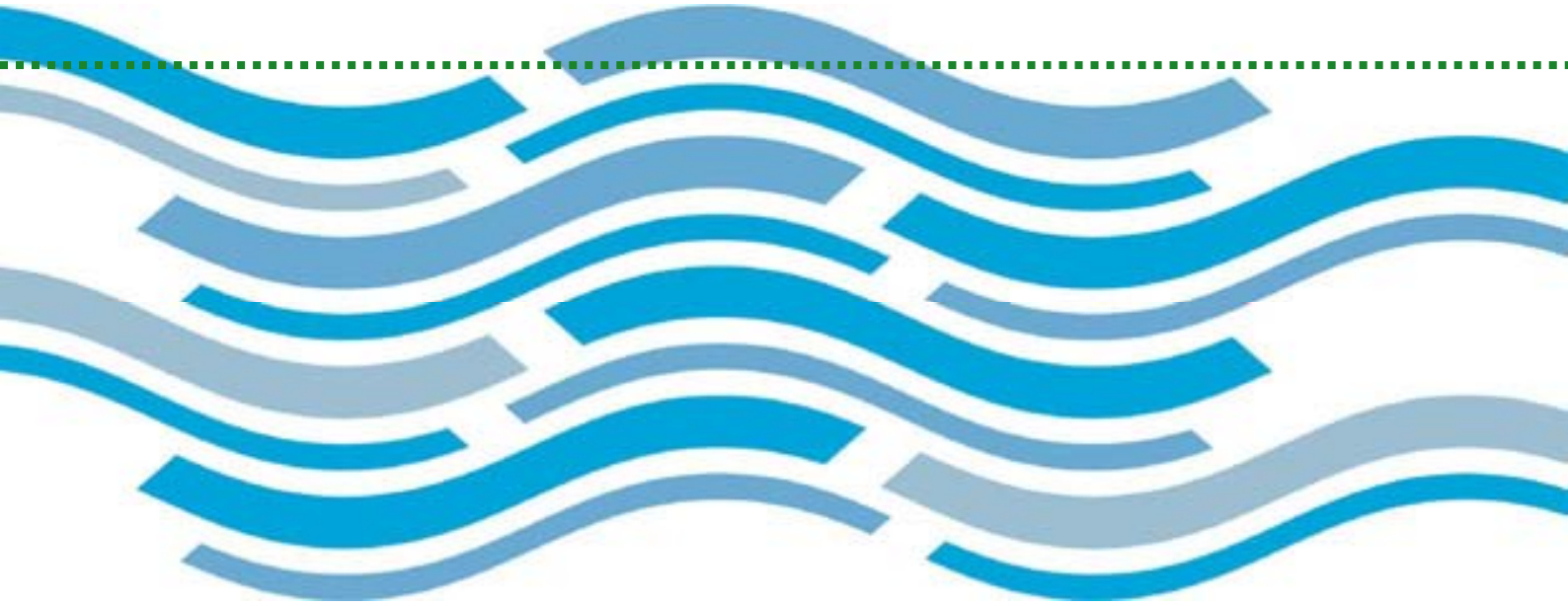
Protecting drinking water quality into the future

Priority areas and land use compatibility in Adelaide's Mount Lofty Ranges Watershed



WaterCare
It's in your hands

Protecting drinking water quality into the future —priority areas and land use compatibility in Adelaide's Mount Lofty Ranges Watershed

Protecting drinking water quality into the future —priority areas and land use compatibility in Adelaide's Mount Lofty Ranges Watershed

Acknowledgements: This report was prepared jointly by SA Water, Catchment Research Centre for Water Quality and Treatment and Environment Protection Authority.

For further information please contact:

Environment Protection Authority
GPO Box 2607
Adelaide SA 5001

Telephone: (08) 8204 2004
Facsimile: (08) 8204 9393
Free call (country): 1800 623 445

Web site: <www.epa.sa.gov.au>

E-mail: <epainfo@epa.sa.gov.au>

ISBN 978-1-921125-06-5

September 2007

Printed on recycled paper

CONTENTS

List of figures

List of tables

SUMMARY

This report has been written to provide technical input to the 2005 review of the Outer Metropolitan Planning Strategy. It reviews current regulation and policy approaches taken by catchment managers across Australia and their applicability to development in Adelaide's Mount Lofty Ranges Watershed (the Watershed). As a result, it proposes the adoption of a hierarchy of water protection areas, with associated development control objectives based on risks to drinking water supplies and national best practice watershed management. The report reviews three development control implementation models and recommends that one of these models be further investigated in consultation with industry, community, and state and local government authorities.

In South Australia, water quality protection is the responsibility of all governments levels, landholders and the public. It is supported by a range of legislation, including the *Public and Environmental Health Act 1987*, *Natural Resources Management Act 2004*, *Environment Protection Act 1993* and the *Environment Protection (Water Quality) Policy 2003*. The *Australian Drinking Water Guidelines 2004* (NHMRC) incorporates the 'Framework for Management of Drinking Water Quality', which sets out a national risk management approach to the protection of drinking water supplies. It promotes the establishment of barriers to help mitigate risks to water quality. Impaired water quality is a recognised risk to drinking water supplies and the environment, and increases water treatment costs. Planning zones have been used in a number of water supply catchments around Australia as a key component of water quality protection practice. They ensure that inappropriate development and land use does not affect water quality excessively.

The water resources in the Watershed need to be protected for a range of environmental values, including aquatic ecosystems and agricultural use. While acknowledging this, the focus of this report, and the promotion of planning zones, is protection of drinking water quality.

Drinking water supply catchments serving Perth, Sydney, Melbourne, Darwin, Hobart and Canberra are predominantly protected native forest set aside for public water supply. In contrast, Adelaide's Mount Lofty Ranges Watershed is a multi-use catchment, which is largely open and subject to a diverse range of land uses. This reflects historical vegetation clearance and agricultural development that pre-dated use of the area for public water supply catchments. Ninety percent of the Watershed area is privately owned and is home to more than 50,000 people. It is the source of much high value agricultural production, a tourist destination and base for a wide range of economic activities.

As a result of land uses in the Watershed, a significant pollutant load drains into the reservoirs. Water pollution may increase if catchment protection is not improved by strengthening the management of existing land uses and developments and by applying more rigorous planning controls to new development. This is particularly so where land management strategies cannot adequately address the risk to public water supplies.

A balance between best practice watershed protection and development is required. It is proposed that this be achieved through a risk-based planning hierarchy—where land use and development is matched to the risk posed to the drinking water supply. A set of priority areas is proposed and each is defined in terms of development control objectives:

- Priority 1 areas (P1) are the immediate hydrological catchments of the primary reservoirs and streams that are directly harvested for drinking water supply. In P1 areas, new development would only be permitted if it results in an improvement in water quality—that is, a change from a more to a less intensive (pollution generating) land use. These P1 areas constitute 23% of the Mount Lofty Watershed catchment.

- Priority 2 areas (P2) are those within 2 km of secondary water supply reservoirs, land within 100 metres of watercourses used to convey River Murray water into Hills reservoirs, and land in flood-prone and high-runoff areas. In P2 areas, new development would only be permitted if it has a neutral or beneficial effect on water quality, such as a change from one land use to another of similar intensity. These areas constitute 11.8% of the catchment.
- Priority 3 areas (P3) include all remaining parts of the Watershed, including catchment areas set aside for future reservoirs. In P3 areas it is acknowledged that water supply catchment functions co-exist with agricultural, residential, commercial and industrial uses. New development in P3 areas should only occur where the land use has a negligibly detrimental, neutral or beneficial impact on water quality. P3 areas constitute the remainder (65.2%) of the catchment.

Specifications for the priority areas are based on precautionary adoption of land use and development controls judged necessary by public health and environmental practitioners from available scientific information.

The Outer Metropolitan Planning Strategy introduced the Watershed Priority Areas concept as proposed in this report. While this report also considers three models for implementing the priority areas concept, the chosen model would need to be the subject of a ministerial plan amendment report process. This would involve a further level of detailed consultation across government, industry and the community.

Planning policy is only one tool that can be used by the state government to protect and improve water quality in the Watershed. Changes to planning policy can only affect new development and must be complemented by other initiatives that address water quality in the Watershed. The intent of this report is only to address issues relevant to planning policy that can be implemented through the Outer Metropolitan Planning Strategy and amendment of council development plans.

1 MOUNT LOFTY RANGES WATERSHED

The Mount Lofty Ranges Watershed (the Watershed) covers approximately 1640 km^2 of relatively high rainfall land that provides, on average, 60% of greater Adelaide's public water supply (refer to Figure 1 on Page 18). Unlike most other capital cities in Australia, the Watershed is extensively developed for a wide range of activities, all of which have an effect on the quality and quantity of water draining into reservoirs in the region. The remaining Adelaide water supply requirement, pumped from the River Murray, is discharged into rivers in the Watershed and is therefore subject to the same quality influences.

The majority of the Mount Lofty Ranges Watershed is used for broadscale grazing (cattle and sheep) with other dominant land uses including native vegetation, vineyards, orchards, forestry, vegetables, horse keeping, urban, rural living and some light industrial activities. The Watershed contains:

- more that 20,000 allotments with houses on approximately ¾ of these allotments
- more than 50,000 people living mainly in towns and rural living areas near the South East Freeway
- more than 9000 farm dams
- parts of nine local council areas, the largest being the Adelaide Hills Council.

Agricultural production in the Watershed makes a substantial contribution of around $720 million per annum to the state's economy. Tourism in the region also makes a significant contribution to the local and state economy. Such a multi-use catchment needs to be managed to balance the needs of the rural community and those required for the protection of drinking water supplies. The Mount Lofty Ranges Watershed is unique in Australia as metropolitan Adelaide depends on water supplies from a predominantly unprotected catchment that is intensively used for living, industry and agriculture (EPA 2000).

The significant demands on land in the Mount Lofty Ranges Watershed can affect water resources. Although water quality problems arose as early as the 1880s, in the early years there was little attempt to control activities along major waterways. Rather, settlement and agricultural development were given priority over the need to maintain catchments for water supplies. The rate of change throughout the ranges since settlement has been significant. In recent years, improved roads and quicker access have resulted in significant population growth in the catchments (EPA 2000).

Water quality protection can take the form of land use management (such as watercourse restoration, and chemical use and soil management programs), waste reduction programs (such as stormwater reduction, wastewater reuse and auditing programs) and land use planning. Many programs are in place to protect and improve water quality, but long-term protection through suitable land use planning is critical.

In 1974 the state government created the Mount Lofty Ranges Watershed through amendments to the *Regulations under the Waterworks Act 1924*. The Watershed (as it became known) includes all existing reservoir water supply catchments and several other catchments considered suitable for future reservoirs. Declaration of the Watershed enabled the State government to establish land management and development controls to protect existing and future water supplies. Although a small area near Kangarilla was annexed from the Watershed in 1990, the Watershed remains largely intact and has now been given legal status in the *Development Act 1993,* associated council development plans, the *Natural Resources Management Act 2004* and the *Environment Protection Act 1993*.

2 BACKGROUND AND APPROACH

This report examines contemporary regulation and policy at a national level, and the approaches applied by catchment managers in Victoria, New South Wales and Western Australia, to determine principles applicable to development in the Watershed. As a result it proposes the adoption of the Watershed priority area concept and associated development control objectives contained in the 2005 Planning Strategy for the Outer Metropolitan Adelaide Region. The report also presents and considers policy options for implementing these strategies and objectives.

The document was written to present policy options, with consideration of regulatory requirements[1], national best practice for watershed management, and the scientific evidence behind the requirement for changes to the planning system. SA Water, the Environment Protection Authority (EPA) and the CRC for Water Quality and Treatment prepared the report jointly. It draws on the knowledge and experience these organisations have in managing the effects of land use and development on water quality in the Mount Lofty Ranges.

It is intended that this report form part of the technical foundation of a range of amendments to planning policy in the Mount Lofty Ranges Watershed, following public consultation and finalisation of the Planning Strategy for Outer Metropolitan Adelaide. This report may also help determine the need for, and form of, legislative changes to assist implement the preferred watershed priority area implementation options.

The concept of priority areas in the Mount Lofty Ranges Watershed should not be considered as an independent strategy. Rather it supports one aspect of watershed protection, with other essential strategies supporting the management of land and water resources. These include on-ground riparian and land management works (funded through the National Heritage Trust, related funds and state natural resources management boards or equivalent), regulation of activities under the Environment Protection Act and the associated *Environment Protection (Water Quality) Policy 2003*, education on chemical use, stormwater and land management, provision of sewers to towns and upgrading household on-site wastewater management systems.

A risk-based approach was taken when developing this strategy (as recommended in the ADWG 2004). The first step was to identify the current risks to drinking water quality in the Watershed. Secondly, the capability of reservoirs to act as barriers was determined and then the three areas were delineated. The desirable level of effects on water quality from new development was then determined for each of the areas. In order to implement the priority areas concept and achieve the desired results, three implementation options were considered. Each of these options matches the risk presented by new land development in each of the priority areas. The variation between options is due to the complexity of this assessment. Consideration was given to resource requirements of development assessment and compliance, the role of supporting legislation and the impact on current and future developments.

[1] Primarily the Australian Drinking Water Guidelines (ADWG) of the National Health and Medical Research Council of Australia (NHMRC 2004) and state acts

3 DRINKING WATER QUALITY PRIORITIES IN THE MOUNT LOFTY RANGES WATERSHED

The priority that the State government assigns to activities that affect water quality depends on the risk to the community. There are three risk levels. The highest priority is given to health risks, which can only be addressed by significant and costly capital improvements to treatment processes. The next priority is health related effects, which can be dealt with by immediate corrective action within the current treatment system. The third level is taste and odour of drinking water. This, while a lower priority, is expensive to deal with.

Table 1 lists land uses and associated water quality risks in the Mount Lofty Ranges Watershed (refer to Appendix A for information on pollutants). The effect on water quality and the subsequent risk is based on a cumulative impact of the land use.

State government agencies must determine when the cumulative effect of a land use has reached, or is about to reach or exceed, the water quality risk threshold. When this has occurred, or is likely to occur, planning regulations are needed to control further development and thus limit the future decline in water quality. It is considered that in the Mount Lofty Ranges Watershed, these planning controls do not need to be applied across the entire watershed. Blanket controls would not support the ecologically sustainable development objective of the State Strategic Plan, whereby development and healthy ecosystems can coexist. Rather, priority areas have been developed within the Watershed where controlling some land uses would have a significant benefit to drinking water quality. Development would be encouraged in parts of the Watershed where impacts on water quality are acceptable.

Table 1 Land use activities and associated priority risks to drinking water quality

Land use activity	Water quality risk examples	Relative priority
Intensive grazing, unsewered residential development, urban stormwater	Chlorine resistant pathogens (*Cryptosporidium*) exceeding treatment capacity	High
Forestry, orchards, market gardening	Pesticides exceeding treatment capacity	High
Orchards, market gardening, residential development, intensive grazing	Nutrients and algae exceeding reservoir management or treatment capacity	High
Pine plantations, forestry, intensive grazing (leading to overgrazing)	Dissolved organic carbon exceeding treatment capability and affecting disinfection processes.	High
Orchards, market gardening, viticulture (establishment) intensive grazing (leading to overgrazing)	Suspended sediment exceeding treatment capability	High
Intensive grazing, unsewered residential development	Chlorine sensitive pathogens exceeding treatment capacity	Medium
Forestry, orchards, market gardening, residential development	Pesticides within treatment capacity	Medium
Orchards, market gardening, residential development	Nutrients or algae within reservoir management and treatment capacity	Medium

Land use activity	Water quality risk examples	Relative priority
Pine plantations, forestry	Dissolved organic carbon within treatment capacity and not affecting disinfection processes	Medium
Orchards, market gardening, viticulture (establishment)	Suspended sediment within treatment capacity	Medium
Native vegetation, revegetation, broadscale low intensity grazing	Nutrients within reservoir management and treatment capacity, and not resulting in health related impacts	Low
Native vegetation, revegetation, broadscale low intensity grazing	Dissolved organic carbon within treatment capability, not affecting disinfection progresses and not resulting in health related impact	Low
Native vegetation, revegetation, broadscale low intensity grazing	Suspended sediment within treatment capacity and not resulting in health related impact	Low

4 NEED FOR PLANNING POLICY CHANGE BASED ON WATER SENSITIVITY

A principle of catchment protection for drinking water quality is the degree to which land management can mitigate potential risks. In some cases, based on water quality findings in the Mount Lofty Ranges Watershed, land management initiatives will not significantly decrease risks. For example, in the Sixth Creek catchment, during two weeks of intense run-off in 1996, 81% of the annual suspended solid load and 67% of the total phosphorus load was exported from the sub-catchment. During this period, the suspended solid concentration went from 62 mg/L to 2010 mg/L (AWQC 2001). Similarly, during 2001 in the Myponga Reservoir catchment, 74% of annual total phosphorus load was delivered in 44 days or 12% of the year (Linden *et al* 2004). This type of event has a major effect on the quality of inflows to reservoirs. It is very difficult to sufficiently reduce the rate of export during these periods. In priority areas of the Watershed, due to the inherent hydrological processes of the Mount Lofty Ranges and their correlation with water quality, risk avoidance measures implemented through land use planning are more suitable than risk reduction measures pursued through land use management.

Section 5 provides additional supporting evidence for the importance of land use planning as a catchment management measure for drinking water quality protection.

5 ASSESSMENT OF INTERSTATE PRACTICES AND DEVELOPMENT CONTROLS

A number of contemporary regulations and policies were reviewed by the CRC for Water Quality and Treatment (CRCWQT) to distil the principles of contemporary watershed management legislation and policies. Appendix B provides a summary of the review findings. Principles that should, or could, be applied to decision making in the Mount Lofty Ranges Watershed so as to be duly diligent and consistent with contemporary Australian and overseas water quality protection legislation and policies are summarised in Table 2.

5.1 National best practice

A reasonable interpretation of the minimum standard, based on national best practice, was considered by the CRCWQT to be as follows:

- pollution that might arise in the watershed should be controlled at source, to the maximum degree practical, and should make use of best practice pollution control measures without full reliance on downstream water treatment controls
- the quality of the receiving waterway should not be degraded as a result of any new development, even if that degradation would not lead to a breach of trigger or guideline values
- in the absence of scientific certainty, the precautionary principle should be applied when defining the nature and level of controls required to ensure no degradation of water
- in general, best practice should be applied to all aspects of watershed management and pollution control, including the development of water quality protection zones and buffers.

Table 2 Principles potentially applicable to development in the Mount Lofty Ranges Watershed

Principle	Australia				NSW		WA	VIC	SA		US	EU
	ADWG	ANZECC	IGAE	GBRMP	SWCM	GOSD			PEH	NRM	CWA	FD
Pollution should be controlled at source	☑											☑
Multiple barriers are required to protect drinking water quality	☑											
Source water for drinking should be protected to the maximum degree practical	☑											
Drinking water quality should be maintained at the highest practicable quality	☑											
Water quality should not be degraded	☑	☑			☑				☑		☑	☑

Principle	Australia				NSW		WA	VIC	SA		US	EU
	ADWG	ANZECC	IGAE	GBRMP	SWCM	GOSD			PEH	NRM	CWA	FD
Water quality should be improved					☑					☑		☑
Quality of life should be increased over time		☑										
Inter-generational equity		☑	☑									
Polluter pays			☑							☑		☑
Precautionary principle			☑	☑						☑		
Offsets must ensure any essential polluting development has a net neutral or beneficial effect on water quality						☑						
Best practice should be applied										☑		
Water is part of natural heritage requiring special protection												☑

5.2 Development controls

A brief review of the land use, land management and associated development control regimes that apply in Sydney, Melbourne, Brisbane, Perth and Ballarat's water supply catchments is provided in this section as best practice benchmarks within Australia.

5.2.1 Sydney

The catchments that supply mains water in the greater Sydney region cover an area of almost 16,000 square kilometres (10 times the size of the Mount Lofty Ranges Watershed). The majority of the catchment area (63%) remains covered with native vegetation. Other major land uses include intensive and extensive agriculture (31%), forestry (11%), infrastructure including roads (7%) and urban areas (<1%). About 25% of the total water supply catchment area is designated as 'Special Areas'. These areas surround the water supply reservoirs and consist of native vegetation that is closed to public access. It is a legal requirement that new development in the catchments must not be approved unless the planning authority is satisfied that the proposal will have a neutral or beneficial effect on water quality. Local government has the primary responsibility for granting development approval for most applications. However, the Sydney Catchment Authority has a major role in reviewing development proposals that pose a risk to water quality.

5.2.2 Melbourne

Melbourne's water supply catchments cover more than 1500 km^2 (about the same size as the Mount Lofty Ranges Watershed). About 90% of the area is covered by mountain ash forests that have been closed to the public for more than 100 years. Melbourne Water and Parks Victoria manage these areas; bushfires, track erosion and unauthorised public entry are the main water quality management issues. Development applications in the other catchments are subject to normal council planning controls, with no system of development application referrals to Melbourne Water currently applying.

5.2.3 Brisbane

In south-east Queensland, mains water supplies for the Gold Coast and Brisbane come from approximately 12,000 km^2 of catchments. In the largest and most important water supply catchments (Wivenhoe and Somerset) dominant land uses are grazing (60%), native forests and scrub (32%), intensive cropping (3.5%) and rural residential (0.2%). South-East Queensland Water, which supplies water to customers in the region, only owns a small area of land (5% of the catchment area) around the margins of their reservoirs. Local councils are primarily responsible for the assessment and approval of development proposals in the water supply catchments. Proponents of all forms of development in the catchments are legally required to minimise effects on watercourses and catchment water quality. The catchments are not currently zoned on the basis of water quality risks; however, there are strict controls on subdivision and the extent of township expansion allowed in some areas that are mandated by the Queensland State government.

5.2.4 Perth

About 40% of Perth's mains water supplies come from surface water catchments in the Darling Range. The remaining 60% is drawn from aquifers in the deep sands of the coastal plain. The surface water catchments cover 3840 km^2, and more than 90% of this area is covered by native forests and pine forests. Less than 5% of the surface water catchment area is developed for other uses such as orchards, housing and grazing. The groundwater that is extracted for mains water comes from a combination of unconfined, semi-confined and confined aquifers. However, the largest groundwater source is drawn from unconfined aquifers north of Perth where recharge areas cover approximately 230 km^2. Land uses in these recharge areas include native and pine forests, horticulture, rural living and urban development. The WA State government has established a drinking water source area protection policy that applies to development proposals and land use in both surface water catchments and groundwater recharge areas used for mains water supplies. Priority 1 areas are defined and managed to ensure there is no degradation of water sources, Priority 2 areas are defined to ensure that water pollution does not increase, and Priority 3 areas are designated where water supply sources co-exist with other land uses and where water pollution can be managed through guidelines and good practice. The WA State government is actively involved in selective land acquisitions in Priority 1 areas.

5.2.5 Ballarat

In the Moorabool Shire, west of Melbourne, towns and cities, including Ballarat and parts of the Geelong region, are supplied with mains water sourced from catchments that drain the southern slopes of the Great Dividing Range. Land in the catchments is mainly privately owned and used for grazing and cropping, rural living and urban land uses. The more mountainous areas contain state-owned forests. The four water authorities in the region are referral bodies under state planning legislation and can veto inappropriate development proposals or impose conditions. Landowners retain the right to seek a review of any decision by the Victorian Civil and Administration Tribunal. To better exercise these powers, the water

authorities have prepared a common policy document that includes housing density controls outside towns (less than one house per 40 ha), a 40-ha minimum allotment size outside towns, setbacks from watercourses, better control and maintenance of housing on-site wastewater disposal systems, and discouragement of intensive animal keeping and large-scale tourist accommodation. These guidelines inform developers and local council planning staff, and are used by the water authorities as the basis for assessing referred development applications.

5.2.6 Summary information

Table 3 summarises catchment management and development controls that apply in the capital city and other regional centre water supply catchments described above. This summary was derived from a survey of Melbourne Water, Central Highlands Water (Victoria), Water Corporation (Western Australia) and Sydney Catchment Authority, conducted by the CRCWQT in 2005.

As can be seen from Table 3, designation of zones or areas differs between water authorities. The determination of defined zones or areas within watershed catchments and associated development criteria is well established as a contemporary approach to the protection of water quality in Australia.

The best practice management provisions as presented in Table 3 reflect a combined Australian position that can be used to inform planning strategy development in South Australia. These planning provisions will be compared with the suggested changes within the Mount Lofty Ranges Watershed in Sections 6 and 7 of this paper.

Table 3 Survey results of the generic or other criteria applied to setting water quality protection and buffer zones around Australia

A: What name is given to the development zones within a few kilometres of drinking water reservoirs and off takes (protection zones, special areas, etc)?

	Zone		
	A The closest or most restricted zone	**B The next zone out or second most restricted zone**	**C The next zone out or third most restricted zone**
Melbourne Water	Public Use Zone 1	Declared water supply catchment	N/A
Water Corporation	Priority classification 1 'Reservoir Protection Zone' (RPZ) for water surface dams and reservoirs.	Priority classification 2	Priority classification 3
Sydney Catchment Authority	Special area—Schedule 1	Special area—Schedule 2	Remaining catchment area
Central Highlands Water	Zones 1 & 2	Zone 3	Zone 4

B: For each of these development zones, what linear distance or other criteria define those zones?

	Zone		
	A The closest or most restricted zone	**B The next zone out or second most restricted zone**	**C The next zone out or third most restricted zone**
Melbourne Water	≈ 0.10 km—land owned by Melbourne Water	Catchment boundary	N/A
Water Corporation	RPZ set at 2 km from top water level of the reservoir	–	–
Sydney Catchment Authority	Minimum 3 km where possible, up to 5 km or greater where undeveloped nature of area permits	Topography & hydrology, extent of existing private development—security significance	Topography & hydrology, extent of existing private development—security significance
Central Highlands Water	Zone 1 less than 45 minutes and Zone 2 less than 90 minutes travel time of surface runoff water to reservoir	Zone 3 less than 135 minutes travel time of surface runoff water to reservoir	Zone 4 less than 180 minutes travel time of surface runoff water to reservoir

C: What generic or other criteria apply to new development in these zones (beneficial effect test, compliance with specific land use)?

	Zone		
	A The closest or most restricted zone	**B The next zone out or second most restricted zone**	**C The next zone out or third most restricted zone**
Melbourne Water	No development allowed	No new (or additional load on existing) septic or on-site wastewater systems No industry, dairy farms, piggeries, cattle feed lots or other intensive animal industries	N/A
Water Corporation	Land Use Compatibility Table produced by Department of Environment (DOE)	as above	as above

	Zone		
	A The closest or most restricted zone	**B The next zone out or second most restricted zone**	**C The next zone out or third most restricted zone**
Sydney Catchment Authority	Reserved for water supply purposes—development prohibited for other than water supply and management of area as bushland. Public access is denied to this classification of reservation	More restricted suite of permissible land uses in areas under private ownership (compared with Zone C) requires the concurrence of the SCA before approval can be granted. The decision maker, whether that be SCA, local government or minister, needs to consider: a) whether the development or activity will have a neutral or beneficial effect on the water quality of rivers, streams or groundwater in the hydrological catchment, including during periods of wet weather b) whether the water quality management practices proposed to be carried out as part of the development or activity are sustainable over the long term.	
Central Highlands Water	Zone 1—land to be purchased and managed by the water authority as buffer Zone 2—no dwellings	Dwelling density not to exceed one house per 60 ha (measured by drawing a 1-km radius from the house site) Setback from waterways for houses and on site treatment systems and wastewater disposal areas to be at least 100 m.	Dwelling density not to exceed one house per 50 ha (measured by drawing a 1 km radius from the house site) Setback from waterways for houses and on site treatment systems and wastewater disposal areas to be at least 100 m

D: What basis is applied for the zoning (examples include historical precedent, scientific risk-based, rule of thumb, expert panel judgement or unknown)?

	Zone		
	A The closest or most restricted zone	**B The next zone out or second most restricted zone**	**C The next zone out or third most restricted zone**
Melbourne Water	Historical land ownership	Catchment boundary	N/A
Water Corporation	The original rationale of the 2-km RPZ limit is uncertain. It has however, proved effective and this, in part, is considered to be the result of the distance limiting line of sight to the reservoir or water body and allowing natural growth to establish and prevent easy access to the water body	N/A	N/A
Sydney Catchment Authority	Expert panel, historical opportunity or lack thereof	Expert panel, historical opportunity or lack thereof	Historical precedent, with increasing emphasis on scientific risk-based analysis to underpin the preparation of draft local environmental plans.
Central Highlands Water	Historical—adopted in 1985. Aimed to provide an overall density of about one house per 40 ha across the whole catchment which is consistent with the local municipal planning scheme which has most of the catchment zoned Rural with a minimum subdivision lot size of 100 ha and a minimum lot size for a dwelling of 40 ha Victorian Code of Practice for septic tanks has default setbacks for septic tanks and aerated treatment plants of 100 m from watercourses	N/A	N/A

5.3 Multiple barrier approach to water supply protection

The Australian Drinking Water Guidelines (ADWG) highlights the importance of understanding and maintaining multiple barriers within water supply systems to manage risks to drinking water consumers (NHMRC 2004). There are a number of protective barriers in Adelaide's mains water supply system. These include:

- catchment protection to prevent pathogens and pollutants from reaching rivers and reservoirs
- detention in major reservoirs (eg Kangaroo Creek and Mount Bold reservoirs)
- water treatment processes (eg water filtration and disinfection)
- protection of the mains water distribution system from subsequent contamination
- plumbing controls to prevent cross-connections.

The multi-barrier approach minimises the risk to water quality at each of a number of barriers, rather than relying on a single barrier. The strength of the multi-barrier approach is that a failure of one barrier may be compensated for by the remaining barriers, minimising the likelihood of contaminants passing through the entire treatment system (NHMRC 2004).

It is now recognised (NHMRC 2004) that watershed protection is a critical first step for protecting bulk raw water quality. Preventative measures should be applied as close to the pollutant source as possible, with a focus on prevention in watersheds rather than reliance on downstream water treatment. Further, water treatment (filtration and disinfection) is not perfect and should not be the sole means of protecting public health.

The economic benefits of establishing and maintaining multiple barriers was examined by Hrudey (2004) who reported that, in a multiple barrier system, risk reduction at each barrier is likely to be more cost effective than a single barrier (eg a water treatment plant). By using barriers in series, thus employing the initial and most economical phase, a much lower cumulative risk can be achieved for a smaller investment.

Failure to adequately manage water quality can be catastrophic to the community and the water supplier. Even if no illness results, the community's trust in its water supplier can be lost. It can take many years to rebuild community confidence. Catchment protection and enhancement measures can minimise the need for more expensive water treatment technologies, reduce risks to human health, and save money.

5.4 Expert recommendations to the South Australian government

Professor Peter Cullen, an Adelaide Thinker in Residence during 2004, recommended that planning policy in the Mount Lofty Ranges Watershed be amended to ensure the water supply quality for the Greater Adelaide region is maintained. His recommendations included:

- 'the need to prevent further subdivisions, hobby farms and closer settlements
- 'the need to explore planning controls on agricultural activities to prevent water quality getting even worse' (Cullen 2004).

Similar recommendations were contained in the state government's 2004 *Water Proofing Adelaide Strategy* (2004), which stated that 'planning strategies for the Mount Lofty Ranges Watershed need to be updated to protect the region from inappropriate development that may impact on water quality' (South Australian Government 2004).

5.5 Development pressure and need for controls based on water quality risk

The current council development plans that apply under the Development Act, generally categorise all forms of development in the Watershed as 'non-complying' outside township boundaries except: farming, farm buildings, forestry, horticulture, agricultural industries

associated with processing primary produce, houses (subject to certain criteria) and land division where no additional allotments are created and where there is no increased risk of water pollution. If a development application falls outside the scope of these exceptions it can only be approved by a council with the concurrence of the Development Assessment Commission (the state planning authority) and then only if it is not seriously at variance with the development plan. In theory, developments listed as 'non-complying' are inappropriate and were not envisaged when such provisions were included in the development plan. However, in practice, many forms of development that are categorised as 'non-complying' in the Watershed ultimately gain approval because they are essentially assessed on their merit against the provisions of the development plan. This can create a precedent for other similar 'non-complying' developments to gain approval in the region.

The Mount Lofty Ranges Watershed is subject to constant development pressure due to its close proximity to Adelaide, the high level of private land ownership, the large number of vacant allotments that remain undeveloped and its unique climate, topography, soils and hydrology. Many industries and activities in the Mount Lofty Ranges have experienced waves of development in the recent past. For example, viticulture, wineries, forestry, orchards and rural living have increased, and dairy farming, poultry and sheep production have declined. Fluctuations in industry drivers such as the price and availability of land, value of the Australian dollar, industry competition, and the availability of necessary infrastructure and trained staff make it very difficult to predict what development pressures will prevail in the Watershed during the next few decades. It is also difficult to predict how climate change will alter rainfall patterns and the sustainability of land uses.

Current development plans applying in the Watershed do not identify priority areas for water quality protection. From a planning perspective, this means that all parts of the Watershed are treated as being equally important, subject to compliance with development controls (eg set-back distances from watercourses). In reality, some areas in the Watershed are more likely to create water pollution than others. Such areas generate high levels of runoff, or are close to watercourses and reservoirs. Pollutants derived from high runoff areas are more likely to be transported into reservoirs and to contribute higher pollutant loads, than those from elsewhere in the Watershed. Pollutants from land close to watercourses or reservoirs is also more likely to enter reservoirs. An example is where a sub-catchment drains directly into a water supply weir or reservoir without detention of pollutants in upstream reservoirs where there is an opportunity for water quality improvement.

Given the degree of land use change and associated levels of uncertainty, it is prudent to adopt a precautionary approach to future land development in the Watershed, based on what is known about the relationship between land uses, land management practices and water quality. Water pollution risks need to be recognised and used as a basis for adopting differential development controls in the Watershed. If a precautionary approach is not used, the incremental nature of land development means that cumulative water quality impacts will not be recognised until large areas have been developed—by which time the process may be irreversible.

6 WATERSHED PRIORITY AREA CONCEPT

As an improved means of controlling development pressures based on water pollution risk, it is proposed that three different priority areas in the Watershed be established for incorporation into council development plans and water resource management regimes. (Justification for each of the priority areas is given in Section 7.)

Priority 1 areas (P1) are those catchments where the provision of the highest quality public drinking water is fundamental. New land development in P1 areas should only occur where the proposed land use has a beneficial effect on water quality.

Priority 2 areas (P2) fall into an intermediate water quality risk category. New land development in P2 areas should only be permitted when the proposed land use has a neutral or beneficial effect on water quality.

Priority 3 areas (P3) include all remaining parts of the Watershed, including catchment areas set aside for future reservoirs. In P3 areas, water supply catchment functions coexist with agricultural, residential, commercial and industrial uses. New land development in P3 areas should only be permitted when the proposed land use has a negligibly adverse, neutral or beneficial influence on water quality.

This three-tiered priority area concept is based on a similar strategy developed by the Western Australian Waters and Rivers Commission in 2002. This was in recognition of the findings of the *Standing Committee on Ecologically Sustainable Development in Relation to the Quality of Perth's Water 2000,* which considered that 'as a first priority, water should be protected through good land use planning'. This strategy is being implemented across Western Australia and is considered an appropriate model for South Australia.

The Sydney Catchment Authority has taken a similar approach. The Sydney Catchment Authority (SCA) was constituted under the *Sydney Water Catchment Management Act 1998* (SWCM Act) to supply bulk water, to manage and protect catchment areas and infrastructure, and to regulate activities that affect catchment areas. The SWCM Act also requires that a regional environmental plan be prepared to manage future land use (through planning controls) and rectify development that does not have a neutral or beneficial effect on the quality of water (pers. com. Lee Morgan, Sydney Catchment Authority). The neutral or beneficial rule is applied in the outer areas of the Sydney watershed as the inner areas are protected by the reservation and management of public land immediately surrounding reservoirs.

7 JUSTIFICATION AND DESCRIPTION OF WATERSHED PRIORITY AREAS

Figure 1 shows the boundary of proposed Priority 1, 2 and 3 areas in the Mount Lofty Ranges Watershed.

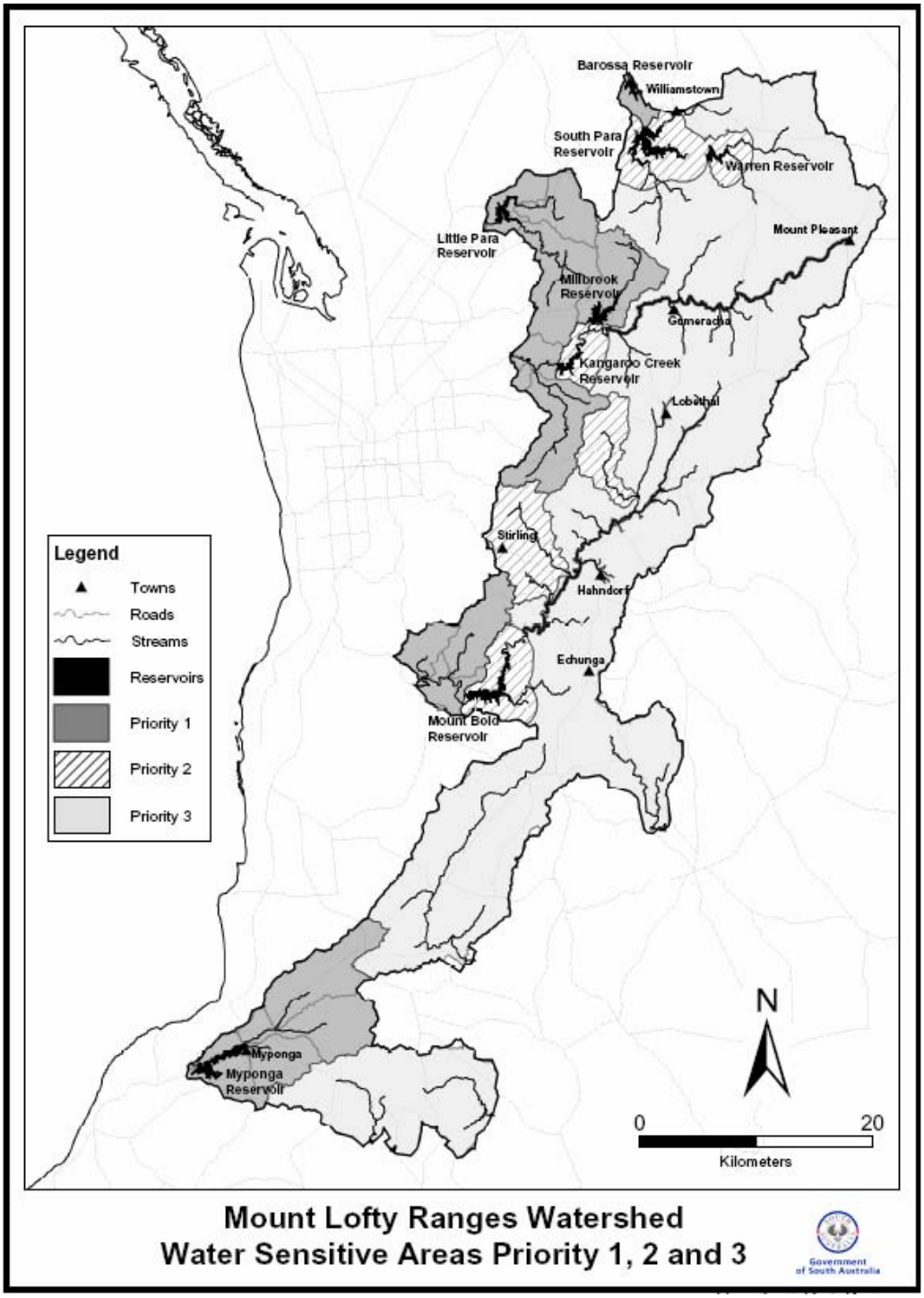


Figure 1 Proposed priority areas in the Mount Lofty Ranges Watershed

Priority 1 (P1)

P1 areas are those catchments that discharge directly upstream of reservoirs or weirs, where water is taken into a water treatment plant. All of the Barossa, Millbrook, Little Para and

Myponga reservoir catchments and land draining to Gorge Weir below Kangaroo Creek Reservoir and land draining to Clarendon Weir below Mount Bold Reservoir is included in this area. These areas make up 23% of the Watershed.

Each water treatment plant has a reservoir that directly supplies water to the plant. These reservoirs are known as primary reservoirs. Stream flow from catchments that discharge directly upstream of these primary reservoirs does not pass through reservoirs that detain pollutants. Sediment, faecal material, nutrients or other hazardous substances may be washed into these water storages and pass quickly into the distribution system, thus short circuiting the normal retention process which occurs in catchments and large upstream reservoirs. As a result, land use activities within P1 are far more likely to result in degradation of water quality than in other areas of the watershed.

Table 4 gives areas of land uses within P1. Predominant land uses are broadscale grazing, protected areas and native vegetation (considered to be a low water quality risk) and intensive grazing (considered to be a high water quality risk). More information on the potential impact of implementing the proposed priority area strategy is provided in section 7).

Table 4 1999 land uses (ground truthed in 2001) in P1 areas of the Watershed

Land use category	Total area (ha)	% Area
Broadscale grazing	37,247	40.16
Cultural	210	0.02
Floriculture	29	0.03
Forestry	784	0.85
Industry or commercial	53	0.06
Intensive grazing	21,192	22.85
Mining or extraction	69	0.08
Native vegetation	5606	6.05
Orchards	909	0.98
Recreation	98	0.11
Recreation or protected area	25,041	27.00
Residential	166	0.18
Row-berries	22	0.02
Utilities or other	5	0.01
Vegetables	49	0.05
Vines	287	0.31
Water bodies	1165	1.26
TOTAL	92,932	100.00

7.1.1 Improvement in water quality in storage reservoirs

Ebsary (1987) reviewed the potential for reservoirs, such as Mount Bold in the Onkaparinga catchment, to retain significant nutrient loads. In this study, Ebsary found that during a 13–year period, Mount Bold Reservoir retained 56% of phosphorus and 90% of suspended sediments. The reduction of nutrient and suspended sediment loads discharged from Mount Bold was found to improve the inflow quality to the downstream Happy Valley Reservoir and its associated water treatment plant.

SA Water assessed monitoring data taken over a five-year period from 1998–2003 and found that there was a significant decrease in pollutants in the Torrens between Gumeracha Weir (in the upper catchment) and the inlet at Hope Valley Water Treatment Plant. The data showed a 77% reduction in average total phosphorous concentration and an 88% reduction in average turbidity between the two locations (refer to Table 5).

Table 5 Water quality comparison—Gumeracha Weir to Hope Valley

Five-year monthly concentration (standard deviation)	Total phosphorus	Turbidity	TKN
Gumeracha Weir	0.15 mg/L (0.09)	51.2 NTU (65.7)	1.04 mg/L (0.47)
Hope Valley Outlet	0.035 mg/L (0.02)	5.8 NTU (7.3)	0.63 mg/L (0.17)

These two findings support the proposition that secondary reservoirs in the Mount Lofty Ranges Watershed are barriers to pollutants as they retain nutrients and sediments and improve the quality of raw water entering treatment plants.

In the case of sub-catchments that drain to locations directly upstream of the primary supply reservoirs or diversion weirs, the only barrier is the detention in the final reservoir before extraction. These reservoirs are often smaller and therefore more susceptible to changes in water quality. Direct inflow into primary reservoirs does not have the advantage of extended catchment transport and settling in upstream reservoirs. These sub-catchments include: Sixth Creek, Kersbrook Creek, Scott Creek, Little Para River and the Myponga River Catchment.

The potential effects of these sub-catchments can be demonstrated by considering Sixth Creek in the Torrens catchment, which flows directly into the Gorge Weir and then into Hope Valley Reservoir—a primary reservoir. Based on results from SA Water's routine monitoring program, between 1983 and 1999, higher average soluble phosphorus and nitrate concentrations were found at the downstream Gorge Weir than at the upstream Kangaroo Creek Reservoir (Cenzato, 1999). For example, the average nitrate concentration in Kangaroo Creek Reservoir was 0.16 mg/L, while at Gorge Weir it was 0.47 mg/L (Figure 1). This increase is considered to be a consequence of Sixth Creek inflows, particularly during storm events when oxidised nitrogen levels exceeding 1.5 mg/L have been recorded (AWQC 2001). The National Monitoring River Health Initiative also reported elevated pesticide levels in Sixth Creek (AWQC, 2001). These examples indicate that land use and management within the Priority 1 sub-catchments, such as Sixth Creek, can have a major effect on water quality within a primary reservoir. As a result, controls are required to ensure that water quality in these areas does not decline and, in fact, is improved in the future.

Although reservoirs can be useful as barriers, it is important to appreciate that they are not absolute barriers. Reservoirs can reduce the amount of pollution that reaches water supply off-takes. However, the degree of reduction is typically only in the order of five- to 10-fold.

Reductions of hundreds- to thousands-fold are required if the catchment is developed. Therefore development needs to be tightly controlled, even if reservoirs are in the system.

Recent studies in Australia have shown that detention times can be reduced significantly due to variations in river inflow. For example, the retention time of Myponga Reservoir (26,000 ML) based on the rate of extraction, is about three years. However, high inflows can short-circuit the reservoir and can reach the off-take point within 30 hours, so limiting the barrier effect of the reservoir (Brookes *et al* 2004). With dilutions of less than 10-fold being experienced, these inflow events contribute to an elevated pollutant load leading to a high risk of pollutants such as pathogens entering the water supply. As a result, the ability of these reservoirs to protect the drinking water supply is considerably less that previously believed, and greater emphasis on catchment protection through adequate planning and land management is required, particularly in areas where no other upstream barrier is available.

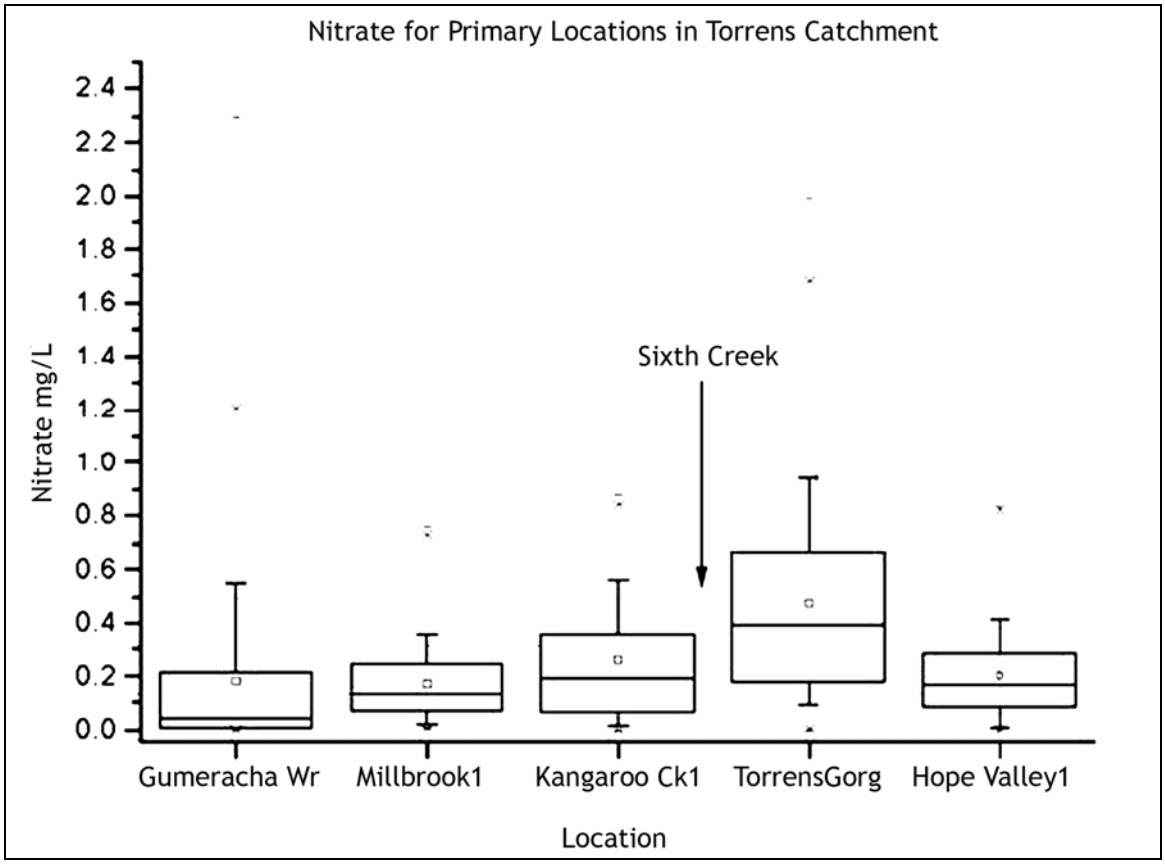


Figure 2 Nitrate concentrations at various River Torrens locations 1983–1999 (reproduced from Cenzato 1986)

7.2 Priority 2 (P2)

P2 areas include:

- land upstream and within 2 km of a secondary reservoir or diversion weir
- land within 100 m of an aqueduct along the River Torrens and Onkaparinga Rivers that is used for conveying pumped River Murray water into downstream reservoirs
- high runoff sub-catchments (exceeding 250 mm annual rainfall equivalent)
- land within 1-in-100 year average recurrence interval floodplains.

These areas make up 11.8% of the Watershed.

The following detailed justification is given for including each of these sub-catchments or areas in the P2 category.

7.2.1 Land upstream and within 2 km of the high water level of existing secondary water supply reservoirs within the Mount Lofty Ranges Watershed

Activities that occur directly around reservoirs have a much greater potential to affect water quality than activities well away from reservoirs. Restricting access or closely managing land use in these areas is the first and most critical barrier in a multi-barrier approach to protecting water quality. If well managed and protected, the surrounding area will not significantly contribute to water pollution. In fact, these inner areas provide some opportunity for reducing pollutants entering water storages through filtration and inactivation. The better the health of the ecosystems in the surrounding area, the more effectively they act as barriers. However, that capability is very limited—the major purpose of the P2 areas is to prevent these areas becoming a significant pollution source.

Protection of P2 areas by controlling land use and management is seen throughout Australia as an appropriate management strategy. In Western Australia, the Waters and Rivers Commission applies a 2-km exclusion buffer where land is state owned or managed. Sydney Catchment Authority applies an exclusion buffer of 3 km around Warragamba Reservoir. Melbourne Water and Sydney Catchment Authority generally adopted the approach of keeping many of their catchments closed, providing significant non-accessible vegetated areas that buffer their catchments and reservoirs. SA Water owns a considerable area surrounding the reservoirs in the Watershed and manages this land in order to maintain a multi-barrier approach. However, the width of areas surrounding SA Water supply reservoirs is not consistent. Buffer widths vary from approximately 40 m (Happy Valley) to 3500 m (Mount Bold).

To help reduce the risk of new development polluting water stored in secondary reservoirs, it is proposed that all land within 2 km of reservoirs be designated as P2 areas. This 2-km buffer distance is not as rigorous as that applied in much of the Sydney and Melbourne catchments. Based on the criteria to apply to development in the Mount Lofty Watershed proposed P2 areas, the entire Sydney catchment is already regulated at that level of rigour. Most of Sydney's and Melbourne's reservoirs are served from catchments that are equivalent to our proposed P1 areas. However, because of the levels of historical development in the Mount Lofty Watershed area, a 2-km buffer is considered a compromise, allowing some existing development to remain whilst recognising that a higher level of risk to water quality will be borne by the Adelaide residents than by those in Melbourne and Sydney. Therefore, the primary basis for defending the 2-km buffer would be to compare it with Western Australia where 2 km is applied to its P2 equivalent[2].

[2] Specifying the distances to be used to designate priority areas can lead to complex considerations of pollutants. An apparently obvious solution is to apply a scientific approach to define the ideal distances, rather than setting values based on comparison with current practice. However, the buffer distances set in water supply catchments around Australia are not based on an explicit scientific investigation that has defined a buffer distance that would mitigate the risk to an acceptable level. Such a scientifically based buffer distance cannot be set. It is well understood that, while some pollutants are not generally very mobile (suspended sediment), others such as viruses (Ferguson *et al* 2003) and soluble nutrients are very mobile. Storms and large runoff events can significantly increase transport rate. There is uncertainty and variability in natural systems, which means that setting buffer distances based on risk would require a precise understanding of what level of risk to accept, an ability to predict that risk and the ability to set a variable buffer across the catchment. In practice, there is no acceptable risk benchmark, the current state of science cannot predict risk with a reasonable level of certainty, and a variable buffer would probably be considered impractical, unworkable and inequitable. Based on the prevailing legislation and policy reviewed above, a precautionary approach should be adopted in the absence of scientific information, and best practice should be considered. As such, the two-km buffer is consistent with an interstate example of source water protection and would hopefully demonstrate an appropriate precautionary level of practice.

Although considerable areas of land around existing reservoirs are owned by the state government, it is not realistic for the government to acquire all land within 2 km of a secondary water supply reservoir in the Mount Lofty Ranges Watershed. Planning controls provide an alternative solution, where future land use can be restricted to minimise risks to the drinking water supply.

7.2.2 Sub-catchments with an average annual runoff exceeding 2.5 ML per hectare

Excluding some very steep sloping P1 areas, the Aldgate Creek, Cox Creek and Lenswood Creek sub-catchments generate by far the greatest volume of runoff per unit area when compared with the rest of the Watershed. Hydrological modelling by the Department of Land, Water and Biodiversity Conservation (Teoh 2002) indicates that each of these three sub-catchments generates more than 2.5 ML of runoff per hectare per year. This equates to more than 250 mm of rainfall on all parts of the catchment being converted entirely to runoff; a rainfall-to-runoff conversion rate of approximately 30%. The next highest yielding sub-catchment, outside P1 areas, generates only 1.8 ML of runoff per hectare per year and has a conversion rate of approximately 19%. Most other sub-catchments generate much less runoff.

The high volume of runoff from the Aldgate, Cox and Lenswood Creek sub-catchments reflects a combination of high rainfall (greater than 900 mm average annual rainfall) steep slopes and, in the case of Aldgate and Cox Creek, few farm dams and a considerable area of hard paved surfaces. Past water quality studies have clearly shown that land use and management in these types of high runoff sub-catchments can lead to the discharge of high pollutant loads into downstream watercourses and reservoirs (Wood 1986; Water Data Services 2002).

A recent study conducted by SA Water on algal blooms in Happy Valley Reservoir identified the Cox Creek sub-catchment as the major source of the nutrients that contribute to this problem (SA Water 2003). The study estimated that 27% of the total phosphorus and 34% of the oxidised nitrogen entering Mount Bold Reservoir at Houlgraves Weir came from the Cox Creek sub-catchment (above the Piccadilly gauging station) even though it makes up only 1% of the reservoir's catchment area. Similarly, the study estimated that 4% and 12% of the oxidised nitrogen entering Mount Bold Reservoir was derived from the Aldgate Creek and the Lenswood Creek sub-catchments, even though these only occupy 2% and 4% of the catchment area respectively. These findings reinforce those derived from previous studies, which clearly identified that these sub-catchments contribute disproportionately high nutrient loads when compared with other sub-catchments in the Watershed (Wood 1986; Water Data Services 2002; EPA, 2005).

On the basis of these studies, Cox Creek, Aldgate Creek and Lenswood Creek sub-catchments are a major source of pollutants and require more stringent development controls to avoid further increases in pollutants in the future.

7.2.3 Land within 100 m of watercourses that are used to convey water from the River Murray into secondary water supply reservoirs

The River Torrens between Mount Pleasant and Kangaroo Creek Reservoir, and the Onkaparinga River between Hahndorf and Mount Bold Reservoir, are used to convey River Murray water to the Adelaide water supply system.

In dry years a very high percentage of Adelaide's water supply is pumped from the River Murray and discharged in the upper Torrens and Onkaparinga Rivers, which then flow into downstream reservoirs. These watercourses can improve water quality through their ability to

detain and assimilate pollutants. This important process is negated if the watercourses are subject to direct pollution. Activities bordering these watercourses have a greater potential to adversely affect reservoir water quality in dry years and at dry times of the year than activities in adjacent watercourses in other parts of the Watershed (particularly for pathogens that are directly deposited by stock with access to watercourses or by failing septic systems (Deere *et al,* in preparation).

Incorporation of a 100 m buffer along the watercourses used to convey water from the River Murray into and down the River Torrens and Onkaparinga Rivers within the P2 area is seen as a means of avoiding the establishment or expansion of high pollution risk activities in these areas. The 100-m buffer is not explicitly justified on the basis of scientific studies, as noted above, leading to the need for a diligent, precautionary approach informed by best practice. Therefore, 100 m has been adopted on the basis of comparison with perennial watercourse setbacks applied in other water supply catchments, which are at least 100 m.

7.2.4 Land subject to 1-in-100 year average recurrence interval flooding

Land uses and buildings on land that is prone to inundation during major floods can be a source of significant pollutant loads. Buildings and other structures on floodplains can pose an obstacle to floodwater flows which, in turn, can lead to increased flooding and erosion of adjoining areas. From a water quality perspective there is justification for avoiding the establishment or expansion of some land uses and buildings on floodplains. Such intervention has been supported by many international studies that have investigated floodplain management and associated planning controls (EU Life-Environment Project 2003; Oates 2003).

Detailed mapping of 1-in-100 year floodplains in the Onkaparinga River catchment has now been completed (Tonkin Consulting 2004) and these areas have been included in the P2 area. In the River Torrens catchment, where data is still to be collected, it is considered that the 100-m buffer of the River Torrens aqueduct is a suitable approximation. However, once flood mapping has been completed in this and other parts of the Watershed, it is envisaged that P2 areas (as mapped) could be extended to cover the additional areas that are known to be on a 1-in-100 year floodplain.

Table 6 gives areas of land uses in P2. Predominant land uses are broadscale grazing, protected areas and native vegetation (considered to be a low water quality risk) and forestry (considered to be a moderate water quality risk). More information on the potential impact of implementing the proposed priority area strategy under various options is provided in Section 8).

Table 6 1999 land uses (ground truthed in 2001) in P2 areas of the Watershed

Land use category	Total area (ha)	% Area
Broadscale grazing	38,877	57.38
Cultural	138	0.21
Floriculture	13	0.02
Forestry	4232	6.25
Industry or commercial	87	0.13
Intensive grazing	71	0.11
Mining or extraction	38	0.06
Native vegetation	5684	8.39

Land use category	Total area (ha)	% Area
Orchards	1065	1.57
Recreation	406	0.60
Residential	1433	2.12
Row-berries	10	0.02
Utilities or other	60	0.09
Vegetables	101	0.15
Vines	883	1.30
Water bodies	1142	1.69
Total	**67,741**	**100.00**

7.3 Priority 3 (P3)

P3 areas include:

- all land upstream of P1 and P2 areas in the South Para, River Torrens and Onkaparinga catchments
- all land in the Angas Creek, Finniss River, Hindmarsh River and Currency Creek catchments upstream of future reservoir sites identified by Shepherd (1973).

These areas make up 65.2% of the Watershed.

P3 areas tend to have lower rainfall and runoff than other parts of the Watershed. These areas also tend to have a greater density of farm dams (and total storage volume per unit of catchment) than other parts of the Watershed. These dams have a potential benefit for water quality (eg sediment deposition, nutrient uptake, microorganism die-off). As these areas also drain into large secondary reservoirs that form substantial barriers to water pollutant transport further downstream, development in P3 areas presents the lowest risk of polluting raw water used for public water supplies in the Watershed. For this reason, it is proposed that land development in P3 areas should be allowed where the land use has a negligibly adverse, neutral or beneficial impact on water quality.

This implies that, from a water quality perspective, the current development principles would apply, except where current non-complying land uses (or specific activities) have been considered to be an acceptable risk.

Table 7 provides areas of land uses within P1. Predominant land uses are broadscale grazing, intensive grazing, native vegetation, and forestry.

Table 7 1999 land uses (ground truthed in 2001) in P3 areas of the Watershed

Land use category	Total area (ha)	% Area
Broadscale grazing	68,780	65.40%
Cultural	107	0.10%
Floriculture	48	0.05%
Forestry	6961	6.62%
Industry/commercial	206	0.20%
Intensive grazing	8849	8.41%
Mining and extractive industries	108	0.10%
Native vegetation	6527	6.21%
Orchards	842	0.80%
Recreation	421	0.40%
Recreation/protected area	3186	3.03%
Residential	805	0.77%
Row - berries	108	0.10%
Utilities/other	295	0.28%
Vegetables	192	0.18%
Vines	2961	2.82%
Water bodies	2033	1.93%
Unclassified	2732	2.60%
Total	**105,161**	**100.00%**

8 IMPLEMENTATION OPTIONS

8.1 Introduction

With the endorsement of the priority areas concept through the Outer Metropolitan Planning Strategy, models for their inclusion in state and local government planning controls can be developed. Three potential implementation models are discussed in this section, with variation in assessment complexity, resource requirements and outcomes. Considerable work will be required to develop a preferred option, with consultation required across government, industry and community. As a result, the discussion presented here represents the formative stages of each model and is not intended to be comprehensive.

It is important to note that:

- the policy direction recommended for each priority area would need to apply to all zones in each of the priority areas, including township zones that are encompassed by the proposed priority area designation
- converting the recommended implementation models contained in this section into planning policy in development plans would involve the preparation of a ministerial plan amendment report and an associated public consultation process
- the introduction of priority areas and the proposed changes to planning policy is not intended to reduce the viability of existing uses in the Watershed.

8.2 Option 1—Absolute land use controls

A simple way to implement the proposed Watershed Priority Area development control objectives is to establish a list of new land uses and developments that should be excluded from certain areas on the basis of water quality risk. This is essentially how the current local government development plans apply throughout the Watershed, by designating certain developments as non-complying in particular zones, or at least non-complying if they do not meet certain design and location criteria.

Designating certain types of new development as non-complying on the basis of water quality risk could be relatively simple if it was based on an objective interpretation of scientific and best practice information. However, as the current council development plans for the Watershed outside township zones generally make all forms of development non-complying (except general farming, horticulture, farm buildings, forestry, agricultural value adding industries, houses, and certain small-scale tourist accommodation developments), care needs to be taken to ensure that water quality risk factors do not override other complex social, economic and environmental factors that are already in the development plan.

In light of the above, a risk-analysis approach was used to determine which new land uses pose the highest risk to the development control objectives for each priority area, as outlined in Section 5 of this report. This risk analysis involved placing typical land use change and built developments into low, moderate, high and very high water pollution potential categories on the basis of documented data and/or inherent water-affecting processes (refer to Appendix A). The results of this analysis were then considered in light of current development plan provisions applying in the Watershed. Only those land uses and built developments that were considered to have an unacceptable water quality risk and were not already categorised as non-complying in the development plan, or have an acceptable risk, yet were already categorised as non-complying, were seen as warranting a change in planning policy.

Appendix C identifies the selected land uses and developments and whether new development of this nature is compatible with the water quality management objectives for each watershed priority area. The policy direction recommended would necessitate strengthening current planning policy in development plans in some cases (within Priority 1

and 2 areas) and allow the relaxation of current planning policy in other cases (mainly in Priority 3 areas).

An economic impact assessment of how this option would affect agricultural development in Watershed Priority 1 and 2 areas was performed (Morrison *et al* 2004). This assessment used the land use data contained in section 6 to determine the current farm-gate gross value of production for agricultural activities and compared this with the opportunity cost of foregone development over the medium term (5 years) if the land use policy changes were adopted; refer Appendix D for discussion and results.

This option could be implemented using existing development control legislation and would not require council planning staff to have any special technical or scientific knowledge to assess development applications. If a non-complying development designation was generally interpreted as meaning 'this type of development should not be allowed to proceed', there would also be little need for non-complying development applications to be referred to expert State government agencies for assessment and advice. This would make development assessment a relatively quick and easy process.

In order to provide for differential development controls on different forms of horticultural production (eg annual cultivated horticulture and perennial horticulture) in Watershed Priority 1 and 2 areas, some new definitions would need to be included in the *Development Regulations 1993*. Local councils would also need to keep better records of horticultural land use change to ensure that a change from one type of horticulture to another was approved.

From an industry perspective this option would not allow flexibility to manage and negate water quality risks. There would be no incentive to adopt land management practices that reduce or reuse water pollutants. As a result, this approach could be seen as blunt, lacking in sophistication and providing no incentive for land management innovation.

This option has been compromised to some extent by the current 'all forms of development are non-complying except…' type provisions in the development plan. This has resulted in a list of development types that should not occur and does not provide for land capability or performance based development assessment in the Watershed. The result could be a community and industry which feel highly regulated without a clear direction for the region, particularly within the proposed Watershed Priority 1 area.

8.3 Option 2—Risk-based approach

A second, more complicated, option involves assessing the risks associated with a proposed development against the development control objectives established for each priority area. This option would require the establishment of firm criteria for assessing the net land use change for individual development applications. The following criteria are suggested at this stage. A new development in:

- P1 areas should only be approved if it replaces a land use, activity or development of a higher water quality risk ranking contained in Appendix E (ie leads to a beneficial effect on water quality)
- P2 areas should only be approved if it replaces a land use, activity or development of an equal or higher water quality risk ranking contained in Appendix E (ie leads to a net neutral or beneficial effect on water quality)
- P3 areas should only be approved if it replaces a land use, activity or development of an equal or higher water quality risk ranking or, if this cannot be achieved, has a moderate or lower water quality risk ranking in its own right; refer Appendix E.

This option could allow low risk activities and agricultural land uses to be promoted, with incentives and management agreements established to achieve best practice management through investment and a stewardship program. Those activities with a moderate risk could

be allowed if the proposed development has a neutral or beneficial effect on water quality, and potential adverse effects are avoided through enhanced and audited management practices. However, developments with a high water quality risk in each priority area would be considered to be incompatible and not in line with the development control objectives established for that area.

This option would provide local councils with a more subjective assessment tool than Option 1, as decisions on the degree to which water quality risks can be negated through design and management could be considered at the development application stage. This option would place a strong emphasis on a whole-of-government approach, whereby provision of incentives, management agreements, compliance, concurrence powers and detailed assessments could be provided and integrated into the planning system. Compliance requirements would need to be increased to ensure that development conditions, management provisions and the subsequent management objectives for the priority areas have been achieved. This additional investment in compliance would be required by local councils but also those authorised officers with powers under the Natural Resource Management Act, Environment Protection Act, and *Native Vegetation Act 1991*.

From an industry perspective, this option would reinforce the primacy of water resource management in the Watershed, while at the same time giving established agricultural producers confidence in the future, and encouragement to continue investing in sustainable agriculture and positive environmental outcomes. It would represent a response to industry requests that water quality should be considered in light of net land use change. It would also allow flexibility to manage and negate water quality risks by adopting land management activities designed to reduce, reuse or safely dispose of water pollutants. A key requirement in the implementation of Option 2 is a sound understanding of the drivers behind water quality outcomes, so that land management can focus on negating key risks. Provision of this information will make it possible to determine which land uses can eliminate water quality risk through management and which have risks which are too high and cannot be practically managed.

The implementation of this model aims to provide a cross-government vision for priority areas in the Watershed. Protection of water quality will be emphasised, but within the capacity of those who manage the land to minimise the water quality risk. It is considered that this would provide an adaptive planning framework, where land use risks and management actions would be adjusted over time, more information obtained, and land management and pollution control initiatives developed.

8.4 Option 3—Merit-based assessment, with pollution offset

Another way of implementing the Watershed Priority Area concept and associated development control objectives is to allow all types of development applications to be assessed on their merits against agreed guidelines. Applicants would need to provide detailed technical and scientific support documentation to show that their proposed development was going to comply with Watershed Priority Area development control objectives during the construction and establishment phases, and during operation.

In a Watershed Priority 1 Area, any development application would need to include supporting documentation that showed how the proposed development was going to improve water quality. In a Watershed Priority 2 Area applications would need to include documentation that showed how the proposed development is going to have a neutral or beneficial impact on water quality.

Clear guidelines would need to be established for how an applicant would need to demonstrate a beneficial, neutral or negligible water quality effect, depending on where their proposed development was located (ie which Watershed Priority Area). The Sydney

Catchment Authority considers that a neutral or beneficial effect on water quality is demonstrated if one or all of the following factors can be achieved:

- a development has no identifiable impacts on water quality
- adverse effects can be treated or removed through approved systems, such as reticulated sewerage systems
- the impacts can be contained within the development site
- the development maintains the status quo or improves water quality leaving the site
- where any of the above is not possible, the impacts can be managed using approved pollution offsets (Sydney Catchment Authority 2004).

Guidelines of this nature could be devised for use in the Mount Lofty Ranges Watershed to assist planners make an initial determination on whether an application is likely to meet Watershed Priority Area development control objectives.

Most applicants would need to employ specialist consultants to prepare technical and scientific documentation to support their applications. This would increase the cost of preparing development applications for Watershed sites. In the absence of technical or scientifically trained planning staff in local government, many types of development applications may need to be referred to state government water quality risk assessment experts (eg within the EPA, DWLBC, NRM Boards, SA Water) for advice, direction or even concurrence, depending on the nature of the proposed development. This type of arrangement currently operates in the Sydney water supply catchment area. These types of referrals would take more time and add to the cost of development assessment in the Watershed, compared with the current situation.

If a development with significant social and economic benefits to the community is unable to meet Watershed Priority Area development control objectives, it may be possible to provide a mechanism for pollution offsets to ensure, for example, an overall beneficial effect on water quality if it was in a Watershed Priority 1 Area. An offset is an action or set of actions taken outside a development site (but near it and in the same hydrological catchment) that reduces pollution overall.

Pollution offsets would need to be negotiated on a case-by-case basis. Legislative change may be needed to allow this type of strategy and there would also need to be stringent enforcement mechanisms.

In summary, this option would require a dramatic cultural change among people involved in the preparation, assessment and approval of development applications. It would also be complex, costly, present administrative inconsistencies, and may require legislative changes. Alternatively, it would provide the opportunity for economic growth and land use development flexibility in the Watershed, while at the same time achieving the water quality objectives designed to protect Adelaide's water supply system.

8.5 Recommended option

It is recommended that Option 2 be further developed as an action contained in the 2005 Planning Strategy for the Outer Metropolitan Adelaide Region as it provides the most appropriate balance between water quality protection, landholder development opportunities, and administrative efficiency and effectiveness.

9 CONCLUSION

Past water quality studies in the Mount Lofty Ranges Watershed have shown that all developments and land uses increase the concentration and yield of water pollutants when compared with native vegetation catchments (Wood 1986, as verified by more recent, national CRC for Water Quality and Treatment research projects). Past studies also indicate that some developments and land uses generate considerably more water pollution than others when compared on a per unit area of catchment basis. Hence, some developments and land uses have a greater pollution potential than others.

The Australian Drinking Water Guidelines (NHMRC 2004) recommend the use of multiple barriers to protect public water supplies from pollutants that can threaten the quality of the supply. It is now widely recognised that watershed protection is a critical first step in the multi-barrier approach to protecting water quality. Preventative measures should be applied as close to the pollutant sources as possible, with a focus on prevention in watersheds rather than reliance solely on downstream water filtration.

Within the Mount Lofty Ranges Watershed there are varying levels of water quality risk associated with land uses and developments in different catchments and sub-catchments, depending on how readily an area drains to reservoirs and watercourses that are directly harvested for drinking water. These varying levels of risk are derived from the presence or absence of an effective barrier (or multiple barriers) between pollutant sources in catchments and off-takes for mains water supplies. In recognition of these fundamental differences in water quality risk, a set of water quality protection zones is proposed for the Watershed with each having default criteria that should apply to development in that zone.

Watershed Priority 1 Areas are the immediate hydrological catchments of the primary reservoirs and streams used for water supply. Development in these areas would only be permitted if there was a beneficial effect on water quality. Watershed Priority 2 Areas are those areas within 2 km of all secondary water supply reservoirs, land within 100 m of watercourses used to convey River Murray water into Mount Lofty Ranges reservoirs, very high runoff areas, and land prone to flooding. In these areas development would only be permitted if there was a neutral or beneficial effect on water quality. Watershed Priority 3 Areas constitute the remainder of the Watershed. Development would only be permitted here if it had a negligibly adverse, neutral or beneficial effect on water quality.

The Outer Metropolitan Planning Strategy introduced the Priority Areas concept as proposed in this report. This report also considers three broad models for implementing the priority areas concept, with variations in assessment complexity, resource requirements and outcomes. Converting the recommended implementation model (Option 2—Risk-based approach) into planning policy would require the preparation of a ministerial plan amendment report. This process will involve a further level of detailed consultation across government, industry and the community.

10 REFERENCES

Arnold, K and Gallasch, T 2001, *Mount Lofty Ranges Waste Control Project: the nature, function and potential for catchment impact of domestic on-site waste control and disposal in the Mount Lofty Ranges,* Report for the Environment Protection Authority, Onkaparinga Catchment Water Management Board (CWMB), Torrens CWMB, Northern Adelaide and Barossa CWMB, Adelaide.

Australian Bureau of Statistics 2003, Aquaculture and the environment, *Year Book 2003—Forestry and Fishing*, ABS, Canberra.

Australian Water Quality Centre 2001, *Monitoring river health—July 2000*, AWQC, Adelaide.

Brookes JD, Antenucci J, Hipsey M, Burch MD, Ashbolt N and Ferguson C 2004, Pathogen Transport, distribution and fate in lakes and reservoirs, *Environment and International* 30: 741–759.

Cenzato D 1999, *Historic water quality data for the Torrens Catchment Water Management Board: January 1983 to November 1999*, Australian Water Quality Centre, Adelaide.

Cullen P 2004, *Water Challenges for South Australia in the 21st Century*, South Australia Government, Adelaide.

Eco Management Services, Land Energy Pty Ltd, Chapman, J and ARUP Water 2003, *Water quality risk assessment study of winery and ancillary developments in the Mount Lofty Ranges Watershed,* Stage 2 report for the Environment Protection Authority, Adelaide.

Environment Protection Authority 2000, *Nutrient load modelling for the National Pollutant Inventory Water Catchment Reporting 1999,* EPA, Adelaide.

——2006, *Water Quality Snapshot 2001–2002*, EPA, Adelaide.

Ebsary RM 1987, *Nutrient Budget of Mount Bold Reservoir 1973–1985* (Library Ref 87/55), Engineering and Water Supply Department, Adelaide.

Hazell P 1991, *Mount Lofty Ranges Dairy Farm Water Quality Monitoring Program 1987–1989*, unpublished report prepared for the Engineering and Water Supply Department, Adelaide.

Hrudey S and Hrudey, E 2004, *Safe Drinking Water—lessons from recent outbreaks in affluent nations,* IWA Publishing, London.

Hoxley G and Dudding M 1994, Groundwater Contamination by Septic Tank Effluent—Two Case Studies in Victoria, Australia, Water Down Under 94, *Proceedings of the 25th Congress of the International Association of Hydrogeologists and the International Hydrology & Water Resources Symposium of The Institution of Engineers*, Australia, November 1994, Adelaide.

Hughes SJ 1986, *Paired catchment study of water runoff from forest land,* Bachelor of Applied Science (Natural Resource Management) Honours thesis, Roseworthy Agricultural College, South Australia.

Ingleton G 2003, *Nutrient Loads, Cyanobacteria Growth, and Algal Mitigation Options for Happy Valley Reservoir*, South Australian Water Corporation, Adelaide.

Keenan RJ, Parsons M, O'Loughlin E, Gerrand A, Beavis S, Gunawardana D, Gavran M and Bugg A 2004a, *Plantations and Water: a review*, report prepared for the Forest and Wood Products Research and Development Corporation, Bureau of Rural Sciences, Canberra.

Keenan RJ, Gerrand A, Sandanandan N and Parsons M 2004b, *Plantations and water: plantation impacts on stream flow*, Science for Decision Makers paper, Bureau of Rural Sciences, Department of Agriculture, Fisheries and Forestry, Canberra.

Langford KJ and O'Shaughnessy PJ 1977, Some effects of forest changes on water values, *Australian Forestry* 40: 3.

Linden LG, Lewis DM, Burch MD & Brookes JD 2004, *Interannual variability in rainfall and its impact on nutrient load and phytoplankton in Myponga Reservoir, South Australia,* International Journal of River Basin Management, 2(3): 1–11.

Livingston EH 1997, Water quality considerations in the design and use of wet detention and wetland stormwater management systems, *Stormwater BMPs: The Good, the Bad, the Ugly*, Florida Department of Environmental Protection and Watershed Management Institute.

Morrison J 2004, *Economic Impacts of Land Use Changes in the Mount Lofty Ranges Watershed*, report for SA Water, Econsearch Pty Ltd.

Nelson PN, Cotsaris E, Oades JM and Bursill DB 1991, *Organic carbon in water—its sources and role in nutrient transport*, Australian Centre for Water Treatment and Water Quality Research, AWRAC Project Report 86/66.

NHMRC 2004, *Australian Drinking Water*, National Health and Medical Research Council, Canberra.

Oates R (ed) 2003, Technical Report on Policy Analysis—Analysing Barriers to Change: a tool to assist river basin planning, *Wise Use of Floodplains,* EU Life-Environment Project, viewed 31 August 2007, <www.floodplains.org>.

Office of Wastewater Management 1992, *Wastewater Treatment/Disposal for Small Communities* (EPA/625/R–92/005, Sep 1992), US Environmental Protection Agency, Washington DC.

PPK 2000, *Onkaparinga Catchment Water Management Plan Water Quality Technical Paper 1*, PPK Environmental & Infrastructure Pty Ltd, Adelaide.

Rawlinson L 1994, *Review of On-site Wastewater Systems*, New South Wales Environment Protection Agency, Sydney.

Roser D and Ashbolt N 2004, *Source Water Quality Assessment and the Management of Pathogens in Surface Catchments and Aquifers*, Draft Summary Report for CRC–WQT Project Stakeholders on Outcomes of Project 2.2.1 Management of Surface & Subsurface Source Waters, CRC for Water Quality and Treatment.

SA Water 2002, Memorandum of understanding between SA Water Corporation and Forestry SA, Adelaide

——2003, *Nutrient loads, cyanobacteria growth and algal mitigation options for Happy Valley Reservoir*, South Australian Water Corporation, Adelaide.

Shepherd KJ 1973, *Water resources for metropolitan Adelaide and headworks requirements to 2001 AD*, Engineering and Water Supply Department, Adelaide.

South Australian Government 2004, *The Water Proofing Adelaide Draft Strategy*, South Australian Government, Adelaide.

Sydney Catchment Authority 2004, *Neutral or Beneficial Effect on Water Quality Guidelines*, SCA, Sydney.

Teoh K 2002, *Estimating the impact of current farm dams development on the surface water resources of the Onkaparinga catchment*, Department of Water, Land & Biodiversity Conservation, Adelaide.

Tonkin Consulting 2004, *Upper Onkaparinga River Catchment—Flood Mapping Report*, prepared for the Onkaparinga Catchment Water Management Board, Adelaide.

Trust for Public Land and the American Water Works Association 2005, *Source Protection Handbook—using land conservation to protect drinking water supplies*, a report produced with funding from the US Environmental Protection Agency's Office of Groundwater and Drinking Water.

Water Data Services 2002, *Flow proportional composite sample—data summary*, prepared for the Department of Water, Land and Biodiversity Conservation, Adelaide.

Waters and Rivers Commission 2000, *Ecologically Sustainable Development in Relation to the Quality of Perth's Water*, Western Australian Water and Rivers Commission, Perth.

Waters and Rivers Commission 2002a, *Proclaiming Protection Areas*, Western Australian Water and Rivers Commission, Perth.

——2002b, *Land Use Compatibility in Public Drinking Water Source Areas*, Western Australian Water and Rivers Commission, Perth.

——2002c, *Samson Brook Catchment Area Water Source Protection Plan: Waroona and Hamel Town Water Supply Integrated Water Supply System*, Western Australian Water and Rivers Commission, Perth.

EU Life–Environment Project 2003, Project Outline—*Wise Use of Floodplains,* viewed 31 August 2007*,* <www.floodplains.org>.

Wood G 1986, *Mount Lofty Ranges Watershed—Impact of land use on water quality and implications for reservoir water quality management*, (Library Ref 86/19), Engineering and Water Supply Department, Adelaide.

APPENDIX A TECHNICAL JUSTIFICATION FOR LAND USES/ACTIVITIES BEING CATEGORISED AS HAVING A HIGH OR VERY HIGH WATER QUALITY RISK IN P1 AREAS OF THE MOUNT LOFTY RANGES WATERSHED

A: Very high risk

Land use/ development	Inherent processes that cause water pollution	References/pollutant loading rates
Annual cultivated horticulture (market gardening)	Intensive soil cultivation and fertiliser application Seasonal pesticide application Intensive irrigation with high rates of runoff through and over the soil Row crops, generally up and down slopes, that cause increased run-off rates Riparian vegetation removal	Ingleton (2003) concluded that 13% of the total phosphorus and 24% of the oxidised nitrogen entering Mount Bold Reservoir was derived from the Cox Creek sub-catchment (above the Piccadilly gauging station) even though it only occupied 1% of the Mount Bold Reservoir catchment area. This area has been predominantly used for market gardening in the past but has seen viticulture develop in recent years. Wood (1986) quoted the following nutrient yields in runoff for the same market gardening area: • oxidised N (19.6 kg/ha/yr) • total N (26.0 kg/ha/yr) • soluble phosphorus (0.59 kg/ha/yr) • total phosphorus (2.7 kg/ha/yr) • total organic carbon (59.7 kg/ha/yr). These nutrient yields are 196, 17, 30, 27 and 3 times greater, respectively, than the nutrient yields derived from the native vegetation sub-catchment (First Creek) when compared during the same long-term study.

Land use/ development	Inherent processes that cause water pollution	References/pollutant loading rates
Dairies (which are not replacements for existing dairies)	Daily milking shed wastewater production—runoff from areas directly irrigated with wastewater, potential overflow or leakage of wastewater from storage lagoons Intensive stock movement and holding areas in an around milking sheds Manure accumulation and stockpiling or spreading Associated dairy farming practices include: regular fertiliser application, irrigation of intensive grazed areas during summer and autumn and relatively high milking cow stocking rates and associated manure deposition Stock access to watercourses	Roser & Ashbolt (2004) compared a variety of drinking water catchments across Australia, considering the impact of pathogens in dry and wet weather. The study showed that Myponga (dominated by dairy farming) was the catchment most affected by faecal contamination. It also had the highest concentrations of total phosphorus during rainfall events. Hazell (1991) found catchment areas dominated by dairy cattle grazing and dairy sheds in the central Adelaide Hills generated runoff with the following nutrient loads: • total N (90–140 kg/ha/yr) • soluble P (1.3–1.8 kg/ha/yr) • total P (3.4–3.7 kg/ha/yr). These nutrient yields are 66, 75, 30, 35 times greater, respectively, than the nutrient yields derived from a native vegetation sub-catchment (First Creek) as reported by Wood (1986). Nelson *et al.* (1991) found that a small catchment dominated by dairy farming in a central Adelaide Hills sub-catchment dominated by dairy farming generated the following nutrient loads: • total N (66 kg/ha/yr) • soluble P (0.8 kg/ha/yr) • total P (1.1 kg/ha/yr). Again, these nutrient yields are an order of magnitude greater than yields from native vegetation catchments.
Intensive animal keeping, including feedlots, zoos, poultry sheds, dog kennels, catteries	Manure deposition, accumulation, containment and disposal In the case of unroofed intensive animal keeping facilities, soil erosion, and nutrient and pathogen contaminated runoff is a problem.	Hrudey (2004) described the reoccurring themes of waterborne outbreaks in affluent countries. The findings indicate that pathogens pose the greatest and most tangible risk to drinking water safety, making pathogen removal and disinfection of paramount concern.

Land use/ development	Inherent processes that cause water pollution	References/pollutant loading rates
Housing developments: • that would require native vegetation to be cleared to accommodate the building envelope and bushfire protection buffers • that could not dispose of wastewater on the allotment where it is generated, further than 50 m from a watercourse and in a safe, ecologically sustainable, manner • where the only possible building envelope is very close to a watercourse and/or on a 1-in-100 year floodplain	Native vegetation clearance for house footprint and associated access, recreation and bushfire protection buffer purposes Damage to riparian vegetation and aquatic ecosystems if located in close proximity to watercourses Eroded soil getting into drains and watercourses during house construction and initial garden and lawn establishment phase High nutrient and pathogen concentrations in runoff from sites where septic tank effluent is disposed of onto land areas and/or into soils, with inadequate absorptive and assimilative capacities Houses located on floodplains impede floodwater which, in turn, can increase flooding elsewhere and increase rates of soil erosion Houses on flood prone land also threaten human life and property	Past water quality monitoring studies in the Mount Lofty Ranges Watershed have clearly shown that native vegetation generates the least sediment and nutrient pollution per unit area of catchment when compared to any other land uses (Wood 1986). Therefore, native vegetation clearance associated with housing development leads to a decline in water quality. Arnold *et al* (2001) reported that 44% of 1449 houses surveyed in the Adelaide Hills had septic tank effluent subsurface soakage or above-ground aerobic systems that were failing. Of the 212 houses with aerobic systems there was a failure rate of 25%, mainly due to a lack of irrigation area or aerobic sand filter failures. In addition, there is now considerable literature which identifies the link between the smaller size and higher density of allotments used for unsewered housing development, and increased pathogen and nutrient entry into downstream watercourses and reservoirs (Hoxley and Dudding 1994; Office of Wastewater Management 1992; Rawlinson 1994).

Land use/ development	Inherent processes that cause water pollution	References/pollutant loading rates
Land division which creates additional allotments	Creates legal land ownership framework that provides the opportunity for new housing development and, in many cases, associated rural living activities Land division and subsequent housing development would lead to incremental increases in hard surface runoff (eg roofs, driveways, paths, roads) with consequent increases in peak stormwater flows entering drains and creeks, greater rates of in-stream soil erosion and decreased duration of watercourse flows Water quality impacts would also include increased loads of bacteria, nutrients, pesticides, hydrocarbons and metals	Wood (1986) reported that land use intensification led to water quality decline in the Mount Lofty Ranges Watershed. Livingston (1997) has shown a clear relationship between increases in the density of residential development and increases in the loads of sediment, nutrients and metals contained in stormwater runoff.
Any built development that generates greater than 1500 L of wastewater per day per allotment and is not connected to sewer or STEDs including built development that is additional to an existing development on the allotment	Domestic, commercial and/or industrial quality wastewater with nutrient, microbiological and other contaminants 1500 L of wastewater per day per allotment puts the wastewater production rate into a higher than single dwelling range, such rates of wastewater production pose a higher risk of failure and have greater water quality consequences than single dwellings	Hrudey (2004) described the reoccurring themes of waterborne outbreaks in affluent countries. The findings indicate that pathogens pose the greatest and most tangible risk to drinking water safety, making pathogen removal and disinfection the paramount concern. Roser & Ashbolt (2004) compared a variety of drinking water catchments across Australia, considering the impact of pathogens in dry and wet weather. The study showed that Aldgate Creek sub-catchment (dominated by urban development) was polluted by significant faecal contamination during rainfall events. Arnold *et al* (2001) reported an average septic tank failure rate of 43% inside urban settlements and approximately 70% in rural areas in the Mount Lofty Ranges Watershed.

B: High risk

Land use/ development	Inherent processes that cause water pollution	References/pollutant loading rates
Forestry	Soil erosion from: • areas cultivated during plantation establishment • roads, tracks and drains established for plantation, maintenance and harvesting purposes • areas disturbed during thinning and clear felling operations. Ground based and aerial application of herbicides during pre and post plantation phase Fertiliser application during plantation establishment and ongoing growth phase Damage to, or removal of, riparian vegetation, particularly in first order watercourses or indistinct drainage lines Increased runoff during forest establishment and harvest phase but decreased runoff during the growth phase of plantations	In a paired catchment study conducted in Mount Lofty Ranges, Hughes (1986) found that standard forest plantation establishment practices (clearing and ripping) caused 38 times the yield of suspended solids when compared to an area of pasture and pine debris. A number of comprehensive reviews of the water quality and quantity impacts associated with commercial forestry in Australia have been undertaken (Langford *et al* 1977; Keenan *et al* 2004a; Keenan *et al* 2004b).
Aquaculture involving husbandry and/or supplementary feeding in a water flow through system	High concentrations of BOD, nutrients, growth regulators and medications discharged into watercourses or onto land draining into waters Also potential for the escape of exotic species into local waters with adverse impacts on endemic species	The Australian Bureau of Statistics (2003) has summarised the environmental impacts (including water quality) associated with different types of aquaculture systems (including freshwater aquaculture) throughout Australia. This summary report on the industry's impact on the environment provides reference to select research studies in Australia and overseas.

Land use/ development	Inherent processes that cause water pollution	References/pollutant loading rates
Perennial horticulture (orchards, viticulture)	Substantial soil disturbance and cultivation during initial planting phase Regular fertiliser application Seasonal irrigation Seasonal herbicide application for weed control and seasonal pesticide and fungicide application for crop pest control Riparian vegetation removal	Ingleton (2003) concluded that 9% of the oxidised nitrogen entering Mount Bold Reservoir was derived from Lenswood Creek sub-catchment (dominated by orchards) even though the sub-catchment only occupies 4% of the Mount Bold Reservoir catchment. Previous studies by (Wood, 1986; Water Data Services, 2002; EPA, 2005) reinforce those derived from previous studies, which clearly identify that the Lenswood sub-catchment contributes disproportionately high nutrient loads when compared to other sub-catchments in the Watershed.
Wineries not serviced by sewer or STEDS	Wastewater containing high concentrations of biochemical oxygen demand (BOD) and relatively high concentrations of sodium and potassium Potential leakage or spillage of juice, wine, wastewater and/or refrigerant coolants (brine) Spillage or leakage of high BOD wastewater can lead to de-oxygenation of water bodies with consequent adverse impacts on aquatic ecosystems Spillage or leakage of refrigerant brine can have toxic effects on aquatic ecosystems	Eco Management Services *et al* (2003) reported that there is very little risk to water supply reservoirs in the Mount Lofty Ranges from winery and ancillary development if certain locational, design and management criteria were adhered to. The same report did, however, acknowledge that spillages and leakages of grape juice, wine, winery wastewater and refrigerant brine could have substantial adverse impacts on water quality in watercourses depending on the volume of the spill and stream flow conditions.
Housing developments not connected to sewer or STEDS	The failure of on site wastewater systems leading to effluent (pathogens, viruses, nutrients) entering watercourses	Adelaide Hills Councils in collaboration with other state agencies have a program to audit onsite waste control systems. Initial project surveys show a 44% failure rate, or 644 of the 1449 properties. The failures that were identified as either major (151), moderate (212) or aerobic failure (52) were recognised as having the potential to directly or indirectly reach watercourses especially during winter months (Arnold & Gallasch 2001).

Land use/ development	Inherent processes that cause water pollution	References/pollutant loading rates
Land division (boundary rearrangements) which would create allotments containing two or more habitable dwellings	Represents an intensification of land use that could create pressure for additional land divisions around individual dwellings in the future	Refer to above studies showing a relationship between land use intensification and water quality decline.

APPENDIX B DISTILLATION OF PRINCIPLES RECENTLY ESPOUSED IN CONTEMPORARY DEVELOPMENT CONTROL LEGISLATION AND POLICIES AS THESE PERTAIN TO WATER QUALITY PROTECTION IN AUSTRALIA AND OVERSEAS

Jurisdiction	Instrument	Provisions	Principles emerging
Australia	*Australian Drinking Water Guidelines 2004* (Cwlth) ADWG	1.1 Guiding principles: • the multiple barrier approach is universally recognised as the foundation for ensuring safe drinking water • no single barrier is effective against all conceivable sources of contamination, is effective 100 per cent of the time or constantly functions at maximum efficiency • prevention of contamination provides greater surety than removal of contaminants by treatment, so the most effective barrier is protection of source waters to the maximum degree practical. 1.3.2 Guideline values: • water suppliers should adopt a preventive risk management approach, as stipulated in the ADWG, to maintain the supply of water at the highest practicable quality • the guideline values should never be seen as a licence to degrade the quality of a drinking water supply to that level.	• Multiple barriers are required to protect drinking water quality • The most effective barrier is protection of source waters • Source waters should be protected to the maximum degree practical. • Water quality should be maintained at the highest practicable quality • Water quality should not be degraded

Jurisdiction	Instrument	Provisions	Principles emerging
Australia	*Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000* (Cwlth) ANZECC	2.2.1.7 Guiding principles • an overriding principle that should guide management should be continual improvement … in waters that are of better quality than that set by the water quality objectives, some emphasis could still be given to reducing the level of contamination from all sources, particularly for highly modified water resources • wherever possible, ambient water quality should not be allowed to degrade to the levels prescribed by the water quality objectives • the ecologically sustainable development principle applies which is based on the National Strategy for Ecologically Sustainable Development (ESD Steering Committee 1992): [development] using, conserving and enhancing the community's resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future can be increased.	• Water quality should not be degraded • Quality of life should be increased over time • Intergenerational equity

Jurisdiction	Instrument	Provisions	Principles emerging
Australia	Intergovern-mental Agreement on the Environment (1992) IGAE	In Section 3, a number of principles will inform decision-making in the environmental context, including: • polluter pays • intergenerational equity • the precautionary principle. Further, the precautionary principle is defined as: where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. In the application of the precautionary principle, public and private decisions should be guided by: • careful evaluation to avoid, wherever practicable, serious or irreversible damage to the environment; and • an assessment of the risk-weighted options of the various options.	• Polluter pays • Intergenerational equity • Precautionary principle
Australia (particularly Qld, Great Barrier Reef)	*Great Barrier Reef Marine Park Act 1975* (Cth) GBRMP	Subsection 39Z(1): In preparing management plans the Great Barrier Reef Marine Park Authority (GBRMPA) is to have regard to both the protection of world heritage values and the precautionary principle.	• Precautionary principle
NSW (specifically the Sydney hydrological water catchments)	*Sydney Water Catchment Management Act 1998* (NSW) SWCM	• 4, 53, 3, (c) requiring consent authorities to refuse to grant development consent to a development application relating to land to which the plan applies unless the consent authority is satisfied that the carrying out of the proposed development would have a neutral or beneficial effect on the quality of water • 4, 53, 3, (d) requiring the development of action plans to rectify any development of the land to which the plan applies that does not have a neutral or beneficial effect on the quality of water.	• Water quality should be protected from degradation by new developments • Existing developments should be rectified if they are detrimental to water quality

Jurisdiction	Instrument	Provisions	Principles emerging
NSW (specifically the Sydney hydrological water catchments)	Green offsets for sustainable development concept paper April 2002 (NSW EPA) 'GOSD'	A development proposal could demonstrate a 'neutral or beneficial effect' on water quality by offsetting additional water pollution through a pollution offset scheme. Realistically, the offset scheme will not be able to assist all developments to meet the neutral or beneficial effect test. The primary role of the scheme will be to offset long-term cumulative impacts, such as stormwater from different sources. Although zero extra environmental impact from a new development is a good goal, it is not always practical. But often an even better outcome of net environmental improvement can be achieved cost effectively using offsets. Principles of offsets: • environmental impacts must be avoided first by using all cost-effective prevention and mitigation measures. Offsets are then only used to address remaining environmental impacts • all standard regulatory requirements must still be met • offsets must never reward ongoing poor environmental performance • offsets will complement other government programs • offsets must result in a net environmental improvement. Offsets must be: • enduring—they must offset the impact of the development for the period that the impact occurs • quantifiable—the impacts and benefits must be reliably estimated • targeted—they must offset the impacts on a 'like for like or better' basis • located appropriately—they must offset the impact in the same area • supplementary—beyond existing requirements and not already being funded under another scheme • enforceable—through development consent conditions, licence conditions, covenants or a contract.	If a development must go ahead and cannot satisfy the neutral or beneficial effect test, pollution offsets must be put in place so that the net effect is neutral or beneficial

Jurisdiction	Instrument	Provisions	Principles emerging
South Australia	*Public and Environmental Health Act 1987* (SA) PEH	Section 21—Pollution of water: • (1) A person who pollutes a water supply is guilty of an offence. Section 22—Sources of water supply may be closed: • (1) If the authority is of the opinion that a water supply is polluted and that action is necessary under this subsection to prevent human consumption of the water, it may, by notice published in the Gazette, restrict or prohibit the taking of water from that water supply, or the use of water taken from that water supply, for human consumption. Section 3—Interpretation: 'water supply' includes: • any natural or artificial accumulation or source of water. 'the authority' means: • (a) in relation to a local government area—the local council for that area; and • (b) in relation to a part of the State that is not within a local government area—the Minister, 'pollution', in relation to water, connotes: • a degree of impurity that renders the water unfit for human consumption.	Water should not be polluted where it may be used for drinking

Jurisdiction	Instrument	Provisions	Principles emerging
South Australia	*Natural Resource Management Act 2004* (SA) NRM	Section 7—Objects • (1)(c) provides for the protection and management of catchments and the sustainable use of land and water resources and, insofar as is reasonably practicable, seeks to enhance and restore or rehabilitate land and water resources that have been degraded • (3)(b) if there are threats of serious or irreversible damage to natural resources, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation • (3)(f) … people who obtain benefits from the natural environment, or who adversely affect or consume natural resources, should bear an appropriate share of the costs that flow from their activities. Section 9—General statutory duties • (7) In addition, if a person can demonstrate that he or she has acted in a manner consistent with any best practice methods or standards in the relevant industry or sphere of activity that are recognised as being acceptable for the purposes of subsection (1) by the relevant regional NRM board, then, to the extent of the consistency, no action can be taken against the person in connection with the operation of this section.	• Water quality should be improved • Precautionary principle • Polluter pays • Best practice should be applied

Jurisdiction	Instrument	Provisions	Principles emerging
United States	*Federal Water Pollution Control Act Amendments of 1972* (as amended USA) Also known as 'Clean Waters Act' CWA	Anti-degradation Policy: water quality standards include an anti-degradation policy and implementation method. The water quality standards regulation requires States and Tribes to establish a three-tiered anti-degradation program: • Tier 1 maintains and protects existing uses and water quality conditions necessary to support such uses. An existing use can be established by demonstrating that fishing, swimming, or other uses have actually occurred since November 28, 1975, or that the water quality is suitable to allow such uses to occur. Where an existing use is established, it must be protected even if it is not listed in the water quality standards as a designated use. Tier 1 requirements are applicable to all surface waters. • Tier 2 maintains and protects 'high quality' waters—water bodies where existing conditions are better than necessary to support CWA § 101(a)(2) 'fishable/swimmable' uses. Water quality can be lowered in such waters. However, State and Tribal Tier 2 programs identify procedures that must be followed and questions that must be answered before a reduction in water quality can be allowed. In no case may water quality be lowered to a level which would interfere with existing or designated uses. • Tier 3 maintains and protects water quality in outstanding national resource waters (ONRWs). Except for certain temporary changes, water quality cannot be lowered in such waters. ONRWs generally include the highest quality waters of the United States. However, the ONRW classification also offers special protection for waters of exceptional ecological significance, ie those which are important, unique, or sensitive ecologically. Decisions regarding which water bodies qualify to be ONRWs are made by states and authorised Indian tribes.	Water quality cannot be lowered in Tier 3 waters (which would presumably include such waters as the mid-Brisbane River)

Jurisdiction	Instrument	Provisions	Principles emerging
European Union	*Directive 2000/60/EC* (2000) of the European Parliament and of the Council of 23 October 2000 Also known as the 'Framework Directive'. FD	The European Parliament and the Council of the European Union has formalised the following positions in relation to water quality: Preamble: • (1) Water is not a commercial product like any other but, rather, a heritage which must be protected, defended and treated as such • (22) The Directive is to contribute to the progressive reduction of emissions of hazardous substances to water • (24) Good water quality will contribute to securing the drinking water supply for the population • (26) … Where good water status already exists, it should be maintained … • (38) The principle of recovery of the costs of water services, including environmental and resource costs associated with damage or negative impact on the aquatic environment should be taken into account in accordance with, in particular, the polluter-pas principle • (40) With regard to pollution prevention and control, Community water policy should be based on a combined approach using control of pollution at source through the setting of emission limit values and of environmental quality standards. Article 4, Environmental Objectives: • 1.a For surface waters (i) Member states shall implement all the necessary measures to prevent deterioration of the status of all bodies of surface water … Article 7, Waters used for the abstraction of drinking water: • 3 Member states shall ensure the necessary protection for the bodies of water identified with the aim of avoiding deterioration in their quality in order to reduce the level of purification treatment required in the production of drinking water. Member states may establish safeguard zones for those bodies of water.	• Water is part of natural heritage requiring special protection • Water quality should not be degraded • Water quality should be improved • Polluter pays • Pollution should be controlled at source • Drinking water sources should be protected from deterioration to reduce treatment requirements

APPENDIX C IMPLEMENTATION MODEL, OPTION 1—LAND USE COMPATIBILITY FOR EACH WATERSHED PRIORITY AREA

Land use description	Priority 1	Priority 2	Priority 3	Current planning policy
PRIMARY INDUSTRY USES				
Annual cultivated horticulture (market gardening, turf farms, intensive floriculture)	Incompatible	Incompatible	Conditional	Considered on merit in rural zones, except in those parts of the Watershed that are in the Hills Face Zone where horticulture is non-complying in most cases.
Perennial horticulture (orchards, viticulture)	Incompatible	Conditional	Conditional	Considered on merit in rural zones, except in those parts of the Watershed that are in the Hills Face Zone where horticulture is non-complying in most cases.
Dairies which are not replacement dairies	Incompatible	Incompatible	Conditional	Considered on merit in rural zones
Intensive animal keeping, including feedlots, zoos, poultry sheds, dog kennels, catteries	Incompatible	Incompatible	Conditional	Non-complying
Aquaculture involving husbandry and/or supplementary feeding a water flow through system	Incompatible	Incompatible	Conditional	Non-complying
Forestry	Incompatible	Conditional	Conditional	Considered on merit in rural zones

Land use description	Priority 1	Priority 2	Priority 3	Current planning policy
OTHER LAND USES / DEVELOPMENTS				
Housing developments: • that would require native vegetation to be cleared to accommodate the building envelope and any associated bushfire protection buffers • that could not dispose of wastewater, on the allotment where it is generated, further than 50 m from a watercourse and in a safe, ecologically sustainable, manner • where the only possible building envelope is very close to a watercourse and/or on a 1-in-100 year floodplain.	Incompatible	Incompatible	Incompatible	Considered on merit in rural and township zones
Land division that creates additional allotments	Incompatible	Conditional in urban zones3 for aged accommodation Incompatible for other development in other zones	Conditional in urban zones, incompatible in other zones	Non-complying in rural zones subject to minimum zone criteria, ie minimum allotment sizes, in urban zones
Land division (boundary rearrangements) which would create allotments containing 2 or more habitable dwellings	Incompatible	Incompatible	Conditional in urban zones, incompatible in other zones	Considered on merit
Any built development that generates greater than 1500L of wastewater per day per allotment and is not connected to sewer or STEDs including built development that is additional to an existing development on the allotment	Incompatible	Incompatible	Conditional	Non-complying or considered on merit (depending on the type of development)

[3] Urban zones includes centre zones, township zones, country living zones, rural living zones, commercial zones and industry zones

Land use description	Priority 1	Priority 2	Priority 3	Current planning policy
OTHER LAND USES / DEVELOPMENTS				
Cellar door sales buildings	Conditional	Conditional	Conditional	Non-complying (other than if associated with 10 identified wineries)
Wineries (up to 2000 tonnes crush/year) that are not serviced by sewer or STEDs	Incompatible	Incompatible	Conditional	Non-complying (other than 10 identified wineries)

APPENDIX D ECONOMIC IMPACTS ON AGRICULTURAL DEVELOPMENTS

An economic impact assessment of the planning policies recommended in implementation model, Option 1, has been performed for agricultural developments in Watershed Priority 1 and 2 areas (Morrison *et al* 2004). This assessment used the land use data contained in Tables 5 and 6 to determine the current farm-gate gross value of production for identified agricultural activities and compared this with the opportunity cost of foregone development over the medium term (five years) if the land use policy changes where adopted. A summary of the gross value of production for the identified agricultural developments that may be foregone in P1 and P2 areas is contained in Table D1. For full details of the study refer to Morrison *et al* (2004).

Table D1 Estimates of additional farm-gate GVP for identified primary industry land uses in the MLRW region, 2015 (Source: Morrison *et al* 2004)

Land use category	Priority zone 1 ($ million)			Priority zone 2 ($ million)		
	Medium-term growth projection			Medium-term growth projection		
	Low	Most likely	High	Low	Most likely	High
Berries	–0.1	0.1	0.2	0.0	0.0	0.1
Floriculture	0.0	0.0	0.0	0.0	0.0	0.0
Vegetables	0.0	0.0	0.0	–0.1	0.0	0.1
Orchards	0.0	2.7	8.2	–	–	–
Vines	0.0	0.2	0.7	–	–	–
Forestry	0.0	0.3	0.6	–	–	–
Dairy	–0.4	0.0	0.4	0.0	0.0	0.0
Total	**–0.6**	**3.4**	**10.2**	**–0.1**	**0.0**	**0.2**
Change[4]	**–0.8%**	**4.5%**	**13.8%**	**–0.2%**	**0.1%**	**0.2%**

Note: Components may not add up to total due to rounding up of numbers.

[4] Relative to current farm-gate GVP

The opportunity cost of forgone development opportunities in P1 areas could range from –$0.6 million to +$10.5 million in farm-gate gross value of production in 2015, which is equivalent to –0.8% to +14.1% of current farm-gate gross value of production. The most likely outcome would be a $3.5-million reduction in farm-gate gross value of production in 2015. These figures were derived predominantly from growth scenarios envisaged in the orchard industry.

Given that further development of perennial horticulture, viticulture and forestry is not restricted in P2 areas, the opportunity cost of forgone development opportunities in P2 areas is likely to be minimal.

In comparison to these forgone development costs under the most likely growth projection ($3.5 million), the cost of additional water quality treatment would be significantly more. For example, if pathogen numbers were to increase (associated with intensive livestock and urban settlements) additional treatment may be required, with estimates for UV facilities at Hope Valley of approximately $4 million or full-flow micro-filtration at Happy Valley estimated at $45 million (as at 2002). The treatment of algae (associated with nutrient inputs from intensive agriculture and urban settlements) is also costly, with current expenditure in the Watershed exceeding $2.4 million per year. By 2015, assuming no further decline in water quality, this treatment cost is estimated at $4.7 million per year. Other water treatment costs would also increase if raw water quality were to decline.

APPENDIX E IMPLEMENTATION MODEL, OPTION 2—LAND USE COMPATIBILITY FOR EACH WATERSHED PRIORITY AREA

Table E1 Priority Area 1

Water quality risk ranking	Land use, activity, development in Priority 1 areas	Management requirement
Low	Native vegetation, revegetation	Stewardship incentives, Land Management Agreements (NRM Act), Heritage Agreements
	Low intensity grazing (including horses)	Stewardship incentives, riparian management mandated, whole farm planning, animal husbandry guidelines
Moderate	Forestry/agroforestry	Referral with direction (EPA)
	Intensive horse keeping	Riparian buffers
	Perennial horticulture (orchards and vineyards)	Land Management Agreements (NRM Act)
	Aquaculture involving husbandry and/or supplementary feeding in a water flow-through system	Codes of practice developed and enforced (EPA, NRMB)
		EMS—industry driven
		Incentive programs for best practice management and innovation
	Cellar door sales facilities	Referral with direction (EPA)
		EMSS, site conditions based on environmental sensitivity
	Housing development not connected to sewer or STEDS but not in environmentally sensitive location	Referral with direction (EPA)

Water quality risk ranking	Land use, activity, development in Priority 1 areas	Management requirement
High	Annual cultivated horticulture (market gardening, turf farms, intensive floriculture)	Incompatible
	Dairies and associated dairy farming	
	Intensive animal keeping including feedlots, zoos, poultry sheds, dog kennels, catteries	
	Housing developments in environmentally sensitive locations[5]	
	Land division involving the creation of additional allotments outside township zones	
	Land division (boundary re-arrangement that creates allotments containing two or more habitable dwellings	
	Land division involving the creation of additional allotments less than 4000 m^2 in township zones whether unsewered on not	
	Any built development that generates more than the equivalent of 1500 L of domestic strength wastewater per day per allotment	
	Native vegetation clearance	
	Wineries not connected to sewer or STEDS	

[5] Housing development:

- that would require native vegetation to be cleared to accommodate the building envelope and any associated bushfire protection buffers
- that could not dispose of wastewater, on the allotment where it is generated, further than 50 m from a watercourse and in a safe, ecologically sustainable manner.
- where the only possible building envelope is very close to a watercourse and/or on a 1-in-100 year floodplain.

Table E2: Priority Area 2

Water quality risk ranking	Land use, activity, development in Priority 2 areas	Management requirement
Low	Native vegetation, revegetation	Stewardship incentives, Land Management Agreements (NRM Act), Heritage Agreements
	Low intensity grazing	Stewardship incentives, riparian management mandated, whole farm planning, animal husbandry guidelines
	Forestry/agroforestry	Referral to EPA
		Riparian buffers mandated
		Land Management Agreements (NRM Act)
		Codes of practice developed and enforced (EPA, NRMB)
		EMS—industry driven
		Incentive programs for best practice management and innovation.
Moderate	Intensive horse keeping	Referral with direction (EPA)
	Aquaculture involving husbandry and/or supplementary feeding in a water flow-through system	Riparian buffers mandated
		Land Management Agreements (NRM Act, 2004)
	Perennial horticulture (orchards and vineyards)	Codes of practice developed and enforced (EPA, NRMB).
		EMS—industry driven
		Incentive programs for best practice management and innovation
	Housing development not connected to sewer or STEDS but not in environmentally sensitive location	Referral with direction (EPA)
	Land division (boundary re-arrangement that creates allotments containing 2 or more habitable dwellings	Conditional in urban zones for aged accommodation. Incompatible in other development zones.
	Wineries not connected to sewer or STEDS	Referral to EPA, licensed by EPA
	Cellar door sales facilities	Referral with direction (EPA), site conditions based on environmental sensitivity

Water quality risk ranking	Land use, activity, development in Priority 2 areas	Management requirement
High	Annual cultivated horticulture (market gardening, turf farms, intensive floriculture)	Incompatible
	Dairies and associated dairy farming	
	Intensive animal keeping including feedlots, zoos, poultry sheds, dog kennels, catteries	
	Housing developments in environmentally sensitive locations (see Footnote 5)	
	Land division involving the creation of additional allotments outside township zones	
	Any built development that generates more than the equivalent of 1500 L of domestic strength wastewater per day per allotment	
	Land division involving the creation of additional allotments less than 4000 m^2 in township zones whether unsewered on not	
	Native vegetation clearance	

Table E3: Priority Area 3

Water quality risk ranking	Land use, activity, development in Priority 3 areas	Management requirement
Low	Native vegetation, revegetation	Stewardship incentives, Land Management Agreements (NRM Act 2004), Heritage Agreements
	Low intensity grazing	Stewardship incentives, riparian management mandated, whole farm planning, animal husbandry guidelines
	Forestry/agroforestry	Codes of practice developed and enforced (EPA, NRMB). EMS—industry driven Incentive programs for best practice management and innovation.
	Intensive horse keeping Perennial horticulture (orchards and vineyards) Aquaculture involving husbandry and/or supplementary feeding in a water flow through system	EMS and codes of practice developed—industry driven Incentive programs for best practice management and innovation.
	Cellar door sales facilities	Referral to (EPA) Site conditions based on environmental sensitivity
Moderate	Annual cultivated horticulture (market gardening, turf farms, intensive floriculture) Dairies and associated dairy farming Intensive animal keeping including feedlots, zoos, poultry sheds, dog kennels, catteries	Referral with direction (EPA) Riparian buffers mandated Land Management Agreements (NRM Act, 2004) Codes of practice developed and enforced (EPA, NRMB). EMS—industry driven Incentive programs for best practice management and innovation.
	Land division involving the creation of additional allotments outside township zones	Conditional in urban zones for aged accommodation. Incompatible in other development zones
	Land division (boundary re-arrangement that creates allotments containing 2 or more habitable dwellings	Conditional in urban zones for aged accommodation. Incompatible in other development zones.
	Land division involving the creation of additional allotments less than 4000 m^2 in township zones whether unsewered or not	Conditional in urban zones for aged accommodation. Incompatible in other development zones.
	Any built development that generates more than the equivalent of 1500 L of domestic strength wastewater per day per allotment	Conditional
	Housing development not connected to sewer or STEDS but not in environmentally sensitive location	Referral with direction (EPA)

Water quality risk ranking	Land use, activity, development in Priority 3 areas	Management requirement
High	Wineries not connected to sewer or STEDS	Referral to EPA, licensed by EPA
	Native vegetation clearance	Incompatible
	Housing developments in environmentally sensitive locations (see Footnote 5)	Incompatible