The NSW State Groundwater Dependent Ecosystems Policy

A Component Policy of the NSW State Groundwater Policy Framework Document

*To manage the State’s groundwater resources so that they can sustain environmental, social and economic uses for the people of NSW.*

Prepared by:
Department of Land & Water Conservation

NSW Government
A policy prepared for the NSW Government by NSW Department of Land and Water Conservation (DLWC), in conjunction with the State Groundwater Policy Working Group. This Group consists of people from State Government departments, local government, environmental groups, industry and the National Centre for Groundwater Management (University of Technology, Sydney).

Hanging swamp community on the lip of a cliff at Valley of the Waters, Wentworth Falls in the Blue Mountains. The limiting factors of this community include availability of water and enough soil to anchor plants.


FOREWORD

Groundwater is an important source for drinking and irrigation purposes in both inland and coastal areas of New South Wales. There has been an increasing pressure on groundwater resources over the years. There are now a number of groundwater systems in NSW, which are at high risk of over extraction or contamination. This may be jeopardising future supplies to water users and to the environment including the ecosystems dependent on groundwater, such as wetlands, red gum forests, vegetation on coastal sand dunes, springs, ecosystems in streams fed by groundwater and limestone caves.

The NSW Government released the *State Groundwater Framework Policy* in 1997 which aims at achieving efficient and sustainable management of groundwater resources. The *Groundwater Dependent Ecosystems Policy* is a component of the Framework policy. It is a whole of government policy developed by the NSW State Groundwater Policy Working Group consisting of government and non government representatives.

The *Water Management Act 2000* provides the legislative framework for implementing the policy to protect valuable groundwater dependent ecosystems. The policy sets out a process by which the water management plans prepared by water management committees will apply the principles of this policy at a local level, identify and classify groundwater dependent ecosystems and ensure that water is provided to meet environmental needs and the needs of present and future users.

The policy recognises the shared goals of government and the community in promoting the sustainable use and management of groundwater resources in New South Wales and the need for all stakeholders to work together in the protection of groundwater dependent ecosystems.


The Hon. John Aquilina MP
Minister for Land and Water Conservation
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1 SUMMARY

1.1 Background

Groundwater is an important and vital natural resource in NSW. It is coming under increasing pressure to meet human uses for agriculture and industry, as well as drinking water for many country towns. It also sustains a variety of ecosystems.

Some examples of ecosystems which depend on groundwater are:

- wetlands and red gum forests;
- other terrestrial vegetation;
- ecosystems in streams fed by groundwater;
- limestone cave systems;
- springs; and
- hanging valleys and swamps.

Plant and animal communities that depend on groundwater have developed over thousands or even millions of years. These ecosystems have adapted to the natural variation in groundwater levels and quality, including severe drought and flood conditions. In more stable environments, such as caves, some fauna - described as ‘living fossils’ - may have changed very little over the last 200 million years or more. These caves and other highly stable environments such as peat bogs, may also contain fossil material that provides insights into past environments.

Increasing groundwater extraction, rising saline water tables and contamination from various anthropogenic land activities are threatening the survival of many of these ecosystems. Activities such as sand and gravel extraction can impair or destroy the biological filtration function of the aquifer and the hyporheic zone (Figure 1) where groundwater exchanges with surface water of rivers and standing wetlands. Fluctuating water levels can also destroy an ecosystem’s fossil record.

It is extremely difficult, expensive and sometimes impossible to restore degraded groundwater and its dependent ecosystems. The survival of these ecosystems depends on how both the quantity and the quality of the groundwater feeding them is managed now and in the future.

All Australian governments have recognised the need to specifically provide water for the environment and agreed to a set of 12 principles (COE, 1996) to achieve this goal. The Water Management Act 2000 (WMA 2000) includes objects and principles aimed specifically at protecting and restoring water-dependent ecosystems. The Act also requires environmental water rules to be set for all groundwater sources in the State. This is to be achieved as soon as practicable after 1 January 2001. The purpose of developing a State Groundwater Dependent Ecosystems Policy is to ensure that these principles are implemented in NSW.

Scientific knowledge about the role that groundwater plays in maintaining ecosystems is not well understood in the broader community. It is important that the major gaps in our knowledge are identified and filled by focused and relevant scientific research, and that there is effective communication of findings to the community and resource managers. Groundwater management should therefore be seen as an ongoing process, which adapts in response to improvements in scientific knowledge and the value the community places on these ecosystems.
A partnership between the community, industry, local and State government has been adopted for groundwater management. A State Groundwater Working Group, with government and non-government representatives, is overseeing the development of all component groundwater policies (see page 18). All partners will continue to be involved in implementing this policy through management plans and other tools.

At the local level, in several parts of the State, groundwater management committees and water management committees (joint river/groundwater committees) have been established. Their role is to develop management plans. These plans should identify and classify groundwater dependent ecosystems and ensure that water is provided to meet environmental needs. The Groundwater Dependent Ecosystems Policy sets out a process for achieving this.

The NSW Policy will be reviewed after five years.

1.2 NSW Groundwater Dependent Ecosystems Policy

The State Groundwater Dependent Ecosystems Policy is specifically designed to protect our valuable ecosystems which rely on groundwater for survival so that, wherever possible, the ecological processes and biodiversity of these dependent ecosystems are maintained or restored, for the benefit of present and future generations.

This Policy provides guidance on how to protect and manage these valuable natural systems in a practical sense. The range of tools that can be used to manage these ecosystems should be adapted to suit local conditions.

The following principles apply to the management of groundwater-dependent ecosystems in NSW:

**Principle One**

The scientific, ecological, aesthetic and economic values of groundwater-dependent ecosystems, and how threats to them may be avoided, should be identified and action taken to ensure that the most vulnerable and the most valuable ecosystems are protected.

**Principle Two**

Groundwater extractions should be managed within the sustainable yield of aquifer systems, so that the ecological processes and biodiversity of their dependent ecosystems are maintained and/or restored. Management may involve establishment of threshold levels that are critical for ecosystem health, and controls on extraction in the proximity of groundwater dependent ecosystems.

**Principle Three**

Priority should be given to ensuring that sufficient groundwater of suitable quality is available at the times it is needed:

- for protecting ecosystems which are known to be, or are most likely to be, groundwater dependent; and,

- for groundwater dependent ecosystems which are under an immediate or high degree of threat from groundwater-related activities.
**Principle Four**

Where scientific knowledge is lacking, the Precautionary Principle should be applied to protect groundwater dependent ecosystems. The development of adaptive management systems and research to improve understanding of these ecosystems is essential to their management.

**Principle Five**

Planning, approval and management of developments and land use activities should aim to minimise adverse impacts on groundwater dependent ecosystems by:

- maintaining, where possible, natural patterns of groundwater flow and not disrupting groundwater levels that are critical for ecosystems;
- not polluting or causing adverse changes in groundwater quality; and
- rehabilitating degraded groundwater systems where practical.

### 1.3 How the NSW Groundwater Dependent Ecosystems Policy will be implemented

The management tools available to achieve the protection, management and restoration of groundwater dependent ecosystems include:

- environmental planning instruments;
- monitoring;
- research;
- education.

A process for implementing this Policy at a local level is set out in Section 5. It is essentially a planning process that can be undertaken by water management committees, local government or any other management body. It involves an initial rapid assessment of groundwater dependent ecosystems so that priorities for management action can be set.

### 1.4 Policy Development & Review

This policy has been developed through a State Groundwater Working Group. This Group represents a range of interests, both government and non-government. Groundwater management plans are being developed by water management committees. They will be endorsed by Government to ensure that, amongst other things, they are consistent with this Policy. Both the Policy and the plans will be reviewed after five years.
2. INTRODUCTION

2.1 What is a Groundwater Dependent Ecosystem?

Groundwater is the water beneath the earth’s surface that has filtered down to the zone where the earth or rocks are fully saturated. The water occupies the spaces between the particles of clay and sand, or in cracks and crevices in rocks. The top of this saturated zone is called the watertable. (See Figure 1)

An ecosystem may be defined as the community of plant, animal and other organisms existing within a defined area, and their interactions within the community and their non-living environment.

Groundwater dependent ecosystems (GDEs) therefore, are ecosystems which have their species composition and their natural ecological processes determined by groundwater (ARMCANZ & ANZECC, 1996).

Water, alone or in conjunction with temperature, is probably the most important physical factor affecting the ecology of terrestrial plants and animals (Krebs 1985). In a semi arid climate such as Australia’s, where groundwater is available an ecosystem will use it and is likely to become dependent upon it. This means that if the availability of groundwater is reduced, or the water quality is allowed to deteriorate, there will be impacts on these ecosystems (Hatton & Evans 1998).

![Figure 1 - Alluvial groundwater system discharging into a river](image)

There are many native plant species that use groundwater during their life cycle. This includes plants that use groundwater where it discharges at the surface (for example, springs and wetlands), and other plants whose roots are tapped into the watertable at some depth. Animal species that rely on groundwater are less well known and include invertebrates and microscopic organisms that live within the pore spaces that make up an aquifer. These can play an important role in maintaining aquifer health and function by keeping pore spaces free from silt and through their role in chemical and nutrient cycling processes.

There are other animals that live in streams and estuaries where discharging groundwater is an important contributor to flow and to their life cycles. Also, groundwater carries essential dissolved nutrients and organic matter, and up-welling groundwater can supply limiting nutrients that control algal and plant growth in overlying wetlands (Boulton, 1993).
Ecosystems vary dramatically in the degree of their dependency on groundwater, from having no apparent dependence through to being entirely dependent on it. The unique ecosystems of the Great Artesian Basin mound springs, for example, are entirely dependent on groundwater which makes them very vulnerable to local changes in groundwater pressure.

Groundwater extraction by humans disrupts the natural hydrologic cycle. It lowers and alters the natural variability of groundwater levels which, in turn, alters the timing of availability and volume of groundwater to its dependent ecosystems.

As our river systems become more and more stressed, water users are increasingly turning to groundwater to meet their needs. This means that many ecosystems that depend on groundwater for survival have already been degraded or lost.

The level of scientific understanding of the role that groundwater plays in maintaining ecosystems in Australia is generally low, except for the Great Artesian Basin’s mound springs (Hatton & Evans 1998).

More research needs to be undertaken to determine the vulnerability of groundwater dependent ecosystems to groundwater extraction, so that appropriate action can be taken. Until that research is done, a precautionary approach needs to be adopted in the management of groundwater to protect dependent ecosystems.

### 2.2 Values and Threats

Groundwater dependent ecosystems have many values. For example:

- some are rare or unique, for example the plant and animal communities in the Great Artesian Basin’s springs;
- the ecosystems surviving in aquifers and caves may be amongst the oldest surviving on earth, (for example, invertebrates in caves);
- they have water quality benefits - microfauna in groundwater help ‘clean up’ contaminants;
- they have biodiversity value because many species living in groundwater do not live in surface water habitats;
- they add to the ecological diversity of a region. Australia is biogeographically distinct in its groundwater fauna (Humphreys 1999), and the subterranean fauna of NSW is biogeographically distinct from other Australian ‘hotspots’;
- they may play an important but not yet fully understood role in maintaining river health (Boulton 1999);
- they are likely to be connected to other non-groundwater dependent ecosystems and thus integrated into the broader regional environment;
- they can have social and economic values (for example, recreation and tourism);
- they can be bio-indicators (that is, indicators of biological health of an overall system); and
- sites may have cultural significance especially for indigenous Australians.

Valuing dependent ecosystems is a partly subjective process. It involves weighing up environmental, social and economic factors, which can change over time. Large groundwater-fed springs are often the primary source of water in the landscape and have functioned as meeting points and ceremonial sites for indigenous Australians, and often have strong spiritual associations not well understood by non-indigenous Australians. For such springs, indigenous people must be involved in the valuing process.
Groundwater dependent ecosystems are threatened by contamination and over-extraction. On the coast, in particular, both the quality and the quantity of groundwater are highly vulnerable to the impacts of existing activities and further development.

Particular threats include urban development, contamination from industry, intensive irrigation, salinisation, clearing of vegetation and filling or draining of wetlands. In some caves and peat bogs, scientific research into past environments relies upon the fossil record. Fluctuating water levels and changes in water quality can destroy this record.

These threats are already having impacts. Action is needed to ensure that GDEs are protected where possible, or the impacts are at least minimised.

A process for valuing GDEs and prioritising action is given later in this document (Section 5.7).

**2.3 Types of Groundwater Dependent Ecosystems in NSW**

A wide variety of flora and fauna depend directly and indirectly upon groundwater. A recent report on Australian groundwater dependent ecosystems by Hatton and Evans (1998) recognised four types, based mainly on vegetation. All four types (listed below as adapted from Hatton and Evans 1998) are found in NSW and, as acknowledged by the authors, have a range of animal communities associated with each of the plant communities.

Attention is usually given to the larger plants and animals associated with groundwater systems. However, there are many organisms which operate at a microbial level and can play key roles in maintaining ecosystem health and the functioning of aquifers. Care must be taken not to disturb the balance required for these less well known or understood organisms.

**Terrestrial vegetation**

Shallow groundwater can support terrestrial vegetation, such as forests and woodlands, either permanently or seasonally. The groundwater quality needs to be sufficiently high to sustain the vegetation. Examples occur both on the coast (for example, Melaleuca communities, Blackbutt or Sydney Redgum forests on sand dunes), in some types of hilly country (for example, rainforest plants along spring-fed creeks) and inland (for example, River Red Gums along riverbanks and on floodplains of large rivers in the Murray Darling Basin). It should be noted that it may not always be possible to make a clear distinction between this category of terrestrial vegetation and wetlands.

There are animals which depend on this vegetation and therefore indirectly depend on groundwater. Koala populations in some areas of inland NSW may only be able to survive through drought in trees which have reliable groundwater access and can continue to produce sufficient nutritious foliage.

**Base flows in streams**

River flow is often maintained largely by groundwater, which provides base flows long after a rainfall event. The base flow typically emerges as springs or as diffuse flow from saturated sediments or rock underlying the stream and banks and may be crucial for in-stream and near-stream ecosystems. For example, platypus feed upon invertebrates, such as dragonfly and mayfly larvae, which live in the riffle habitats. Reducing the base flow to groundwater–fed streams could dry out the riffles and reduce the invertebrate populations. This will have direct impacts on predators of invertebrates, such as the platypus.

Below many rivers and streams, especially those with sand and gravel beds, water exchanges between the surface and groundwater in a fluctuating region termed the ‘hyporheic zone’ (See Figure 1). The hyporheic zone is an important habitat for many invertebrates, a refuge during droughts and floods, and a vital biological filter capable of improving the water quality of streams and rivers (Boulton et al. 1998)
It is estimated that in NSW, on average up to 40% of any river’s flow duration is made up of groundwater-fed baseflow. Ecosystem dependence is not only related to the amount of base flow, but also to other flow factors such as seasonal variability. This variability is particularly evident in some coastal alluvial groundwater systems – such as tributaries of the Hunter River - which empty rapidly and are replenished during high flow events. Recent work on the hyporheic zone along the Hunter and Goulburn rivers has revealed fauna and microbes living in the sediments that apparently play a role in transforming nutrients, thus affecting water quality of the river.

Aquifer and cave ecosystems

Life exists within aquifers and in underground caves in conditions of total darkness, limited space and limited oxygen. Limestone caves, for example, support fauna such as crustacea. The ecosystems which exist in aquifers are entirely dependent on groundwater. They are called ‘hypogean’ ecosystems. (See Figure 1)

Both overseas and Australian studies suggest life within aquifers may be as rich in diversity as it is above ground (Humphreys 1999, Boulton in press) and that such ecosystems may be quite ancient. Some cave fauna - described as ‘living fossils’ - may have changed very little over the last 200 million years or more (Poore & Humphreys 1992). Fluctuating water levels and changes in water quality can degrade these ecosystems and destroy their fossil record. This fluctuation can happen naturally, but care must be taken not to increase this variation as a result of anthropogenic activities.

As well, some micro-organisms in groundwater systems are important because they can exert a direct influence on water quality. Particular microbes (linked to biofilms as well as in pore water) are capable of transforming dissolved nutrients, organic matter and possibly contaminants. The fauna in groundwater may also play an important role in maintaining the physical structure of an aquifer by keeping the pore spaces free of fine organic matter and grazing on microbial biofilms (Boulton 2000).

Significant examples of caves with GDEs in NSW include Wellington, Jenolan, Wombeyan, Wee Jasper, Yarrangobilly and many locations in the Orange-Wellington area of central-western NSW.

Wetlands

Some GDEs have a mixture of wetland and terrestrial characteristics, and whilst not all wetlands are groundwater dependent, groundwater plays a role in most of Australia’s wetlands. Significant example of these include coastal Melaleuca communities, and River Red Gums along river banks and on floodplains of large rivers in the Murray Darling Basin. This group also includes tidal-flat and coastal inshore waters whose ecosystems may depend on groundwater discharge. This may be as base flows at the mouth of rivers, or as direct discharge as is the case for some seagrasses which predominantly grow in areas where groundwater seeps up from the sea floor.

Wetlands can include the ecosystems on potential acid-sulphate soils (and in the adjacent estuaries), where high water levels are required to prevent the water and soil becoming acidic and toxic. The vegetation of the Great Artesian Basin mound springs, which has been extensively studied, is also included in this group (Hatton & Evans, 1998).

Peat bogs have traditionally been highly stable environments which may contain fossil material that provides insights into past environments. Over-extraction of water, like the practice of draining wetlands for agriculture and other development, can destroy this valuable source of scientific data as peat can combust as it dries, and can become more susceptible to erosion as in the case of the Wingecarribee Swamp in the Southern Highlands.
2.4 Location of Groundwater Systems and their Dependent Ecosystems in NSW

There are five broad types of groundwater systems in NSW; each with associated dependent ecosystems. They are:

Deep Alluvial Groundwater Systems

These groundwater systems occur under the floodplains of the major rivers west of the Great Dividing Range. Examples include: the Namoi alluvium, Macquarie alluvium, Lachlan alluvium, Murrumbidgee alluvium and Murray alluvium.

Groundwater in these systems can occur only a few metres below the ground surface and generally can go down to about 120 metres. The Murray alluvium however can be as deep as 350 metres. It can support a whole array of ecosystems including terrestrial vegetation, wetlands, hypogean ecosystems, base flow and hyporheic zone ecosystems (see Figure 1).

Groundwater flow in deep alluvial systems, in many cases, is ‘semi-confined’ to ‘confined’, which means that there is a layer of clay, impervious rock or other material (that is, a confining layer) above the aquifer that restricts the vertical flow of water. Horizontal groundwater flow is predominant in these systems. Often groundwater extraction impacts on dependent ecosystems can occur many kilometres away from groundwater pumping sites.

Most of the groundwater used in NSW comes from these systems, mainly in rural areas. Groundwater uses include water for domestic purposes, town water supplies, agriculture and mining activities.

In the past, the volume of groundwater that could be sustainably extracted from these systems was over-estimated, resulting in many systems now being over-allocated. Action is under way in NSW to reduce allocations in these cases and to restrict total extractions to the sustainable yield of the aquifer (see Section 4).

Shallow Alluvial Groundwater Systems

Shallow alluvial aquifer systems are associated with coastal rivers and also the higher reaches of rivers west of the Great Dividing Range. Examples include: the Hunter alluvium, Peel alluvium, Cudgegong alluvium, and the beds and lateral bars of the lower Macleay, Bellinger and Nambucca Rivers.

These groundwater systems are often in direct connection with surface water bodies, such as rivers and wetlands. The groundwater level can be only a few metres below the ground and go down about 30 metres. These systems can be quickly recharged and water levels restored when droughts break. The groundwater is likely to support base flows and hyporheic ecosystems, wetlands, terrestrial vegetation and hypogean ecosystems (See Figure 1). Active hypogean zones have been described from the Hunter, Gwydir & Macleay rivers, and tributaries of the Bellinger River.

The groundwater in shallow alluvial aquifers is mostly used for irrigation. These aquifers have a smaller volume of water in storage. Hence they do not yield as much water as deep alluvial systems and are not as reliable during droughts. While the natural variability of these systems can make them more robust and able to tolerate fluctuating water levels, significant changes to the water regime – such as levels falling below a threshold or falling too quickly – can lead to ecosystem damage.
Major impacts on these groundwater systems can come from the operation of dams (the effect of capture and discharge regimes) and waterlogging due to the frequent or prolonged bank-full flow associated with delivery of irrigation water. The reduction of flooding events as a result of stream flow regulation can also lead to a reduction in the quantity and quality of water which recharges aquifers adjacent to rivers. Impacts can also result from over-extraction for irrigation, especially during dry times, which can lead to a reduction in baseflows. Also, lack of flushing flows may lead to river bed clogging and sedimentation that prevent the surface water exchanging with the hyporheic zone, damaging both ecosystems (Boulton 1999).

**Fractured Rock Groundwater Systems**

In NSW all outcropping and sub-cropping rocks contain a mixture of fractures, joints, bedding planes and faults that contain and transmit small and occasionally large amounts of groundwater. Examples of fractured rock aquifers include the Alstonville Basalt, Molong Limestone and the Young Granite. The groundwater in these systems may support base flows to rivers, wetlands, caves, terrestrial vegetation and hypogean ecosystems. (See Figure 2)

![Types of Springs](image)

**Figure 2 - Types of Springs**

A DEPRESSION SPRING

B CONTACT SPRING

C FAULT SPRING

D SINKHOLE SPRING

E JOINT SPRINGS

F Fracture Spring

Source: CW Fetter, 1988, *Applied Hydrology*, Merrill Publishing Co., Columbus, Ohio, USA
Bores constructed in fractured rock aquifers usually yield much smaller amounts of groundwater than other aquifers. These low-yielding bores are generally suitable for stock and some domestic purposes. High yields suitable for irrigation occur very occasionally from limestone voids and some rocks that are highly fractured.

Higher yielding bores are often unreliable during drought because the available storage is generally small and requires regular recharge to maintain water levels. Salinity is highly variable in fractured rock aquifers, generally becoming more saline in drier, inland areas and is often related to rock type. Groundwater is also generally more saline in lower parts of a catchment, where it discharges.

Limestone has the particular characteristic that it is soluble in water that is mildly acidic. Chemical dissolution of the limestone may occur in fractures and joints, which results in caves being formed. The caves can form both above and below the watern table and can store and transmit large amounts of groundwater over large distances when many caves are interconnected. Impacts on water quality and quantity can thus occur considerable distances away from sites of contamination or extraction. The limestone caves of NSW possess unique aquatic fauna with ancient lineages and care must be taken to minimise impacts on them.

**Coastal Sand Bed Groundwater Systems**

There are significant sand beds along the coast of NSW which are highly permeable and easily recharged through rainfall. They are also very vulnerable to contamination. The groundwater in these systems mainly supports wetlands, terrestrial vegetation and hypogean ecosystems. These wetlands are often referred to as groundwater windows as they indicate the groundwater levels in the surrounding sandbeds. (See Figure 3)

It is important that over-extraction from these systems does not occur, as saline water can be drawn into the aquifer from the ocean and nearby estuaries, degrading the quality of the groundwater. Similarly, due to the highly permeable nature of these systems, groundwater can easily become contaminated by sewage, industry and poor land use practices. Water quality can be extremely difficult or impossible to restore once it has been degraded.

In Sydney, the Botany sand beds supply industry and parks in the south Sydney area with water and also support the Lachlan Lakes wetlands. Likewise, Tomago sand beds support wetlands and provide part of Newcastle’s water supply. Both aquifers also have dependent vegetation, and both have areas of potentially irreversible degradation as a result of industrial practices.

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*Figure 3 – Coastal sand aquifer with wetland and pumping bore. This diagram also shows water intrusion.*
**Sedimentary Rock Groundwater Systems**

Sedimentary rock aquifers include sandstone, shale and coal. In NSW examples of sedimentary rock aquifers can be found in the Great Artesian Basin, the Sydney Basin and the Clarence Moreton Basin, all of which store significant volumes of groundwater.

Sedimentary rock aquifers support a wide variety of ecosystems, including springs and soaks, hanging swamps, terrestrial vegetation, hypogean ecosystems, hyporheic zones and base flows (See Figures 1 & 2). The Blue Mountains sandstone aquifer includes examples of most of these ecosystem types.

In general, the aquifers in the Sydney and Clarence Moreton Basin rocks are sub-artesian. The water is mostly used for stock and domestic purposes, but occasionally higher yields suitable for irrigation and mining are extracted. In the Sydney Basin, notably in the Blue Mountains National Park, groundwater supports hanging valleys and swamps, which are especially susceptible to changing conditions in groundwater quantity and quality. Gallery forests, where trees are perched high above the valley floor, are also supported by groundwater flows.

The Great Artesian Basin (GAB) is the largest freshwater artesian basin in the world, covering one fifth of the Australian continent. In north-west NSW it provides the only reliable source of water for the region. There are approximately 1400 bores tapping GAB sediments in NSW, some of which have never flowed to the surface. Of the bores which flowed at the time of drilling, nearly half have stopped flowing due to a steady drop in pressure over the last century.

This pressure drop has also affected the artesian springs. At present, about one third of the GAB springs have ceased to flow and the rest have been reduced to mere trickles or seeps. These remaining springs are clearly vulnerable to local changes in groundwater pressure and will fail if pressures fall below critical levels.

New South Wales has developed a program for bore rehabilitation and piping to restore groundwater pressure, as around 90% of artesian water coming to the surface can be wasted through seepage and evaporation along open bore drains. The program involves capping bores which are free flowing and replacing bore drains with pipes to reduce water wastage. NSW is also represented on an interstate committee (the GAB Consultative Council) which has developed a strategic management plan for the whole GAB.
3. MANAGEMENT FRAMEWORK

3.1 Policy

National Water Reform Agenda
In 1994 the Council of Australian Governments (the Commonwealth Government and all
the State and Territory governments) endorsed a ‘Strategic Framework for Water Reform’.
This framework included an agreement to provide water for the environment.

National Principles for Provision of Water for Ecosystems, 1996
In 1996 the ‘National Principles for Provision of Water for Ecosystems’ were adopted by all
Australian governments1. These twelve principles are aimed at sustaining and, where
necessary, restoring ecological processes and biodiversity of water dependent ecosystems.
The principles are listed in Appendix A. The NSW State Groundwater Dependent
Ecosystems Policy provides ways to apply these principles.

As well as these principles, a set of recommendations for the allocation and use of
groundwater has been developed2. An important recommendation is that groundwater
management plans should identify environmental water provisions and develop strategies
for reducing consumptive water use to sustainable levels in over-allocated systems.

The NSW Government is committed to applying this recommendation and the other national
principles.

NSW Water Reform Program
In 1997 the NSW Government introduced its major water reform program. Important
aspects of this program were the release of the State Groundwater Policy Framework
Document and the establishment of local river and groundwater management committees to
give advice to the Government.

Several committees have been established for aquifers at high risk from over-extraction and
for major river systems. These committees need to operate within the Water Management
Act 2000 and policy framework, which includes developing ways to provide water for the
environment in a practical way.

NSW State Groundwater Policy Framework
NSW Government policy is to encourage the ecologically sustainable management of the
State’s groundwater resources, so as to:

• slow and halt, or reverse any degradation of groundwater resources;
• ensure sustainability of groundwater dependent ecosystems;
• maintain the full range of beneficial uses of these resources;
• maximise economic benefit to the region, State and nation.

1 This work was conducted through the Australian and New Zealand Environment and Conservation Council (‘ANZECC’), which is
made up of the Commonwealth, State & Territory Ministers responsible for the environment and conservation and through the
Agriculture and Resource Management Council of Australia and New Zealand (‘ARMCANZ’), which is made up of the
Commonwealth, state & territory Ministers responsible for agriculture, land and water resources and rural adjustment policy.

2 Allocation and Use of Groundwater: A National Framework for Improved Groundwater Management in Australia. 1996. This
work was also endorsed by ANZECC and ARMCANZ.
The Groundwater Dependent Ecosystems Policy will complement existing NSW groundwater policies, namely:

- the NSW State Groundwater Policy Framework Document, 1997 - which sets the overall direction for groundwater management in NSW, with broad objectives and principles to guide decisions; and
- the NSW State Groundwater Quality Protection Policy 1998 - which provides more detail and guidance on how to protect groundwater quality.

A NSW State Groundwater Quantity Management Policy is also being developed and a draft is due for release late in 2000. It will guide decisions on the allocation of groundwater. Figure 4 shows how the Groundwater Dependent Ecosystems Policy will fit into the overall State policy framework for groundwater management.

Effective management of groundwater dependent ecosystems in NSW will also necessarily involve recognition of the principles and strategies of other NSW State policies, including the NSW State Rivers and Estuaries Policy, the Salinity Strategy, the NSW Biodiversity Strategy, the NSW State Wetland Management Policy and its component State Wetland Action Plan. Further details of relevant policy and legislation in NSW are included in Appendix B.

### 3.2 Legislation

Many statutes can apply to the management of groundwater dependent ecosystems.

Under the *Water Management Act 2000*, the Minister for Land and Water Conservation controls and manages groundwater extraction and use in NSW. The Act is aimed at the sustainable and integrated management of water. It includes principles that must be applied by decision makers and any one else who is exercising functions under the Act. These principles include the following:

- water sources, floodplains and dependent ecosystems (including groundwater and wetlands) should be protected and restored and, where possible, land should not be degraded - see section 5(2)(a) of the Act
- the water quality of all water sources should be protected and, wherever possible, enhanced - see section 5(2)(c) of the Act
- sharing of water from a water source must protect the water source and its dependent ecosystems - see section 5(3)(a) of the Act.

The Act is largely administered by the NSW Department of Land and Water Conservation. The Act also requires all the State’s groundwater sources to be classified according to the extent to which they are at risk, subject to stress, or hold conservation value. In systems classified as high risk, high stress or high conservation value, Minister’s plans are required
to be established in 2001/2002 for a number of priority systems. These plans will establish the water sharing arrangements for the system, including environmental water rules, arrangements for domestic and stock use and an access (sharing and extraction) regime for licence holders.

The Act also requires environmental water rules to be established for all other groundwater systems as soon as practicable after 1 January 2001. These rules will ensure that water is specifically provided to meet the needs of groundwater dependent ecosystems. The Department licenses private entities and government authorities to extract and use groundwater. The licences can include conditions designed to protect groundwater dependent ecosystems. A new licensing and approvals system will begin operating in late 2002.

Development and use of land is the one consistent element in the list of potential threats to groundwater. Land use planning legislation and instruments, therefore, provide some control over the uses to which land is put. Land use planning in NSW is administered by the Department of Urban Affairs and Planning, and local councils under the Environmental Planning and Assessment Act 1979 (EP&A Act).

The EP&A Act requires the potential effects on groundwater of proposed developments to be assessed as part of the environmental impact assessment process. It also provides for the preparation of environmental planning instruments which may control, restrict or limit development at local, regional and State levels. The Act applies both to local councils approving private developments and carrying out their own activities. It also applies to State government agencies issuing approvals, including licences for groundwater extraction.

The Protection of the Environment Operations Act 1997 administered by the EPA is one of the legislative tools for the control of water pollution, including the pollution of groundwater. This Act consolidate previous environmental legislation including the Clean Waters Act, prohibits the pollution of any waters and provides for a licensing scheme. People acting in accordance with a licence have a defence against prosecution for polluting. This Act establishes a tiered structure of offences and penalties for pollution based on the intent of those involved and the severity of the harm caused.

There are other statutes which can also be used to protect GDEs or minimise impacts on them. These are listed in Appendix B.

### 3.3 Who manages Groundwater Dependent Ecosystems?

A range of people, both in government and in the community, are making decisions and carrying out activities which affect groundwater dependent ecosystems. They include:

- State government - agencies such as the Department of Land & Water Conservation (DLWC), the Department of Urban Affairs & Planning (DUAP), the Environment Protection Authority (EPA), the National Parks and Wildlife Service (NPWS), NSW Fisheries, the Department of Mineral Resources (DMR), and State Forests;
- Local government - through land use planning instruments, development approvals and their own activities, particularly managing waste disposal and sewage disposal;
- Catchment Management Boards (CMBs) & Water Management Committees (WMCs) through the development of management plans; and
- Individual property owners – landholders with significant groundwater dependent ecosystems on private land have roles in managing GDEs and protecting water quality. They can also enter into conservation agreements and management arrangements with government agencies.
Because there are so many people involved in managing GDEs, a partnership approach needs to be taken to the implementation of this policy. The GMCs and WMCs are important in this context because they have a mix of stakeholders, both government and community, and represent a range of interests. They should apply the principles of this policy at a local level through their management plans. Agencies and others whose activities affect GDEs should determine how they can best contribute to achieving the Policy’s goal.

A carpet of pouched coral ferns (Gleichenia dicarpa), a typical plant of hanging swamps.
4. GROUNDWATER DEPENDENT ECOSYSTEMS: MANAGEMENT PRINCIPLES

Groundwater systems should be managed through a range of regulatory and non-regulatory mechanisms so that, wherever possible, the ecological processes and biodiversity of their dependent ecosystems are maintained or restored, for the benefit of present and future generations.

Through licensing, there is a need to ensure that groundwater extraction does not have a significant impact on dependent ecosystems. Land use planning instruments, such as local environmental plans developed by local councils, can also be used to zone protection areas. Development applications can be refused or be granted with conditions designed to minimise impacts on these ecosystems. In all cases, the Precautionary Principle shall apply.

**Principle One**

The scientific, ecological, aesthetic and economic values of groundwater-dependent ecosystems, and how threats to them may be avoided, should be identified and action taken to ensure that the most vulnerable and the most valuable ecosystems are protected.

*Valuing groundwater dependent ecosystems*

Groundwater dependent ecosystems can have a wide range of environmental, social and economic values. The nature of these values will influence community expectations for management of the ecosystems. As different interest groups within the community will often have different priorities for the same ecosystem, management strategies need to incorporate a balance of the various needs and expectations. Achieving this balance requires a clearly defined and consistent assessment process for identifying the groundwater dependent ecosystems, and enabling equitable community involvement.

This Policy proposes a rapid assessment process to identify management priorities for key groundwater dependent ecosystems in NSW. This is discussed further later in this document (see Section 5.7).

**Principle Two**

Groundwater extractions should be managed within the sustainable yield of aquifer systems, so that the ecological processes and biodiversity of their dependent ecosystems are maintained and/or restored. Management may involve establishment of threshold levels that are critical for ecosystem health, and controls on extraction in the proximity of groundwater dependent ecosystems.

*Managing to Sustainable Yield*

Groundwater extractions will be managed within the ‘sustainable yield’ of a system, so that the availability of the resource is sustained for present and future generations, and ecological processes remain viable. This involves both limiting long term average extraction
to the sustainable yield of the whole system, and managing the locations, timing, volume, rate and depth of extraction where necessary to keep ecosystems viable.

In NSW, ‘sustainable yield’ is defined as:

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

The sustainable yield is effectively the extraction limits set for a groundwater system. The Water Management Act 2000 requires rules for the identification, establishment and maintenance of environmental water to be set for all groundwater systems in the State, via a management plan, as soon as practicable.

The amount of water to be set aside for the environment (the environmental provision) will vary according to the characteristics and dynamics of each groundwater system, the significance of any groundwater dependent ecosystems, and the reliance of existing extractive users on the groundwater.

The proportion of long term average annual recharge, therefore, set aside for the environment will be determined according to the unique features of each managed area, as identified by local groundwater management committees, or by government where these committees do not exist.

As a default value, many groundwater systems in NSW have an assigned sustainable yield of 70% of average long term annual recharge. The other 30% has been allocated to the environment. In groundwater systems where the assessment process (as outlined in Section 5.7) identifies highly valued and/or environmentally sensitive GDEs, a proportion larger than 30% may need to be provided to the environment. Conversely, where the assessment process identifies no significant GDEs a smaller proportion may be acceptable, providing that sufficient investigation has been carried out.

In systems which are currently over_allocated to consumptive users, strategies for bringing allocations back to sustainable yield levels will be negotiated with the community and phased in over time. Refined estimates of GDE water needs will also be made to ensure that this process is properly informed and equitable for the environment and the extractive users.

Because it is difficult to calculate the recharge of a groundwater system, the sustainable yield volume will change over time as our scientific and technical knowledge improves, or if there is evidence of degradation of local groundwater dependent ecosystems. It might also be varied according to long term changes in climate and variations in other natural conditions. In some instances it may also be necessary to apply seasonal restrictions on extractions to maximise recharge opportunities.

Whatever the value set for sustainable yield, it should be considered as a trigger level to instigate further investigations into the groundwater system, and any associated GDEs.

**Managing to critical groundwater levels**

In some aquifers, it may be possible to sustainably manage the groundwater resource by setting critical threshold water level values that will ensure the protection of the GDEs without unnecessarily limiting use of the resource. Examples include keeping water levels high enough for vegetation or streams that depend on groundwater during dry seasons, or maintaining high water levels in areas of potential acid-sulphate soils.

Where sensitive GDEs have been identified, “buffer zones” are to be created to restrict access to groundwater extraction and protect the local environment. These zones may
surround the ecosystems or may be restricted to the recharge path of flow, and can specify water table limits for extraction. Rules governing the timing of extractions may also be necessary in some situations. Management decisions for these areas will be supported by appropriate monitoring regimes.

**Principle Three**

Priority should be given to ensuring that sufficient groundwater of suitable quality is available at the times when it is needed:

- for protecting ecosystems which are known to be, or are most likely to be, groundwater dependent; and
- for groundwater dependent ecosystems which are under an immediate or high degree of threat from groundwater-related activities.

**The nature and degree of dependency on groundwater**

Ecosystems vary in the nature and the degree of their dependency on groundwater. Some, such as hypogean fauna, the mound springs of the Great Artesian Basin and the peat bogs found on the tablelands and in alpine areas are entirely dependent on groundwater. Other types of ecosystems have a dual dependency, that is, they depend on groundwater for only part of their water needs and use surface water as well. Examples include the swamp heaths on the Hawkesbury Sandstone in the Blue Mountains and the permanent lakes that support paperbark swamp forest and other vegetation on the coast of northern NSW.

Other ecosystems are less dependent overall, but changes to the timing of water availability or water quality may still impact on them. Providing water for the environment, therefore, is not just about setting aside a volume of water. It is also important to maintain the pattern of availability. Examples of this include the daily water regimes influenced by tidal variation, as applies in some estuarine, coastal mangrove and salt marsh ecosystems.

In other instances groundwater may be required only for the dry season or in times of extreme drought, as is the case with ecosystems of the north coast sand dunes and along inland river channels. GDEs also obtain dissolved nutrients and organic matter from groundwater, and so the dependency on groundwater may not be just for water alone, but also what is contained in it. Obviously, the degree and nature of the dependency on groundwater will govern the extent to which ecosystems are affected by changes to groundwater availability and quality. This will in turn govern how these ecosystems and groundwater are to be managed.

**Contamination**

To address groundwater quality issues specifically, the State’s Groundwater Quality Protection Policy was released in 1998. It has objectives and principles for managing and protecting groundwater quality. These objectives and principles also apply to the management of groundwater dependent ecosystems.

Groundwater contamination may be caused by a range of activities, such as:

- urban and rural development;
- excessive use of fertilisers and pesticides;
- leaking sewage pipes and septic tanks;
- sewage exfiltration, wastewater and sludge disposal;
- poor location of tip sites;
- salt water intrusion caused by over-extraction;
- mining; and
- seepage from contaminated lands.

These activities may act independently or cumulatively.

Groundwater moves slowly to the point where it discharges, for example into a wetland, or as base flows to a stream. Figures 1, 2 and 3 show how this process occurs. Contaminated groundwater exists in both rural and urban areas in NSW and ecosystems fed by contaminated groundwater have already been degraded or lost altogether.

Contaminated groundwater can be very costly or even impossible to clean up completely. Even detecting groundwater contamination can be more difficult in many cases than detecting surface water contamination. Prevention is clearly better than cure.

On coastal floodplains, acid sulphate runoff is also a major threat to aquatic ecosystems. It is caused through excavation and drainage works exposing the atmosphere iron sulphides contained in the soil. Acid groundwater can then be released into streams. Acidity also mobilises toxic heavy metals (Boulton & Brock 1999). Acidification of groundwater in areas at risk can be prevented by careful management of groundwater levels.

**Salinity**

Unnaturally high levels of saline groundwater, caused by broad scale tree clearing and/or irrigation practices and river regulation, can affect dependent ecosystems such as terrestrial vegetation. At these sites, native vegetation is often replaced by introduced, salt-tolerant species.

Likewise, saline effluent produced by sewage, mining and other industry, can raise groundwater levels locally and may impact on groundwater dependent ecosystems. Effluent management needs to be carried out in a way that ensures that ecosystems are not adversely affected.

There are strategies in place in the Murray-Darling Basin for managing salinity. In the Murray Basin, a strategy for minimising the impacts of salinity on a GDE may be to encourage groundwater pumping from nearby shallow aquifers.

There may even be occasional circumstances where a groundwater system could be ‘overdrawn’. An example may be using very salty groundwater for mining, as long as the environmental impacts of use and disposal of the water have been assessed and appropriate licensing conditions implemented.
Principle Four

Where scientific knowledge is lacking, the precautionary principle should be applied to protect groundwater dependent ecosystems. The development of adaptive management systems and research to improve understanding of these ecosystems is essential to their management.

Knowledge Gaps

The connections between groundwater and its dependent ecosystems are not well known and may change within groundwater systems through variations in weather conditions. In some instances, reducing groundwater availability may cause a proportional decrease in the health, resilience or size of an ecosystem. In cases where ecosystems are entirely dependent on groundwater, if groundwater availability is reduced either below a threshold or if it stops flowing at the surface, an entire ecosystem may collapse.

The level of protection needed depends on the value or significance of the dependent ecosystem, its sensitivity to changes in groundwater quality and availability, and the severity of the threats. The lack of knowledge about groundwater dependent ecosystems and processes that control their existence means that a precautionary approach to management is needed. Action is required as a matter of urgency and should include both protection measures and appropriate research.

Principle Five

Planning, approval and management of developments, water use and land use activities should aim to minimise adverse impacts on groundwater dependent ecosystems by:

- maintaining, where possible, natural patterns of groundwater flow and not disrupting groundwater levels that are critical for ecosystems;
- not polluting or causing adverse changes in groundwater quality;
- rehabilitating degraded groundwater systems where practical.

In particular, where developments are proposed in sensitive areas (that is, within the zone of influence of a significant groundwater dependent ecosystem and especially in groundwater recharge areas), a risk assessment must be prepared in conjunction with any Environmental Impact Assessment. For existing developments within sensitive areas, a risk assessment must be prepared when seeking to renew extraction licences or obtain additional approvals from local and/or State government agencies.

Integrated management

Parts of the environment cannot be considered in isolation. This Policy adopts an integrated approach to groundwater management. This means that groundwater quantity and quality issues should both be considered when making decisions that affect dependent ecosystems. Equally important is the need to consider surface water, soils, vegetation and land use planning issues when making decisions.

In particular, where developments are proposed in sensitive areas (that is, within the zone of influence of a significant groundwater dependent ecosystem and especially in groundwater recharge areas), a risk assessment must be prepared in conjunction with any Environmental Impact Assessment. For existing developments within sensitive areas, a risk assessment must be prepared when seeking to renew extraction licences or obtain additional approvals from local and/or State government agencies.
5. POLICY IMPLEMENTATION

This Policy will be implemented through a number of mechanisms. Some are already under way. Others are newer and will need to be further developed and implemented.

5.1 Groundwater and other Water Management Plans

Groundwater systems in NSW which have been classified as being at high risk from over-extraction or from contamination, or both, are being given priority for management action. Water sharing plans which include environmental water rules are being set for these systems in 2001/2002. Groundwater management committees have been established for many of these systems and are currently developing management plans. Also, other groundwater systems, including those classified as having high conservation value, will have environmental water rules set for them as soon as practicable.

These plans will be consistent with this and other resource management policies, and will set out the management strategies and actions for sharing and protecting groundwater quality, quantity and dependent ecosystems at a regional or local level.

However, there is currently little information on GDEs available for the water management committees, and the timetable for producing water management plans will require some decisions to be made without absolute certainty. The GDE rapid assessment process (Sec. 5.7), with its emphasis on broad stakeholder consultation, will be the main tool for management committees to identify values and threats relating to GDEs and to prioritise action plans. Further information gained at a later date can be used to support or adapt existing strategies.

There are also water management committees which cover both river and groundwater management within a defined catchment. Water management plans are currently being developed in several systems where there is a high degree of connection between the river and the groundwater systems. It is likely that there will be GDEs within these systems that are also at high risk from over-extraction and/or contamination, and management plans will acknowledge this interaction between the river and groundwater systems.

When plans are endorsed by the Government there is a commitment to their implementation. There are also statutory mechanisms (such as licensing and environmental planning instruments) and non-statutory mechanisms (such as education and research), that will be used to implement them.

Through early stages of management plan development, Groundwater Management Committees will rely heavily on local knowledge of known and likely GDEs and adopt a cautious approach until definite information becomes available. The plans will be reviewed and updated every five years, as information on water usage, water levels, water quality and groundwater dependent ecosystems is updated.

5.2 Groundwater Licences and Approvals

The DLWC administers the licensing system for access to groundwater. The precautionary principle will be applied through groundwater licence conditions designed to protect groundwater dependent ecosystems. A rapid aquifer risk assessment has been followed by sustainable yield assessment for aquifers identified as being at risk from over extraction. In many of these high risk systems, an embargo has been placed on new groundwater licence applications.

In non-embargoed areas, a groundwater licence condition specifying the minimum distances between the location of a bore and a groundwater dependent ecosystem will be placed on all
new licences that have the potential to affect the health of the ecosystem. The distances between bores and GDEs will vary from place to place depending on seasonal variations in ecosystem needs, the depth of the bore, local hydrogeological characteristics, the degree of groundwater dependency and the significance of the ecosystem. Maximum and minimum levels to which groundwater can be drawn down will also be specified as a licence condition in situations where the GDEs are highly valued by the community.

The new licensing and approvals system under the *WMA 2000* begins operating late in 2002. An access licence being required to extract groundwater. Further, approval will be required for water use and water supply works. An aquifer interference approval will be required for excavation activities that interfere with groundwater, but do not involve extraction from an aquifer.

The Environment Protection Authority licenses site-specific activities that can affect groundwater quality, such as garbage tips and sewage treatment works. Conditions imposed to protect groundwater include siting, risk minimisation, monitoring, plans for response to monitoring results and reporting. If existing licensed activities are likely to pollute groundwater they will be required to implement pollution prevention or reduction programs.

### 5.3 Environmental Planning Instruments

Under the *WMA 2000*, a management plan can contain environmental protection provisions (section 34). These provisions can:

- identify zones in which development should be controlled to minimise harm to water sources in the area;
- identify development that should be controlled in the zone and the types of control
- subject State and local government to decision-making criteria;
- require development consent for, or the Minister’s concurrence to, the development; and/or
- require action plans to encourage abandonment of existing uses that cause harm to water sources.

If a management plan contains environmental protection provisions, the Minister for Urban Affairs and Planning must include those provisions in a regional environmental plan (REP).

In addition, under Part 3 of the *EP&A Act*, environmental planning instruments may be prepared which control, restrict or limit development at local, regional and State levels. These can exclude groundwater contaminating industries from specified areas, or establish appropriate buffer zones around a groundwater dependent ecosystem, or the groundwater flow path to a groundwater dependent ecosystem.

There is considerable scope for environmental planning instruments to be used to assist in the implementation of the principles of this Policy. Groundwater and water management plans will identify groundwater issues that need to be addressed in the development consent process and in environmental planning instruments. These instruments operate at different scales, from local to State-wide. They include Development Control Plans, Local Environmental Plans, Regional Environmental Plans and State Environmental Planning Policies.

These environmental planning instruments have a significant influence on the environmental impact assessment process and the granting of development consents. These environmental planning instruments acknowledge significant ecosystems and ecosystems which may not necessarily be unique, but have value in terms of local landscape conservation. Local and State Government agencies are expected to take water management plans into account in their decision-making processes and the development of environmental planning instruments.
5.4 Education

Education is an important part of policy implementation if people are to change attitudes and practices. This is a new aspect of groundwater management and there needs to be recognition by all resource managers and users of the importance of groundwater dependent ecosystems and the need to value and protect them. It is important that this message also be conveyed to the wider community to:

- enhance understanding and transparency of decision-making and development management processes; and
- encourage local ownership of groundwater management plans and GDEs.

Education programs are currently being developed at several levels that will assist in achieving a better understanding of GDEs and groundwater flow. Both university and ‘in-house’ government training schemes are also being developed.

Scientists, groundwater managers, groundwater users, and ecosystem managers should assist in raising community awareness of these ecosystems and their values, and educating the wider community as to how threats to these ecosystems may be avoided. Brochures and other educational material focused at a community level will be prepared for the different groundwater management regions.

5.5 Monitoring

Monitoring programs are important to:

- provide baseline information;
- improve our knowledge of groundwater dependent ecosystems;
- ensure compliance with licences and other approvals;
- review performance of management strategies (such as setting buffer distances and water level limits); and
- identify natural and induced variations in water levels and quality, and in the composition and abundance of GDEs.

Priority should be given to monitoring the systems:

- which are most at risk from development or other human activities; and
- where there is a lack of information.

Groundwater dependent ecosystem monitoring is limited at present in NSW. Government agencies will undertake a review of monitoring requirements and seek industry partnerships to undertake additional monitoring. In some instances general knowledge within a community may provide some insight into long term trends in local GDEs. In the absence of other monitoring data, early management decisions can be informed by these and other such informal sources. It may also be practical for landholders and other interested members of the community to monitor the effects of management strategies.

A combination of qualitative and quantitative monitoring indicators needs to be developed for groundwater and dependent ecosystem conservation. Monitoring of these indicators will enable the water quality and health of these dependent ecosystems to be determined over time. These indicators will then become the basis by which the supplementary or complementary management strategies can be developed. Adjustments to the management plans and strategies can be made if the desired outcomes are not being achieved.
This Policy does not specify monitoring parameters. Monitoring requirements will vary according to local conditions and the nature of the threats to GDEs. Specialist personnel in government agencies and on individual water management committees will need to make these decisions as situations are identified through the committee processes. The results of any monitoring programs are to be provided to the DLWC for collation into the GDE database. A register of identified valuable GDEs will also be commenced by the DLWC to support the work of Groundwater Management Committees.

The new State Water Monitoring Strategy includes monitoring of groundwater levels. The final strategy will also include monitoring of groundwater quality. This will facilitate better management of groundwater dependent ecosystems.

5.6 Research

There is an urgent need for research in the area of GDEs, particularly in aquifers identified as being at high risk (NSW Government 1998a). Little is known about the various values of GDEs and how they react to and recover from pollution stresses and changes in watertable levels. The level of investigation should reflect the various values of the ecosystem and the perceived level of threat.

Cooperative research has been identified as the most appropriate way to gain a better understanding of the processes governing GDEs. Government agencies are developing partnerships with universities and other research organisations to achieve this aim. Community knowledge is also recognised as a significant potential source of information in identifying and understanding GDEs. This can include information on locations, past and present physical characteristics as well as behaviour in relation to climatic variation. Landholders and other interested members of the community can also carry out or contribute to some of the research needed to understand these ecosystems and groundwater interactions.

Research priorities are the same as for monitoring – see Section 5.5 above.

5.7 Rapid Assessment Process – for identifying GDEs and setting priorities for action

In developing the State’s groundwater resources there will always be the need for trade-offs between the environment and economic imperatives. In reality it may not be possible to protect all GDEs from degradation. For this reason, priorities need to be established to focus management efforts, including monitoring and research, to protect GDEs where possible.

Management and research priorities for GDEs can be determined by first identifying them and creating a register of their special features (See Appendix C). This register needs to be maintained and updated as knowledge levels increase in particular systems. Next, their vulnerability and their environmental and other values can be assessed. The outcome will be a prioritised list of where protection needs to occur. Major information gaps and the priority areas for research can be identified at this stage.

This process, which is largely adapted from the process given in ‘Desktop Methodology to Identify Groundwater Dependent Ecosystems’ (Nature Conservation Council 1999), can be used by a Groundwater management Committee (GMC), Water Management Committee (WMC) or other planning or management group, (for example, a local council), by drawing on the collective knowledge of the group. The aim is to develop a list of priorities for action.
and/or research relatively quickly. It must be emphasised here that this is a rapid process designed to fit within the short term needs of current management groups, as well as to establish a process and information base for longer term needs.

For areas with a high degree of conflict over water use it will be necessary to initiate more detailed assessments at a later stage. These assessments may either support or refute the notion of groundwater dependence for particular sites and changes may need to be made. However, it is easier to adapt management strategies than to repair damaged aquifers or to recover degraded ecosystems. In line with the Government’s commitment to the precautionary principle, action has to be taken in the short term to protect and manage ecosystems which are most likely to be groundwater dependent, while the major gaps in information are being filled through monitoring and research.

The detailed steps of this process are included in Appendix D.
6. POLICY REVIEW

The implementation of this Policy will be overseen by a State working group with agency and community representatives. The group will meet regularly to review policy performance and make sure that implementation is progressing.

The Policy will be formally reviewed every five years.

Groundwater and water management plans will be reviewed and committees will report to the Government on progress in implementing them.

GLOSSARY

**Allocation**  the volume of water that may be extracted annually by a licensed water user.

**Anthropogenic**  associated with human activities and development.

**Aquifer**  a body of earth, sand or rock from which useable volumes of water can be extracted.

**Biofilm**  an organic matrix supported by substrates (such as sand and other aquifer particles) which contains an often diverse and abundant microfauna and microflora.

**Ecosystem**  the community of plant, animal and other organisms existing within a defined area, and their interactions within the community and their non-living environment.

**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**  ecosystems which have their species composition and their natural ecological processes determined by groundwater (ARMCANZ & ANZECC, 1996).

**Hyporheic zone**  the fluctuating zone of water exchange between the surface stream and the groundwater.

**Hypogean ecosystems**  ecosystems which exist within aquifers.

**Riffle**  a section of a stream with shallow, fast-flowing water with a distinctly disturbed surface, and usually with a gravel or pebble base.
APPENDIX A – NATIONAL PRINCIPLES FOR THE PROVISION OF WATER FOR ECOSYSTEMS

1. River regulation and/or consumptive use should be recognised as potentially impacting on ecological values.

2. Provision of water for ecosystems should be on the basis of the best scientific information available on the water regimes necessary to sustain the ecological values of water dependent ecosystems.

3. Environmental water provisions should be legally recognised.

4. In systems where there are existing users, provision of water for ecosystems should go as far as possible to meet the water regime necessary to sustain the ecological values of aquatic ecosystems whilst recognising the existing rights of other water users.

5. Where environmental water requirements cannot be met due to existing uses, action (including reallocation) should be taken to meet environmental needs.

6. Further allocation of water for any use should only be on the basis that natural ecological processes and biodiversity are sustained (that is, ecological values are sustained).

7. Accountabilities in all aspects of management of environmental water provisions should be transparent and clearly defined.

8. Environmental water provisions should be responsive to monitoring and improvements in understanding of environmental water requirements.

9. All water uses should be managed in a manner which recognises ecological values.

10. Appropriate demand management and water pricing strategies should be used to assist in sustaining ecological values of water resources.

11. Strategic and applied research to improve understanding of environmental water requirements is essential.

12. All relevant environmental, social and economic stakeholders will be involved in water allocation planning and decision-making on environmental water provisions.
APPENDIX B – SUMMARY OF POLICY & LEGISLATION FOR GROUNDWATER DEPENDENT ECOSYSTEMS

1. POLICY

Australia has signed a number of international agreements that are relevant to the management of the ecosystems which depend on groundwater. The principles in these agreements have been applied at the national and state government level in Australia through a number of policies. They apply to the management of the quality, quantity and ecosystem aspects of managing groundwater. A summary of these policies follows.

<table>
<thead>
<tr>
<th>Name of Policy</th>
<th>Agreed to by</th>
<th>How it relates to groundwater dependent ecosystems</th>
</tr>
</thead>
<tbody>
<tr>
<td>National Strategy for Ecologically Sustainable Development (ESD), 1992</td>
<td>Commonwealth, state and territory governments</td>
<td>Identifies the need to:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• develop and manage the quality and quantity of surface water and groundwater in an integrated way; and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• to develop ways of maintaining ecological systems while meeting economic, social and community needs.</td>
</tr>
<tr>
<td>National Strategy for the Conservation of Australia’s Biological Diversity, 1993</td>
<td>Commonwealth, state and territory governments</td>
<td>Aims to ensure the effective identification, conservation and ecologically sustainable use of Australia’s biodiversity.</td>
</tr>
<tr>
<td>Strategic Framework for Water Reform, 1994</td>
<td>COAG(^3)</td>
<td>Agreement to formally allocate water to the environment.</td>
</tr>
<tr>
<td>National Principles for the Provision of Water for Ecosystems, 1996 (see App.B)</td>
<td>ARMCA NZ(^4) &amp; ANZECC(^5)</td>
<td>Aims to sustain and where necessary restore ecological processes and biodiversity of water dependent ecosystems.</td>
</tr>
<tr>
<td>Allocation and Use of Groundwater - A National Framework for Improved Groundwater Management in Australia, 1996</td>
<td>ARMCA NZ(^4) &amp; ANZECC(^5)</td>
<td>Recommends that groundwater management plans:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• identify environmental water provisions; and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• develop strategies for reducing consumptive water use to sustainable levels in over-allocated systems.</td>
</tr>
</tbody>
</table>

\(^1\) ‘COAG’ is the Council of Australian Governments. It is made up of the Prime Minister (Commonwealth Government) all Premiers of the Australian states and Chief Ministers of territorial governments and representatives of local government.

\(^4\) ‘ARMCA NZ’ is the Agriculture and Resource Management Council of Australia and New Zealand. It is made up of the Commonwealth, state & territory Ministers responsible for agriculture, land and water resources and rural adjustment policy.

\(^5\) ‘ANZECC’ is the Australian and New Zealand Environment and Conservation Council. It is made up of the Commonwealth, state & territory Ministers responsible for the environment and conservation.
There are other international agreements that Australia has adopted which aim to protect wetlands which may be groundwater fed, or birds which may rely on wetlands. Examples are:

- Convention on Wetlands of International Importance Especially as Habitat for Water Birds (1971);
- International Convention on Wetlands of International Importance - the ‘Ramsar Convention’, (1974);
- Japan-Australia Migratory Birds Agreement (1974); and

State policies for wetlands include:

- NSW Wetlands Management Policy, 1996; and
- State Environmental Planning Policy No. 14 - Coastal Wetlands (SEPP 14).

For base flows in rivers, the NSW State Rivers and Estuaries Policy (1993) applies. Management of GDEs in NSW will also have to be consistent with the aims and principles of the NSW Biodiversity Strategy.

### 2. LEGISLATION

There are a number of Commonwealth statutes that influence groundwater dependent ecosystems. More specific legislation is found in state legislation. Following is a summary of NSW legislation which is relevant to groundwater dependent ecosystems and the organisations which administer it:

<table>
<thead>
<tr>
<th>Statute</th>
<th>Principal Administering Authority</th>
<th>Relevance to Groundwater Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Management Act 2000</td>
<td>NSW Dept. of Land and Water Conservation (DLWC)</td>
<td>s.12: The State controls extraction and use of water.</td>
</tr>
<tr>
<td>Water Act 1912</td>
<td>DLWC</td>
<td>Part 5 gives DLWC powers to:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• license bores / groundwater usage;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• declare embargoes on further groundwater licences;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• reduce / increase groundwater allocations or reduce access;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• impose penalties for not complying with licence conditions; and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• take action against unauthorised water extraction.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(These provisions operate until the new licensing and approvals regime is introduced in late 2002).</td>
</tr>
<tr>
<td>Protection of the Environment Administration Act 1991</td>
<td>Environment Protection Authority (EPA)</td>
<td>The EPA is given general environmental responsibilities - that is, to protect, restore and enhance the quality of the environment in NSW, having regard to ecologically sustainable development (ESD).</td>
</tr>
<tr>
<td>Protection of the Environment Operations Act 1997</td>
<td>EPA</td>
<td>The EPA promotes prevention of pollution and has powers to licence activities that may pollute water. There are penalties for pollution by people not acting in accordance with a licence and with due care.</td>
</tr>
<tr>
<td>Contaminated Land Management Act 1997</td>
<td>EPA</td>
<td>Where site contamination is considered to pose a significant risk of harm to health or the environment, the EPA has powers to direct investigation and / or remediation of polluted land and groundwater.</td>
</tr>
<tr>
<td>Statute</td>
<td>Principal Administering Authority</td>
<td>Relevance to Groundwater Management</td>
</tr>
<tr>
<td>---------------------------------------------</td>
<td>-----------------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Environmentally Hazardous Chemicals Act 1985</td>
<td>EPA</td>
<td>• Controls (through licensing) the movement, storage and disposal of gazetted ‘chemical wastes’; and&lt;br&gt;• establishes a committee responsible for investigating contamination of the environment by chemicals and chemical wastes.</td>
</tr>
<tr>
<td>Environmental Planning and Assessment Act 1979</td>
<td>Department of Urban Affairs and Planning (DUAP)</td>
<td>• Specifies environmental impact assessment requirements and procedures for some developments and activities; and&lt;br&gt;• establishes a planning system for State, regional and local plans.</td>
</tr>
<tr>
<td>Local Government Act, 1993</td>
<td>DUAP &amp; local councils throughout NSW</td>
<td>Requires councils to:&lt;br&gt;• have regard to the protection of the environment when carrying out responsibilities (s 7);&lt;br&gt;• manage, develop, protect, restore, enhance and conserve the environment (s 8); and&lt;br&gt;• annually plan and report on its environmental management.</td>
</tr>
<tr>
<td>Crown Lands Act 1989</td>
<td>DLWC</td>
<td>Creates a system for management and sale of Crown land, which may overlie groundwater.</td>
</tr>
<tr>
<td>National Parks &amp; Wildlife Act 1974</td>
<td>National Parks &amp; Wildlife Service (NPWS)</td>
<td>NPWS administers:&lt;br&gt;• national parks, nature reserves etc.;&lt;br&gt;• conservation and management of flora and fauna; and&lt;br&gt;• Aboriginal heritage &amp; culture.</td>
</tr>
<tr>
<td>Fisheries Management Act 1994</td>
<td>NSW Fisheries</td>
<td>Creates a system for managing and protecting fish and their habitats.</td>
</tr>
<tr>
<td>Fisheries Management Amendment Act 1997</td>
<td>NSW Fisheries</td>
<td>Requires consideration of s.5A of the EP&amp;A Act to apply to threatened fish and marine vegetation, as listed in Schedules 4&amp;5 of the Fisheries Management Act 1994.</td>
</tr>
<tr>
<td>Mining Act 1992</td>
<td>Department of Mineral Resources &amp; Energy</td>
<td>Regulates exploration and mining activities, particularly through the administration and conditioning of titles.</td>
</tr>
<tr>
<td>Rivers &amp; Foreshores Improvement Act 1948</td>
<td>DLWC</td>
<td>• Protects aquifers which contribute directly to surface flow; and&lt;br&gt;• controls excavations in aquifers in the bed or banks of streams.</td>
</tr>
<tr>
<td>Threatened Species Conservation Act 1995</td>
<td>NPWS</td>
<td>Lists specific plant and animal species as threatened and establishes requirements to assess impacts on them and procedures for managing them.</td>
</tr>
<tr>
<td>Native Vegetation Conservation Act 1997</td>
<td>DLWC</td>
<td>Manages native vegetation clearing through the development consent and planning processes.</td>
</tr>
</tbody>
</table>
APPENDIX C – PROPOSED STRUCTURE FOR A REGISTER OF GROUNDWATER DEPENDENT ECOSYSTEMS

Location
Aquifer Category
Ecosystem Category
Specific Features
Level of Knowledge
Threat
Level of Dependence
Type of Dependency

APPENDIX D – RAPID ASSESSMENT PROCESS FOR GROUNDWATER DEPENDENT ECOSYSTEMS

Following are the steps for identifying and valuing GDEs. The approach is summarised after the final step, in Figure 4. Monitoring and research actions have been listed separately, as they are particularly important for the management of GDEs, given the present lack of scientific information.

Step 1 Identify Geographical Area

Define the specific geographical area. This could be any size. It may be the whole or part of the areal extent of any aquifer. It could be a local government area for which an environmental planning instrument, such as a local environmental plan or a development control plan, is being developed or modified.

Step 2 List GDEs

List known or likely GDEs within the defined area. They should be described in terms of their:
- location;
- type of ecosystem, classifying them into: wetlands, terrestrial vegetation, base flows, aquifer / cave ecosystems and other GDEs (as described in Section 2.2 of this Policy);
- type of groundwater system, i.e. deep alluvial, shallow alluvial, fractured rock, coastal sand bed and sedimentary rock (as described in Section 2.3 of this Policy).

Mapping may be the best way to describe some or all of these features. Any existing maps should be gathered as a first step and major gaps in mapped information identified. Other information gaps should also be listed.

Step 3 Assess vulnerability of GDEs

Identify each ecosystem’s vulnerability due to over-extraction, contamination or other threats. This involves assessing the degree or likely degree of dependency on groundwater. The nature of the dependency, if it is known, should also be described (for example, whether
the ecosystem only uses groundwater at certain times of the year, or only in dry times). This assessment is important for determining how vulnerable a groundwater-fed ecosystem is to groundwater extraction. Ecosystems also need a certain quality of groundwater. The tolerance of different ecosystems to water quality changes varies. The likely threats to GDEs from contamination should, therefore, be assessed.

GDEs such as wetlands and terrestrial vegetation, can also be at risk from clearing for development.

The Department of Land and Water Conservation has begun to map groundwater vulnerability in NSW. Some maps have been prepared for local government areas; others are at regional scale.

**Step 4 Assess value of the ecosystems and decide priorities for action**

An important step in working out priorities for action is to assess the overall value that a local and wider community places on its GDE. The overall value of a GDE depends on a number of factors. The uniqueness of an ecosystem, in ecological terms, depends on its biodiversity and how rarely it occurs. As well as ecological values, protecting a GDE may have social and economic benefits. This can be directly from industries which rely on a healthy functioning aquifer for sustainable water supply, as well as from recreation and tourism. They could also be important to Aboriginal people; or they may have aesthetic value for many people in the community.

Once this assessment has taken place action can then be tailored towards:

- protecting the GDEs most at threat; and
- minimising the impacts of groundwater extraction and land use activities which contaminate other GDEs, through conditions on licences and other approvals.

Weighing up these various environmental, economic and social values can be complex. There are a number of clear and structured assessment mechanisms that can assist in this process. Multi Criteria Analysis is one such method however individual groups will need to decide which best suits their situation. As there will often be major gaps in information, gaps should be listed, to help prioritise monitoring and research needs.

**Step 5 List management tools for protecting and managing GDEs**

GDEs are vulnerable, to varying degrees, to changes in groundwater quality or groundwater quantity or both. Some, such as terrestrial vegetation and wetlands, can also be destroyed by clearing for urban development, agriculture or industry – all of which are activities regulated by other acts and policies.

Even where there are major gaps in information, the precautionary principle should be applied and action taken to protect GDEs or minimise impacts on them. There is a range of possible management actions available to landholders and government. Management plans developed by GMCs and WMCs should list those which can be applied in the local area and make recommendations as to their suitability. They include both regulatory and non-regulatory actions. Some examples include investigation and risk assessment, negotiated changes to associated land use practices, and restricted access and use conditions on groundwater licences, such as setting minimum distances between bores and GDEs:

**Step 6 Prioritise management actions**

Actions need to be evaluated for costs and benefits and prioritised for implementation in the short to long term. Contingency response strategies will also need to be developed to be implemented in response to specified incidents or emergency situations.
Step 7  Implement management actions

Some actions – those such as licensing which involve the exercise of a statutory function - can only be implemented by government authorities. Recommendations should be made to the relevant authority, which can then act on them.

Step 8  Review

Scientific knowledge is continually evolving. At the same time, community attitudes towards the environment can change. These attitudinal changes may need to be reflected in management actions to bring about greater resource protection. It is essential to monitor a plan to evaluate its effectiveness. Review of a plan should occur at least every five years. This review should consider the extent to which the plan has been implemented and has succeeded in meeting its goals (Australian Water Resources Council, 1992).

Figure 6 – Process for Deciding Management Priorities for Groundwater Dependent Ecosystems

Adapted from the Nature Conservation Council, 1999
APPENDIX E – SUGGESTED FURTHER READING


APPENDIX F – GROUNDWATER CONTACTS

Department of Land and Water Conservation:

Sydney          02 9895 7875
Tamworth        02 6764 5927
Dubbo           02 6884 2560
Newcastle       02 4929 4346
Deniliquin      02 6041 1650
Wagga Wagga     02 6953 0745
Grafton         02 6640 2000

Environment Protection Authority:

Sydney          02 9995 5000

Headwater of Pretty Gully Creek, a spring fed creek with baseflow from a basaltic aquifer