



Department of
Primary Industries
Office of Water

Water Sharing Plan

Murray-Darling Basin Fractured Rock Groundwater Sources

Background document



Publisher

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The NSW Office of Water manages the policy and regulatory frameworks for the state's surface water and groundwater resources, to provide a secure and sustainable water supply for all users. It also supports water utilities in the provision of water and sewerage services throughout New South Wales.

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Water Sharing Plan for the Murray-Darling Basin Fractured Rock Groundwater Sources – Background document

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Introduction

Water sharing plans are being progressively developed for rivers and groundwater systems across NSW following the introduction of the *Water Management Act 2000*. These plans protect the health of our rivers and groundwater while also providing water users with perpetual access licences, equitable conditions, and increased opportunities to trade water through separation of land and water. In July 2004, 31 water sharing plans commenced in NSW, bringing these water sources and about 80 per cent of water extracted in the state, under the management and licensing provisions of the *Water Management Act 2000*.

In recent years, water sharing plans for the unregulated¹ rivers and groundwater systems have been completed using a macro or broader-scale river catchment or aquifer system approach. About 95 per cent of the water extracted in NSW is now covered by the *Water Management Act 2000*. The macro planning process is designed to develop water sharing plans covering most of the remaining water sources across NSW. Each macro plan covers a large river basin rather than a single sub-catchment, or in the case of groundwater systems, covers a particular type of aquifer, such as fractured rock, within that basin. These macro plans will generally apply to catchments or aquifers where there is less intensive water use compared with the areas that were covered by plans in 2004.

The *Water Sharing Plan for the NSW Murray-Darling Basin Fractured Rock Groundwater Sources* covers 10 groundwater sources.

Water sharing provisions that the plan focuses on are:

- environmental water provisions – the share of the water reserved for the environment
- the long term average extraction limit for each water source
- access, dealing (trade) and work² approvals rules.

In developing the plan other water management tools are applied, including:

- available water determinations – for allocating water to access licence water accounts
- water allocation account management rules
- management of surface and groundwater connectivity rules
- rules for granting access licences – the types of licences that may be granted
- rules for granting new and amending existing works, such as the types of set back conditions that are required
- mandatory conditions on access licences and water supply works approvals
- system operation rules.

This document provides background to the development of the rules in the plan and includes:

- the purpose of the statutory plan
- a physical description of the NSW Murray-Darling Basin fractured rock groundwater sources
- the process of plan development including scope, history and basis for decisions
- the use of adaptive management

¹ The supply of water in unregulated rivers is typically not controlled by releases of water from dams but rather is dependent solely on rainfall and natural river flows.

² For groundwater, these work approvals are usually for bores.

- the activities associated with implementation, monitoring and review of the plan.

This document is part of a range of material available specifically on the plan including:

- the Water Sharing Plan for the NSW Murray-Darling Basin Fractured Rock Groundwater Sources – a draft legal instrument written in its required statutory format
- *Water sharing plans – Inland NSW groundwater sources – Overview* – a plain English document explaining the key sections and rules in the plan
- rules summary sheets for each groundwater source detailing the management rules.

In addition, general information on the macro planning process is available in the Water sharing plans section of the NSW Office of Water website www.water.nsw.gov.au and includes:

- *Macro water sharing plans - the approach for groundwater. A report to assist community consultation* – explains the macro approach to groundwater methodology, including assessment of risk and determination of sustainability indexes for aquifers
- Setting rules for water sharing plans – information outlining the key steps for developing the rules.

Purpose of the plan

Why are water sharing plans being prepared?

The expansion of water extraction across NSW in the 20th century has placed most valleys at or close to the limit of sustainable water extraction. This has seen increasing competition between water users (towns, farmers, industries and irrigators) for access to water. This has also placed pressure on the health and biological diversity of our rivers and aquifers.

Water sharing plans provide a legislative basis for sharing water between the environment and consumptive purposes. Under the *Water Management Act 2000*, a plan for the sharing of water must protect each water source and its dependent ecosystems and must protect basic landholder rights. For groundwater, basic landholder rights referred to in the plan are domestic and stock rights as defined in section 52 of the *Water Management Act 2000*³. Sharing or extraction of water under any other right must not prejudice these. Therefore, licensed water users are effectively the next priority for water sharing. Amongst licensed water users, priority is given to water utilities and licensed stock and domestic use, ahead of commercial purposes such as irrigation and other industries.

Water sharing plans also recognise the economic benefits that commercial users such as irrigation and industry can bring to a region. Upon commencement access licences held under the *Water Act 1912* are converted to access licences under the *Water Management Act 2000* and land and water rights are separated. This facilitates the trade of access licences and can encourage more efficient use of water resources. It also allows new industries to develop as water can move to its highest value use.

In conjunction with other provisions of the *Water Management Act 2000*, water sharing plans also set rules so that commercial users can also continue to operate productively. In general, commercial licences under the *Water Management Act 2000* are granted in perpetuity, providing greater commercial security of water access entitlements. Water sharing plans also define the access rules for commercial users for 10 years providing all users with greater certainty regarding sharing arrangements⁴.

Benefits for water users

With the introduction of a water sharing plan, a number of benefits will flow to water users including:

- greater certainty for water users – the plan sets out the water sharing arrangements for a 10 year period;
- clear trading (dealing) and access rules which will help foster trading; and
- automatic conversion of licences in the plan area to perpetual water access licences providing greater security for water users – meaning the volumetric water access licences do not have to be renewed; however approvals for the works used to extract water under these access licences will need to be renewed.

³ Section 55 of the *Water Management Act 2000* also allows for native title holders to take and use water in the exercise of native title rights. At the time the plan was completed there were no native title rights to water held in the plan area.

⁴ Security versus reliability. These terms are used differently across different jurisdictions, often interchangeably. The National Water Commission encourages the adoption of nationally consistent terminology based on the National Water Initiative. The definitions in the glossary relate to National Water Initiative-consistent use of these terms. In summary, security provides better tenure for an entitlement and does not necessarily provide greater reliability as this is determined by seasonal and climatic conditions.

Environmental considerations

Water sharing plans are required to reserve water for the overall health of the groundwater source and to protect specific ecosystems that depend on groundwater, such as wetlands. This share of water reserved for the environment is also intended to sustain the aquifer system's aquatic fauna and flora.

Most of the groundwater within the area covered by the plan is protected from extraction. The total volume of water licensed for extraction in each water source is generally much less in comparison to their average annual recharge.

The plan also imposes new restrictions on access that may be applied to specific areas that need protection or to manage groundwater surface water connectivity. Distance criteria are also used for any new water supply works, such as bores or spear points that result in exclusion zones around any groundwater dependent ecosystems (GDEs) that require protection from extraction.

Description of the plan area

The NSW Murray-Darling Basin (MDB) fractured rock groundwater sources are located within the NSW portion of the MDB. In general, the plan area includes all fractured rock groundwater sources that are not included in other water sharing plans, such as fractured rock groundwater sources in the *Water Sharing Plan for the Peel Valley Regulated, Unregulated, Alluvial and Fractured Rock Water Sources 2010*. The plan also includes miscellaneous, unmapped alluvial sediments that overly outcropping fractured rock groundwater sources as well as porous rock sediments that occur within groundwater sources that are predominantly fractured rock.

The groundwater sources within the plan cover an area of approximately 24,404,000 hectares, which includes:

- the Adelaide Fold Belt MDB Groundwater Source
- the Inverell Basalt Groundwater Source
- the Kanmantoo Fold Belt MDB Groundwater Source
- the Lachlan Fold Belt MDB Groundwater Source
- the Liverpool Ranges Basalt MDB Groundwater Source
- the New England Fold Belt MDB Groundwater Source
- the Orange Basalt Groundwater Source
- the Warrumbungle Basalt Groundwater Source
- the Yass Catchment Groundwater Source
- the Young Granite Groundwater Source

Appendix 1 includes a map of the area covered by the plan, showing each of the ten groundwater sources. Each of these is described below.

Fractured rock groundwater sources

There are 10 groundwater sources within NSW MDB fractured rock plan area.

The **Adelaide Fold Belt MDB** Groundwater Source covers an area of 592,000 hectares. In NSW and within the Murray-Darling Basin, it comprises the Curnamona Province centred about the Curnamona Craton which, in New South Wales, forms the consolidated basement outcropping as inliers (the Broken Hill and Euriovie blocks). The cratonic units consist of strongly deformed and metamorphosed sedimentary and igneous rocks of Palaeoproterozoic age, termed the Willyama Supergroup hosting the famous silver lead and zinc deposits at Broken Hill. These rocks within the water source accumulated within, or on the edge of, the Proterozoic Australian Craton in continental (including glacial) to shelf marine environments.

The **Inverell Basalt** Groundwater Source covers an area of 175,000 hectares. It is located within a region dominated by fractured rock aquifers including Palaeozoic and Mesozoic granites, basalts, unconsolidated sediments and metasediments. The region is underlain by sandstones, shales and mudstones of the Great Artesian Basin. The basalt formation occurs in places throughout the whole district around Inverell and extends for some distance to the west. In the south-west it forms the watershed with the Gwydir and Macintyre Rivers.

The **Kanmantoo Fold Belt MDB** Groundwater Source covers an area of 3,355,000 hectares. It is an Early Palaeozoic, orthotectonic orogenic belt containing inliers of strongly deformed Cambrian Strata. In NSW the Kanmantoo Fold Belt occupies the area between the Tasman Line and the Koonenbury

Fault zone, and also includes the Morden-Stawell Zone farther east, bounded in part by the Olepoloko Suture in the north-east and the by the Avoca Fault and a lineament in its continuation in the south-east.

The **Lachlan Fold Belt MDB** Groundwater Source covers an area of 16,722,000 hectares. It consists of Cambrian to Lower Carboniferous rock successions. The eastern margin is truncated by the present coastline in the south and is overlapped by the Permo-Triassic succession of the Sydney Basin and its northern equivalents; the northern margin is overlaid by the Mesozoic Great Artesian Basin succession; the southern margin is truncated by the present Tasmanian coastline, and is overlaid by Permian and younger successions. The western margin is largely covered by the mainly Cainozoic Murray Basin successions. The final stage of sedimentation and tectonism in the Kanmantoo Fold Belt and the oldest geological activity in the Lachlan Fold Belt are contemporaneous.

The **Liverpool Ranges Basalt MDB** Groundwater Source covers an area of 286,000 hectares. The Liverpool Ranges volcanic lava-field province comprises alkali basalt formed 70 to 30 million years ago. The ranges start from the volcanic plateau of Barrington Tops and runs for approximately 100 km westwards, forming the northern boundary of the Hunter Valley district. Parts of the Liverpool Range form the watershed between the coastal and inland drainage of New South Wales and thus form a component of the Great Dividing Range. The western end of the Liverpool Range merges into the Warrumbungle Range.

The **New England Fold Belt MDB** Groundwater Source covers an area of 2,799,000 hectares. It occurs in the north-east of New South Wales (the New England Province) and stretches from Newcastle along to the central Queensland coast and evolved during more than 200 million years from Silurian to Triassic times between approximately 430 Ma to 200 Ma. In the middle of it, the Carboniferous (about 350-290 Ma) was marked by a period of orogeny and deformation typical for active collision zones. It is possible that several volcanic island arcs developed during this time.

The New England Fold Belt comprises an eroded mountain range bounded on the south and west by border thrust fault systems. The central zone consists of moderately to highly deformed Silurian to Permian rocks which increase in the degree of deformation from west to east. The basement rocks include phyllites, cherts, jaspers and greywackes with interbedded basic volcanic. These are overlain by Carboniferous shallow marine sediments comprising mudstones, sandstones, limestones, conglomerates and tuffs with interbedded rhyolites. The western zone of the New England Fold Belt is bounded to the east by the Great Serpentine Belt and to the west by the Hunter-Mooki Thrust Fault System.

The **Orange Basalt** Groundwater Source covers an area of 98,000 hectares. It is associated with the numerous basalt extrusions of the Canobolas Volcanic Complex, either as weathered zones (old land surfaces) between successive flows, or as jointed and/or scoriaceous zones within the flows. The basalts are strewn around the edges of the Canobolas volcano near Orange, and are generally 2-60 metres thick with a maximum thickness of 150 metres. The main groundwater source is associated with interconnected joints and fractures mostly developed during the cooling of the basalt flows, and subsequent secondary fractures developed during regional diastrophism (faulting and folding due to tectonic movement).

The **Warrumbungle Basalt** Groundwater Source covers an area of 110,000 hectares. The basalts of the Warrumbungle volcano occupy an approximately circular outcrop area about 50 km in diameter west of the township of Coonabarabran. Outliers of basaltic rocks of the same age as those of the main volcano extend in a broad belt to the south-east, towards the western limit of the Liverpool Range. K-Ar age data correspond to a total range of 17-13 Ma for the Warrumbungle Volcano.

The **Yass Catchment** Groundwater Source covers an area of 195,000 hectares. It is dominated by fractured rock aquifers on Cambrian metasedimentary, Silurian volcanic and Silurian to Devonian

sedimentary rocks of the Lachlan Fold Belt. Shallow unconsolidated sediments occur along the major drainage lines including the Yass and Murrumbidgee Rivers. The eastern margin of the catchment is defined by the Lake George Fault, which has an impressive topographic expression and has been associated with Tertiary faulting and is associated with the development of Lake George.

The **Young Granite** Groundwater Source covers an area of 72,000 hectares. East of the Coolac-Narromine Suture, the Late Silurian Young Granodiorite is in thrust contact with the Mooney Mooney Sub-terrane. The main groundwater source within the granodiorite is associated with weathering, especially in heavily jointed zones, has provided a degree of secondary porosity and permeability in the rock mass. The overlying alluvial sediments contain some groundwater in places but this is an inconsequential part of the aquifer system as a whole.

Land use history

The outcropped areas of the groundwater sources covered by the plan make up 40.8 per cent of the NSW portion of the Murray-Darling Basin. When the buried areas are included, 100 per cent of the NSW portion of the Murray-Darling Basin is covered. Given the extent of the plan, land use history is wide and varied. It will not be summarised here.

Climate

Climate is also wide and varied given the area covered by the plan. It will not be summarised here.

Entitlement and use

There are approximately 104,394 unit shares of entitlement in the area covered by the plan. The majority of these licences are for irrigation purposes, with a significant proportion also used for industrial purposes.

Table 1 shows the current volumes of licensed entitlement

Table 1 Total entitlement for each groundwater source

Groundwater Source	Entitlement (unit shares)
Adelaide Fold Belt MDB	1,466
Inverell Basalt	3,079
Kanmantoo Fold Belt MDB	755
Lachlan Fold Belt MDB	73,599
Liverpool Ranges Basalt MDB	334
New England Fold Belt MDB	7,672
Orange Basalt	7,920
Warrumbungle Basalt	11
Yass Catchment	3,204
Young Granite	6,354
Total	104,394

Groundwater is also extracted within the Murray-Darling Basin to meet basic landholder rights. Extraction for this purpose does not require a licence. The figures given in Table 1 only include licences with a volumetric allocation, so does not include water extracted to meet basic land holder

rights. Table 2 shows the estimate of domestic and stock requirements. This estimate is based on the number of dwellings and an approximate requirement for each.

Table 2 Total estimated requirements of domestic and stocks rights for each groundwater source

Groundwater Source	Estimated requirements (ML/year)
Adelaide Fold Belt MDB	2,143
Inverell Basalt	1,073
Kanmantoo Fold Belt MDB	8,154
Lachlan Fold Belt MDB	74,311
Liverpool Ranges Basalt MDB	1,828
New England Fold Belt MDB	14,520
Orange Basalt	1,158
Warrumbungle Basalt	540
Yass Catchment	1,153
Young Granite	759
Total	105,639

Local water utility requirements

Current extractions for town water supplies are small in proportion of the total entitlement within these water sources, as seen in Table 3.

Table 3 Licensed town water supplies from groundwater for each groundwater source

Groundwater Source	Entitlement (ML/year)
Adelaide Fold Belt MDB	0
Inverell Basalt	56
Kanmantoo Fold Belt MDB	0
Lachlan Fold Belt MDB	5,101
Liverpool Ranges Basalt MDB	0
New England Fold Belt MDB	667
Orange Basalt	160
Warrumbungle Basalt	0
Yass Catchment	279
Young Granite	38
Total	6,301

Developing the plan

Scope of the plan

For the purposes of water planning in NSW, aquifer types have been grouped into four basic categories:

- Porous rock aquifers found in rock formations such as sandstone, siltstone or conglomerate. Groundwater occurs within the pore space in the rock matrix
- Fractured rock aquifers found in rock formations such as granite, basalt, meta-sediments and limestone. Groundwater in these rocks occurs mainly within the fractures and joints as well as in solution channels in limestone
- Coastal sand aquifers, where groundwater is contained in the pore spaces in the unconsolidated sand sediments and
- Alluvial aquifers, where groundwater is contained in the pore spaces in the unconsolidated floodplain material.

The aquifer types and groundwater sources that occur within the boundaries of the plan and their connectivity characteristics are given in Table 4. It is based on principles and recommendations in *Towards a National Framework for Managing the Impacts of Groundwater and Surface Water Interaction in Australia* by Sinclair Knight Merz (2006). When developing the plan, the level of connectivity, the relative level of impact and the timing of connection between the surface water and aquifers has been considered. Those aquifer types that have a significant level of connection and a high possibility of impact on the instream values of the related surface water system generally have rules developed that specifically consider this connection.

Table 4 Connectivity between aquifer types and surface water

Aquifer type	Groundwater sources	Level of connection between surface and groundwater	Level of impact on instream values	Estimated travel time between groundwater and surface water
Fractured rock	Adelaide Fold Belt MDB	Low – moderate	Low since not major contributor	Years to decades
Fractured rock	Inverell Basalt	Low – moderate	Low since not major contributor	Years to decades
Fractured rock	Kanmantoo Fold Belt MDB	Low – moderate	Low since not major contributor	Years to decades
Fractured rock	Lachlan Fold Belt MDB	Low – moderate	Low since not major contributor	Years to decades
Fractured rock	Liverpool Ranges Basalt MDB	Low – moderate	Low since not major contributor	Years to decades
Fractured rock	New England Fold Belt MDB	Low – moderate	Low since not major contributor	Years to decades
Fractured rock	Orange Basalt	Low – moderate	Low since not major contributor	Years to decades
Fractured rock	Warrumbungle Basalt	Low – moderate	Low since not major contributor	Years to decades
Fractured rock	Yass Catchment	Low – moderate	Low since not major contributor	Years to decades
Fractured rock	Young Granite	Low – moderate	Low since not major contributor	Years to decades

Water management units

The plan falls across a number of **water management areas**, including the Border Rivers, Central West, Gwydir, Lachlan, Lower Murray-Darling, Murray, Murrumbidgee, Namoi and Western. Water management areas are constituted areas of land by an order under section 11 of the *Water Management Act 2000*. These are generally declared at the catchment level.

Water sharing plans generally have a hierarchy of planning units to which the plan provisions may apply. Some surface water sharing plans include **extraction management units**. These are the highest management unit in which rules apply. They may be as large as a water management area but with different boundaries to a water management area and they cover one or several water sources. Extraction management units are usually defined for the purpose of establishing a geographic area over which the long-term average annual extraction limit (LTAAEL) for surface water applies. The plan does not establish extraction management units.

The highest level of managements unit described in this plan is the **water source**. There are ten water sources established in the plan. Water sources in this context are one or more places where water occurs naturally below the surface of the ground. These have been established for the purpose of creating a geographic area over which the LTAAEL applies. An available water determination (AWD) can be made for each licence category within the water source and any growth in extraction above the LTAAEL is managed across the water source. Access and trading rules are also generally applied at the water source level. The spatial extent of the water sources in this plan is shown in Appendix 1.

A water **management zone** is the next level down in the planning unit hierarchy and is part of a water source and is the level at which more refined implementation of access or trading rules are applied. In the plan only one groundwater source (the Lachlan Fold Belt MDB) has been split into management zones for more refined management of trade. These are:

Table 5 Water management units

Groundwater sources	Water management zones
Adelaide Fold Belt MDB	No water management zones
Inverell Basalt	No water management zones
Kanmantoo Fold Belt MDB	No water management zones
Lachlan Fold Belt MDB	Lachlan Fold Belt MDB (Mudgee) Lachlan Fold Belt MDB (Other)
Liverpool Ranges Basalt MDB	No water management zones
New England Fold Belt MDB	No water management zones
Orange Basalt	No water management zones
Warrumbungle Basalt	No water management zones
Yass Catchment	No water management zones
Young Granite	No water management zones

Project groups

State Interagency Panel

The State Interagency Panel has overall responsibility for the statewide strategic direction of water sharing planning, to ensure that adequate resources are available from each agency and the varying policy and statutory requirements of the relevant NSW Government agencies are met. The State

Interagency Panel also has the role of making water sharing decisions in cases where the interagency regional panel cannot reach agreement or where the issue has statewide significance.

The State Interagency Panel is chaired by the NSW Office of Water. The group has representatives from the Office, the NSW Office of Environment and Heritage (OEH) and agriculture, fisheries and aquaculture specialists from the NSW Department of Primary Industries (DPI). There are also three catchment management authority (CMA) representatives. The Office is responsible for the overall project management.

State Groundwater Panel

The plan rules have been recommended by the State Groundwater Panel. This is an interagency group consisting of representatives from NSW Office of Water, OEH, DPI and CMAs. Appendix 2 lists the names of the State Groundwater Panel representatives and their areas of expertise. The State Groundwater Panel had access to staff from the agencies to provide technical and scientific information. The key roles of the State Groundwater Panel were to review, and where appropriate modify the outcomes of the regional assessment and the proposed groundwater sharing rules produced by the regional working groups to ensure integration and overall consistency across groundwater sources.

Because this plan covers only groundwater and no surface water sources, it was reviewed and endorsed only by the State Groundwater Panel and not by the State Interagency Panel.

Regional Assessment Working Groups

The regional assessment working groups used local knowledge and expertise to do a risk assessment for each groundwater source in their region and propose plan provisions. Long term average annual extraction limits and water reserved for the environment were defined based on these risk assessments. These assessments and the plan provisions were reviewed by the State Groundwater Panel.

Policy context

There are a number of national and state policies that impact on and direct the development of water sharing plans.

National Water Initiative

The NSW Government is a partner to an intergovernmental agreement, the National Water Initiative, which was signed by the Council of Australian Governments (COAG) in June 2004. The National Water Initiative recognises the continuing imperative to increase the productivity and efficiency of Australia's water use, the need to service rural and urban communities, and to ensure the health of river and groundwater systems by establishing clear pathways to return all systems to environmentally sustainable levels of extraction.

The National Water Initiative has a number of relevant requirements for water planning in Clauses 23, 25, 35 to 40, 52, 78, 79 and Schedule E (refer to the National Water Commission website www.nwc.gov.au in the Water Reform section for details). This intergovernmental agreement contains provisions on water planning including:

- settling the trade-offs between the competing uses must be based on the best available science and socio-economic analysis, as well as consultation with the community
- ensuring that environmental and other public-benefit outcomes are provided for through planned and adaptive environmental water on a statutory basis and achieved, including actions to sustain high-conservation value rivers, reaches, and groundwater areas
- providing for water trading to enhance water markets
- recognising and addressing surface and groundwater connectivity
- managing local impacts in groundwater areas as well as protecting groundwater dependent ecosystems (GDEs)
- providing for indigenous consultation and aboriginal cultural and commercial entitlements
- assessing and addressing interception
- monitoring and reporting on implementation.

The National Water Initiative sets outcomes, guidelines and timelines for water plans and planning processes. The National Water Commission is an independent statutory body responsible for providing advice to COAG on the implementation of the National Water Initiative and national water issues and undertakes a biennial assessment of each state's progress on implementing the National Water Initiative.

Natural Resources Commission

The macro water sharing plans also comply with the NSW Natural Resources Commission's statewide standards and contribute to the relevant statewide targets such as Targets 5 and 6 (see www.nrc.nsw.gov.au for details) which is a requirement of the State Plan, Priority E4 (see

www.nsw.gov.au/stateplan for details). The Natural Resources Commission was established in 2003 to provide the NSW Government with independent advice on natural resource management issues. To achieve this it has developed and recommended a Standard for Quality Natural Resource Management and 13 statewide targets for natural resource management in NSW, which have been embedded in the NSW State Plan. As with the National Water Initiative, the components of the State Standard focus on the use of the best available knowledge, use of appropriate information management systems, delivery of integrated outcomes, engagement of the community and regular monitoring, measuring, evaluation and reporting to specify how delivery of the targets is progressing. The Natural Resources Commission reviews water sharing plans against this Standard and its associated targets.

Table 6 Contribution of the plan to the relevant Natural Resources Commission's statewide targets

Relevant statewide target	Contribution by water sharing plan
By 2015 there is an increase in the recovery of threatened species populations and ecological communities (Target 3)	Rules developed to help protect specific groundwater dependent ecosystems (GDEs).
By 2015 there is an improvement in the ability of groundwater systems to support their groundwater dependent ecosystems and designated beneficial uses (Target 6)	Rules will be applied which protect significant GDEs
By 2015 there is an improvement in the condition of important wetlands, and the extent of those wetlands is maintained (Target 8)	Rules developed to help protect specific GDEs, including wetlands.
Natural resource decisions contribute to improving or maintaining economic sustainability and social well-being (Target 12)	Plans provide a defined share of water and defined security of access. Water markets encourage movement of water licences to high-value uses. Rules developed based on risk assessment which considered community dependence on water extraction.

Catchment action plan

The plan is consistent with and contributes to the following catchment action plans:

- Border Rivers Gwydir Catchment Action Plan (BRGCAP), June 2006, Border Rivers Gwydir Catchment Management Authority, www.brg.cma.nsw.gov.au
- Central West Catchment Action Plan (CWCAP), February 2007, Central West Catchment Management Authority, www.cw.cma.nsw.gov.au
- Lachlan Catchment Action Plan, January 2007, Lachlan Catchment Management Authority, www.lachlan.cma.nsw.gov.au
- Lower Murray-Darling Catchment Action Plan, January 2008, Lower Murray-Darling Catchment Management Authority, www.lmd.cma.nsw.gov.au
- Murray Catchment Action Plan, January 2007, Murray Catchment Management Authority, www.murray.cma.nsw.gov.au
- Murrumbidgee Catchment Action Plan, January 2008, Murrumbidgee Catchment Management Authority, www.murrumbidgee.cma.nsw.gov.au
- Namoi Catchment Action Plan, January 2007, Namoi Catchment Management Authority, www.namoi.cma.nsw.gov.au

- Western Catchment Action Plan, January 2007, Western Catchment Management Authority, www.western.cma.nsw.gov.au

One of the CMA's responsibilities, as observer, is to provide the State Groundwater Panel with advice on the alignment of the proposed classification and extraction limits and rules with the priorities in their catchment action plan.

Basin Plan

The Commonwealth *Water Act 2007* requires the Murray-Darling Basin Authority (MDBA) to prepare and oversee a Basin Plan. This plan is a legally enforceable document that provides for the integrated management of all the Basin's water resources. Some of the main functions of the Basin Plan will be to:

- set and enforce environmentally sustainable limits on the quantities of surface water and groundwater that may be taken from Basin water resources
- set Basin-wide environmental objectives, and water quality and salinity objectives
- develop efficient water trading regimes across the Basin
- set requirements that must be met by state water resource plans
- improve water security for all uses of the Basin water resources.

The Basin Plan will provide the new foundation for managing the Basin's water resources in accordance with any rules and plan accreditation criteria established by the MDBA. At the heart of the Basin Plan will be limits on the quantities of surface water and groundwater that can be taken from Basin water resources. These are known as 'sustainable diversion limits' (SDLs). As the SDLs come into effect, they will set limits on the taking of both groundwater and surface water from the Basin.

Further details can be found on the MDBA website www.mdba.gov.au in the Basin Plan section.

Other considerations

Protecting Aboriginal values

Aboriginal cultural values may be affected by water extraction from aquifers. Most of the information about groundwater and flow related Aboriginal values resides with Indigenous communities.

Aboriginal communities have indicated that water sharing rules should protect natural instream values and groundwater dependent ecosystems. Whilst Aboriginal groups acknowledge the rights of commercial water users, they believe that this entitlement should not be at the expense of the environment or cultural values. In their view, the priority for water sharing plans should be to provide for natural flowing rivers with healthy aquatic biodiversity and groundwater dependent ecosystems. This is consistent with the proposed provisions of the plan.

Further opportunities for granting licences for Aboriginal cultural purposes throughout the Murray-Darling Basin are included in the plan. These can be used for purposes such as manufacturing traditional artefacts, hunting, fishing, gathering, recreation and ceremonial purposes.

Further meetings are planned with the Aboriginal community following the public exhibition period to inform future plan reviews. For more information on macro water sharing plans and Aboriginal water users, visit the Office of Water website at www.water.nsw.gov.au.

Key environmental assets

The Murray-Darling Basin contains a significant number of GDEs, some of which are sensitive to water extraction. A list of the high priority GDEs such as karsts, springs, wetlands and vegetation communities is included in the plan. The plan sets out specific provisions for protection of the listed GDEs. These and other environmental assets were also considered when assessing the environmental value of the groundwater source and its risk from extraction when determining the long term average annual extraction limit for each water source.

It is recognised that there are varying levels of risk to aquifers from groundwater extraction across the plan area. In particular, one groundwater source (Orange Basalt) was identified as having high risk to its aquifer assets i.e. ecological, water quality and aquifer integrity assets, (see Table 7). In this groundwater source, larger portions of the recharge were reserved for the environment (as compared to other groundwater sources with the same socio-economic assets), and where there was also a risk to the accessibility, mitigating rules included in the plan provisions to protect the aquifer asset, while maintaining access.

Table 7 Groundwater source with a high risk to aquifer assets

Groundwater Source	Factors considered that rate the risk as high
Orange Basalt	The risk of a change in groundwater levels on GDEs is considered high because GDEs on the western edge of the groundwater source would suffer permanent habitat loss with that change. The risk of a change in the timing of groundwater level fluctuations on GDEs, however, is considered moderate because of the seasonality of drawdowns on those GDEs. It may be expected that a reduction in groundwater level(s) or piezometric pressure beyond seasonal variations could result in the permanent loss of defined habitat types. This water source includes 4 significant GDEs which are classified as springs.

Key economic and social assets

The plan recognises the economic benefits to the region that are generated by commercial users such as irrigators and industry. There are varying levels of community dependence on access to groundwater across the plan area. The plan therefore sets rules so that commercial users can continue to operate productively. In particular one groundwater source (Orange Basalt) was considered to have a high community dependence on commercial extraction from groundwater. This meant there was a high risk to some financial or social assets should there be a change to access rules or availability of the groundwater resource in these areas, (see Table 8). In these groundwater sources larger portions of the recharge are available for extraction (as compared to other groundwater sources with the same aquifer assets), and where there is also a risk to the aquifer assets or the environment then specific mitigating rules may be included in the plan provisions to protect the aquifer asset, while maintaining access.

Table 8 Water sources with a high risk to financial and/or social assets

Groundwater source	Factors considered that rate the risk as high
Orange Basalt	The risk to investment in agriculture and industry is considered high because this water is generally used to support significant investments in mining. The dependence on groundwater related activities, however, is considered low in this water source as there is limited entitlement in relation to annual recharge.

Protecting basic landholder rights

For groundwater, basic landholder rights includes water for domestic and stock purposes which is extracted from any aquifer underlying the landholder's property. It also includes water extracted for native title purposes. Under section 52 of the *Water Management Act 2000*, groundwater may be extracted to meet defined domestic and stock purposes without a licence, although the work (usually a bore) must still be approved by the NSW Office of Water.

The principles of the *Water Management Act 2000* also require that water sharing must protect basic landholder rights. The plan does this by including an estimate of the water requirements for domestic and stock users. There are currently no extractions to provide for native title rights. However, these rights may be activated during the term of the water sharing plan. Further, there are usually less stringent rules applying to works in the plan for basic landholder rights users compared with the rules for other extraction.

Domestic and stock rights can be restricted by the Minister under section 324 of the *Water Management Act 2000*, for instance, to protect the environment or public health, or to preserve existing basic landholder rights. These restrictions are outside the framework of the plan. The NSW Office of Water is also developing a 'reasonable use guideline' which will limit extractions under domestic and stock rights to a reasonable volume and more clearly define what is considered to be a reasonable purpose, which is important where these extractions are not metered.

Other water sharing considerations

There are a number of policies and water related issues that required consideration with the development of the plan and the associated water sharing rules. A large range of reference material was also used in addition to the knowledge of panel members and technical support staff. Reference material is listed in Appendix 3.

Rules for groundwater sources

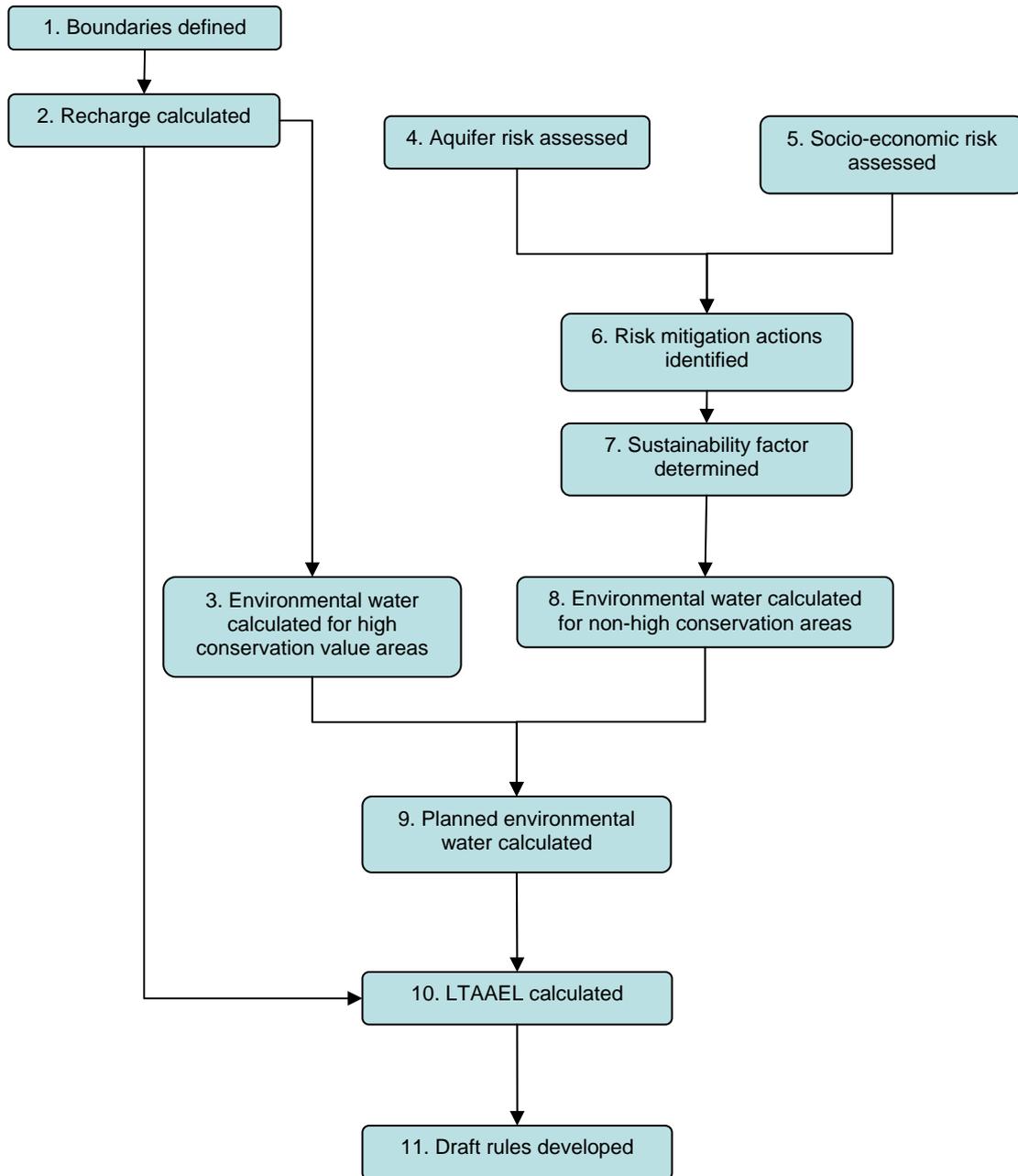
Risk assessment approach to determining sustainable limits

The plan was developed based on the groundwater 'macro planning' risk assessment process. This is the current approach of the NSW Office of Water to developing water sharing plans for non-highly connected groundwater sources and is described in *Macro water sharing plans – the approach for groundwater. A report to assist community consultation*. The macro approach is a risk-based approach based on best available information that gave a relative assessment for groundwater sources and provided the basis for rules for water access and for managing water supply works that relate to groundwater extraction. The process used assessments ('high', 'moderate' and 'low') to indicate different levels of risk. The adopted approach helped to clarify a range of values and risks, indicating where an optimal balance might be between extraction and retention of groundwater recharge in an aquifer to meet environmental needs. In some areas, natural assets need strong protection; in others there is more socio-economic reliance on groundwater for extraction. The broad scale relative assessments allowed the most appropriate provisions to be developed for inclusion in water sharing plans.

The environmental values of the 10 MDB fractured rock groundwater sources were weighed up against the socio-economic dependence and consideration was given to the possibility of any actions that could be taken to reduce (mitigate) the risk to the environmental values. As a result, a 'sustainability index' was determined for each of these groundwater sources. This factor then went towards determining the volume of average annual recharge to each aquifer which is reserved as environmental water and the volume which may be available for extraction. Rules were also then developed for the water source and endorsed by the State Groundwater Panel. An outline of the risk assessment process for groundwater is detailed in Figure 1.

General details of the risk assessment process are presented in the report *Macro water sharing plans – the approach for groundwater. A report to assist community consultation*, available on the NSW Office of Water website www.water.nsw.gov.au.

Figure 1 Macro planning risk assessment process



Recharge calculations

Recharge is the volume of water that infiltrates into an aquifer. It is expressed as a volume in megalitres per year (ML/year). Recharge usually comes from rainfall and from surface water, such as river flows or from other aquifers. The recharge calculations for all of the Murray-Darling Basin fractured rock groundwater sources are based on rainfall recharge only i.e. the calculation does not include other forms of recharge such as river recharge, side slope or upward recharge. It is calculated based on a percent of infiltration of average annual rainfall over the water source area. This approach is precautionary and goes towards the determination of the volume of groundwater reserved as planned environmental water and the volume that is potentially available for extraction in each groundwater source.

The average annual rainfall recharge volumes for the Murray-Darling Basin groundwater sources are displayed in Table 9. The recharge figure for high conservation value areas within each of the groundwater sources is treated separately from the rest of the recharge in that 100 per cent of this recharge is reserved as planned environmental water, while the percentage of the recharge for the remainder of the water source that is reserved as environmental water is determined by the sustainability factor.

Note that for the purposes of defining recharge, high environmental value areas include national parks, nature reserves, historic sites, Aboriginal sites, state conservation areas and Karst conservation areas.

Table 9 Average annual recharge for the outcropped areas of the MDB Fractured Rock Groundwater Sources

Water Source	Area (ha)	Average annual rainfall (mm/yr)	Infiltration rate (%)	High environmental value areas Estimated average annual rainfall recharge (ML/yr)	Non-high environmental value areas Estimated average annual rainfall recharge (ML/yr)	Total Estimated average annual rainfall recharge (ML/yr)[#]
Adelaide Fold Belt MDB	592,050.4	213.19	4	0.00	50,487.45	50,487.45
Inverell Basalt	175,252.6	749.15	4	902.28	51,614.28	52,516.56
Kanmantoo Fold Belt MDB	3,354,917.0	239.37	4	23,611.74	297,624.25	321,235.99
Lachlan Fold Belt MDB	16,721,908.4	519.43	4	189,362.53	3,285,001.88	3,474,364.42
Liverpool Ranges Basalt MDB	285,754.5	702.96	4	4,049.46	76,299.90	80,349.37
New England Fold Belt MDB	2,798,643.9	771.57	4	44,603.58	819,134.06	863,737.65
Orange Basalt	98,342.7	842.21	4	715.01	32,415.01	33,130.01
Warrumbungle Basalt	110,319.2	648.80	4	5,788.69	22,841.17	28,629.86
Yass Catchment	195,105.6	678.02	4	587.36	52,326.45	52,913.81
Young Granite	71,502.9	666.49	4	4.79	19,057.58	19,062.37
Total	24,403,797.4			269,625.45	4,706,802.03	4,976,427.48

[#] Average annual rainfall recharge (ML/yr) = [(water source area (ha) x mean rainfall(mm))/100] x % infiltration rate.

Risk assessment

The aquifer risk assessment considered the risk that groundwater extraction placed on the groundwater source and its high priority groundwater dependent ecosystems and identified risks to ecological, water quality and aquifer integrity assets. The socio-economic risk assessment looked at the dependence of local communities on groundwater extraction in terms of the risk to financial and sociological assets. An overall risk valuation was attained for the groundwater source, which is equal to the highest value attained on any criterion, less any mitigation measures.

Mitigation measures, applied through rules in the water sharing plan, can reduce the impact of extraction on a groundwater source. For example, a groundwater source which is at high environmental risk may have its risk reduced to moderate if the effect of extraction can be successfully mitigated. Mitigation measures were applied to the Lachlan Fold Belt MDB, Liverpool Ranges Basalt MDB and Warrumbungle Basalt Groundwater Sources.

Sustainability factor

The recharge volume calculated for the area outside the high environmental value areas of each groundwater source is split between the environment and water potentially available for extraction. The sustainability factor was based on a matrix and determined the percentage of recharge in these parts of each groundwater source that was reserved as planned environmental water. The remaining percentage in the non-high conservation area was included in the long term average annual extraction limit (LTAAEL) *i.e.* the volume potentially available for extraction. The sustainability factors for the groundwater sources covered by the plan are in Figure 2.

Figure 2 Sustainability factors for the MDB Fractured Rock Groundwater Sources

High environmental risk	5%	25%	50% Orange Basalt
Moderate environmental risk	25% New England Fold Belt MDB Lachlan Fold Belt MDB* Warrumbungle Basalt* Liverpool Ranges Basalt MDB*	50% Young Granite Yass Catchment	60%
Low environmental risk	50% Inverell Basalt	60% Kanmantoo Fold Belt MDB Adelaide Fold Belt MDB	70%
	Low socio-economic risk	Moderate socio-economic risk	High socio-economic risk

* Notes that the Sustainability Index Value is calculated assuming mitigation is in place.

Defining planned environmental water

Planned environmental water is derived from the average annual rainfall recharge volumes. A percentage of this rainfall recharge from the high environmental value areas (either 95 or 100 per cent) has been added to a percentage of rainfall recharge from the non-high environmental value areas (dependent on the sustainability factor) for each water source. Details of the planned environmental water reserved for each water source in the plan are in Table 10.

Annual rainfall recharge reserved in high environmental value areas

Groundwater extraction is generally not permitted in areas such as national parks and reserves to ensure protection of groundwater dependent ecosystems. The approach to restrict extraction and reserve the annual rainfall recharge volumes as planned environmental water in these high environmental value areas is consistent with the precautionary principle. This means that volumes made available for licensed use are limited until the groundwater system is further assessed (such as, assessment of through flow) and the effect of groundwater extraction is better known.

Therefore, all groundwater sources have 100 per cent of the recharge generated from the high environmental value areas reserved as planned environmental water.

Annual rainfall recharge reserved in non- high environmental value areas

Following the results of the risk assessment each groundwater source was placed in the sustainability matrix to provide the percentage of recharge in the non-high environmental value areas to be reserved as planned environmental water. This percentage is 100 minus the sustainability factor percentage.

A minimum 30 per cent to a maximum 95 per cent of the long term average annual rainfall recharge volume in the non-high environmental value area of each groundwater source may be reserved as planned environmental water for a groundwater source depending on the outcomes of the risk assessment. This builds on the original *NSW Groundwater Dependent Ecosystem Policy (2002)* which recommended a minimum of 30 per cent.

In the plan a minimum of 40 per cent and a maximum of 75 per cent of the rainfall recharge has been reserved as planned environmental water in the non-high environmental value areas.

Table 10 Planned environmental water for the MDB Fractured Rock Groundwater Sources

Water source	High environmental value areas Average annual rainfall recharge (ML/yr)	% of average annual rainfall recharge from high environmental value areas reserved for the environment	Non-high environmental value areas Average annual rainfall recharge (ML/yr)	% of average annual rainfall recharge from non-high environmental value areas reserved for the environment	Planned Environmental Water (ML/yr)
Adelaide Fold Belt MDB	0.00	100%	50,487.45	40%	20,194.98
Inverell Basalt	902.28	100%	51,614.28	50%	26,709.42
Kanmantoo Fold Belt MDB	23,611.74	100%	297,624.25	40%	142,661.44
Lachlan Fold Belt MDB	189,362.53	100%	3,285,001.88	75%	2,653,13.95

Water source	High environmental value areas Average annual rainfall recharge (ML/yr)	% of average annual rainfall recharge from high environmental value areas reserved for the environment	Non-high environmental value areas Average annual rainfall recharge (ML/yr)	% of average annual rainfall recharge from non-high environmental value areas reserved for the environment	Planned Environmental Water (ML/yr)
Liverpool Ranges Basalt MDB	4,049.46	100%	76,299.90	75%	61,274.39
New England Fold Belt MDB	44,603.58	100%	819,134.06	75%	658,954.13
Orange Basalt	715.01	100%	32,415.01	50%	16,922.51
Warrumbungle Basalt	5,788.69	100%	22,841.17	75%	22,919.57
Yass Catchment	587.36	100%	52,326.45	50%	26,750.59
Young Granite	4.79	100%	19,057.58	50%	9,533.58
Total	269,625.45		4,706,802.03		3,639,034.55

Defining the long term average annual extraction limit

The percentage of water potentially available for extraction is termed the long-term average annual extraction limit (LTAAEL) and is expressed in megalitres per year (ML/year); this is the estimated sustainable limit for each of the water sources. The LTAAEL for the groundwater sources in the MDB fractured rock is as expressed in Table 11. The LTAAEL was calculated by applying the sustainability factor derived from the risk assessment process, which determined the percentage of the average annual rainfall recharge over the non-high environmental areas that can be potentially made available for extraction.

Table 11 LTAAEL for the MDB Fractured Rock Groundwater Sources

Water source	High environmental value areas Average annual rainfall recharge (ML/yr)	% of average annual rainfall recharge from high environmental value areas made available for possible extraction	Non-high environmental value areas Average annual rainfall recharge (ML/yr)	Sustainability factor (% of average annual rainfall recharge non-high environmental value areas made available for possible extraction)	LTAAEL (ML/year)
Adelaide Fold Belt MDB	0.00	0%	50,487.45	60%	30,292.47
Inverell Basalt	902.28	0%	51,614.28	50%	25,807.14
Kanmantoo Fold Belt MDB	23,611.74	0%	297,624.25	60%	178,574.55
Lachlan Fold Belt MDB	189,362.53	0%	3,285,001.88	25%	821,250.47
Liverpool Ranges Basalt MDB	4,049.46	0%	76,299.90	25%	19,074.98
New England	44,603.58	0%	819,134.06	25%	204,783.52

Water source	High environmental value areas Average annual rainfall recharge (ML/yr)	% of average annual rainfall recharge from high environmental value areas made available for possible extraction	Non-high environmental value areas Average annual rainfall recharge (ML/yr)	Sustainability factor (% of average annual rainfall recharge non-high environmental value areas made available for possible extraction)	LTAEL (ML/year)
Fold Belt MDB					
Orange Basalt	715.01	0%	32,415.01	50%	16,207.50
Warrumbungle Basalt	5,788.69	0%	22,841.17	25%	5,710.29
Yass Catchment	587.36	0%	52,326.45	50%	26,163.23
Young Granite	4.79	0%	19,057.58	50%	9,528.79
Total	269,625.45		4,706,802.03		1,337,392.93

Water sharing rules

Managing extraction to the LTAEL

Total extraction in the water source is managed to the LTAEL. A growth in water use response will be triggered if average annual usage over a three year period in a water source exceeds the LTAEL by more than five percent. Growth in water use is managed through a reduction (from 100 per cent) in the available water determination for aquifer access licences in the water source. The AWD will be reduced by an amount necessary to return total water extractions to the LTAEL.

Unassigned water

The plan includes a provision for review of recharge and long term average annual extraction limits during the fifth year of the plan. Unassigned water is the water potentially available for extraction under the LTAEL that is not yet allocated to an access licence and not estimated to be required to meet current and potential future priority requirements for extraction such as basic landholder rights extraction, extractions by specific purpose access licences e.g. major and local utilities (town and urban water supply) and Aboriginal cultural or from exemptions under the *Water Management Act 2000*.

Without other constraints, the unassigned water component in some groundwater sources could theoretically become fully assigned to new entitlements by the fifth year of the plan. To avoid this occurring, a staged process for any release of new entitlements is being developed for those systems that have a defined volume of unassigned water.

There will be no unassigned water made available through the controlled allocation process where entitlements plus basic landholders' rights equal 90 per cent or more of the LTAEL. In groundwater sources where total entitlement plus basic landholder rights is less than 90 per cent there may be trading in existing water entitlement. However, in these water sources there is also the potential for the Minister to issue new entitlement through a controlled allocations order under the *Water Management Act 2000*.

The current and potential future priority requirements for extraction must be accounted for (including an estimate for growth) before defining the amount that could be released as a controlled allocation. Any increase in these priority requirements over and above the LTAEL must be met through a

reduction in available water determinations to aquifer access licences. Estimating and reserving water to meet future priority requirements before releasing water through any controlled allocation will prevent over-allocation or sending misleading signals to the water market.

In water sources that, after consideration of current and future priority requirements, have unassigned water only a percentage of this volume may be release through the controlled allocation process before a review is initiated.

Aquifer interference

Activities which intersect ('interfere with') an aquifer may involve:

- the extraction of groundwater that flows into a void to allow the activity to operate safely. This is often called de-watering, and the water extracted is often referred to as 'incidental groundwater'; and
- other impacts resulting from the intersection of the aquifer, such as changes to groundwater flow paths and gradients, subsidence, compaction of the aquifer structure, and artificial aquifer recharge.

Volumes of water incidentally taken in the course of aquifer interference activities, such as the water intercepted during mining operations, have in the past required a licence under the *Water Act 1912*.

Operators of these activities will continue to be required to hold an access licence under the *Water Management Act 2000* and sufficient account volume to account for incidental water taken. This includes activities where extraction associated with aquifer interference activity was occurring at the commencement of the plan.

Protecting environmental values and groundwater dependent ecosystems

The groundwater reserved for the environment, or 'planned environmental water' has been detailed above in the section titled '*Defining planned environmental water*'. This is part of the the defined environmental water in the plan. All aquifer storage volumes in each groundwater source are also reserved for the environment.

The plan also includes a number of additional provisions that protect environmental assets. These include the identification of high priority (high conservation value) groundwater dependent ecosystems (GDEs). These GDEs are listed in schedules to the plan. The GDE lists were developed through an interagency expert panel which included karst, wetlands, vegetation and groundwater experts.

The GDE schedules may be updated after gazettal of the plan. Additional protection for these identified GDEs and for protecting base flow in connected rivers is afforded through specific rules for granting or amending water supply works approvals. See section '*Water supply works approvals*' for detail. The distance rules cover new or replacement works such as bores, and stipulate a minimum distance these works are required to be located from high priority GDEs or the associated river.

There are also powers in section 324 of the *Water Management Act 2000* for managing the environmental impacts of existing works within these groundwater sources e.g. on high priority GDEs.

Water supply works approvals

The plan contains rules for granting or amending water supply work approvals and the management of existing works for groundwater sources. These rules determine where water supply works can be located and how existing works may be managed where they are already within the distance restriction. For new and replacement works there are rules to:

- minimise interference between neighbouring works

- locate works away from contaminated sites
- protect water levels for high priority GDEs
- protect groundwater dependent culturally significant sites;
- manage surface and groundwater connectivity

Note also that powers in section 324 of the *Water Management Act 2000* can be used to manage temporary local impacts on new and existing works.

The plan also contains rules to manage existing works where the work is located close to the river. These rules are described below in '*Managing connectivity and access rules*'. This is to limit any additional potential impacts on the adjacent river.

The development of rules for the granting or amending of water supply works and management of existing works has followed a two-stage process:

- Stage 1: regional staff identified draft recommendations for rules; and
- Stage 2: the State Groundwater Panel reviewed the regional recommendations and recommended rules which were consistent across groundwater aquifers in the state. Note that while there is a need for consistency across aquifer types, a change to the rules may have been warranted to cater for local conditions.

This work was reviewed and reconsidered in light of the significant progress made on rules development by the State Groundwater Panel, as a result of the development of draft water sharing plans in other areas of the state.

For details about the proposed rules for water supply works approvals for each groundwater source covered by the plan, refer to individual rule summary sheets or the plan document.

Managing connectivity and access rules

Groundwater and surface waters are inextricably linked. The actual connections between surface and groundwater systems vary significantly between systems. For example, surface water recharging alluvial aquifers may emerge again at a discharge point in the river within hours. In contrast, water recharging aquifers in the Western Murray Fractured Rock Groundwater Source, for example, may not discharge to streams for many years or decades. The connection characteristics need to be considered in linking surface water and groundwater planning, because in some cases, the same water is being accessed.

The fractured groundwater sources within the plan are considered to have a relatively low connection to the surface waters in the same areas.

Available water determinations

The maximum available water determination (AWD) for a water source is used to manage growth in extractions, above the LTAAEL i.e. if growth is assessed to have occurred then the maximum AWD will be reduced to respond to less than 1 ML/unit share.

Available water determinations are primarily used to credit water into a licences water allocation account. The AWD for groundwater access licences in all the groundwater sources in the plan is 1 megalitre per unit share, i.e. 100 per cent of entitlement, unless a growth in use response is required. If a growth in use response is required, the AWD will be reduced by an amount necessary to return total water extractions to the LTAAEL.

Carryover and water accounts

The maximum water that can be carried over from one water year to the next in water allocation accounts for aquifer access licences is 10 percent of the access licence share component expressed as ML/year or 0.1 ML multiplied by the number of unit shares for the licence and expressed as unit shares, in the large regional systems and some localised systems. This includes the Adelaide Fold Belt MDB, the Kanmantoo Fold Belt MDB, the Lachlan Fold Belt MDB, the New England Fold Belt MDB, the Orange Basalt, the Yass Catchment and the Young Granite Groundwater Sources.

The maximum water that can be carried over from one water year to the next in water allocation accounts for aquifer access licences is 20 percent of the access licence share component expressed as ML/year or 0.2 ML multiplied by the number of unit shares for the licence and expressed as unit shares, in the remaining localised systems. This includes the Inverell Basalt, the Liverpool Ranges Basalt MDB and the Warrumbungle Basalt Groundwater Sources.

Carryover is prohibited in allocation accounts that are for domestic and stock, local water utility, salinity and water table management and major water utility access licences in all water sources covered by this plan.

Trading of access entitlement

The water market is an effective and equitable way to reallocate water between users. Trading can occur either on a permanent or temporary basis. The National Water Initiative sets out guidelines for water trading and these will be largely superseded in the Murray-Darling Basin once the Basin Plan commences. Trading of water entitlement needs to be addressed in the plan within a framework that maximises the flexibility for users to be able to use water to its highest value but does not adversely impact on water sources or existing users.

In most groundwater sources trading is allowed within a groundwater source, but no trading is allowed into or out of the groundwater source. The exception to this is within the Lachlan Fold Belt MDB Groundwater Source, where there are additional restrictions on trade into the Lachlan Fold Belt MDB (Mudgee) Management Zone. This is to ensure that any groundwater source cannot be further degraded as a result of trading into that source. Trade that results in conversions of an access licence of one category to another category is prohibited except where permitted under the Minister's Access Licence Dealing Principles, and trade that results in interstate transfer and assignment of water allocations to or from these groundwater sources is prohibited.

Consultation

The risk assessments and the State Groundwater Panel's recommended rules underwent targeted consultation with specific interest groups⁵ before the draft plan was written. Formal public exhibition⁶ of the draft plan then ensured wider public consultation.

While developing the plan, the participating agencies (the NSW Office of Water /OEH, NSW DPI and the CMAs) identified areas where better data was needed for making future water planning decisions. Similarly, the community suggested areas where further analysis or data gathering was required. This input was essential in the finalisation of the plan.

With the State Groundwater Panel's support, the NSW Office of Water managed the public consultation process, and ensured that all stakeholders and interested parties had an opportunity to examine and comment on the proposed water sharing rules. In particular, the NSW Office of Water looked for stakeholders to provide:

- local knowledge and expertise – for example, there may have been other natural or socio-economic values that had not yet been considered by the State Groundwater Panel;
- feedback on the practical elements of the proposed water sharing rules - to make certain they are easily implemented by the licence holders;
- confirmation that there are no unintended outcomes from the plan – it was essential that this was given due consideration before the plan was finalised; and
- specific comments on any Minister's notes included in the plan.

Targeted consultation on the draft rules

Targeted consultation on the plan began in August 2010 (Table 12). The objectives of this consultation were:

- to provide background as to why the water sharing plans were being developed, how they were developed, what rules were proposed in the various areas and how stakeholders could provide feedback; and
- to provide a 'first opportunity' to informally consult with key stakeholders to test the suitability of the proposed water sources, management zones, access and trading rules.

Table 12 Key groups consulted in the plan area as part of the targeted consultation

Date	Group	Location
10 August 2010	ACT Environment	Canberra
1 September 2010	Yass Valley Shire Council, licence holders	Yass
7 September 2010	Gwydir Valley Irrigators, Namoi Water, NSW Irrigators	Sydney

⁵ Targeted consultation refers to informal consultation held with key stakeholders to test the suitability of the proposed water sharing rules and provide feedback on the rules potential impacts.

⁶ Public exhibition is the formal exhibition of a plan where the Minister invites submissions on the plan and in particular will seek comment on a range of key issues.

Date Group		Location
7 September 2010	Namoi Regional Organisation of Councils, Minerals Council	Sydney
8 September 2010	Lachlan Valley Water, NSW Farmers	Orange
8 September 2010	Central Tablelands Water, Parkes Shire Council, Orange City Council	Orange

Public exhibition of the draft water sharing plan

The draft plan was put on formal public exhibition from 6 December 2010 to 31 January 2011. The objectives of this exhibition period were:

- to provide background to stakeholders as to why the water sharing plan is being developed, how it has been developed to date, what rules are proposed in the various areas and how stakeholders can provide feedback
- to formally consult with a broad range of stakeholders to explain the proposed water sharing rules and how they will be implemented and
- to seek feedback from stakeholders and the general community about the proposed water sharing rules.

During this period, five public meetings were held to inform stakeholders of the draft rules and how they could make a submission. These meetings were held at various locations throughout the plan area (Table 13).

Table 13 Public meetings held during the formal Public Exhibition period

Date	Location
13 January 2011	Wagga Wagga
14 January 2011	Queanbeyan
18 January 2011	Broken Hill
18 January 2011	Dubbo
19 January 2011	Gunnedah

Stakeholders were encouraged to submit their comments in writing. A total of 22 fractured rock submissions were received as a result of the public exhibition, which includes five submissions that were for both this plan and other plans also on public exhibition. It should be noted that it is believed that six of the submissions received should have been submitted for the *Draft Water Sharing Plan for the NSW Murray-Darling Basin Porous Rock Groundwater Sources 2011*. These were reviewed by the State Groundwater Panel and changes were made to the draft water sharing rules where appropriate.

Refining water sharing rules as a result of targeted consultation, public exhibition or updated data

The State Groundwater Panel reviewed all the submissions and the matters raised at the meetings and consequently made some changes to the initial draft water sharing rules. During this review process, submissions were incorporated into the assessment process. Table 14 outlines the changes to the proposed rules as a result of this consultative process as well as the inclusion of new data.

Table 14 Changes to water sharing rules as a result of targeted consultation, public exhibition or updated data

Groundwater source	Change to water sharing rules	Justification
All groundwater sources	Amendment to the groundwater source definitions (clause 4)	These more-specific definitions more accurately reflect the three-dimensional nature of groundwater. They are a result of the <i>NSW Policy for Managing Access to Buried Groundwater Sources 2011</i> .
All groundwater sources	Removal of management zones (clause 5)	Management zones in place purely for administrative requirements were unwarranted. All management zones except those with distinct rules have been removed.
General plan	Update of planned environmental water figures (notes within clause 16) and long-term average annual extraction limits (clause 24)	Based on new data
General plan	Removal of provision allowing granting of aquifer (subcategory "Aboriginal community development") access licences.	This was a Minister's Note in the draft plan. No submissions were received.
General plan	Inclusion of amendment provision that allows consideration of Aboriginal water dependent cultural assets to be identified during the term of the plan.	Based on submission
General plan	Update of Schedule 3, High Priority Groundwater Dependent Ecosystems	Based on new data

Adaptive management

Adaptive management is an important part of a water sharing plan. Adaptive management refers to the process of ongoing data collection monitoring, evaluation and review during the life of the plan that either enables plan amendment or remaking of a better plan after 10 years. Adaptive management is a requirement of both the *Water Management Act 2000* and the National Water Initiative, and has been allowed for during the life of the plan through amending provisions and establishment of 'limits of change' to the plan.

Where adaptive management is identified further studies may be undertaken within agencies or by external organisations which may assist in informing the review of plan provisions.

Monitoring of plan performance

The NSW Office of Water is also developing a Monitoring, Evaluation and Reporting (MER) Framework. This framework will be developed in collaboration with key stakeholders and will be consistent with the MER needs of the Natural Resources Commission and the National Water Commission. The intention is that the framework can be applied to existing water sharing plans and macro water sharing plans to enable the development of a specific MER plan.

Performance indicators

The plan includes a number of performance indicators that will be monitored over the 10 year life of the plan.

It is not practicable to monitor all issues in all water sources. The performance indicators identify that monitoring will be undertaken for specific issues in key water sources. The actual procedure for monitoring each indicator may change over the period of the plan as improved methods are developed.

Plan review

Under the *Water Management Act 2000*, the Natural Resources Commission is required to undertake a review of this plan prior to any decision to extend its term or to make a new plan.

The MER framework developed will consider the statutory requirements for the different types of evaluation:

- an audit of the plan, at intervals of no more than five years, for the purpose of ascertaining whether its provisions have been given effect to. This audit is to be carried out by the State Interagency Panel, which has now been appointed by the Minister for Primary Industries
- an audit of the plan by the Natural Resources Commission to assess to what extent the water sharing provisions have contributed to the relevant statewide targets, and natural resource standards and targets in the relevant catchment management area. The Natural Resources Commission will call for public submissions when undertaking its review
- an annual review of Implementation Programs
- the application of information from the relevant monitoring and evaluation programs to inform progress against the relevant statewide targets and requirements of the National Water Commission under the National Water Initiative.

Implementation

Implementation programs

The Minister may elect to establish an implementation program, which sets out the means by which the objectives of this plan are to be achieved. The process for monitoring of the performance indicators will be outlined in the implementation program.

Where an implementation program has been established, it will be reviewed annually to determine whether it is being effective in implementing the water sharing provisions. The results of this review will be included in the NSW Office of Water's Annual Report.

Monitoring water extractions

Each water sharing plan establishes the relevant mandatory conditions for extraction, including that all licences undertake measurement of extraction. The NSW Office of Water will develop a measurement of extractions strategy to meet the objectives of the NSW Water Extraction Monitoring Policy.

Measurement of extractions may be via meters or other forms of monitoring devices fitted to approved works, or via alternate monitoring systems, to provide water extraction estimates. Different types of devices may be required depending on the nature of the water supply work installation, the size of the work, and the affect that the operation of the work may have on the water source and other water users.

Under the Water Use Monitoring Program assessment of water sources is being undertaken across the state to identify priority areas of measurement of extractions and to determine the most suitable measurement options. It is likely that this will be implemented in high priority areas initially, with roll out to all water sources over time, as appropriate.

Note: Decisions regarding the timetable for introduction of measurement of extractions are still under consideration. In the interim, water users are encouraged to use other forms of self-measurement to assist them to extract water in compliance with their licence conditions, which will be developed from the relevant plan provisions. Water users may install flow meters of their own volition. Meters need to meet new national water meter standards and be installed in accordance with the manufacturer's specifications.

Compliance

The NSW Office of Water will undertake compliance activities as necessary to enforce compliance with legal entitlements including each individual's licence conditions, which are developed based on the provisions of the plan once it is implemented. Some reliance is placed on local water users to identify inappropriate or unlawful behaviour and report this to the Office. Reports may be made by phone at 1800 633 362, email to watercompliance@water.nsw.gov.au or via the Office of Water website www.water.nsw.gov.au.

Glossary

Many of the terms in this document are defined in the *Water Management Act 2000* and are therefore not redefined here. However, there are some terms that are not and have therefore been defined below to assist with understanding the water sharing plan.

Connectivity: A connected system is defined as any system with significant connectivity occurring between an aquifer and a surface water system. Connected systems are those where there is a zone of continuous saturation between the river and the aquifer.

Extraction of water: The taking of water from a water source.

Extraction management unit (EMU): A group of water sources; defined for the purpose of managing long-term annual average extraction.

Groundwater: The water beneath the earth's surface that has filtered down to the zone where the earth or rocks are fully saturated.

Groundwater dependent ecosystems (GDEs): Ecosystems relying on groundwater for their species composition and their natural ecological processes.

Long-term average annual extraction limit (LTAAEL): The limit set for total extractions within a groundwater source.

Macro water sharing plans: Water sharing plans which apply to a number of water sources across catchments or different types of aquifers. The macro planning process is designed to develop broader-scale water sharing plans covering most of the remaining water sources in NSW.

Management zone: An area within a water source used for defining the location of applicability of water sharing rules, but secondary to the water source. A management zone (MZ) is more likely to be designated where local dealing restrictions are in place or where rules for works approvals apply.

Security: The legal status and tenure of a right to access water. This includes the level and assurance that a water access entitlement will provide that which it specifies. Security thus includes the reliability of supply. The range of water access entitlement characteristics detailed in the National Water Initiative contributes to the security of a water access entitlement.

Sustainable yield: That percentage of annual recharge which is allowed to be extracted from groundwater after considering the aquifer's ability to recharge and the needs of the environment.

Water sharing plan: A plan made under the *Water Management Act 2000*, which sets out the rules for sharing water between the environment and water users within whole or part of water source.

Water year: The 12 months running from 1 July to 30 June.

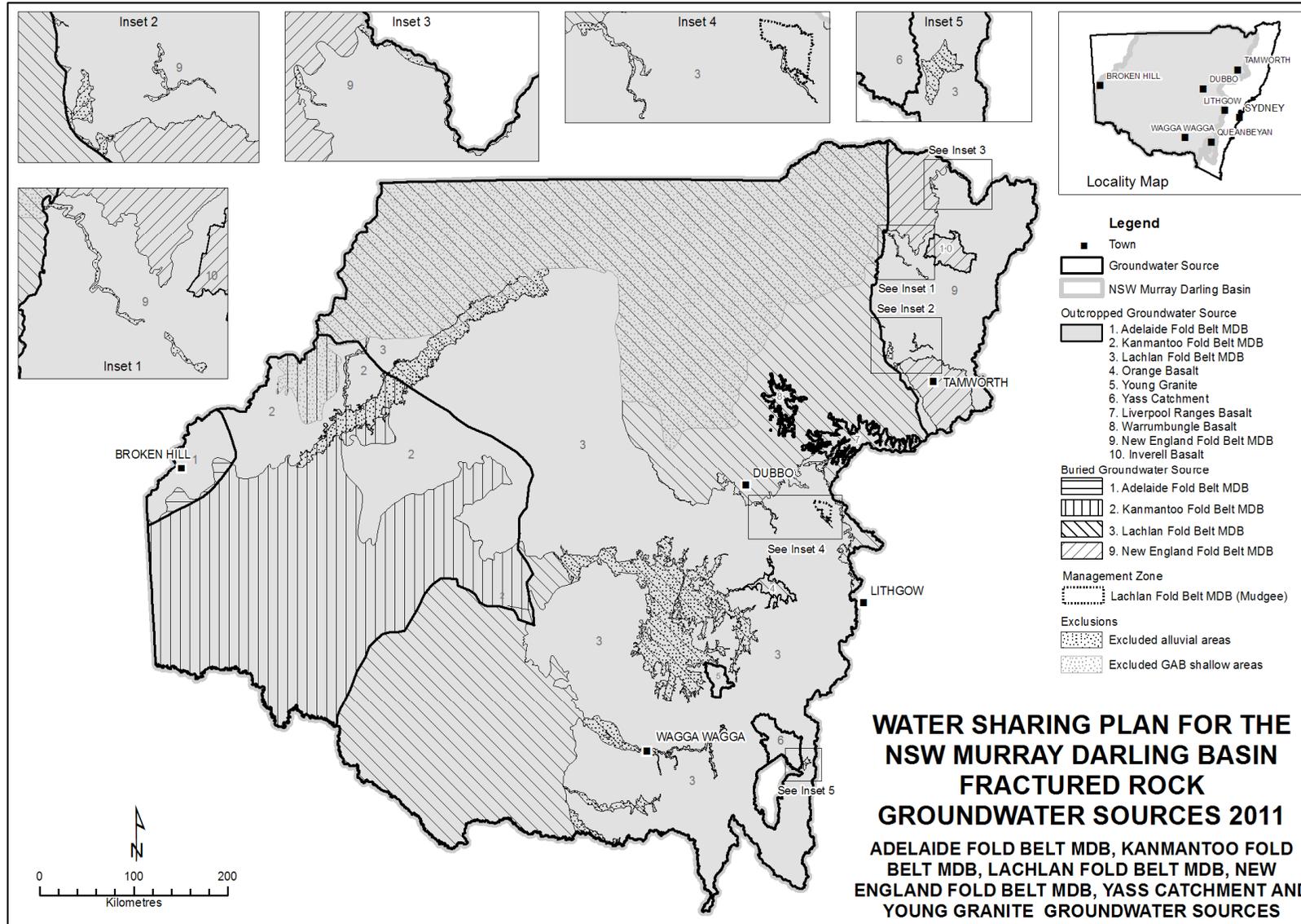
References

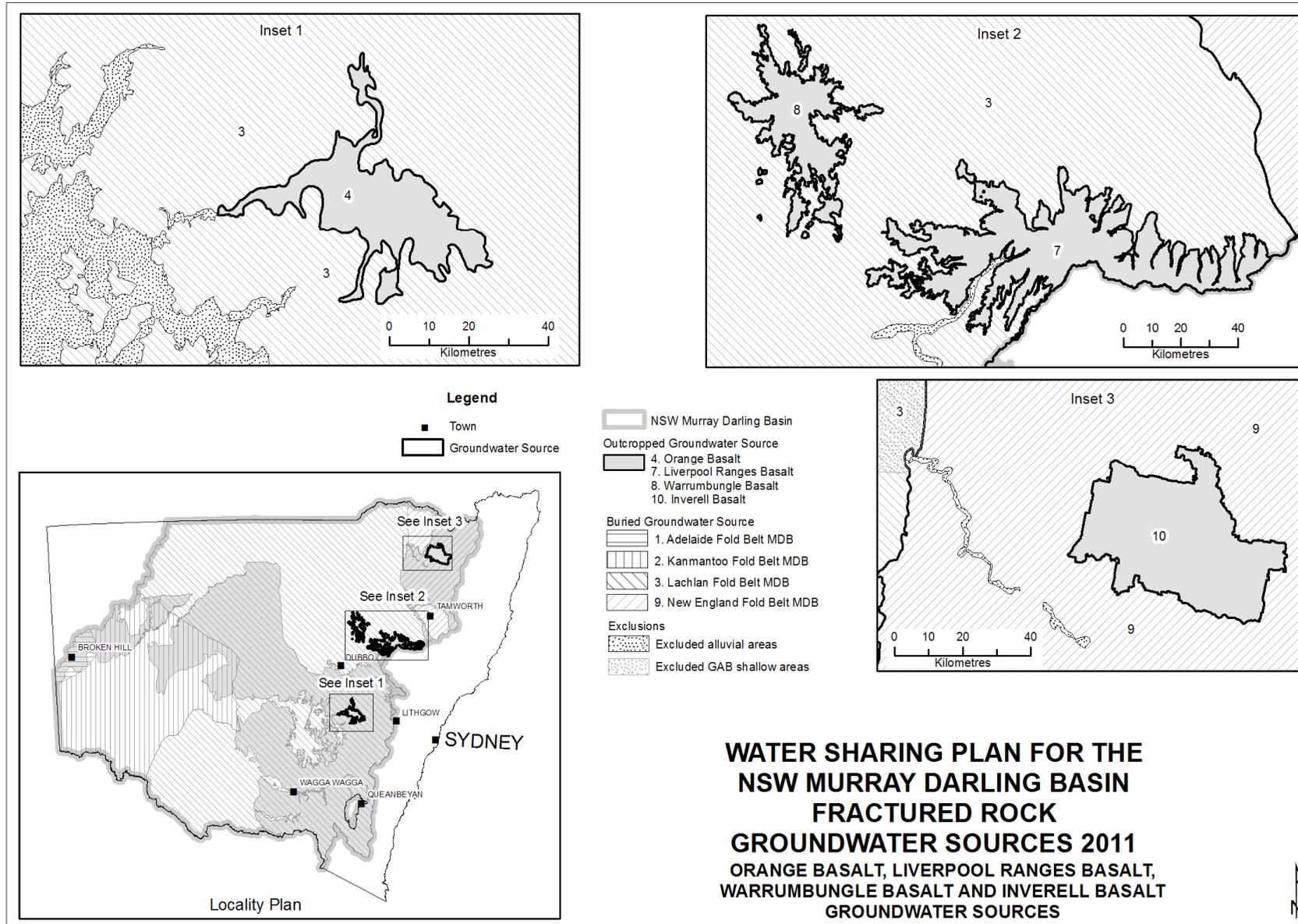
Bish, S., Gates, G., Gill, J. and Williams, R.M., 2006, *Assessment of Sustainable Limits for Groundwater Sources in NSW*, 10th Murray-Darling Basin Groundwater Workshop, Murray-Darling Basin Commission, Canberra.

Department of Land and Water Conservation, 2002, *The NSW State Groundwater Dependent Ecosystems Policy. A Component Policy of the NSW State Groundwater Policy*. ISBN 0 7374 5225 3

Sinclair Knight Merz, 2006, *Towards a National Framework for Managing the Impacts of Groundwater and Surface Water Interaction in Australia*.

Appendix 1: Water sharing plan area





Appendix 2: State groundwater panel and support staff - membership and expertise

Name	Agency	Role	Expertise
Interagency Regional Panel			
George Gates	NSW Office of Water	Agency representative	Extensive background, experience and expertise in hydrogeology and related groundwater management. Worked on developing groundwater policies and water sharing plans for NSW Office of Water and its predecessors. Current position is state groundwater manager.
Danny Norris	DPI (formerly I&I NSW)	Agency representative	Water policy implementation including water use, enterprise management and basic structural adjustment strategies for water users, water licensing, groundwater/surface water interactions, flow data analysis, local knowledge of flow behaviour of catchments.
Peter Lloyd Jones (formerly David Winfield)	OEH (formerly DECCW)	Agency representative	Measuring ecological response of environmental flows, regional input and delivery of water reforms / water sharing plan development, input into state water policy development.
Fiona Marshall	Hunter-Central Rivers CMA	Observer	Currently General Manager of Hunter Central Rivers CMA. Previous experience with CMA as Business Manager Investment. Experience with DIPNR and DLWC delivering programs such as Landcare, property planning etc to the community. Over 25 years experience in the natural resource field.
Alexandra Anthony	Murray CMA	Observer	Currently chair of Murray CMA, convenor of the Water Working Group for NSW CMAs, chair of the Murray-Lower Darling Environmental Water Advisory Group, chair of the Barmah-Millewa Consultation Reference Group, member of the Murray-Lower Darling State Water Customer Service Committee.
Support Staff			
Kristanne Mahony	NSW Office of Water	Project coordinator (Murray-Darling Basin Groundwater WSPs)	Surface water and groundwater management, planning/ policy development and implementation
Cate Barrett	NSW Office of Water	Policy/technical support	
Anna Bailey	NSW Office of Water	Technical support/ Alternate State Groundwater Panel representative	Surface water and groundwater management, planning/ policy development and implementation
Lyndal Betteridge	NSW Office of Water		Water policy and planning, utility planning arrangements, water sharing plan development and implementation, project management
Michael Williams	NSW Office of Water	Technical support	Aquifer framework, hydraulic parameters and groundwater flow path data. Modelled impacts of other users, GDE's and streams.

Appendix 3: Reference materials

General

- Aust. Drinking Water Guidelines (1996) - *National Water Quality Management Strategy, Australian Drinking Water Guidelines*. National Health and Medical Research Council & Agriculture and Resource Management Council of Australia and New Zealand.
- Bish S and Ross J (2001) *Recharge Assessment for Priority groundwater Systems within NSW DLWC*.
- CSIRO (1998). *Studies in Catchment Hydrology: The Basics of Recharge and Discharge*. CSIRO Publishing.
- Department of Land and Water Conservation (1997) - *The NSW State Groundwater Policy framework Document*.
- Department of Land and Water Conservation (1998) - *The NSW State Groundwater Quantity Management Policy. A Component Policy of the NSW State Groundwater Policy*. Unpubl.
- Department of Land and Water Conservation (2002) - *The NSW State Groundwater Dependent Ecosystems Policy. A Component Policy of the NSW State Groundwater Policy*. ISBN 0 7374 5225 3
- Department of Land and Water Conservation (1998) - *The NSW Groundwater Quality Protection Policy A Component Policy of the NSW State Groundwater Policy*. ISBN 0 7313 0379 2
- DLWC (1998b); *Aquifer Risk Assessment Report*. April 1998. ISBN 0 7313 03664 4.
- EPA (1995b) - *NSW State of the Environment Report*. Environment Protection Authority.
- Hatton T and Evans R (1998) - *Dependence of Ecosystems on Groundwater and its Significance to Australia. Land and Water Resources Research & Development Corporation*. Occasional Paper No 12/98. ISBN 0 642 26725 1.
- Hill R A (1946) – *Discussion on groundwater Storage in Conkling H (1946) Utilisation of Ground-water Storage in Stream System Development*. American Society of Civil Engineers Paper 2272 pp306 to 311.
- Kalaitzis P, Banks R, Banks V and Merrick (2000). - *Optimising Groundwater Usage to Mitigate Native Vegetation Decline in the Namoi Valley, NSW*. LWWRDC Milestone Report No 2, Project No. NDW23 Phase 1 Eco-Physical Investigations.
- Salt Action (undated) *Soil and Water Salinity Calculator*. Salt Action, Deniliquin.
- Sophocleous M (1998) *Perspectives on Sustainable Development of Water Resources in Kansas*. Kansas Geological Survey.
- Hamilton S., Williams R.M. and Woolley D.R. (1987) - *Groundwater in New South Wales: Assessment of Pollution Risk (1:2 000 000 scale map)* Department of Water Resources of NSW.

Appendix 4: Identified high priority groundwater dependent ecosystems

Identified high priority groundwater dependent ecosystems in the Murray-Darling Basin Fractured Rock Groundwater Sources

High priority groundwater dependent ecosystem	GDE type	Easting (MGA 94)	Northing (MGA 94)	Zone	Groundwater Source
Ados Spring	Spring	677703.83	6532133.65	55	Warrumbungle Basalt Groundwater Source
Baileys Springs	Spring	751090.66	6418748.43	55	Lachlan Fold Belt MDB Groundwater Source
Battyle Browns Springs	Spring	683284.58	6317607.72	55	Orange Basalt Groundwater Source
Bedlam Spring	Spring	700448.51	6037998.50	55	Lachlan Fold Belt MDB Groundwater Source
Belmont Spring	Spring	621819.09	6246486.86	55	Lachlan Fold Belt MDB Groundwater Source
Belougerrie Spring	Spring	690492.35	6537453.90	55	Warrumbungle Basalt Groundwater Source
Big Springs	Spring	537976.35	6091943.69	55	Lachlan Fold Belt MDB Groundwater Source
Black Hill Spring	Spring	698461.17	6262761.10	55	Lachlan Fold Belt MDB Groundwater Source
Black Spring	Spring	308623.02	6598429.16	56	New England Fold Belt MDB Groundwater Source
Black Spring	Spring	284938.26	6507400.97	56	New England Fold Belt MDB Groundwater Source
Black Springs	Spring	661644.95	6232025.91	55	Lachlan Fold Belt MDB Groundwater Source
Black Springs	Spring	690991.34	6199116.44	55	Lachlan Fold Belt MDB Groundwater Source
Black Springs	Spring	748845.71	6210705.09	55	Lachlan Fold Belt MDB Groundwater Source
Blue Springs	Spring	745060.86	6429068.47	55	Lachlan Fold Belt MDB Groundwater Source
Bocannecals Springs	Spring	693730.36	6220326.85	55	Lachlan Fold Belt MDB Groundwater Source
Bogong Swamp	Wetland	621946.46	5996898.84	55	Lachlan Fold Belt MDB Groundwater Source
Booroonbunyah Spring	Spring	687054.45	6522729.49	55	Warrumbungle Basalt Groundwater Source
Brundah Springs	Spring	620325.09	6250202.75	55	Lachlan Fold Belt MDB Groundwater Source
Budgerydickeys Springs	Spring	658863.47	6343916.72	55	Lachlan Fold Belt MDB Groundwater Source
Burbie Spring	Spring	685699.13	6535691.52	55	Warrumbungle Basalt Groundwater Source
Burras Spring	Spring	748066.05	6423446.94	55	Lachlan Fold Belt MDB Groundwater Source

High priority groundwater dependent ecosystem	GDE type	Easting (MGA 94)	Northing (MGA 94)	Zone	Ground water Source
Burras Springs	Spring	746473.62	6422561.26	55	Lachlan Fold Belt MDB Groundwater Source
Burrows Spring	Spring	748066.05	6423446.94	55	Lachlan Fold Belt MDB Groundwater Source
Cartwrights Spring	Spring	544650.91	6219442.90	55	Lachlan Fold Belt MDB Groundwater Source
Cherry Tree Springs	Spring	721855.35	6174387.68	55	Lachlan Fold Belt MDB Groundwater Source
Chinamans Spring	Spring	429135.16	6259940.69	55	Lachlan Fold Belt MDB Groundwater Source
Chinamans Swamp	Wetland	219066.39	6481781.58	56	Liverpool Ranges Basalt MDB Groundwater Source
Conapaira Spring	Spring	429135.16	6259940.69	55	Lachlan Fold Belt MDB Groundwater Source
Coopers Swamp	Wetland	723229.82	6020800.97	55	Lachlan Fold Belt MDB Groundwater Source
Currys Springs	Spring	774654.31	6252545.79	55	Lachlan Fold Belt MDB Groundwater Source
Dawsons Spring	Spring	687088.64	5977247.09	55	Lachlan Fold Belt MDB Groundwater Source
Dawsons Springs	Spring	227558.50	6646605.86	56	New England Fold Belt MDB Groundwater Source
Deadbird	Spring	318262.70	6690991.74	56	New England Fold Belt MDB Groundwater Source
Deadbird Spring	Spring	318262.70	6690991.74	56	New England Fold Belt MDB Groundwater Source
Dilladerry Spring	Spring	634659.47	6396028.09	55	Lachlan Fold Belt MDB Groundwater Source
Dwyers Springs	Spring	655444.62	6229356.81	55	Lachlan Fold Belt MDB Groundwater Source
Emu Swamp	Wetland	639354.60	6349758.04	55	Lachlan Fold Belt MDB Groundwater Source
Euglah Spring	Spring	226001.00	6644717.71	56	New England Fold Belt MDB Groundwater Source
Finchs Springs	Spring	674921.41	6371373.05	55	Lachlan Fold Belt MDB Groundwater Source
Gibraltar Springs	Spring	375264.72	6776747.17	56	New England Fold Belt MDB Groundwater Source
Gunntanna Spring	Spring	674562.69	6534034.57	55	Warrumbungle Basalt Groundwater Source
Gunnyannah Spring	Spring	674562.69	6534034.57	55	Warrumbungle Basalt Groundwater Source
Hill Dyke Spring	Spring	694462.69	6039981.83	55	Lachlan Fold Belt MDB Groundwater Source
Hyandra Hill	Spring	634932.74	6416353.45	55	Lachlan Fold Belt MDB Groundwater Source
Icely Spring	Spring	672802.88	6253091.15	55	Lachlan Fold Belt MDB Groundwater Source

High priority groundwater dependent ecosystem	GDE type	Easting (MGA 94)	Northing (MGA 94)	Zone	Ground water Source
Indi Springs	Spring	606587.43	5927110.44	55	Lachlan Fold Belt MDB Groundwater Source
Jacko Springs	Spring	623407.93	6250163.21	55	Lachlan Fold Belt MDB Groundwater Source
Jacobs Well	Spring	660299.17	6336499.29	55	Lachlan Fold Belt MDB Groundwater Source
Jerrys Spring	Spring	701565.03	6535398.74	55	Warrumbungle Basalt Groundwater Source
Jokers Spring	Spring	227650.75	6642909.85	56	New England Fold Belt MDB Groundwater Source
Kellys Creek Springs	Spring	627957.46	6244557.60	55	Lachlan Fold Belt MDB Groundwater Source
Lamberts Springs	Spring	625841.19	6318520.56	55	Lachlan Fold Belt MDB Groundwater Source
Leachs Springs	Spring	723295.83	6170653.45	55	Lachlan Fold Belt MDB Groundwater Source
Maman or Wattle Spring	Spring	683950.29	6526481.13	55	Warrumbungle Basalt Groundwater Source
Meglo Swamp	Wetland	711094.89	6225501.72	55	Lachlan Fold Belt MDB Groundwater Source
Mogongong Spring	Spring	620325.09	6250202.75	55	Lachlan Fold Belt MDB Groundwater Source
Mogongong Springs	Spring	621819.09	6246486.86	55	Lachlan Fold Belt MDB Groundwater Source
Monkeybung Spring	Spring	676148.92	6534008.05	55	Warrumbungle Basalt Groundwater Source
Mont Waters Spring	Spring	610910.29	5987800.65	55	Lachlan Fold Belt MDB Groundwater Source
Mulga Springs	Spring	562396.59	6477109.44	54	Adelaide Fold Belt MDB Groundwater Source
Munkerbung Spring	Spring	676148.92	6534008.05	55	Warrumbungle Basalt Groundwater Source
Murphys Swamp	Wetland	626122.96	6076349.43	55	Lachlan Fold Belt MDB Groundwater Source
Naman Spring	Spring	683950.29	6526481.13	55	Warrumbungle Basalt Groundwater Source
New Spring	Spring	684080.16	6533871.82	55	Warrumbungle Basalt Groundwater Source
Norfolk Island Swamp	Wetland	219015.98	6483629.99	56	Liverpool Ranges Basalt MDB Groundwater Source
O'Hares Creek	Wetland	304198.85	6209411.96	56	Lachlan Fold Belt MDB
Old Mortray Springs	Spring	597336.42	6263403.60	55	Lachlan Fold Belt MDB Groundwater Source
Peppers Swamp	Wetland	727529.14	6009588.67	55	Lachlan Fold Belt MDB Groundwater Source
Pine Spring	Spring	700048.87	6378293.02	55	Lachlan Fold Belt MDB Groundwater Source
Porters Camp Spring	Spring	271151.47	6558873.11	56	New England Fold Belt MDB Groundwater Source

High priority groundwater dependent ecosystem	GDE type	Easting (MGA 94)	Northing (MGA 94)	Zone Ground	water Source
Pulpulla Spring	Spring	331668.90	6554464.80	55	Lachlan Fold Belt MDB Groundwater Source
Rankin Springs	Spring	479931.72	6315618.28	55	Lachlan Fold Belt MDB Groundwater Source
Rankins Spring	Spring	429135.16	6259940.69	55	Lachlan Fold Belt MDB Groundwater Source
Rotten Swamp	Wetland	767100.40	6213903.84	55	Lachlan Fold Belt MDB Groundwater Source
Salters Springs	Spring	684403.72	6552348.24	55	Warrumbungle Basalt Groundwater Source
Sauls Spring	Spring	580343.02	6261713.64	55	Lachlan Fold Belt MDB Groundwater Source
Siding Spring	Spring	695287.30	6539214.16	55	Warrumbungle Basalt Groundwater Source
Sidling Spring	Spring	695287.30	6539214.16	55	Warrumbungle Basalt Groundwater Source
Snake Spring	Spring	682493.89	6533899.55	55	Warrumbungle Basalt Groundwater Source
Stains Springs	Spring	723340.43	6172502.19	55	Lachlan Fold Belt MDB Groundwater Source
Sullivans Springs	Spring	669255.52	6227270.26	55	Lachlan Fold Belt MDB Groundwater Source
Swatchfield Springs	Spring	743227.19	6231202.12	55	Lachlan Fold Belt MDB Groundwater Source
Teatree Springs	Spring	714207.13	6174567.66	55	Lachlan Fold Belt MDB Groundwater Source
The Black Springs	Spring	735998.09	6188838.06	55	Lachlan Fold Belt MDB Groundwater Source
The Springs	Spring	587179.01	6167391.23	55	Lachlan Fold Belt MDB Groundwater Source
The Springs	Spring	759417.80	6203942.67	55	Lachlan Fold Belt MDB Groundwater Source
The Springs	Spring	733943.71	6292476.60	55	Lachlan Fold Belt MDB Groundwater Source
Three Sugarloaf Swamp	Wetland	374832.27	6761966.07	56	New England Fold Belt Groundwater Source MDB
Thurrima Springs	Spring	732887.51	6187066.47	55	Lachlan Fold Belt MDB Groundwater Source
Towan Dirt Holes	Spring	654309.57	6351383.14	55	Lachlan Fold Belt MDB Groundwater Source
Tunnel Spring	Spring	679321.39	6533954.28	55	Warrumbungle Basalt Groundwater Source
Turkey Springs	Spring	539418.32	6075301.51	55	Lachlan Fold Belt MDB Groundwater Source
Turners Springs	Spring	718074.72	6176327.16	55	Lachlan Fold Belt MDB Groundwater Source
Warm Spring	Spring	634246.03	6044797.25	55	Lachlan Fold Belt MDB Groundwater Source
Wattle Spring	Spring	684242.14	6543110.08	55	Warrumbungle Basalt Groundwater Source

High priority groundwater dependent ecosystem	GDE type	Easting (MGA 94)	Northing (MGA 94)	Zone Ground	water Source
Webbs Springs	Spring	601009.29	6174644.35	55	Lachlan Fold Belt MDB Groundwater Source
Wyndhams Springs	Spring	333918.25	6720798.25	56	New England Fold Belt MDB Groundwater Source
Yewrangara Springs	Spring	686942.33	6226936.23	55	Lachlan Fold Belt MDB Groundwater Source

Identified high priority karst environment groundwater dependent ecosystems in the Murray-Darling Basin Fractured Rock Groundwater Sources

High priority karst environment groundwater dependent ecosystem	GDE type	Groundwater Source	Approximate location
Abercrombie	Karst	Lachlan Fold Belt MDB	2.5 km east of Abercrombie
Apple Tree Flat	Karst	Lachlan Fold Belt MDB	23 km south-east of Mudgee
Ashford	Karst	New England Fold Belt MDB	16.5 km north-west of Ashford
Bakers Swamp	Karst	Lachlan Fold Belt MDB	22 km south of Wellington
Boduldura	Karst	Lachlan Fold Belt MDB	30 km north-west of Molong
Borenore	Karst	Orange Basalt	42 km north-east of Canowindra
Bowan Park	Karst	Orange Basalt	7 km west of Bowan Park
Browns Creek	Karst	Lachlan Fold Belt MDB	2 km north-east of Browns Creek
Burrans Burrans	Karst	Lachlan Fold Belt MDB	7.5 km north-west of Wellington
Canomodine	Karst	Lachlan Fold Belt MDB	16 km north-east of Canowindra
Canowindra	Karst	Lachlan Fold Belt MDB	12 km north-east of Canowindra
Cave Flat	Karst	Lachlan Fold Belt MDB	4 km south of Burrinjuck
Cliefden/Walli	Karst	Lachlan Fold Belt MDB	30 km north-east of Cowra
Cooimbil	Karst	Lachlan Fold Belt MDB	16 km east of Yarrangobilly
Coolesman Plain	Karst	Lachlan Fold Belt MDB	7 km north-west of Coolesman
Cooyal	Karst	Lachlan Fold Belt MDB	16 km south of Ulan
Copperhanian	Karst	Lachlan Fold Belt MDB	4.5 km north-west of Abercrombie
Cowombat Flat	Karst	Lachlan Fold Belt MDB	58 km south-west of Jindabyne
Cudgong	Karst	Lachlan Fold Belt MDB	11 km north-west of Kandos
Cudgong West	Karst	Lachlan Fold Belt MDB	16 km north-west of Kandos
Cumnock	Karst	Lachlan Fold Belt MDB	23 km north-west of Molong
Dripstone	Karst	Lachlan Fold Belt MDB	12 km south of Wellington
Duckmaloli	Karst	Lachlan Fold Belt MDB	18 km east of Oberon
Geurie	Karst	Lachlan Fold Belt MDB	Geurie
Goodradigbee (Upper)	Karst	Lachlan Fold Belt MDB	45 km east of Tumut
Indi	Karst	Lachlan Fold Belt MDB	60 km south-west of Jindabyne
Jeremiah Creek	Karst	Lachlan Fold Belt MDB	10 km south-west of Burrinjuck
Jounama Creek	Karst	Lachlan Fold Belt MDB	39 km north-east of Tumbarumba

High priority karst environment groundwater dependent ecosystem	GDE type	Groundwater Source	Approximate location
Kandos	Karst	Lachlan Fold Belt MDB	6 km north-west of Kandos
Kybean	Karst	Lachlan Fold Belt MDB	25 km south-east of Cooma
Lake Windamere	Karst	Lachlan Fold Belt MDB	22 km North-west of Kandos
Limekilns	Karst	Lachlan Fold Belt MDB	22 km north-east of Kelso
London Bridge	Karst	Lachlan Fold Belt MDB	18.5 km north-west of Captains Flat
MacPhersons Swamp	Karst	Lachlan Fold Belt MDB	44 km east of Gundagai
Michelago	Karst	Lachlan Fold Belt MDB	40 km south-west of Captains Flat
Molong	Karst	Lachlan Fold Belt MDB	3.5 km south of Molong
Mudgee	Karst	Lachlan Fold Belt MDB	2 km north of Mudgee
Numeralla	Karst	Lachlan Fold Belt MDB	19 km south-east of Cooma
Portland	Karst	Lachlan Fold Belt MDB	Portland
Queens Pinch	Karst	Lachlan Fold Belt MDB	17.5 km south of Mudgee
Ravine	Karst	Lachlan Fold Belt MDB	15.5 km north of Cabramurra
Regans Creek	Karst	Lachlan Fold Belt MDB	19 km north-east of Canowindra
Rock Flat Creek	Karst	Lachlan Fold Belt MDB	8.5 km north-west of Cooma
Rockley	Karst	Lachlan Fold Belt MDB	26 km west of Oberon
Rosebrook	Karst	Lachlan Fold Belt MDB	10 km north-east of Cooma
Rosebrook north	Karst	Lachlan Fold Belt MDB	14 km north-east of Cooma
Stuart Town Finches Caves	Karst	Lachlan Fold Belt MDB	27 north-east of Molong
Taemas	Karst	Lachlan Fold Belt MDB	12 km east of Burrinjuck
Talmo	Karst	Lachlan Fold Belt MDB	6 km north-west of Burrinjuck
Tuena	Karst	Lachlan Fold Belt MDB	1.5 km north-west of Tuena
Tuena East	Karst	Lachlan Fold Belt MDB	4 km north of Tuena
Warroo/Taemas	Karst	Lachlan Fold Belt MDB	17 km south-west of Yass
Wee Jasper	Karst	Lachlan Fold Belt MDB	2 km south-west of Wee Jasper
Wellington	Karst	Lachlan Fold Belt MDB	7.5 km south of Wellington
Wellington/Molong	Karst	Lachlan Fold Belt MDB	26 km north of Molong
White Rocks	Karst	Lachlan Fold Belt MDB	4.5 km south-east of Queanbeyan
Yarrangobilly	Karst	Lachlan Fold Belt MDB	38 km south-east of Batlow