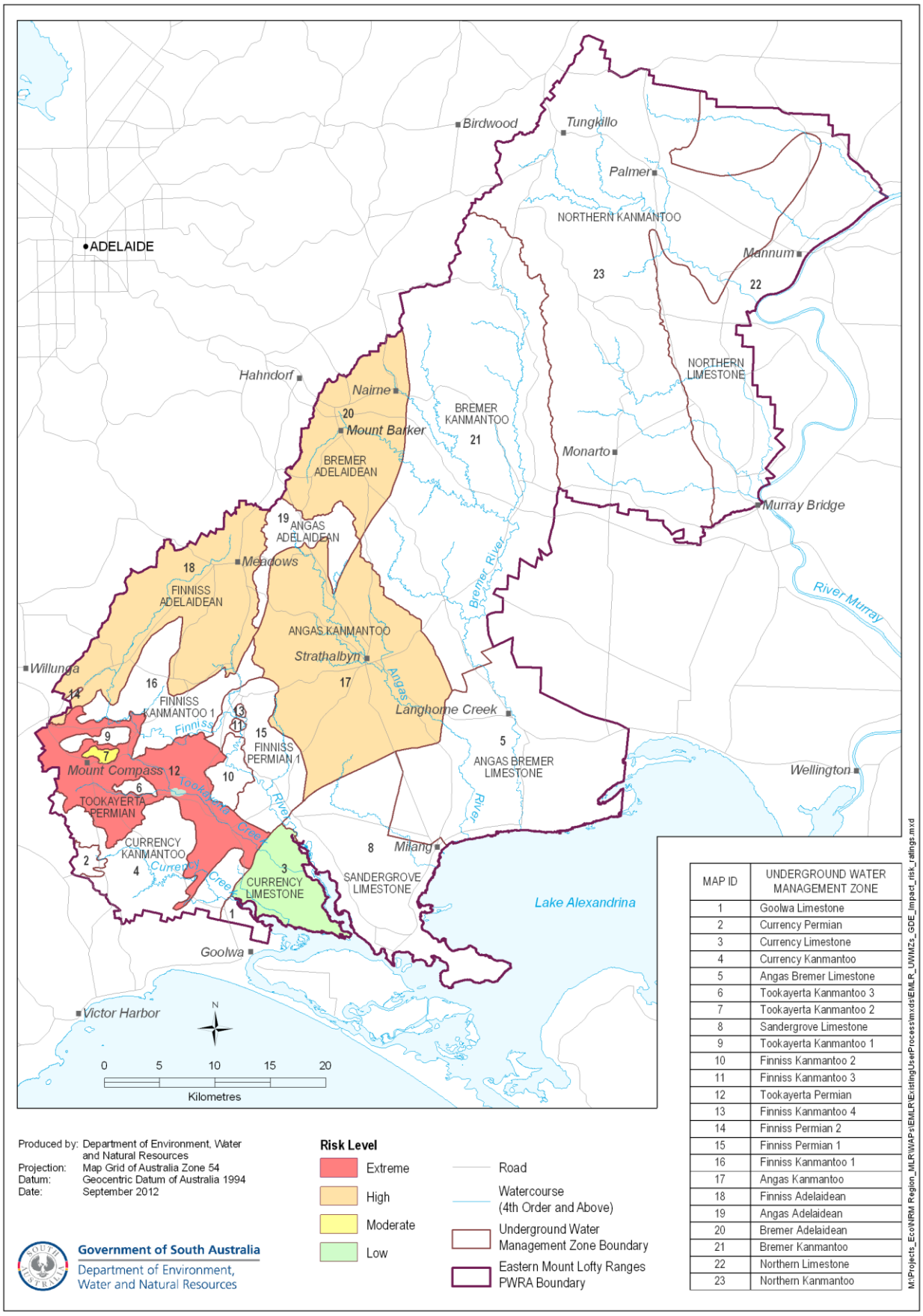
MAP ID	UNDERGROUND WATER MANAGEMENT ZONE
1	Goolwa Limestone
2	Currency Permian
3	Currency Limestone
4	Currency Kanmantoo
5	Angas Bremer Limestone
6	Tookayerta Kanmantoo 3
7	Tookayerta Kanmantoo 2
8	Sandergrove Limestone
9	Tookayerta Kanmantoo 1
10	Finniss Kanmantoo 2
11	Finniss Kanmantoo 3
12	Tookayerta Permian
13	Finniss Kanmantoo 4
14	Finniss Permian 2
15	Finniss Permian 1
16	Finniss Kanmantoo 1
17	Angas Kanmantoo
18	Finniss Adelaidean
19	Angas Adelaidean
20	Bremer Adelaidean
21	Bremer Kanmantoo
22	Northern Limestone
23	Northern Kanmantoo

Figure 10. Risk ratings assessed for Underground Water Management Zones in regard to altered resource condition



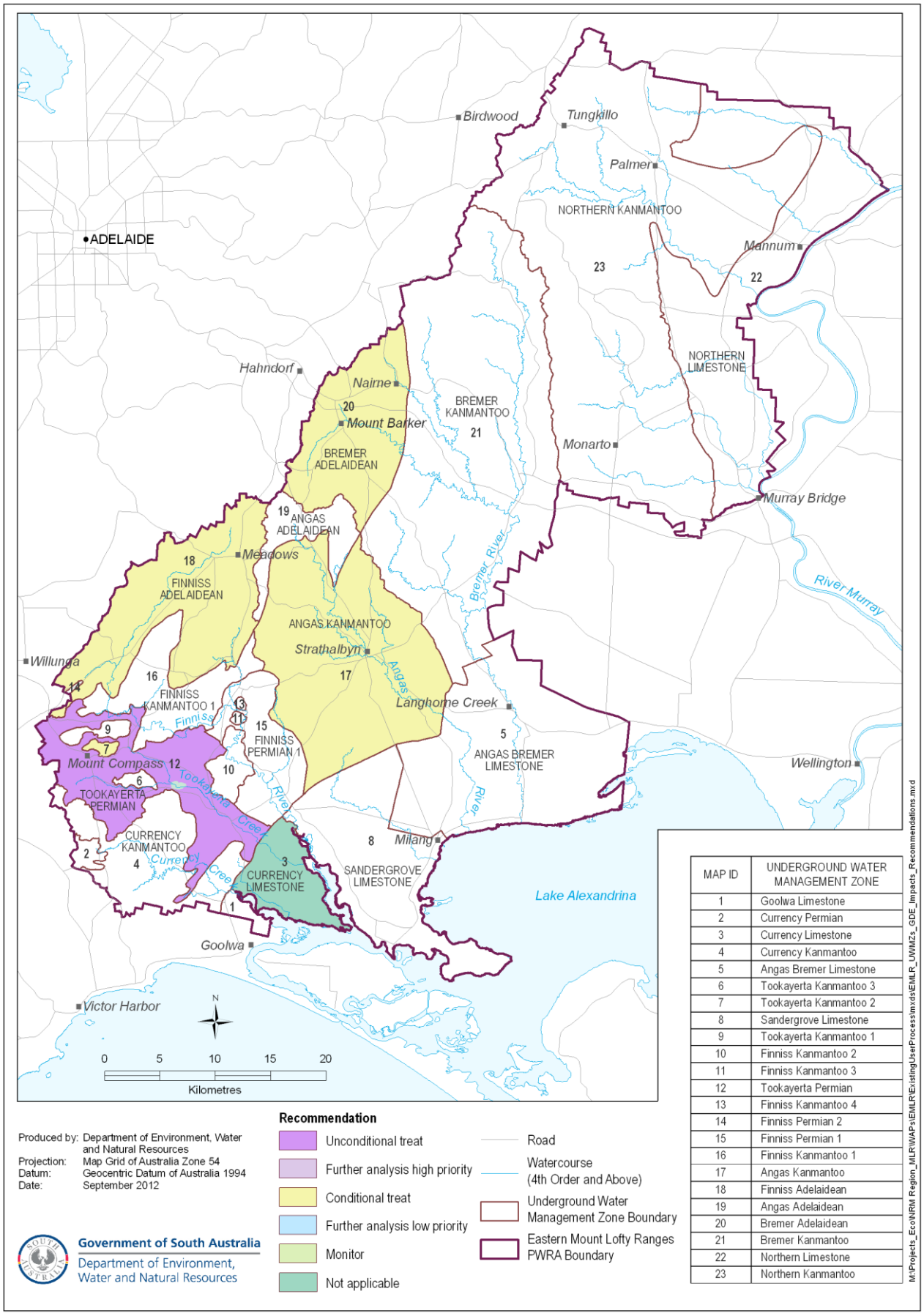
MAP ID	UNDERGROUND WATER MANAGEMENT ZONE
1	Goolwa Limestone
2	Currency Permian
3	Currency Limestone
4	Currency Kanmantoo
5	Angas Bremer Limestone
6	Tookayerta Kanmantoo 3
7	Tookayerta Kanmantoo 2
8	Sandergrove Limestone
9	Tookayerta Kanmantoo 1
10	Finniss Kanmantoo 2
11	Finniss Kanmantoo 3
12	Tookayerta Permian
13	Finniss Kanmantoo 4
14	Finniss Permian 2
15	Finniss Permian 1
16	Finniss Kanmantoo 1
17	Angas Kanmantoo
18	Finniss Adelaidean
19	Angas Adelaidean
20	Bremer Adelaidean
21	Bremer Kanmantoo
22	Northern Limestone
23	Northern Kanmantoo

Figure 11. Recommendation levels associated with risk ratings assessed for Underground Water Management Zones in regard to altered resource condition



MAP ID	UNDERGROUND WATER MANAGEMENT ZONE
1	Goolwa Limestone
2	Currency Permian
3	Currency Limestone
4	Currency Kanmantoo
5	Angas Bremer Limestone
6	Tookayerta Kanmantoo 3
7	Tookayerta Kanmantoo 2
8	Sandergrove Limestone
9	Tookayerta Kanmantoo 1
10	Finniss Kanmantoo 2
11	Finniss Kanmantoo 3
12	Tookayerta Permian
13	Finniss Kanmantoo 4
14	Finniss Permian 2
15	Finniss Permian 1
16	Finniss Kanmantoo 1
17	Angas Kanmantoo
18	Finniss Adelaidean
19	Angas Adelaidean
20	Bremer Adelaidean
21	Bremer Kanmantoo
22	Northern Limestone
23	Northern Kanmantoo

Figure 12. Risk ratings assessed for Underground Water Management Zones in regard to impacts to Groundwater Dependent Ecosystems



MAP ID	UNDERGROUND WATER MANAGEMENT ZONE
1	Goolwa Limestone
2	Currency Permian
3	Currency Limestone
4	Currency Kanmantoo
5	Angas Bremer Limestone
6	Tookayerta Kanmantoo 3
7	Tookayerta Kanmantoo 2
8	Sandergrove Limestone
9	Tookayerta Kanmantoo 1
10	Finniss Kanmantoo 2
11	Finniss Kanmantoo 3
12	Tookayerta Permian
13	Finniss Kanmantoo 4
14	Finniss Permian 2
15	Finniss Permian 1
16	Finniss Kanmantoo 1
17	Angas Kanmantoo
18	Finniss Adelaidean
19	Angas Adelaidean
20	Bremer Adelaidean
21	Bremer Kanmantoo
22	Northern Limestone
23	Northern Kanmantoo

Figure 13. Recommendation levels associated with risk ratings assessed for Underground Water Management Zones in regard to impacts to Groundwater Dependent Ecosystems

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5. Definitions

Allocation Limit (this terms only applies to groundwater resources)	*The allocation limit is equal to the consumptive use limit minus non-licensed in demand (stock and domestic demand). This is the volume of water available for applicants who are considered existing users.*
Consumptive Use Limit (For surface water this term is used to describe the equivalent of 'Allocation Limit')	*The volume of water available for consumptive purposes, including licensed and non-licensed purposes (including forestry interception of recharge), after considering resource capacity and environmental needs.*
Demand (water demand)	*For the purposes of the present report demand is assumed to be water required for licensed use by existing users. Thus demand is used interchangeably with Proposed Water Allocations in this document. Note that the use of this terminology in this report may be inconsistent with more general use of the term, where it is assumed to include non-licensed use (i.e. stock and domestic, forestry interception) against the consumptive use limit as well.*
Environmental Asset	*Flora and fauna species of significance and significant aquatic habitats – i.e. Pools, River Red Gums, main watercourses (generally at least 3rd order) and wetlands. It also refers to 'significant environmental assets' as defined in the WAP. This term has been used interchangeably with water dependent ecosystem.*
Existing User	*A person (or company):* *a) who took water from the resource at any time during the establishment period (1 July 2000 – 15 October 2003); or* *b) who did not take any water during this period but who needs water for a development, project or undertaking to which he or she was legally committed or in respect of which he or she had, in the opinion of the Minister, committed significant financial or other resources during the establishment period.*
Existing User Process	*The process undertaken to issue existing users with their water licences, having taken into consideration their reasonable requirements and the capacity of the water resource. The capacity of the resource is the total amount of water available to meet all water demands (in terms of quality and quantity), including consumptive use and the needs of the environment, on a long-term average annual basis.*
Groundwater Dependent Ecosystem	*Environmental assets supported by groundwater – i.e. Persistent pools, baseflow supported sections of watercourses and groundwater fed wetlands*
Proposed Water Allocations (may also be referred to as 'water allocations' or 'allocations')	*The proposed volumes of water that have been calculated for existing users, based on their 'reasonable requirements' or water demands. It does not consider environmental water provisions or broader social or economic factors (economic considerations may be taken into account at an individual water user level).*
Reasonable Requirements	*The quantity and quality of water reasonably required to properly conduct the relevant activity (or activities) during the establishment period. Consideration is given to both the actual practices of each user in terms of the type and area of crops planted and irrigation methods used, and the usual industry standards and practices for any particular crop and area. Theoretical crop requirements and dam capacity may also be taken into account.*

Appendix

Example risk assessments:
SWMZ 426AR026 and UWMZ Tookayerta Permian

Surface Water Management Zone – '426AR026'

426AR026 is part of the Angas River catchment. It is located on the plains and is considered to be a receiving zone (Figure 2).

Likelihood

The risk assessment considers sources of risk internal and external to a SWMZ. The likelihood assessment for a zone accumulates the impact of existing user allocations in all hydrologically connected surface and groundwater management zones by the following means:

- Comparison between the total upstream consumptive use limit to total upstream demand, where 'upstream' refers to the entire catchment area at and above the zone being assessed, and
- Consideration of the impact of overallocation of groundwater on baseflow that flows into the SWMZ being assessed and all upstream zones.

Based on investigations undertaken for the WAP, the resource capacity of 426AR026 was calculated as 0 ML. The 26 connected upstream catchments have a resource capacity of 8407.7 ML.

The total demand value for the zone considers the extent of overallocation for the associated UWMZ (i.e. the Angas Bremer Limestone UWMZ) and is calculated as 69.2 ML. The total demand for the zone, including the associated upstream catchments and reduction in baseflow due to overallocation of unconfined UWMZs is 2526.9 ML.

The percentage demand is calculated (i.e. 2526.9 ML/8407.7 ML * 100), which equals 30%. This is 10% more than the consumptive use limit of 20%, giving a likelihood score of 'likely' (Table 31).

Consequence

The consequence score is based on the quantification of potential loss of environmental values at the management zone scale as a result of allocations to existing users.

The ephemeral flows (three to four months per year) typically experienced by 426AR026 support significant fish species such as the southern pygmy perch which have been sighted in the terminal wetland (Table 3 and Table 4). Other fish species include the carp gudgeon and jollytail. The macroinvertebrate species observed in 426AR026 warrant a low rating while wetlands were assigned a moderate rating.

The overall consequence level is based on the maximum value of the three attributes assessed (i.e. fish, macroinvertebrates and habitat). Therefore the presence of pygmy perch justify the highest consequence rating for this zone (i.e. catastrophic) (Table 31).

Risk Level, Tolerability and Recommendation

The risk level for 426AR026 is extreme given the likelihood score of likely and the consequence score of catastrophic (Table 31).

The team knowledge and agreement attributes of confidence were rated high. As the data used for the consequence assessment was considered to be sufficiently current (i.e. up to 10 years old) and given that survey sites were located within the SWMZ, confidence in the data underpinning the assessment was also rated high, leading to high overall confidence in the consequence rating.

Given that the percentage of demand in comparison to the resource capacity can be considered to be within 5% of the threshold between possible and likely (i.e. 30%) a confidence modifier needs to be applied. This changes the confidence rating from high to moderate (Table 1).

According to the risk evaluation criteria (Table 15 to Table 17) the risk level in 426AR026 is rated as intolerable, and as such should be treated in a timely manner. Table 31 provides a summary of the assessment for this SWMZ.

Table 31: '426AR026' SWMZ Risk Assessment Summary

Risk Criteria/Results	Score or Rating
Catchment	Angas River
Risk rating	Extreme
Demand:Resource Capacity	0.301
Likelihood	Likely
Consequence	Catastrophic
Confidence	Moderate
Tolerability	Intolerable
Recommendation	Unconditional treat

Underground Water Management Zone – 'Tookayerta Permian'

The Tookayerta Permian UWMZ (shown on Figure 3) represents the Permian Sands aquifer where it intersects the Tookayerta Creek catchment boundary.

Likelihood

The interim proposed water allocation considered for this UWMZ is 6759.45 ML. The allocation limit from the WAP is 2530 ML, thus the demand to allocation limit ratio is 2.67 or 267%. This level of allocation relative to the limit means it is almost certain that an impact will occur over the timeframe of this assessment if all the allocation is used (Table 33 and Table 34).

Consequence

Altered UWMZ resource condition

This assessment is based on two criteria; 'time to adverse impact' and 'resource response'.

Data was obtained from the Obswell database based on Currency Creek and Mt Compass Network wells that were identified as being within the Tookayerta Permian UWMZ according to ArcGIS analysis. The consequence analysis considered the reduced standing water level data for 33 wells. Linear trend analysis shows that in general (i.e. for the majority of these wells) there has been a small yet steady decline (i.e. 0.02 to 0.28 m/y) over the last 8–20 years (Figure 14 to Figure 17).

Water levels have generally stabilised over the five years leading up to 2012 (three wells with gradual decline, 21 with steady trend, three with overall gradual increase). However, if extraction levels approach allocations it is expected that water levels will decline further within five years. Therefore the consequence score for the 'time to impact' attribute is four (Table 7).

Analysis of the resource response consequence attribute leads to a minimum score of 2 as it can be assumed that declining water levels will be experienced given the extent to which allocations exceed the allocation limit (Table 8). It is assumed that as water levels decline the salinity will increase. Based on the data available regarding salinity levels, this water resource is very fresh (less than 700 mg/L - Table 32) therefore supporting a score of four (Table 33). The resource is effectively renewable meaning the score remains as four rather than increasing to five. (i.e. +1 for a non-renewable resource).

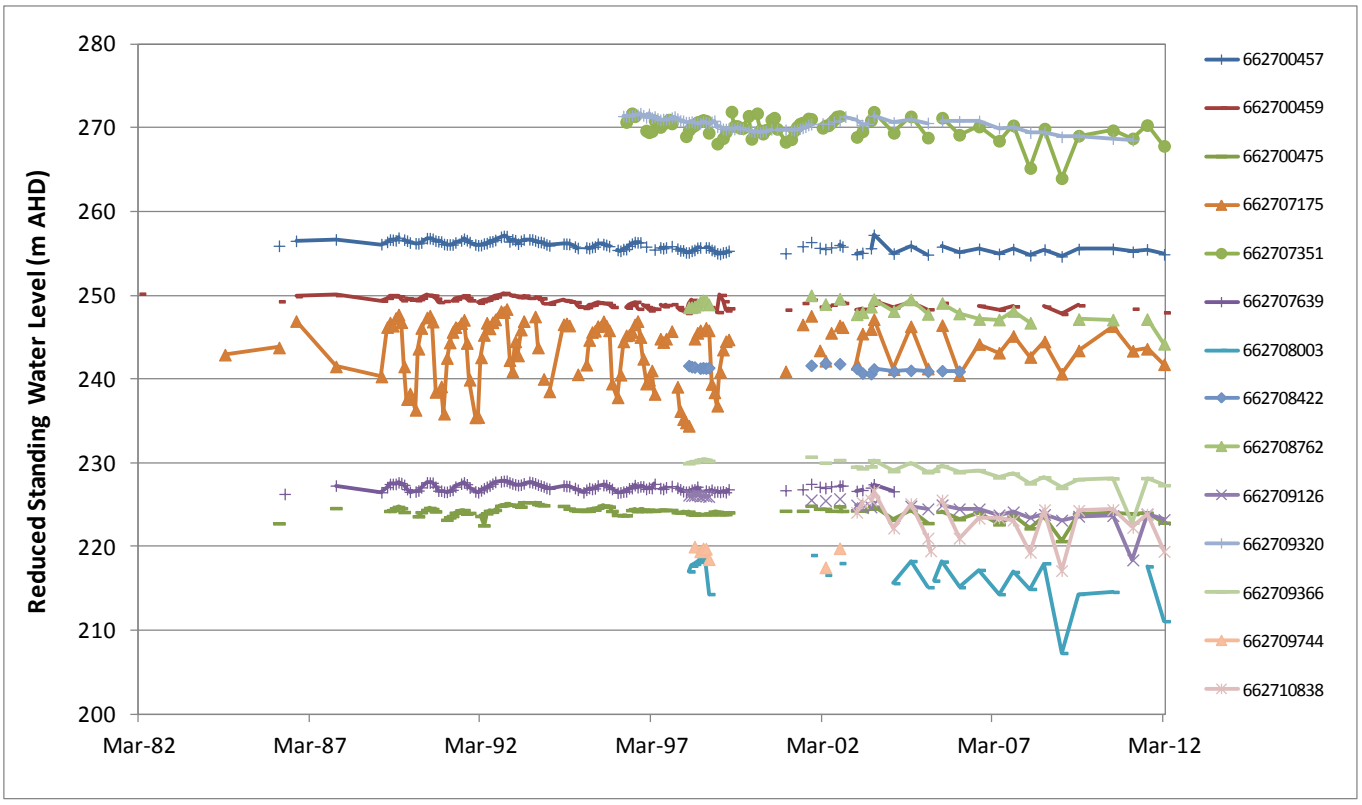

Figure 14. Tookayerta Permian UWMZ Water Level Hydrograph for Reduced Standing Water Levels ranging between 200 and 280 m AHD

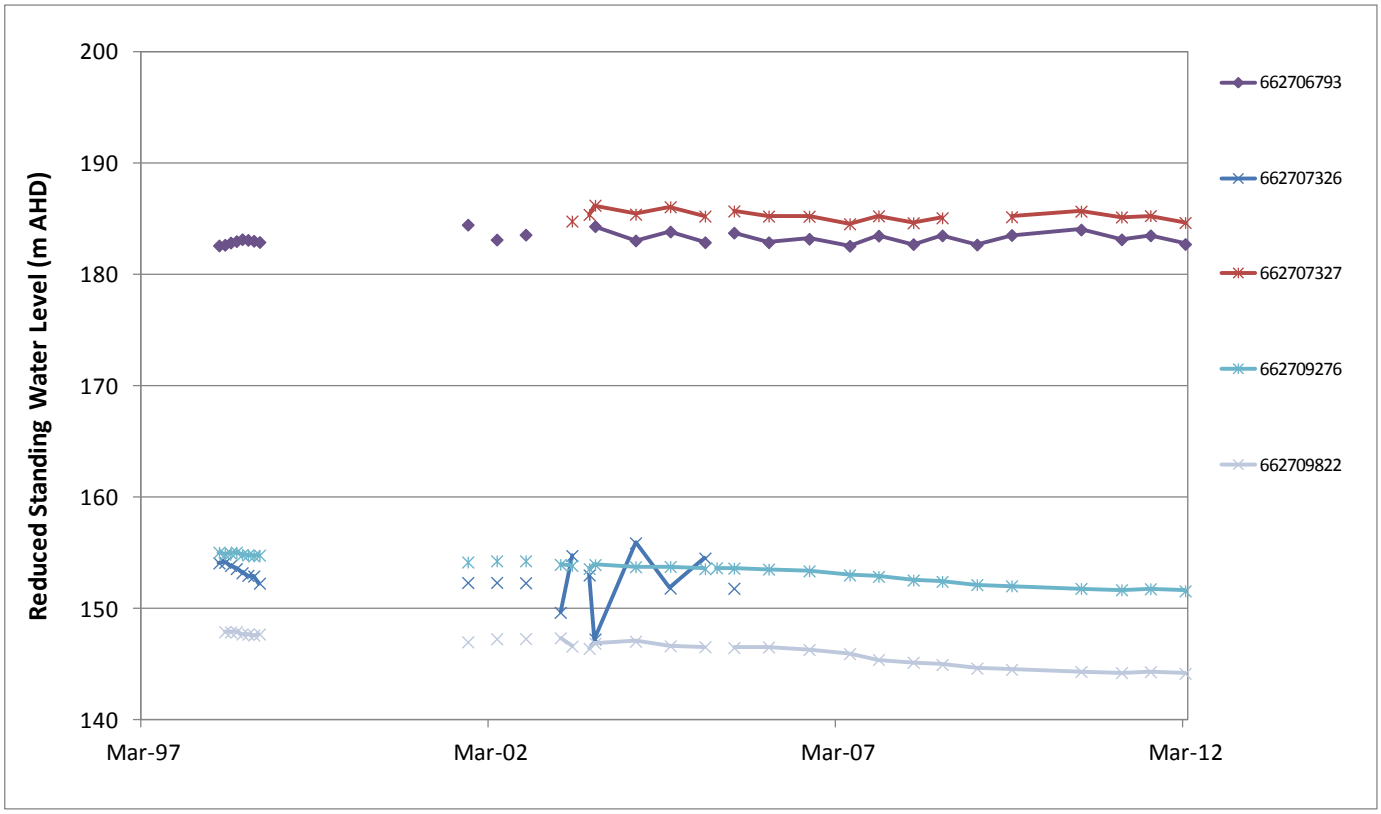

Figure 15. Tookayerta Permian UWMZ Water Level Hydrograph for Reduced Standing Water Levels ranging between 140 and 200 m AHD

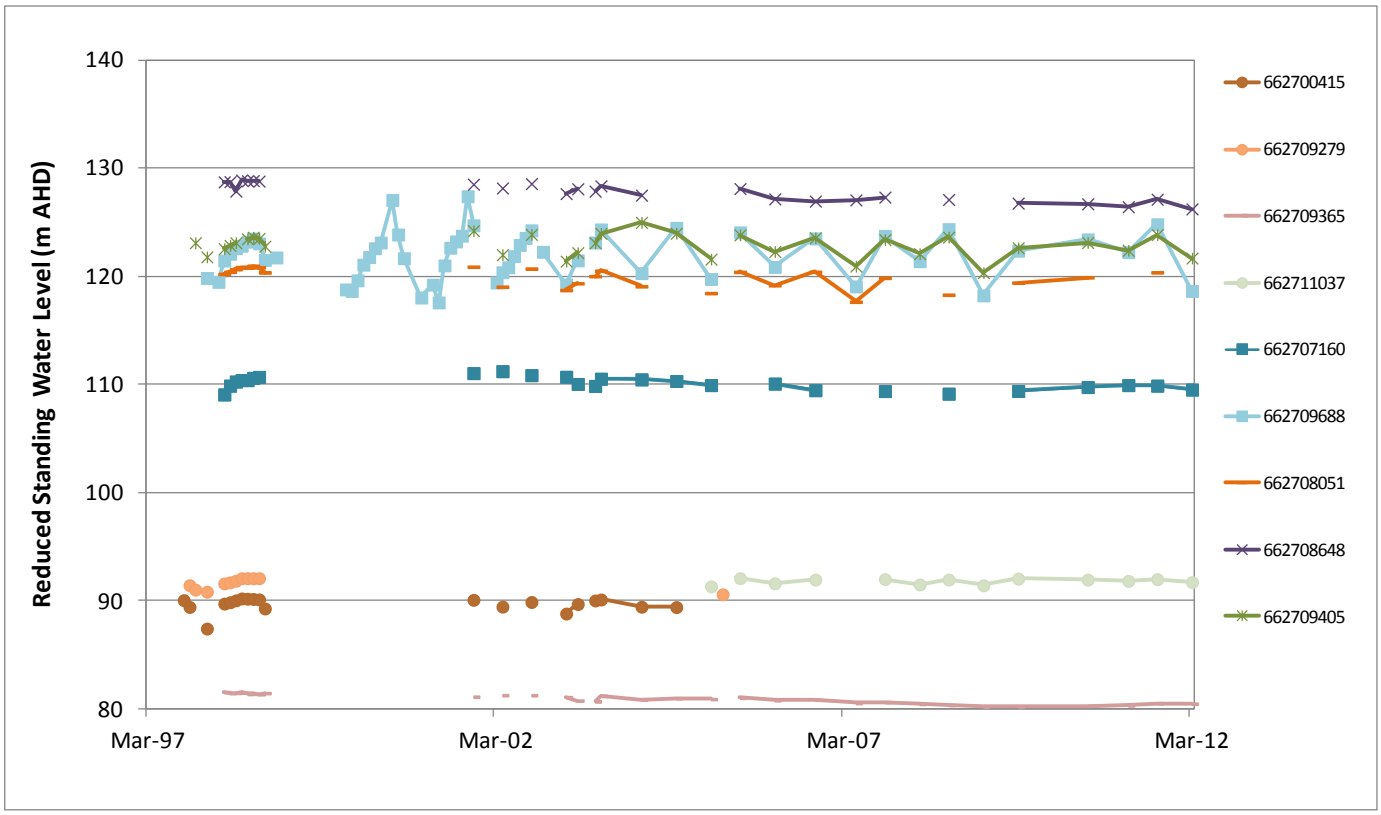

Figure 16. Tookayerta Permian UWMZ Water Level Hydrograph for Reduced Standing Water Levels ranging between 80 and 140 m AHD

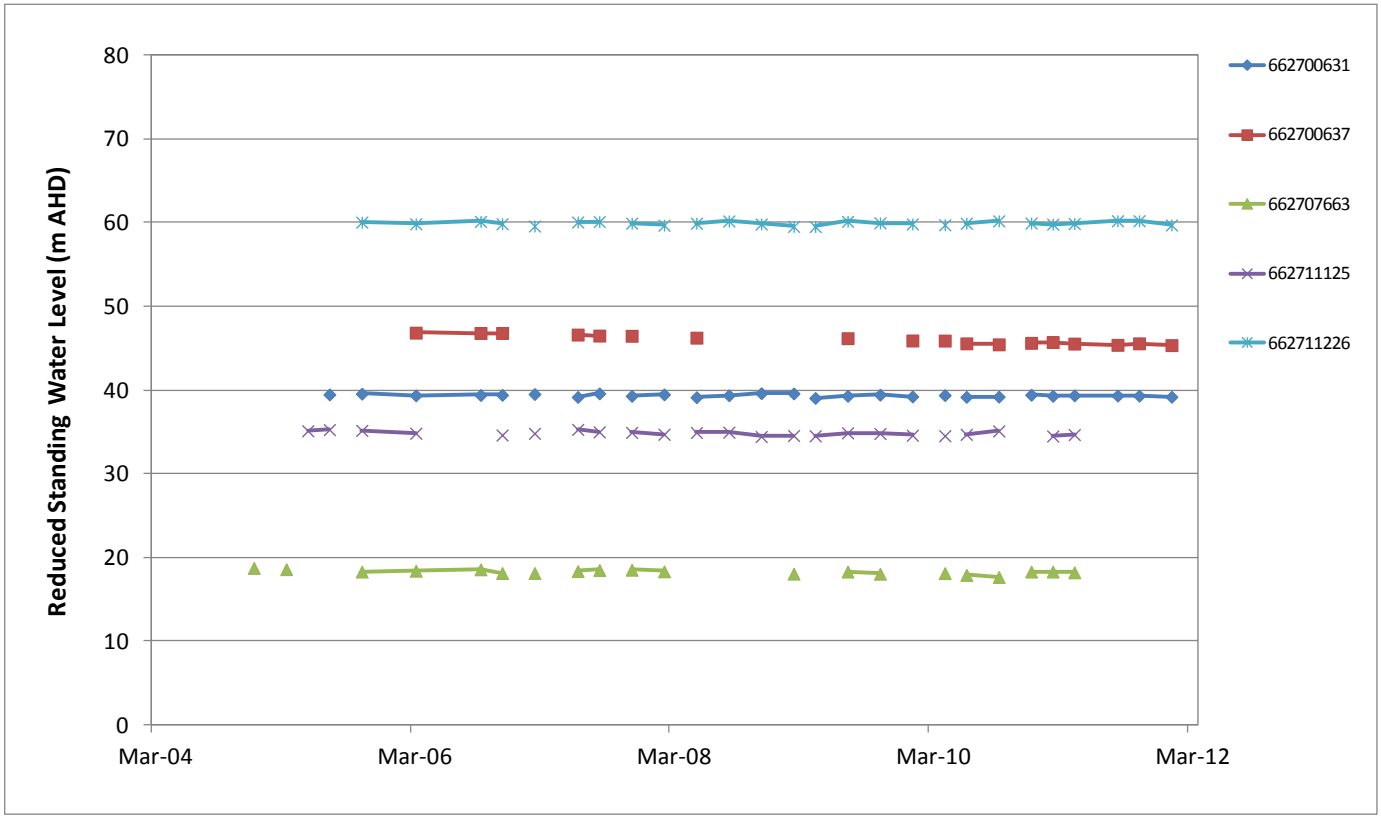

Figure 17. Tookayerta Permian UWMZ Water Level Hydrograph for Reduced Standing Water Levels ranging between 0 and 80 m AHD

Table 32: Total Dissolved Solids concentrations for wells located within the 'Tookayerta Permian' UWMZ

	TDS Concentrations (mg/L)						
Well Unit No.	**Apr-75**	**Jan-80**	**Sep-84**	**Jun-86**	**Jul-86**	**Mar-96**	**Apr-96**
662700457	77					72	
662700459	88					77	
662700461		264				253	
662700475	683						
662707175			430			187	
662707639				182	195	182	440

Impact on GDEs

This consequence class is based on local impacts of groundwater use within the Tookayerta Permian zone.

The potential for impacts to GDEs within a UWMZ was determined to be a function of indicators of GDE vulnerability and value as follows:

Consequence rating (GDEs inside UWMZ) = Vulnerability of the GDEs + Value of the GDEs

The vulnerability component was based on the number of existing user wells located within 50 m of an aquatic asset as identified in the aquatic assets GIS layer and the number of wells which had buffers of influence intersecting the 50 m aquatic assets buffer.

For the Tookayerta Permian zone this assessment indicated that there were seven existing user wells located within the 50 m Aquatic Assets buffer and 53 wells that had buffers intersecting the 50 m Aquatic Assets buffer. The total area of Aquatic Assets (including the 50 m protection buffer) was determined to be 6.916 km^2 based on an intersection assessment in ArcGIS.

The following calculation was used to determine vulnerability:

$$\textit{Vulnerability of GDEs in the UWMZ} = \frac{\textit{(Number of wells in 50 m Environmental Asset buffer x 2) + Number of well buffers intersecting Environmental Asset buffer}}{\textit{Total Area of Environmental Assets including the 50m buffer within the UWMZ (km2)}}$$

The vulnerability of GDEs to water use within the UWMZ was calculated to be 9.69 which placed the zone in bin 5–15 (Table 9) giving the vulnerability rating of three.

The value component of this assessment was similar to that undertaken for the SWMZs as it was based on existing biological datasets and expert knowledge. For the Tookayerta Permian zone the following factors were taken into consideration:

- Macroinvertebrate surveys
- Fish surveys indicating southern pygmy perch (multiple records), mountain galaxias (multiple records) and river blackfish located in relatively degraded wetland sites
- Survey sites present downstream of where wells and well buffers intersect aquatic asset buffers.
- Wetlands/areas of inundation present along most of the streams within this zone, there are also lots of persistent pools.
- Most wetlands/areas of inundation display signs of being impacted by rural development, except in State Parks and Heritage Agreements, e.g. Hesperilla Conservation Park, which is in close proximity to a mountain galaxias sighting (2004).

This resulted in a rating of five based on the criteria of Table 3 and Table 4. Therefore the total consequence score is eight, which gives a consequence level of four or 'major' (Table 34).

Risk Level, Tolerability and Recommendation

Altered UWMZ resource condition

Based on the scores for the likelihood and consequence assessments, the risk level in regard to altered resource condition is extreme (Table 33). Confidence ratings for the team knowledge and agreement attributes were both rated high. Confidence in likelihood data led to a score of 'moderate/high' as there is inherent uncertainty in the allocation limit determined for the zone yet high confidence in the proposed water allocation data. There is high confidence in the consequence components of this assessment given the high confidence rating regarding the team knowledge and agreement attributes and moderate confidence in the data underpinning the assessment. This leads to overall confidence in the risk assessment being high.

According to the risk evaluation criteria (Table 15 to Table 17) this risk is rated as intolerable. Therefore, it is recommended that action be taken to treat the risk to reduce the overall risk level in a reasonable timeframe. Table 33 presents a summary of the outcomes of this assessment.

Table 33: 'Tookayerta Permian' UWMZ – Summary for 'Altered UWMZ resource condition' risk assessment

Risk Criteria/Results	Score or Rating
Risk Level	Extreme
Likelihood	Almost certain
Time to adverse impact (out of 5)	4
Resource response (out of 5)	4
Consequence	Major
Confidence	High
Tolerability	Intolerable
Recommendation	Unconditional treat

Impact on GDEs

Based on the scores for the likelihood and consequence assessments, the risk level in regard to 'impact on GDEs' within the 'Tookayerta Permian' UWMZ is extreme (Table 34). Similar to the assessment of altered UWMZ resource condition for the Tookayerta Permian UWMZ, confidence regarding team knowledge and agreement for the likelihood assessment were both rated as high whereas confidence in the data underpinning the assessment was rated as moderate/high given the inherent uncertainty in the allocation limit determined for the zone. There is high confidence in the proposed water allocation data. Thus there is high confidence in the consequence components of this assessment given the high confidence rating regarding the team knowledge and agreement attributes and high confidence in the data underpinning the assessment. This leads to overall confidence in the risk assessment being high.

According to the risk evaluation criteria (Table 15 to Table 17) this risk is rated as intolerable. Therefore, it is recommended that action be taken to treat the risk to reduce the overall risk level in a reasonable timeframe. Table 34 presents a summary of the outcomes of this assessment.

Table 34: 'Tookayerta Permian' UWMZ – Summary for 'Impact on GDEs' risk assessment

Risk Criteria/Results	Score or Rating
Risk Level	Extreme
Likelihood	Almost certain
GDE Vulnerability (out of 5)	3
GDE Value (out of 5)	5
Consequence	Major
Confidence	High
Tolerability	Intolerable
Recommendation	Unconditional treat

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