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Sustainable Management of the Great Artesian Basin: an analysis based on Environmental Economics and Law

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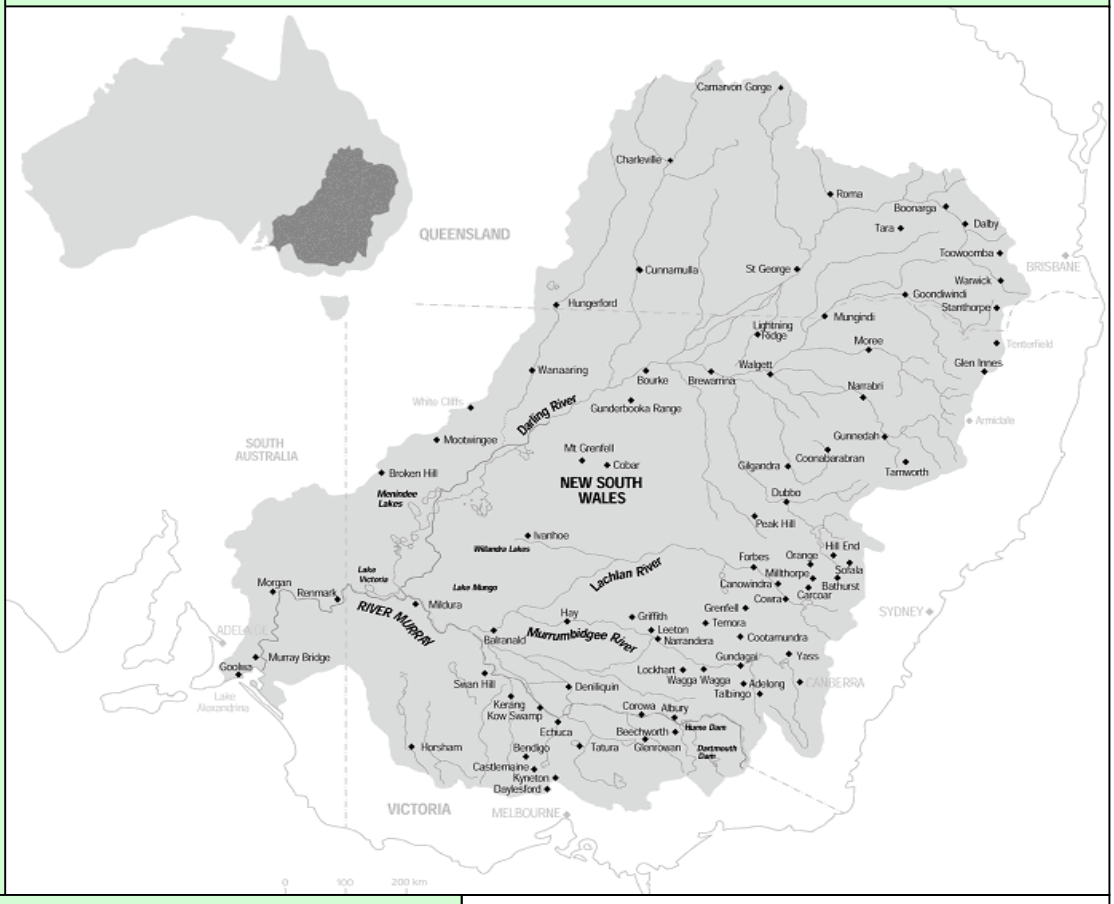

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1. Introduction

Groundwater has been a vital resource to humans through the ages. Ancient societies depended on the ability to construct and maintain useful wells. The Persians had systems of *qanats* as far back as 1500 BC. These were underground conduits for tapping groundwater made by sinking a series of wells and connecting them. The technology was also used in Roman aqueducts, and brought by Arabs to North Africa and Spain.

The story of the exploitation of Australia's groundwater resources is of far more recent vintage. Interstate rivalry over the control of surface water resources has been recognised as a factor shaping our federal constitution,[1] but few realise how much the management of our underground water resources is interwoven with our colonial history.

In important respects, both the policy debate and the development of institutions to manage groundwater have run in parallel with that of policies regarding surface water. The parallels are particularly close regarding two of Australia's most significant resources of each kind: the Murray-Darling Basin and the Great Artesian Basin. Policy, management structures and remedial solutions developed in response to the problems of the Murray-Darling Basin tend to set the tone for discussion of the Great Artesian Basin, in some cases to the point where ideas developed for management of the Murray-Darling Basin are applied directly to the Great Artesian Basin.

The purpose of this article is to provide a framework for discussion of the current policy issues surrounding management of the Great Artesian Basin, with reference to the historical development of existing legislation and institutions. Of particular

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[1] See SD Clark and IA Renard, "Constitutional, Legal and Administrative Problems" in HJ Firth and G Sawer, *The Murray Water: Man, Nature and a river system,* Angus and Robertson, Sydney, 1974, 265-6; D Wright, "The River Murray: A Microcosm of Australian Federal History", in BW Hodgkins et al *Federalism in Canada and Australia: the early years,* ANU Press and Wilfred Purier UP, Canberra and Waterloo, 1978, 280.

interest is the applicability of lessons learned from the debate over management of the Murray-Darling Basin.

The article is organised as follows. Section 2 provides hydrological and historical background information, covering the period from the initial exploitation of artesian water to the 1970s. Section 3 deals with the development of concern over unsustainable resource use and possible adverse environmental impacts from the 1970s to the late 1990s. Section 4 deals with more recent developments, mainly associated with the general reforms to water law and policy initiated by the Council of Australian governments. In Section 5, the issues surrounding the Murray-Darling Basin and the Great Artesian Basin are compared and contrasted. Finally some concluding comments are offered.

2. Background

2.1 Great Artesian Basin

The Great Artesian Basin (GAB) is located beneath parts of Queensland, NSW, South Australia and the Northern Territory (NT). It underlies about 22% of Australia's land area with most of the Basin in the named States.[2] As the NT accounts for only 3.8% of total use, and there is no discernable drop in pressure in that part of the Basin, discussion in this article will be confined to Queensland, NSW and SA.

The oldest water of the Basin occurs in the south-western part of the Basin and is thought to be almost 2 million years old. Vertical layers of sediment make up the three major constituent basins of the GAB: the Eromanga, Surat and Carpentaria Basins. The depth of the aquifers rangse from less than 100 metres at the margins to over 3,000 metres at the centre. Intake points for recharge of the aquifers are located mainly along the Great Dividing Range on the eastern margin. Only about 2% of rainfall falling at these intake points enters the basin. The water yielded by the aquifers is mostly fresh.

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[2] Information sourced from the Great Artesian Basin Consultative Committee, *Great Artesian Basin Resource Study*, 1998 (hereinafter referred to as the GABCC, 1998).

Most of the area over the western part of the GAB is arid or semi-arid. The north has wet to dry tropical conditions. All the surface water systems in the Basin are characterised by variable discharge and flow duration. The most variable river systems, the Diamantina and Cooper, are located in the Lake Eyre basin, with the least variation in the tributaries of the Darling River.

Groundwater generally flows in a westerly or southwesterly direction. Groundwater flow paths are affected by a 'divide' in the northern part of the Basin causing flow towards the Gulf of Carpentaria in the north and towards Lake Eyre in the south. The flow is extremely slow. It can take two million years before water entering recharge areas in Queensland discharge through mound springs located in South Australia. These springs are natural outlets from which the groundwater flows to the surface. These feature in Aboriginal myths and are significant for cultural and spiritual reasons. There are about 600 spring complexes in 12 major groups around the margins of the basin[3]. Most of the mound springs in north western NSW have dried or have been greatly reduced as a result of extractions from the basin. The most active springs are in northern SA while areas of western and central western Queensland have many still active.

Natural discharge from the GAB may occur through other means: subsurface outflows into neighbouring basins and towards regional water tables. They form a considerable body of water and comprise a major part of the groundwater flowing through the GAB. Scientists think that this natural discharge is mostly featured in marginal areas where the confining beds are relatively thin, pressures are high and watertables shallow.

Artificial discharge occurs by means of free or controlled artesian flow and sub-artesian bores. There is a distinction - purely a human construct – as not all groundwater is considered artesian. An artesian bore is one where the water flows out at the surface due to natural pressure. A sub-artesian bore is one where the water has

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[3] C Harris, S Lewis and H Angas, "South Australia's Mound Springs: Maintenance and Improvement of their Environment and Heritage Values," (Paper presented at GABFest, Toowoomba, 10 March 2002) available at http:www.gab.org.au/inforesources/downloads/gabfest/papers/harris_r.pdf (29 March, 2004).

to be raised by pumping. In addition, 'vertical leakages' occur throughout the GAB. This term refers to water 'leaked' from a number of sources: from free flowing bores due to faulty construction or the action of corrosive water, or bore that have control valves that cannot be turned off; and wastage from open bore drains.

Low intensity beef cattle and sheep grazing are carried out on non-desert land. This is the main use of artesian water in the GAB (See Table 1). Irrigation for cotton is a new use of the alluvial plains of major streams in the south east of the basin. In SA groundwater from GAB is predominantly used for pastoral purposes and it supports an emerging tourist industry. Mining activity that involves the use or extraction of groundwater is also significant in SA.[4]

[4] D Leek, "Management of the Great Artesian Basin in South Australia – Looking Back, Looking Forward", (Paper presented at GABFest, Toowoomba, 10 March 2002) available at <http:www.gab.org.au/inforesources/downloads/gabfest/papers/leek_d.pdf> (29 March, 2004).

Table [5]

	Discharge/Extraction ML per day	Percentage of total discharge
Pastoral bores		
Flowing artesian bores	1200-1500	42.6–48.2
Non-flowing artesian bores	300	10.7–9.6
Oil and gas	70	2.5–2.2
Mining (Olympic Dam and Roxby downs)	12	0.5
Springs	130	4.6-4.2
Vertical leakages	1100	39.1-35.3
TOTAL	2815-3115	

2.2 Discovery and early management

Oxley and Sturt wrote the first colonial observations of the land over the GAB.[6] While Oxley in 1820 recorded a very wet year on land at the edge of the GAB, Sturt in 1833 recorded a dry one in the GAB's southern parts. Sturt observed that plains were

[5] This table is based on figures presented in PJ Reyenga, MA Habermehl and SM Howden, *The Great Artesian Basin – Bore Rehabilitation, Rangelands and Groundwater Management*, Bureau of Resource Sciences, Canberra, 1998. These figures are now slightly outdated. Olympic Dam and Roxby Downs in SA now take over 40 Ml/d see Power at note 75. There is also considerable water extracted from mining in Queensland that is not reflected in this table. More accurate figures on use are not readily available. It is estimated that 20,000 ML per annyum is used by towns, 11,000 and 6,000 ML per annum for irrigation and industry respectively: GABCC, 1998 note 2 at 101.

[6] R Blick and T Ferrier, "Lessons from the Past – Visions for the Future", (Paper presented at GABFest, Toowoomba, 10 March 2002) also available at <http:www.gab.org.au/inforesources/downloads/gabfest/papers/blick_r.pdf> (29 March, 2004).

gasping for moisture, and that hollow after hollow of what is now known as the Bogan River although of considerable depth, were dried up.

Drilling for the first artesian bore on the GAB occurred at 'Kallara' station near Bourke around 1878. The NSW government quickly recognised the importance of artesian water and moved to exploit it.[7] It was intended to open a well watered stock route from a goldfield at Mount Brown to the railway terminus at Bourke. However much of the artesian water tapped was unsuitable for stock although it was considered broadly suitable for irrigation. The government successfully carried out two experiments for irrigating farms with artesian water. By 1890 the artesian water of NSW was recognised as being part of the south eastern portion of the GAB.

The common law applied to groundwater resources at this time. At common law, the riparian doctrine applied to underground water *known* to flow in a *defined* channel. It has been observed that 'defined and known' underground channels occurred more often in law reports than in nature.[8] Australian courts held that a course would be considered known and defined if its existence is demonstrated by excavation or could be inferred by observable facts. In such a case, the riparian doctrine of law limited the amount of water which could be taken by overlying landowners. They had a right to make "ordinary use" of the water for domestic purposes, and watering of a reasonable amount of livestock. These ordinary uses were not subject to restriction at common law. In addition, landowners has the right to use water for any other purpose, but they were obliged to not diminish either the quantity or quality of water flow. Thus the common law doctrine of riparian rights was underpinned by two principles (1) the right to use water for basic needs, and (2) for secondary needs the mutual use by all riparians was to be respected.

Where the channel was not 'known' in the legal sense, then the riparian doctrine did not apply. Groundwater was then treated as percolating, and the overlying landowners had an absolute right to take such water in such quantities and for such purposes as

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[7] Information on NSW sourced from C Lloyd, *Either Drought or Plenty: Water Development in NSW,* Department of Land and Conservation, Sydney, 1988.

[8] SD Clark, *Groundwater law and administration in Australia,* AWRC Technical Paper no 44, AGPS, Canberra, 1979 (hereafter referred to as Clark, 1979) at 9.

they saw fit.[9] Under North American common law, this right was considered limited to extraction for reasonable use. However there have been scarce pronouncements by Australian courts on the issue and our legal principles therefore mirror those stated in the English decisions.

Although mainly of historical interest, there does not appear to be any case law on, or previous analysis of whether the GAB resources constituted water in a known and defined channel. On this basis it must be assumed that at the time of its discovery and for many years after, its resources would have been regarded as percolating groundwater. Thus, the common law did not impose conditions on the quantity that could be extracted, the purposes for which it could be used or the manner of its extraction.

In Queensland, successful boring for sub-artesian water occurred in 1882 near Cunnamulla.[10] In 1887 Barcaldine produced Queensland's first major supply at 211 metres with an estimated flow of 796,000 litres in its early years. In the same year the *Artesian Wells Act* 1897 (NSW) was passed. It related to artesian and sub-artesian water and allowed a group of settlers to have a bore funded by the Crown who also undertook the risk of finding no water. The Act provided that the consent of three quarters of the settlers was needed to have the scheme go ahead. Settlers made some repayment for the bore through an annual rate when was assessed by the local Land Board. The move was seen by Clark as one aimed at controlling the construction of artesian wells, [11] but arguably the primary objective was to provide for public funds to encourage the use of groundwater.

Within 10 years it was recognised that there was a need to guard against indiscriminate boring or waste of water. The *Water and Drainage and Artesian Wells (Amendment) Act* 1906 (NSW) was passed to require licensing of bores. Licensing

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[9] Ibid at p 28. However English courts in cases such as *Ballard v Tomlinson* (1884) 29 Ch D 115 did not recognised this right as a proprietary interest. It was a right to appropriate and use, not a right of ownership of the water. Only when the percolating water was extracted either in a well or through a bore, did a proprietary right in the water arise.

[10] J Powell, *Plains of Promise, Rivers of Destiny: Water Management and the Development of Queensland,* Boolarong, Brisbane, 1991 (hereinafter referred to as Powell, 1991).

[11] Clark, 1979 note 8 at 90.

was required for new artesian wells or to enlarge deepen or alter existing artesian wells. It introduced strict controls over artesian developments partly to safeguard smaller graziers and farmers taking up resumed pastoral leaseholds.

Early NSW legislation was primarily concerned with financing and controlling the construction of bores. The *Water Act* 1912 (NSW) continued the legal framework of the *Artesian Wells Act* 1897 (NSW) and initially provided for licensing and construction standards for all bores over 30 m deep in the western division. Amended in 1930, 1955 and 1965, it provided for:

- Co-operative schemes where the NSW Water Conservation and Irrigation Commission (WCIC) would undertake construction at the cost of all landowners potentially benefiting from the supply. Artesian Well Districts and Bore Water Trusts were created.
- Licences for private bores to be issued, and if the Commission deemed it necessary, a public enquiry would be held.
- Licences to be issued but routinely renewed – s 116 allowed the Commission to grant a licence for a limited period but any license so limited 'shall … be renewed by the Commission from time to time'.

In contrast, boring in Queensland was privately funded, although there was involvement by the government.[12] JB Henderson and RL Jack, State Hydraulic Engineer and Geologist respectively were involved in the exploration and utilisation of artesian resources. They were both mindful that stringent controls were needed for water conservation. In the 1880s and 1890s, with remarkable foresight, they recommended that the Crown should be recognised as the owner of all water resources and that meters should be attached to all wells, enabling the introduction of charges by volume. Their recommendations resulted in the tabling of the *Water*

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[12] For a history of artesian boring in Queensland see Queensland Government, *Artesian water supplies in Queensland. Report following first Interim Report (1945) of Committee appointed by the Queensland Government to investigate certain aspect relating to the Great Artesian Basin (Queensland portion) with particular reference to the problem of diminishing supply*. Department of the Coordinator-General of Public Works Queensland, Parliamentary Paper A 56-1955, 1954 (hereinafter referred to as Queensland Government, 1954) at 22.

Supply (Wells and Tanks) Bill 1891 (Qld) by the Treasurer of Queensland. Some members of the Legislative Council believed that there was little point in attempting to curb usage in Queensland if equivalent controls were not place in NSW. Queensland was considered to house the 'head of supply' therefore would suffer less from diminishing supplies. The bill was severely criticised in the Legislative Council and failed to pass.[13]

The Rights in Water and Water Conservation and Utilisation Act 1910 (Qld) was the first Australian legislation to declare that the right to the use and flow of water in artesian bore and subterranean supply was vested in the Crown for all purposes whatsoever.[14] No new artesian bore could be constructed or existing artesian bore deepened except pursuant to a license. Bore Water Supply Areas and Boards were created. The Minister had extensive powers under the Act. If the Minister was of the opinion that water from any artesian bore was being improperly used or wasted, the Minister could order partial closure of the bore, or such other precautions deemed necessary to prevent improper use of the water. This particular provision applied only after 10 years from commencement of the Act. There is no record that these powers were ever used. However the licensing scheme put some control on the drilling and construction of new artesian bores, headworks and drains and was subsequently extended to cover sub-artesian bores in proclaimed areas. This scheme of conservation by regulation of bore flows was continued by later Acts.

The Queensland government considered that it was difficult to promote the principle of conservation on the plains, where land was held under leasehold tenure.[15] This was attributed to the fact that was no agreed explanation for diminished water volume and pressure for artesian bores.

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[13] Sourced from Powell, 1991 note 10.

[14] In 1966 amending legislation to the *Water Act* 1912 (NSW) conferred on Crown the supervening right to use flow and control of subsurface water.

[15] In 1966 amending legislation to the *Water Act* 1912 (NSW) conferred on Crown the supervening right to use flow and control of subsurface water.

2.3 Interstate conferences and postwar legislation

In 1908, the NSW government seeking federal action to tackle the problem of excessive extraction, organised a conference, but only the South Australian government sent a delegation.[16] A second attempt in 1912 resulted in a series of interstate conferences on artesian water.[17] This attempt to reach a federal coordination of water policy predated the River Murray Agreement by several years. The conferences concentrated on the collection of data, the understanding of the geology and hydrological working of the GAB, securing continued supply of water for domestic and stock uses, and the common use of terms. One of the recommendations of the 1912 conference in Sydney was that uniform legislation be enacted in all states to ensure effective control of all existing bores and the drilling of new bores.

By 1918, over 1,500 flowing artesian bores existed throughout the Basin.[18] The availability of reliable water supply allowed the development of the sheep and cattle industry. Small open channels known as bore drains ran for thousands of kilometres to distribute water around pastoral properties.

By the 1921 conference it was recognised that state boundaries within the GAB were artificial, and there was a need for coordinating access and usage of the water.

After five national conferences, it was agreed in 1939 that water from free flowing bores was the major problem. Poorly constructed bores were thought to be the main reason for wastage.[19] It was estimated that 90% of bore water was lost through evaporation, seepage and general wastage.[20] At the final conference, NSW Water Conservation and Irrigation Commission officers predicted that artesian supply for the pastoral industry would fail in 50 years time.

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[16] See Queensland Government, 1954 note 12.

[17] Between 1912 and 1928, five Interstate Conferences on Artesian Waters were held. For a summary of the conferences and a list of all recommendations see Queensland Government, 1954 note 12.

[18] GABCC, 1998 note 2.

[19] Queensland Government, 1954 note 12

[20] Department of Natural Resources and Mines, Queensland, "How is Artesian Water Being conserved?," http:/www.nrm.qld.gov.au/water/gab/conservation.html (9 January, 2003).

Some remedial action was taken. From the 1930s, new bores were required to have control valves installed and water distributed by pipelines instead of open drains. However the demands of war overtook domestic policy. The *Farm Dams Water Supplies Act* 1946 (NSW) continued to allow bores to be sunk with financial assistance from the State

It was not until 1952 that an Investigations Committee reported on the problem. Even so, a fragmented approach to the report was adopted – each of the States addressed the problems separately. In Queensland the reports of 1945 and 1954 noted the diminution of the basin, but explained that this was because of 'elastic storage.'[21] The elastic effect is said to be responsible for a greater flow when an aquifer is first pierced by a bore. This theory, now no longer referred to, explained that pressure in an aquifer was immediately reduced and gave rise to the initial first flush experienced at all bores. Gradually the reduction of pressure decreased until a steady flow was reached. After many years, the bore would discharge only at the rate at which water could be transmitted from the intake. Diminution was seen as a disability but the view was taken that in general water would always be available at the depths from which it can be pumped to replace bores which ceased to flow. It was seen not to threaten the future of the pastoral industry.

The Queensland reports recommended that the allocation of ground water should give first priority to domestic use, next to stock watering and lowest priority to irrigation. No general programme for the conservation of flows from existing artesian bores was proposed, but all cases of surplus flows were to be examined on a case by case basis. Supply of water for irrigation was seen to be at the expense of stock watering. Remedial measures which were rejected as uneconomic were the artificial recharge of waters, distribution by piping, and the lining of drains.

Decades after legislation was made in NSW and Queensland regarding groundwater, South Australian legislation was passed in 1959. The *Underground Waters Preservation Act* 1959 (SA) applied in defined areas to require a permit for sinking, or deepening or carrying work on a bore. An application could be refused if the bore was likely to cause contamination or deterioration of groundwater. Under the *Water*

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[21] Sourced from Queensland Government, 1954 note 12.

Resources Act 1969 (SA) which subsumed the earlier legislative regime, all permits to take groundwater were limited in duration to 12 months. Conditions could be attached to these permits in order to prevent the unequitable distribution of groundwater and the undue depletion of supply.

3. Reasons for reform

The Australian Water Resources Council was formed in 1963 by State and Federal governments and was the first effort by governments to discuss water resource matters at a national level since federation. Amongst its many activities, the Council commissioned a legal report on groundwater law and administration in Australia. Clark's report called for a legislative overhaul of inconsistencies over the years, particularly in NSW and Queensland.[22] Regarding NSW legislation he commented that 'in many instances, regulatory controls have been imposed through apparently uncontested implementation of administrative policy, rather than clear statutory provisions'.[23] He pointed to numerous areas which needed attention including granting procedures, limited power to refuse a licence, lack of power to back-up controls on licensed bores, lack of power to control unlicensed bores, and lack of authority to refuse to renew a licence.

Clark's groundwater report focused on inconsistencies between states, lack of statutory power and lack of clarity in the state regulatory framework. It was written in an era where considerable public concern over the protection of the environment was developing. In 1983, just four years after that report, *Water 2000,* a comprehensive study of Australia's water resources confirmed that there were serious economic and environmental issues to be dealt with.[24] These views related mostly to surface water resources. Regarding groundwater, the study reported that assessment of available groundwater resources was often made after prolonged consumptive use rather than

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[22] Clark, 1979 note 8 at 179.

[23] Clark, 1979 note 8 at 174.

[24] Department of Resources and Energy, *Water 2000: A Perspective on Australia's Water Resources to the year 2000, A report of the Steering Committee in conjunction with the Department of Resources and Energy*, AGPS Canberra, 1983.

the reverse, as was generally the case, prior to the commitment of surface water resources. Further, except in relation to aquifers then in constant heavy use, there was little information on sustainable yields in terms of quantity or quality. On addition, there was little information on water movement in the aquifers**.** The report revealed a lack of knowledge on groundwater resources and the tendency of government to focus on surface waters because those problems were more easily observed.

Since the *Water 2000* report, groundwater use has increased 90% compared to a 65% increase in use of surface water in the same period from 1985 to 1996-97. The 2001 State of Environment Report states that groundwater is now overused and over-allocated in many Groundwater Management Units.[25] A recent study by the Murray-Darling Basin Commission reveals that in the 1990s, irrigators have switched from river diversions to use of groundwater and this could now be undermining reform measures taken in the Murray-Darling Basin.[26]

The rate of groundwater extraction exceeds the rate of recharge in many aquifers along the East Coast of Australia, the small aquifers in the Murray-Darling and most significantly in the GAB. Such rates of extraction cannot be sustained indefinitely and are commonly referred to as 'groundwater mining'.

When extraction rates exceed recharge rates, pressure in the aquifer declines, reducing the rate of flow. Many bores initially flowed at rates of over 10 megalitres per day (ML/d). The majority of flows are now between 0.01 and 6 ML/d.[27] About 1500 artesian bores have ceased to flow, springs flows have declined significantly and some springs have dried up.[28] Predictions, based on the theory of 'elastic storage', that flows would stabilise after an initial decline in pressure, have proved overoptimistic.

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[25] *Australia State of the Environment 2001,* Independent Report to the Commonwealth Minister for the Environment and Heritage, 2001 (hereinafter referred to as SOE, 2001) at 3.

[26] Murray–Darling Basin Ministerial Council, *The Living Murray. A discussion paper on restoring the health of the River Murray,* Canberra MDBMC, 2002

[27] Department of Natural Resources and Mines, Queensland, "The Great Artesian Basin", <http:/www.nrm.qld.gov.au/water/gab/basin.html> (9 January, 2003).

[28] GABCC, 1998 note 2.

Particularly severe problems have arisen with bore drains. Nearly 34,000 km of bore drains are currently in use in Queensland and NSW. Up to 95% of water that goes into these drains is wasted through evaporation and seepage.[29] Additional disadvantages of the use of bore drains for water distribution include infestations of invasive weeds around the drains, increased salinity of land, and increase of feral animals.

The impact of artesian water, particularly from bore drains, has a major impact on biological values of the landscape. The negative impacts of bore drains on biodiversity may be attributed to the fact that prior to the sinking of bores there was very little surface water, and that when surface water did flow, it was ephemeral. Studies have shown that Australia's terrestrial mammal fauna is particularly susceptible to decline. One third of the world's extinct mammals in the last 400 years are Australian, with 22 species now extinct in this country.[30] Terrestrial ecosystems that have been identified as poorly known include mound springs and other groundwater and groundwater dependent ecosystems.[31]

With the drying up of mound springs due to the significant loss of pressure in the Basis, rare species of flora and fauna have been put at risk. Hatton and Evans noted that

> the general level of understanding of the role of groundwater in maintaining ecosystems is very low. Groundwater resource managers and investigators tend to underestimate ecosystem vulnerability with respect to groundwater development, pollution and land use change, although there is greater awareness in some regions such as south-western WA. The translation of the

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[29] Department of Natural Resources and Mines, Queensland, "How is Artesian Water being Wasted?", <http:/www.nrm.qld.gov.au/water/gab/wastage.html> (9 January 2003).

[30] National Land and Water Resources Audit, "Australian Terrestrial Biodiversity Assessment," <http://audit.deh.gov.au/ANRA/vegetation/docs/biodiversity/bio_assess_mammals.cfm> (29 March 2003).

[31] Biological Diversity Advisory Committee, "Biodiversity Conservation Research: Australia's Priorities", <http://www.deh.gov.au/biodiversity/science/bdac/research-priorities/summary.html> (29 March 2004).

> COAG concept of provision for the environment, in a groundwater sense, is poorly defined.[32]

Groundwater quality is seriously compromised in many areas. There are several problems particularly affecting groundwater. Once groundwater is contaminated – reversal is near impossible. The slow rates of groundwater flow and low microbial activity limit any self–purification. Additionally the remediation costs of groundwater systems are very high.[33] Further, it is not easy to detect contamination and its consequences are not obvious to users. Consequently groundwater management suffers from an 'out-of sight-out of mind' mindset.[34] Very little information exists for many aspects of groundwater quality. Studies so far show that the most significant widespread pollutant of groundwater is nitrate from a wide range of sources. There is limited data on this, however in agricultural areas nitrate contamination is likely to occur mainly through the use of fertilisers, and through grazing and clear felling of land.[35] In agricultural areas pesticides have also been found in groundwater. In urban areas, localised groundwater contamination results from underground storage tanks, industrial discharge, stormwater runoff and contaminated sites.[36]

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[32] T Hatton, T and R Evans, *Dependence of Ecosystems on Groundwater and its Significance to Australia*, Occasional Paper No 12/98, Land and Water Resources Research and Development Corporation, Canberra, 1998.

[33] Department of Land and Water Conservation, NSW, *The NSW Groundwater Quality Protection Policy*, DLWC, Sydney, 1998.

[34] D I Smith, *Water In Australia: Resources and Management,* Oxford University Press, Melbourne 1998 at 38.

[35] P Bolger and M Stevens, *Contamination of Australian Groundwater Systems with Nitrate,* LWRRDC Occasional Paper 03/99, Land and Water Resources Research Development Corporation, Canberra, 1999, at 47-8.

[36] SOE, 2001 note 25.

4. Policy and legislation from 1997

4.1 National groundwater policy

National groundwater policy must be assessed within the context of broader policies. These include the National Strategy for Ecologically Sustainable Development (NSESD) 1992, the National Strategy for Conservation of Australia's Biological Diversity 1993, the Council of Australian Governments (COAG) water reform initiatives, namely the COAG Strategic Framework for Water Reform, 1994, the National Water Quality Management Strategy, 1995 and the National Water Initiative 2004.[37]

In the mid 1990s the Commonwealth and state governments agreed that reform was necessary for an efficient and sustainable use of water resources. They noted widespread natural resource degradation and called for new measures to halt this. A policy document developed in 1995 by Agricultural and Resource Management Council of Australia and New Zealand (ARMCANZ) established principles for achieving the objectives of water reform.[38] It called for:

- the introduction of comprehensive planning systems, based on hydrological assessment, for consumptive and non-consumptive water uses before a property rights regime was implemented;
- clearly specified water entitlements which separate water property rights from land title;
- allocation of water for the environment, and where river systems were over-allocated, for 'substantial progress' to provide a better balance in water resource use with consideration given to re-allocation of water; and
- public consultation where new initiatives were proposed especially in relation to pricing, specification of water entitlements and trading in those entitlements.

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[37] All of these documents are available though the Australian Government's Environmental Portal at http://www.environment.gov.au/

[38] Agricultural and Resource Management Council of Australia and New Zealand, *Water Allocations and Entitlements: A National Framework for the Implementation of Property Rights in Water,* Occasional Paper No 1, Task Force on COAG Water Reform, Canberra, 1995.

Following the National Water Reforms Framework, all Australian states have now passed new water legislation.[39] However the reform process has concentrated on the management and allocation of surface water. Although the scope of National Water Reforms Framework extends to the reform of provisions for groundwater, this aspect of reform tends to lag behind in most States.[40]

In response to COAG, specific groundwater policy, A National Framework for Improved Groundwater Management in Australia, was formulated.[41] Based on the concept of sustainability, this policy sets out a strategy for groundwater for achieving the COAG water reform. Its recommendations include:

- principles of ecologically sustainable development should be adopted in the management of the resource;
- licensing of drillers;
- efficient well design and construction;
- a need for plans for groundwater management to be based on a sound understanding of the resource;
- a need for intra-aquifer trading to be based on properly made groundwater management plans;

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[39] For a discussion of the policy see generally A Gardner, 'An Administrative Framework of Land and Water Management in Australia', (1999) 16 E*nvironmental and Planning Law Journal.* For analysis of reform in Victoria see PL Tan, 'Irrigators come first: A study of the conversion of existing allocations to Bulk Entitlements in the Goulburn and Murray catchments, Victoria', (2001) 18 *Environmental and Planning Law Journal*, 154; for Western Australia see A Gardner, 'Water Resources Law Reform in Western Australia- Implementing the CoAG Water Reforms' (2001) 19 *Environmental and Planning Law Journal,* 6.

[40] SOE 2001 note 25 and R Cox, "Water Reform in Queensland – A Great Artesian Basin perspective" (Paper presented at GABFest, Toowoomba, 10 March 2002) also available at <http:www.gab.org.au/inforesources/downloads/ gabfest/papers/cox_r.pdf> (9 January, 2003).

[41] Agricultural and Resource Management Council of Australia and New Zealand and Standing Committee of Agriculture and Resources Management, *Allocation and use of groundwater. A national framework for improved groundwater management in Australia*, Taskforce on COAG Water Reform Sustainable Land and Water Resource Management Committee, Occasional Paper No 2, 1996.

- data collection and information systems on bore construction and levels;
- recovery of full cost of groundwater management from users; and
- groundwater and surface water resource management be better integrated.

4.2 National water ecosystems policy

Concurrent with the groundwater policy and pursuant to COAG directions, twelve principles were developed on the provision of water for ecosystems by ARMCANZ and Australian and New Zealand Environment and Conservation Council (ANZECC).[42] They are –

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

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

3 Environmental water provisions should be legally recognised.

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

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

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

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

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[42] Agricultural and Resource Management Council of Australia and New Zealand and Australian and New Zealand Environment and Conservation Council, *National Principles for the Provision of Water for Ecosystems,* Occasional Paper SWR No 3, Canberra, 1996.

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

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

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

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

12 All relevant environmental, social and economic stakeholders will be involved in water allocation planning and decision-making on environmental water provisions.

The purpose of the Ecosystems Principles is to provide policy direction on how the specific issue of water for the environment should be dealt with in the context of general water allocation decisions. The principles state that environmental water provisions are to provide water to maintain ecological values of *ecosystems*, not for water quality purposes or recreation, nor for the protection of any one element or species of the ecosystem.[43] The principles have a strong focus on surface water dependent ecosystems although they are meant to apply broadly to all water resources. For this reason a nationally commissioned report on groundwater dependent ecosystems recommend that the principles should be restated to make their application to groundwater and their dependent ecosystems explicit.[44] This has not yet occurred.

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[43] See J Allan and S Lovett, *Impediments to managing environmental water provisions,* Canberra, Bureau of Resource Sciences, 1996, at 81-2 for a discussion on how adoption of a single value for example trees, birds or fish may have a detrimental effect of the ecosystem as a whole.

[44] C Clifton and R Evans, *Environmental Water Requirements of Groundwater Dependent Ecosystems,* Environmental Flows Initiative Technical Report No 2, Commonwealth of Australia, Canberra, 2001.

4.3 Basin level strategy

The first attempt at a joint strategy for groundwater was made by the GAB Consultative Council which was formed in 1997. It carried out a resource study in 1998 which became the basis of a strategic plan known as the Great Artesian Basin Sustainability Initiative (GABSI). GABSI is a voluntary project jointly funded by Federal and State governments and pastoral bore owners. Its role is to preserve the flow pressure of the GAB by rehabilitating uncontrolled bores and replacing bore drains with polyethylene pipes, tanks and troughs for livestock.[45] The Federal government committed $31.8 million over 5 years from 1999 to projects delivered through state agencies on condition that states match this dollar for dollar. Landholders contribute to project costs through different formulas applied in individual States.

States have been working on rehabilitation measures prior to GABSI. For example, measures have been in place in NSW since 1952. Under GABSI the NSW government provides for an 80% subsidy for the rehabilitation of bores and since 1993, a 20% subsidy for the piping program. There is some variation to the subsidised amounts – in the Western Division of NSW, a 40% subsidy is provided with a limit to the full amount. All subsidies are funded on a nominal 50:50 basis between the Commonwealth and State.

In Queensland, the GAB Rehabilitation Project (GABRP) which commenced in 1989 provides technical and financial support to bore owners to either repair or replace their existing bores so as to allow them to only take the amount of flow necessary for use. Bore owners pay 20% of the costs and under GABSI funding arrangements the annual expenditure is $2 million. In addition, the Bore Drain Replacement Project (BDRP) subsidises replacement of open drains with pipes. Two different schemes apply in Queensland with joint state-federal subsidies between 55 to 60% of costs. Up to $1.8 million of works is funded under this scheme.

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[45] Department of Natural Resources and Mines, Queensland, "The Great Artesian Basin Sustainability Initiative: Fact Sheet", <http://www.nrm.qld.gov.au/factsheets/pdf/water/w69web.pdf> and <http://www.nrm.qld.gov.au/water/gab/conservation.html> (7 April, 2004).

In SA as at 1998, only the rehabilitation aspect of the scheme was available. 207 bores were capped or repaired with about 14 needing extensive rehabilitation and 20 minor work. A 100% subsidy applied to the cost of the work with the funding being shared equally between the Commonwealth and State governments.[46] There was no piping program in SA for open bore drains.

While GABSI is focussed on capping and piping issues, the Strategic Management Plan (SMP) formulated in 2000 has a much wider key aim that is, to promote sustainable use of GAB groundwater resources, with management aimed at achieving optimum economic, environmental and social benefits. There are six more detailed objectives which include establishing legislative and administrative frameworks for sustainable water management and use, and maintaining and enhancing environmental and cultural heritage values affected by use of basin groundwater. In very clear terms, the SMP identified key issues for resolution, and identified performance targets to be achieved over a 15 year period. Regular monitoring, review and reporting of implementation of the targets are to provide accountability. As of 2004 no reports have been publicly made available on the implementation of the SMP or of GABSI.[47]

The Federal government's commitment to funding GABSI continues under the 2004 Budget, with $42.7 million over the next five years. It is timely for all governments to review the limited objectives of GABSI. In defining its role, there was little heed to several of recommendations comprised in the specific groundwater management policy set out by ARMCANZ and SCARM in 1996. Amongst the omissions, GABSI did not set out to adopt ESD nor encourage groundwater planning based on sustainable yield. In particular the strategy of subsidies adopted by GABSI ignored the recommendation that users should bear full cost of groundwater management.

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[46] Industry Commission A Full Repairing Lease: Inquiry into Ecologically Sustainable Land Management, Report No 60, Canberra, 1998 at 271.

[47] Therefore most of the data in this article is based on information made available in GABCC, 1998 note 2.

4.4 State level Policy

Except for NSW, none of the GAB States have clearly articulated their groundwater policy. NSW has four relevant policy documents. A Framework document sets out overall direction of groundwater management in NSW and provides broad objectives and principles. [48] There are three component policies (quality, quantity and dependent ecosystems) that build on this approach and provide more details and guidance. As at 1997 there were 14 groundwater management plans in existence in NSW.[49] The eight policy principles established by the Framework document are -

(1) An ethos for the sustainable management of groundwater resources should be encouraged in all agencies, communities and individuals who own, manage or use these resources, and its practical application facilitated.

(2) Non-sustainable resource uses should be phased out.

(3) Significant environmental and/or social values dependent on groundwater should be accorded special protection.

(4) Environmentally degrading processes and practices should be replaced with more efficient and ecologically sustainable alternatives.

(5) Where possible, environmentally degraded areas should be rehabilitated and their ecosystem support functions restored.

(6) Where appropriate, the management of surface and groundwater resources should be integrated.

(7) Groundwater management should be adaptive, to account for both increasing understanding of resource dynamics and changing community attitudes and needs.

(8) Groundwater management should be integrated with the wider environmental and resource management framework, and also with other policies dealing with human activities and land use, such as urban development, agriculture, industry, mining, energy, transport and tourism.

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[48] Department of Land and Water Conservation, NSW, *The NSW Groundwater Policy Framework Document*, DLWC, Sydney, 1997.

[49] Ibid

Groundwater quality will be protected through the assessment, classification and prioritisation of groundwater systems according to their level of risk from over extraction and contamination. This was completed in 1998, and groundwater management plans were commenced by 2000/01.

Groundwater policy in NSW is formally reviewed on a five yearly basis, and each plan is also reviewed by the management committee over the same period.

Recently NSW policy was considered in a decision by the Land and Environment Court (LEC). In *Murrumbidgee Ground-water Preservation Association v Minister for Natural Resources* Chief Justice McClellan accepted that the relevant policy for sharing groundwater in NSW in aquifers which were over-allocated was based on a uniform reduction of entitlements in a water sharing plan.[50] The reduction would therefore not be based on current users' levels of development or history of use. This decision will be further discussed in section 5.3 of this article.

4.5 Current legislative framework for groundwater allocation and management

The first generation of Australian groundwater legislation was to encourage, organise and subsidise the use of groundwater, particularly artesian water. The second generation was primarily concerned with regulating the construction of artesian bores for controlling waste. SA, Queensland and NSW have adopted new water legislation which may be characterised as the third generation. A key feature of the legislation is that water resources, including groundwater, should be managed in a sustainable manner. SA which relies on its one major river the Murray, is acutely aware that its own use and use by others upstream affect the sustainability of the river. The *Water Resources Act* 1997 (SA) provides for sustainable use of water. It reads:

> *s. 6(1) The object of this Act is to establish a system for the use and management of the water resources of the State -*

[50] [2004] NSWLEC 122 at [197] to [200].

(a) that ensures that the use and management of those resources sustain the physical, economic and social well being of the people of the State and facilitate the economic development of the State while

- ensuring that those resources are able to meet the reasonably foreseeable needs of future generations; and

- protecting the ecosystems (including their biological diversity) that depend on those resources; and

(b) that, by requiring the use of caution and other safeguards, reduces to a minimum the detrimental effects of that use and management.

In addition, all persons and bodies involved in the administration of the Act, including the Minister, must act consistently with, and seek to further, the object of the Act and *must* specifically have regard to a range of matters, including the protection and enhancement of ecosystems that depend on naturally occurring water.

Water legislation in Queensland and NSW also provides objectives of water management consistent with principles of ESD.[51] The *Water Act* 2000 (Qld) recognizes that efficient use of water includes water recycling.[52] *The Water Management Act* 2000 (NSW) goes further than other States in implementing the ARMCANZ and ANZECC *Ecosystem Principles*[53] in its objects clause. Its objects clause emphasises long term sustainable management rather than consumptive use, and refers specifically to protection, enhancement and restoration of water sources, their associated ecosystems, ecological processes, biological diversity and water quality.[54] In particular management principles for water sharing state unequivocally that:

(a) the sharing of water ... must protect the water source and its dependent ecosystems; and

(b) ....the basic landholder rights of owners of land; and

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[51] *Water Act* 2000 (Qld) ss 10,11; *Water Management Act* 2000 (NSW) s 3.

[52] *Water Act* 2000 (Qld) s 10(3).

[53] See note 42.

[54] *Water Management Act* 2000 (NSW) s 3.

(c) sharing or extraction of water under any other right must not prejudice the principles set out in paragraphs (a) and (b).[55]

Basic landholder rights are defined to include domestic and stock rights,[56] harvestable rights[57] and native title rights.[58] Water for other consumptive use, for example for irrigated agriculture, is provided through access licences.[59] These management principles provide a *clear priority for water sharing* between consumptive and non-consumptive use.[60]

In NSW, water management principles state that water sources, floodplains and dependent ecosystems (including groundwater and wetlands) should be protected and restored and, where possible, land should not be degraded.[61] General provisions regarding access licences apply to groundwater as it applies to surface water.[62] The licensing model is based on a 10 year planning process.[63] These licences are linked to a share component and/or an extraction component established after the planning process.[64] The licences are subject to water management plans based on a 10 year period and a review of the plan after 5 years.[65] Management committees are

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[55] *Water Management Act* 2000 (NSW) s 5(3).

[56] *Water Management Act* 2000 (NSW) s 52.

[57] *Water Management Act* 2000 (NSW) s 53.

[58] *Water Management Act* 2000 (NSW) s 55.

[59] *Water Management Act* 2000 (NSW) s 56.

[60] *Water Management Act* 2000 (NSW) s 5(3).

[61] *Water Management Act* 2000 (NSW) s 5(2).

[62] *Water Management Act* 2000 (NSW) s 56.

[63] The new Act uses the word 'rights' only in reference to state and basic landholder rights. All other users obtain 'licences', denoting that their interests, although tradable, are ranked lower than the two rights. Generally licences are issued for a period of 15 years: *Water Management Act* 2000 (NSW) s 69(1)(a). However local and major water utility access licences are issued for 20 years and regulated river (supplementary water) access licences are issued for the term of the associated access licence: ss 69(1)(b) and (c) and 70.

[64] *Water Management Act* 2000 (NSW) s 56(5).

[65] *Water Management Act* 2000 (NSW) s 43.

established in each declared area to carry out specific planning tasks, for example preparing a draft plan for water sharing. Public consultation of draft plans is mandatory.[66] Around 36 water sharing plans have been prepared for NSW's surface and ground waters in areas 'constituted' under s 11 by order of the Minister. About nine of these relate to groundwater resources. In the making of such management plans a range of state policies are applicable, and plans must be consistent with all the groundwater policies referred to in the Act.[67]

The only specific provisions regarding aquifers and groundwater appear in Chapter 2 Division 6 of the Act. All groundwater management plans *must* deal with identification of 'controlled activity' or any aquifer interference causing impacts including cumulative impacts on water sources or their dependent ecosystems, and the extent of those impacts, and the specification of those activities which are to require approvals. The term 'controlled activity' is defined in such a way to refer mainly to activities that impact on surface water and has little relevance to groundwater. A groundwater management plan may deal with an additional list of matters including the undertaking of work for the purpose of restoring or rehabilitating a water source or dependent ecosystem, specific controls on activities causing unacceptable impact, the preservation and enhancement of quality of water in the area.[68]

Water legislation in SA requires sustainable management of water. Groundwater is governed by general water legislation. Generally a person has the right to take water from a well for domestic uses and watering stock. The general right does not apply if water is taken from a prescribed watercourse, lake or well.

The general right to take water is also subject to the provisions of any existing water plan. Provisions regarding planning are found in Part 7, *Water Resources Act* 1997 (SA). All plans must be consistent with State Water Plan.[69] The catchment water management boards then produce catchment water management plans (CWMPs) in relation to all water resources in the catchment area and also water allocation plans

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[66] *Water Management Act* 2000 (NSW) ss 38-9.

[67] *Water Management Act* 2000 (NSW) s 16.

[68] *Water Management Act* 2000 (NSW) s 33.

[69] *Water Resources Act* 1997 (SA) s 90.

(WAPs) for each prescribed water resource in the area. WAPs must include an assessment of quantity and quality of water needed by ecosystems. This provision with that of NSW, go further than those in the Queensland which does not provide for maintenance of quality of water.

Powers are given to the Minister to prohibit or restrict the taking of water or direct that dams or other structures be modified if in his or her opinion there is a risk that available water will not be sufficient to meet future demand, or the rate at which water is extracted is likely to affect the quality of the underground aquifer, or that it is likely to suffer any damage.[70] When determining the demands on available water, it is specifically provided that the water needs of ecosystems is to be taken into account.

Two borefields serving the Olympic Dam project and the town of Roxby Downs are Prescribed Well Areas under a management regime established under the *Roxby Downs (Indenture Ratification) Act* 1982 (SA). A Special Water Licence has been issued to the operator but this does not specify the maximum volume. Instead a maximum volume of extraction is currently set at 40 Ml/day determined through the environmental assessment process which was part of the development approval for the project.[71] The 1982 Act allows the Minister power to restrict the abstraction of water by notice if he or she has reason to believe that the current use is detrimental to the water resource or there is a reasonable possibility of a complete or partial failure of the resource. This management system is thus firstly based on a maximum extraction rate. Secondly, the system limits the extraction of water to a rate which will not reduce the potentiometric pressure by more than an agreed amount at the boundary of the Designated Area.[72] This limitation is imposed for a thirty year period from the date of licence.

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[70] *Water Resources Act* 1997 (SA) s 16.

[71] N Power, "Roxby Downs Indenture Arrangements for Water Management" GABFest, 10 March 2002, Toowoomba, http:www.gab.org.au/inforesources/downloads/gabfest/papers/power_n.pdf (29 March, 2004)

[72] Ibid. The pressure for the existing designated areas has been set at 5m, and a lower value of 2.2m was set for a more sensitive area near the Hermit Hill spring complex.

Despite the legislative power available and except for the Roxby Downs operations, up to 1998 none of the revisions or rewrites of the water legislation in SA have so far materially affected the management of the GAB in SA.[73] Wells within the GAB area were not prescribed until 2003. Without declaring the GAB areas as prescribed, no restriction of volume or rate of extraction could be imposed. In addition, it appears that it is unclear who owns most of the artesian and subartesian wells in SA.[74]

In addition to the *Water Resources Act* 1997 (SA), there are other pieces of water legislation that relate to groundwater but do not impact on the GAB. The first is the *Groundwater (Border Agreement) Act* 1985 (SA) which relates to the joint management of bores by SA and Victoria in a designated area bordering the two states. More important is the *River Murray Act* 2003 (SA) passed as part of the SA's government's election promise to improve the state of the river. It has not yet received assent. It specifically seeks to integrate river protection into some 22 other SA Acts. The new Act creates a new 'duty of care,' a duty not to harm the river through one's actions, and the creation of a referral mechanism that requires the referral of proposed statutory planning instruments and many types of applications (for licences, etc) made under other Acts to the Minister for the River Murray.[75] This Act does not appear to have implications for the GAB. Neither does the *Groundwater (Qualco-Sunlands) Control Act* 2000 (SA) which aims to reduce the risk of waterlogging, salinisation of land and increased levels of salinity in the River Murray from irrigation in the specific area. It is apparent that policy and legislative attention in SA is very much directed towards the River Murray.

In Queensland, all water including groundwater is vested in the State. The *Water Act* 2000 (Qld) authorises the Minister to prepare a WRP for groundwater. Where there is a risk that the taking of groundwater may significantly affect the availability of existing water entitlements in the area, or the water requirements of natural ecosystems or the quality of water, then any WRP is required to regulate the taking of

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[73] GABCC, 1998 note 2.

[74] GABCC, 1998 note 2.

[75] See analysis by M Dyson, "The South Australian River Murray Act 2003" (Paper presented at 5th Australasian Natural Resources Law and Policy Conference, Melbourne, 27-28 November 2003).

subartesian water.[76] There is limited express reference to artesian and subartesian water, and its extraction is governed by the general provisions on the taking and use of water resources. The regulation of groundwater also occurs through the regulation of water bore drillers.[77]

There does not appear to be any specific resource plans for artesian water in Queensland. Artesian water in the Georgina - Diamantina catchment in far western Queensland is part of the GAB. The draft WRP for the Georgina - Diamantina catchment was released in late 2003. It deals with water courses, overland flows associated dams and weirs and subartesian water which is hydraulically linked to surface water within the plan area. It will be adopted under the Lake Eyre Intergovernmental Agreement signed in 2000 with South Australia and Northern Territory. However the WRP does not deal with artesian water which is expected to be dealt with in a separate process.[78]

For subartesian water, the *Water Regulation* 2002 (Qld) provides that a licence is required to take or intefere with the resource in declared areas.[79] The general exception is where water is used for stock and domestic purposes. Other than for these purposes, works constructed or installed to take subartesian water in declared areas are generally assessable development under the *Integrated Planning Act* 1997 (Qld). For subartesian areas that are defined in water resource plans, the area-specific water licencing and development permit requirements apply. At any one time there may be two plans for a geographical area of Queensland - one a general water resource plan in relation to surface water and the other a water resource plan for artesian water and subartesian water and springs which are connected to artesian water.

Subartesian water resource planning appears to be somewhat of an afterthought. Take for example the WRP for the Pioneer Valley near MacKay which was concluded in December 2002. In June 2003, the Minister announced that since the region's surface

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[76] *Water Act* 2000 (Qld) s 38(5).

[77] *Water Act* 2000 (Qld) Chapter 2 Part 10.

[78] Department of Natural Resources and Mines, Queensland, *Georgina-Diamantina Water Resources Planning*, http://www.nrm.qld.gov.au/wrp/georgina_diamantina.html (7 April, 2004).

[79] *Water Regulation* 2002 (Qld) Sched 11.

and groundwater resources were closely interconnected it made sense to include these underground resources in the same management framework. Only then were groundwater-related environmental flow issues considered during a proposed extension of the Pioneer Valley Water Resources Plan.[80] A similar announcement was made regarding subartesian water in the Bundaberg area which has long been notorious for groundwater problems. A WRP for the area commenced in 2000.[81] A moratorium on drilling bores was not declared until late 2003 and later amendments would be made to the the relevant WRP.[82] Although not within the GAB, these examples serves to show that in Queensland even where groundwater issues are serious, surface water issues take priority.

The incidental extraction of water during coal seam gas mining is yet another issue which is relevant in Queensland. Coal seam gas refers to a mixture of gaseous hydrocarbons found in coal seams.[83] Its mining is seen as a growing industry in Queensland. Currently it is produced at Bowen and there are proposals to establish mining in the Surat Basin of the GAB. [84] At present exploration is carried out under two different regulatory regimes – the *Petroleum Act* 1923 (Qld) and *Mineral Resources Act* 1989 (Qld). A sizeable amount of water is extracted during the mining, but there is almost no certainty about volume and rates of extraction because of the special characteristics of each seam. Draft legislation is being prepared to streamline regulation of the industry within the petroleum regime, to licence the extraction of water bearing in mind the impact of activities on existing water entitlements. This is

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[80] Department of Natural Resources and Mines, Queensland, Media Release dated 30 July 2003, http://statements.cabinet.qld.gov.au/cgi-bin/display-statement.pl?id=13637&db=media_prev_beattie_2 (7 April, 2004).

[81] *Water Resource (Burnett Basin) Plan* 2000 (Qld) commenced on 15 December 2000.

[82] Department of Natural Resources and Mines, Queensland, Media Release, 3 October 2003, http://statements.cabinet.qld.gov.au/cgi-bin/display-statement.pl?id=14657&db=media_prev_beattie_2 (7 April, 2004).

[83] Department of Natural Resources and Mines, Queensland, "A New Coal Seam Gas Regime for Queensland" <http://www.nrm.qld.gov.au/mines/pdf/coalgas_paper.pdf> (8 April, 2004).

[84] Department of Natural Resources and Mines, Queensland (2004), "Queensland Coal Seam Gas Facts", <http://www.nrm.qld.gov.au/factsheets/pdf/mines/M3.pdf> (8 April, 2004).

commendable. However given the uncertainty over volume and rates of water extracted, and how to define sustainability in relation to the GAB, questions remain unanswered over the sustainable use and effects on the environment as a result of the proposed licensing of water in coal seam gas extraction.

5. The GAB and the MDB

It is impossible to avoid comparisons between the issues arising in the management of the Great Artesian Basin and of the Murray-Darling Basin. To begin with, there is, to some extent a physical interaction between the two problems. The need for integrated management of groundwater and surface water has become apparent in the Murray-Darling Basin, and the Darling catchment overlaps with the GAB.

More importantly perhaps, the same group of policy makers is involved in both problems and the same sets of ideas are likely to be applied. Given the greater economic importance and higher policy profile of the Murray-Darling Basin, it is natural to expect an extension of policy and management ideas from the Murray-Darling to the GAB.

Such an extension of policy ideas raises two possible sources of policy error. First, policy mistakes may be repeated. Second, policies that are appropriate in one context may be inappropriate in another.

The most significant policy problem in the recent management of the Murray-Darling has arisen from the conversion of a wide variety of rights to use water into tradeable and semi-permanent water rights. By enhancing the durability and security of rights, the effect was to exacerbate existing problems of overallocation. This was most evident in the case of 'sleepers', that is, rights to use water, normally attached to particular parcels of land, that had never been exercised. By separating water rights from land ownership, and making them tradeable, the demand for water associated with such rights was increased.

The most important lesson for the GAB is that substantial reductions in actual and potential extraction rights should precede, not follow, the introduction of secure, well-defined and tradeable rights. Ideally, the aggregate quantity of extraction rights should be made consistent with an appropriate concept of sustainable use, and trade among

users should allocate these rights to their highest-value uses. Compensation is not available on legal grounds where allocations under current licences are adjusted or restricted.[85] Any payment for structural adjustments, for those deprived of existing rights should be based on actual use values rather than the sale values potentially created by the introduction of markets for extraction rights.

5.1 Sustainable management

The right to the use and flow of water in artesian water was vested in the States in Queensland since 1910, in NSW to all of groundwater in 1966 and in SA in 1960. Even prior to the 'vesting' of the use and flow of artesian water, States had power to regulate use under its general power to make laws for the peace, welfare and good government of the State. Whether 'vesting' took place earlier or later, and regardless of power to terminate licences because of undue depletion of supply, there was little attempt to exercise legislative and administrative powers to curb the wastage of groundwater. In Queensland especially, despite sober reminders of the dangers of wastage, a complacent attitude was adopted. Domestic and stock uses received priority and wastage not was seen as a threat to the future of the pastoral industry. The giving of control over natural resources is seen as State guardianship of the resource for social purposes. This was the finding of the High Court in *Yanner v Eaton*[86] regarding fauna in Queensland. There is ample evidence to suggest that the same broad objective applied to groundwater. In the era before ecological considerations were recognised, the main social purposes would have been the avoidance of waste and the conservation of dwindling groundwater.

Definition of ESD

Since the formulation of the National Strategy of Ecologically Sustainable Development (NSESD) and the Intergovernmental Agreement on the Environment

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[85] PL Tan, "Water licences and property rights: the legal principles for compensation in Queensland", Nov 1999 *Water*, 34-36.

[86] (1999) 73 ALJR 1518.

(IGAE) in 1992, core objectives and principles of ESD have been generally accepted by Federal and State government although there are variations in definitions adopted in legislation. The three core objectives of ESD are -

- to enhance individual and community well-being and welfare by following a path of economic development that safeguards the welfare of future generations.
- to provide for equity within and between generations.
- to provide biological diversity and maintain essential ecological processes and life-support systems.

In achieving the core objectives the following guiding principles are adopted -

- Decision-making processes should effectively integrate both long and short-term economic, environmental, social and equity considerations.
- 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.
- The need to develop a strong, growing and diversified economy which can enhance the capacity for environmental protection should be recognised.
- Decisions and actions should provide for broad community involvement on issues that affect them.

Groundwater mining, where the rate of extraction exceeds the rate of discharge, is occurring in the GAB. With serious depletion of the resource becoming obvious through many artesian bores ceasing to flow, spring flows declining and drying up, use by the present generation is prejudicing use by future generations. Intergenerational equity requires groundwater mining to stop. How this is done is a challenge for groundwater management.

In addition, the protection of biological diversity is critical. The SOE Report 2001 stated that the loss of biological diversity is perhaps Australia's most serious environmental problem. It was noted earlier in this article that open bore drains, drying up of mound springs, contamination of groundwater aquifers have deleterious impact on biological diversity.

A recent inquiry into land management found that the incorporation of ecological

sustainability into policy has been ad hoc, incomplete and tentative. The central problem was identified as the failure of Australian governments to put in place 'comprehensive, integrated and far-sighted ways of promoting the ecologically sustainable management of natural resources'.[87] Another recent inquiry into the implementation of ESD by Commonwealth agencies came to similar conclusions.[88] Typically, financial costs and benefits were clearly identified in decision-making processes, but environmental and social costs and benefits were less clear and more difficult to take into account. There were general concerns about poor implementation of policy, especially for water resources because of the complicated nature of the use of the resource. From the recent experience with water resource planning in Queensland, one sees that these comments apply particularly to groundwater.

5.2 Difficulty with implementation

Although legislation and policy statements make frequent reference to 'sustainability' and 'sustainable use', implementation of the concept is difficult in respect to the GAB and indeed all groundwater resources. Consider the concept of sustainability that was adopted for NSW aquifers in the 1990s. The example does not directly relate to the GAB but illustrates how difficult it is to achieve an agreed nationally consistent definition and approach to sustainable yield.

Allocation guidelines were adopted in NSW on the basis that a third of the aquifer could be extracted over 30 years, and that a proportion of the extracted volume would recharge over this period. For example, in 1991 the ceiling for use in the Lower Lachlan was set at 330,000 ML per year. The Lower Lachlan is an area which stretches westwards from Lake Cargelligo to Ivanhoe and southwest to Booligal,

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[87] Industry Commission *A Full Repairing Lease: Inquiry into Ecologically Sustainable Land Management*, Report No 60, Canberra, 1998.

[88] Productivity Commission, *Implementation of Ecologically Sustainable Development by Commonwealth Departments and Agencies*, Canberra, Ausinfo, 2000.

covering the Hillston area.[89] Yet just six years later, policy makers redefined sustainable yield to mean that proportion of the long term average annual recharge which could be extracted each year without causing unacceptable impacts on the environment or groundwater users.[90] Thus defined, sustainable yield in 1997 amounted to between 105,000 and 150,000 ML/year, about *half* of the previous limit. With current allocation about 234,380 ML/year, groundwater is substantially overallocated, and the Lower Lachlan aquifer is now regarded as high risk.[91] The one redeeming feature of groundwater management is that the NSW Department of Land and Water Conservation adopted an informal timetable for reviewing groundwater allocation policy every 5 years.

Many of the issues commonly discussed in terms of sustainability may also usefully be considered in other analytical frameworks based on concepts such as property rights and externalities.[92]

In relation to the GAB, it is useful to begin with the observation that, prior to the beginning of extraction, the Basin was in a state of equilibrium with recharges along the Great Dividing Range being matched by discharges through springs and soaks. A definition of sustainability that required the maintenance of pre-existing discharges would imply a requirement for zero discharges.

A more plausible definition of sustainable use is one that requires extractions and natural discharges to be matched by recharge, so that the total volume in aquifers remains unchanged. There are several difficulties with this definition.

First, on most views of sustainability, it would be necessary to maintain natural discharges in sensitive environments. This would require side constraints.

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[89] Department of Land and Water Conservation, NSW, *Lower Lachlan Groundwater Management Area 012, Status report*, unpublished paper, 1999.

[90] Department of Land and Water Conservation, *NSW State Groundwater Policy Framework*, DLWC, Sydney, 1997.

[91] Department of Land and Water Conservation, NSW, *Lower Lachlan Groundwater Management Area 012, Status report*, unpublished paper, 1999.

[92] J Quiggin, "Environmental Economics and the Murray-Darling river system", (2001) 45 (1) *Australian Journal of Agricultural and Resource Economics*, 67-94.

Second, even if the sustainability requirement is met in adequate, individual aquifers may be depleted. Again, this might require the imposition of constraints at the local level.

Third, this definition of sustainability would require substantial reductions in extractions. Under plausible arguments about future improvements in technology, the result would be to reduce welfare for the current generation of users without a comparable improvement in the welfare of future generations. Unless the maintenance of existing water levels in the aquifer is considered desirable in itself (and it is difficult to justify such an objective in any widely-accepted ethical framework) such a policy will not be optimal.

The most plausible sustainability constraint for the GAB as a whole is that the flow of services from the basin should be maintained over time. This is consistent with a gradual decline in the volume of water in the aquifer, and in the rate of extraction, provided that the technical efficiency of extraction and water use is increasing over time.

This classification suggests the need for concepts of sustainable use to be applied at both local and global levels. Controls on aggregate use can be implemented through a system of tradeable extraction rights. However, the specification of rights and the structure of markets will be complicated by the need to ensure sustainable use of individual local aquifers. This means, for example, that the transfer of rights from lightly-used to heavily-used aquifers must be constrained.

5.3 Precautionary principle

One principle of ESD is of particular relevance – the precautionary principle. This principle was a response to the recognition that the environment could not assimilate the consequences of all the activities impacting on it, and that science and the scientific method had limitations. It was therefore unlikely that the full impact of a particular act upon the environment could be known in advance. Thus, a combination of the forces of inherent uncertainty, risk of bias in scientific methods, and perennial lack of resources and lack of data to assist scientists led to the formulation of the two limbs of the precautionary principle. The IGAE entered into by all Australian states in

1992 provides that the two limbs of the principle are that private and public decisions should be guided by -

(i) careful evaluation to avoid wherever practicable, serious or irreversible damage to the environment; and

(ii) an assessment of the risk-weighted consequences of various options.

The term "risk-weighted consequences" refers to "an attempt to undertake a semi-quantitative analysis, and determine the likelihood of irreparable damage or an undesired or adverse outcome arising from a particular development or activity".[93]

One of the first applications of the precautionary principle in Australia by the courts was in *Leatch v National Parks and Wildlife Service*[94] a case regarding land development. Justice Stein of the NSW Planning and Environment Court refused a licence to take or kill endangered fauna. The precautionary principle applied although the legislation under which the licence was sought did not specifically refer to it. Further, he held that the principle required consideration of options with the protection of the environment being of primary importance. Alternative actions should have been considered by the New South Wales Parks and Wildlife Services and these had been discarded too early in the decision process. A number of cases have since applied the principle in wide-ranging situations but there has been some inconsistency and uncertainty in its application.[95]

In 1999 the Full Court of the Environment, Resources and Development Court (ERDC) in SA accepted that the precautionary principle was relevant in a consideration whether a development would be ecologically sustainable. In three cases (the Tuna Boat Owners cases) regarding the building of infrastructure for tuna farms, the ERDC had to consider whether the proposal was consistent with the

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[93] Ecologically Sustainable Development Steering Committee, *Draft National Strategy for Ecologically Sustainable Development: A Discussion Paper*, AGPS, Canberra, 1992.

[94] (1993) 81 LGERA 270.

[95] E Fisher, and R Harding, "The Precautionary Principle in Australia: From Aspiration to Practice?" in T O'Riordan, J Cameron and A Jordan, *Reinterpreting the Precautionary Principle,* Cameron May, London, 2001.

Development Plan for Louth Bay area in Spencer Gulf, SA: *Conservation Council of SA v Development Assessment Commission and Tuna Boat Owners Association of SA*.[96]

One of the objectives of the Plan provided that marine aquaculture development should be carried out in an 'ecologically sustainable way'. The ERDC accepted the SA Conservation Council's argument in determining whether development fulfilled this criteria, the precautionary principle should apply. This was because SA was party to the National Strategy for ESD and IGAE, and had a version of the precautionary principle in the *Environmental Protection Act* 1993 (SA).

More recently the precautionary principle was applied in *Murrumbidgee Groundwater Preservation Association v Minister for Natural Resources*.[97] Water users challenged the water sharing plan for the Lower Murrumbidgee Groundwater Sources 2003 (the Plan) made by the Minister under s 50 of the *Water Management Act* 2000 (NSW). The Lower Murrumbidgee Groundwater Management Area (LMGMA) subject to the plan comprised two groundwater sources commonly referred to as (1) the Shepparton and (2) the Calivil and Renmark source. Significant salinity problems were apparent in some parts of the Area. Water users gave evidence that during the earlier part of the 1990s water managers had encouraged farmers to take water from deep groundwater sources with the aim of lowering the water table. This was seen as a suitable measure for reducing the salt content of the water at or near the surface and commonly referred to as a 'controlled groundwater depletion policy'. The policy has since been discontinued but, with other factors, it led to an over-allocation of the groundwater aquifer.

The Plan treated the two groundwater sources as one area, although the users' expert evidence pointed that recharge was site specific and its occurrence was highly variable. Yield therefore was not equally distributed throughout the LMGMA. The Plan implemented a policy of uniform reduction of all existing entitlements, and this was discussed earlier. In some areas groundwater levels were not in danger of declining, but entitlements in these areas were still subject to reductions. Nonetheless

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[96] [1999] SAERDC 86 (16 December 1999).

[97] [2004] NSWLEC 122 at [197] to [200].

the court accepted that in the long term the plan was dealing with one large groundwater system, and that the sources were interconnected even though little was known about the degree of connection between the different parts of the groundwater system.

Another argument before the Land and Environment Court was that the Plan failed to maximise the social and economic benefits to the community. Uniform reductions, it was argued would mean that existing users which had installed pumps and developed their land and businesses would need to buy water entitlements from those who held entitlements which they did not or could not use. The outcome of the plan, so the users argued, would mean windfall gains to some and financial hardship to others, with discordant social and economic outcomes.[98]

Relying on well established principles of administrative law, McClellan CJ ruled that a Minister's decision to make a plan could only be overturned if it were unreasonable or irrational when assessed against objective criteria, in other words that the relevant decision must be incapable of justification.[99] In deciding that the Minister's decision was not irrational, the Court took into consideration several matters:

- the precautionary principle, adopted in the *Water Management Act* 2000 (NSW) and numerous other NSW statutes,[100] that required a regime to be put in place which was likely to sustain the water source even if, as was the case, full scientific knowledge of the structure and behaviour of the aquifer was not available;
- that the Minister's ultimate duty was to the long term sustainability of groundwater;[101]
- and by providing a limited access to other sources of water for those who would suffer financial hardship through the operation of the Plan, the Minister

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[98] Ibid, at [143] to [147].

[99] Ibid at [[156] to [171]. The well-established principles are found in *Associatied Provincial Picture Houses v Wednesbury Corporation* [1948] 1 KB 233, *Minister for Aboriginal Affairs v Peko Wallsend Ltd* (1986) 162 CLR 24 and other cases cited in McClellan CJ's decision.

[100] Ibid [175] to [178]

[101] Ibid at [186].

had allowed for a period of adjustment and achieved the objectives of the *Water Management Act* 2000 (NSW).

The complexity of the facts in the case, lack of scientific knowledge, and the impenetrable language used in the plan, illustrate the difficult nature of groundwater management. In the context of development decisions where the precautionary principle has mostly been applied, Australian courts require that those opposing development have to show that there is a prospect of serious or irreversible damage to the environment should the proposed development proceed. When the opponents are able to establish the threshold criterion, the *onus of proof* switches to the proponents. They would need to provide evidence that that the two limbs of the principle have been satisfied. The proponents would have to satisfy the court of 'the likely consequences of the proposal, including scientific evidence (with its limitations) as to the proposed management regime and measures that will be taken (within limits of practicability) to avoid serious or irreversible damage to the environment'. Further, evidence to assist the Court in the assessment of risk-weighted consequences of the proposal will also be required of the proponents.

In civil proceedings the usual standard is that of the balance of probabilities.[102] Legislation in all states provides that the court in deciding whether it is so satisfied may take into account a variety of matters including the nature of the cause of action, the nature of the subject-matter of the proceeding and the gravity of the matters alleged. In *Briginshaw v Briginshaw* the High Court held that

> "… when the law requires the proof of any fact, the tribunal must feel an actual persuasion of its occurrence or existence before it can be found. It cannot be found as a result of mere mechanical comparison of probabilities independently of any belief in its reality… 'reasonable satisfaction' should not be produced by inexact proofs, indefinite testimony, or indirect inferences."[103]

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[102] L De Plevitz, "The *Briginshaw* 'Standard of Proof' in Anti-Discrimination Law: 'Pointing with a Wavering Finger'", (2003) 27 *Melbourne University Law Review,* 308; CR Williams, "Burdens and Standards in Civil Litigation", [2003] *Sydney Law Review,* 9.

[103] *Briginshaw v Briginshaw* (1938) 60 CLR 336 per Dixon J at 361-362.

In deciding whether the proponent has discharged the onus of proving the two limbs of the precautionary principle have been satisfied, courts should be satisfied with the quality of the evidence relied on by the proponent. Economic analysis supports this argument.[104] Consideration of risky innovations should be held to a more stringent standard than that they are shown to be optimal by a (necessarily incomplete) decision-theoretic analysis. This claim is based on the 'incompleteness metahypothesis', namely that estimates of project outcomes derived from formal models of choice under uncertainty are inherently incomplete. Incomplete estimates will generally be overoptimistic and that the errors will be greater, the less well the problem in question is understood. Therefore incompleteness, and the associated bias towards poorly-understood options affects all formal decision procedures, from the commonplace 'best projection' approach to more sophisticated expected-utility analysis.

In public decisions where there is no specific proponent, it is arguable that if the decision is challenged, the responsibility lies on the public authority to satisfy the court that any decision taken is ecologically sustainable. With groundwater pollution and depletion having the great potential of irreversible harm, states should not be waiting for scientific certainty to delay taking action. In addition government authorities when making any public decision should be guided by careful evaluation of the consequences of various options.

As all of the States comprising the GAB have adopted the precautionary principle in state legislation regarding water resources, both private and public decisions should be guided by careful evaluation to avoid wherever practicable, serious or irreversible damage to the environment. In public matters the principle has been extended to require more than just the shifting of the onus of proof. Where governments have been 'vested' control over use and flow of groundwater, their guardianship function would justify a strong precautionary approach being reflected in policy and legislation.

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[104] J Quiggin, "The incompleteness hypothesis and the precautionary principle", (Paper presented at the 48th Annual Conference of the Australian Agricultural and Resource Economics Society, Melbourne, 10-13 February 2004).

5.4 Allocation of entitlements and provision of water for ecosystems

Concern about the relationship between groundwater resources and natural ecosystems was relatively slow to develop. For most of its history, the GAB was viewed as a source of water for extractive use and the main concern was that of conserving the resource to maintain its value into the future. It has increasingly been recognised, however, that extraction of groundwater may reduce flows to natural ecosystems, notably through springs and soaks.

Drawing on the analogy with the Murray-Darling Basin it seems likely that the response to these concerns will have two main components. The first, already being implemented, is the general policy of reducing losses through open drains, uncapped bores and the like. Concern about ecosystem impacts may help to justify such policies even when an analysis of market costs and benefits suggests that investments designed to reduce wasteful use of water may have a negative net present value.

The second possible approach is the identification of a limited number of specific sites seen as having high ecosystem value and the development of management strategies for those sites, incorporating allocations of groundwater that would otherwise be taken for extractive purposes.

5.5 Trading and markets

In theory water reform measures apply to groundwater but hardly any of these measures have been specifically formulated for the resource. These reform measures introduce markets in water resources. Trading is envisaged in groundwater. Yet market issues like externalities, third party effects have not been explored in any depth. A recent report on rights-markets to manage diffuse groundwater pollution for example tradeable emission rights does not even address actual trade in groundwater.[105]

Developments in the Murray-Darling system suggest that reliance on trade in extraction rights as the primary mechanism for achieving an efficient and sustainable

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[105] MD Young and R Evans, *Right opportunity: using right markets to manage diffuse groundwater pollution,* LWRDC Occasional paper 19/97, Canberra, 1998.

allocation of resources is likely to prove problematic. Although there is an active market in temporary trades in water rights, that is transfers for a single season, permanent transfers of water have been much more limited.

In particular, market processes have so far done little to promote the transfer of water use from areas where irrigation has large adverse environmental effects to areas where adverse effects are limited. An experimental market allowing interstate trade in water rights produced only very modest transfers of rights to South Australia from upstream States, which would normally be expected to be environmentally beneficial.[106]

It seems likely that an appropriate reallocation of water rights between catchments and between States will require the introduction of public or quasi-public intermediaries at the catchment or State level. These intermediaries would negotiate transfers of water at the catchment level, including arrangements for restructuring of irrigation systems and joint responses to environmental problems. The transfers would be undertaken by the intermediaries through purchases in one catchment and sales in another. Thus, the solution will involve a mixture of bottom-up and top-down approach.[107]

Constraints on aggregate extractions, designed to ensure sustainable use, may be seen as a response to the existence of intertemporal externalities, as extractions by current generations reduce the availability of water for future generations. Interactions between current users are comparable in importance and considerably more complex. To simplify the discussion, at the risk of over-simplification, it is useful to characterize interaction effects as either local or basin-wide interaction effects. Extraction of water from an individual well may be seen as affecting both the characteristics of the local aquifer from which it is drawn, such as water pressure, and the volume of water available in the basin as a whole. Hence, there is a direct externality effect on water users sharing the same aquifer as well as a global effect on the volume of water held in the basin.

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[106] L Crase, L O'Reilly. and B Dollery, 'Water markets as a vehicle for water reform: the case of New South Wales', (2000) 44(2), *Australian Journal of Agricultural and Resource Economics*, 299-322.

[107] See Quiggin 2004 note 104.

In view of the complexity of environmental issues in the Great Artesian Basin, and the limited capacity for physical transfer of water, it seems unlikely that implementation of a plan for sustainable usage of the artesian water resources can be based primarily on trade in marketable rights. It will probably be necessary to adopt a mixture of market-based and administrative arrangements.

5.6 Implementation of SMP, Audit and Reporting

Some of the lessons that the GABCC may learn from the MDBCC would be in the area of public auditing and reporting. It was noted earlier that the GAB Strategic Management Plan (SMP) has set for itself a 15 year timeframe for achieving its targets. Targets within the first 5 years of the SMP which must be met by 2005 include:

- 30% of bore drains will be replaced and 30% of bores rehabilitated;
- indigenous interests in the Basin should have been identified and integrated into the management and planning process where appropriate;
- no net loss of natural groundwater dependent ecosystems would have occurred; and
- water entitlement systems should be in place including water for the environment.

Since the audit of 1994 which led to the MDBC Cap on water extractions, the MDBCC has issued yearly audits of the Cap. Information from the MDBC on water management is readily available to the general public, whereas information is not as well managed for the GABCC. While there do not appear to be any official audits of the GAB activities, a recent report prepared for the federal agency Agriculture, Fisheries and Forestry – Australia shows that progress in capping and piping still remains to be made especially in Queensland where an estimated 567 bores still need to be rehabilitated, capped and piped.[108]

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[108] Centre for International Economics and Resource Policy & Management, *Farm costs, benefits and risks from bore capping and piping in the GAB: Consultant's Report,* CIE, Canberra and Sydney, 2003.

6. Concluding comments

From the rise of public concern about environmental and resource issues until the late 1980s attention was focused primarily on localised pollution problems and on the preservation of specific sites of recreational, aesthetic or ecological value. Attention has now shifted to more diffuse and intractable problems involving the degradation of resource systems spread over large areas. Australian examples include the Murray-Darling Basin and the Great Barrier Reef. The most prominent global example is that of climate change due to the release of greenhouse gases as a result of human activity.

The management of the Great Artesian Basin is a problem of this kind. It was realised as early as 1908 that a cooperative approach was need to manage the resources of the GAB. A call for uniform legislation across the States was made in 1912. Delays occurred over reform because of the usual interstate tensions, and because States argued over causes of dwindling supply in 1954. In the 1980s the *Water 2000* report confirmed that management of groundwater suffered from a lack of understanding of the resource from quantity and quality perspectives. Although the economic significance of the GAB is modest by comparison with that of the surface water resources of the Murray-Darling Basin, its management raises many of the same issues and challenges. The complexity of the groundwater resource tends to make its management an afterthought.

In formulating policy for the management of the GAB, it will be useful to draw on the experience of the Murray-Darling Basin. A particularly important lesson is that tradeable property rights should be viewed as a management tool rather than a panacea. In the absence of sufficient knowledge to ensure that the aggregate volume of property rights and the conditions on trade are consistent with local and global sustainability, the property-rights approach can do more harm than good.

Sustainable management of the GAB will require intervention at many different levels, from remediation of individual sites to the Basin as a whole. There is a corresponding need for a range of policy instruments, including both market-based instruments and regulatory controls.

Past policy instruments have been based on theories which now have now been discredited. For example the controlled groundwater depletion policy in NSW in the

1980s has now been abandoned, similarly the elastic storage theory popular in Queensland in the 1940s and 50s. However if we look further back in time, we see that Henderson and Jack, Queensland pioneers of the 1900s, took a sober and cautious approach to development of artesian water. Unfortunately their foresight was not supported by politicians of the day. In the new millennium, policymakers and politicians are legally obliged to adopt a precautionary and long-term approach to the management of groundwater. Let the spirit of Henderson and Jack live on!

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