16

WATER RESOURCES

This chapter is divided into two major parts—existing water resources in Australia and the management of these resources. The former provides information on such topics as the geographic background to water resources, surface and ground water supplies and use, and the drainage divisions in Australia. The latter summarises Australian and State assessment and management of water resources.

The information in this chapter is largely derived from the *1985 Review of Australia's Water Resources and Water Use* (published by the Department of Primary Industries and Energy for the Australian Water Resources Council, November 1987, and available from AGPS bookshops).

For information concerning general, descriptive and historical matter *see Year Book* No. 37, pages 1,096–1,141 and *Year Book* No. 51, pages 228–31.

Introduction

Rainfall, or the lack of it, is the most important single factor determining land use and rural production in Australia. Chapter 5, Physical Geography and Climate of Australia contains details on geographical and climatic features that determine the Australian water pattern. The scarcity of both surface and ground water resources, together with the low rates of precipitation which restrict agriculture (quite apart from economic factors), has led to extensive programs to regulate supplies by construction of dams, reservoirs, large tanks and other storages.

Geographic Background

General

Water resources are determined by rainfall, evaporation and physical features including soil, vegetation and geology. Chapter 5, Physical Geography and Climate of Australia, contains a detailed description of the climatic features of the country. A brief description of the landforms appears in *Year Book* No. 61, pages 25–27. In assessing Australia's water resources, dependability and quality of supply must be considered, as well as quantity.

Topography

The major topographical feature affecting the rainfall and drainage patterns in Australia is the absence of high mountain barriers. Australia's topographical features range from sloping tablelands and uplands along the east coast Main Divide, through the low plain and marked depression in the interior to the Great Western Plateau.

Drainage

Only one-third of the Australian land mass drains directly to the ocean, mainly on the coastal side of the Main Divide and inland with the Murray–Darling system. With the exception of the latter, most rivers draining to the ocean are comparatively short but account for the majority of the country's average annual discharge. Surface drainage is totally absent from some arid areas of low relief.

Climate

Australia's large area (7.7 million square kilometres) and latitudinal range (3,700 kilometres) have resulted in climatic conditions ranging from alpine to tropical. Two-thirds of the continent is arid or semi-arid, although good rainfalls (over 800 mm annually) occur in the northern monsoonal belt under the influence of the Australian–Asian monsoon, and along the eastern and southern highland regions under the influence of the great atmospheric depressions of the Southern Ocean. The effectiveness of the rainfall is greatly reduced by marked alternation of wet and dry seasons, unreliability from year to year, high temperatures and high potential evaporation.

Settlement

The availability of water resources controls, to a large degree, the possibility and density of settlement; this in turn, influences the quality of the water through production and disposal of waste. Most early settlements were established on the basis of reliable surface water supplies and, as a result, Australia's population is concentrated along the coast, mainly in the comparatively fertile, well-watered east, south-east and far south-west.

As settlement spread into the dry inland grazing country, the value of reliable supplies of underground water was realised. Observations of the disappearance of large quantities of the rainfall precipitated on the coastal ranges of eastern Australia eventually led to the discovery of the Great Artesian Basin which has become a major asset to the pastoral industry. Development, however, has not been without costs. Significant environmental degradation and deterioration in water quality are becoming evident.

For further information on the influence of water resources on the spread of settlement in Australia *see Year Book* No. 61, page 860.

In the text and tables below, water volume, usage and flow are shown in litres rather than in cubic metres as in earlier issues. Equivalence and terms used are:

(KL) Kilolitres= 1.00 x 10^3 litres (1 cubic metres)
(ML) Megalitres= 1.00 x 10^6 litres
(GL) Gigalitres= 1.00 x 10^9 litres
(TL) Teralitres= 1.00 x 101^2 litres

Surface Supplies

Distribution and volume

As described above, permanent rivers and streams flow in only a small part of the continent. The average annual discharge of Australian rivers has been recently assessed at 398 teralitres (TL) of which 100 TL is now estimated to be exploitable for use on a sustained yield basis. This is small in comparison with river flows on other continents. In addition, there is a pronounced concentration of runoff in the summer months in northern Australia while the southern part of the continent has a distinct, if somewhat less marked, winter maximum.

Variability of flow

Even in areas of high rainfall, large variability in flow means that, for local regional development, most streams must be regulated by surface storage. However, in many areas evaporation is so great that storage costs are high in terms of yield. Extreme floods also add greatly to the cost of water storage, because of the need for adequate spillway capacity.

Potential development

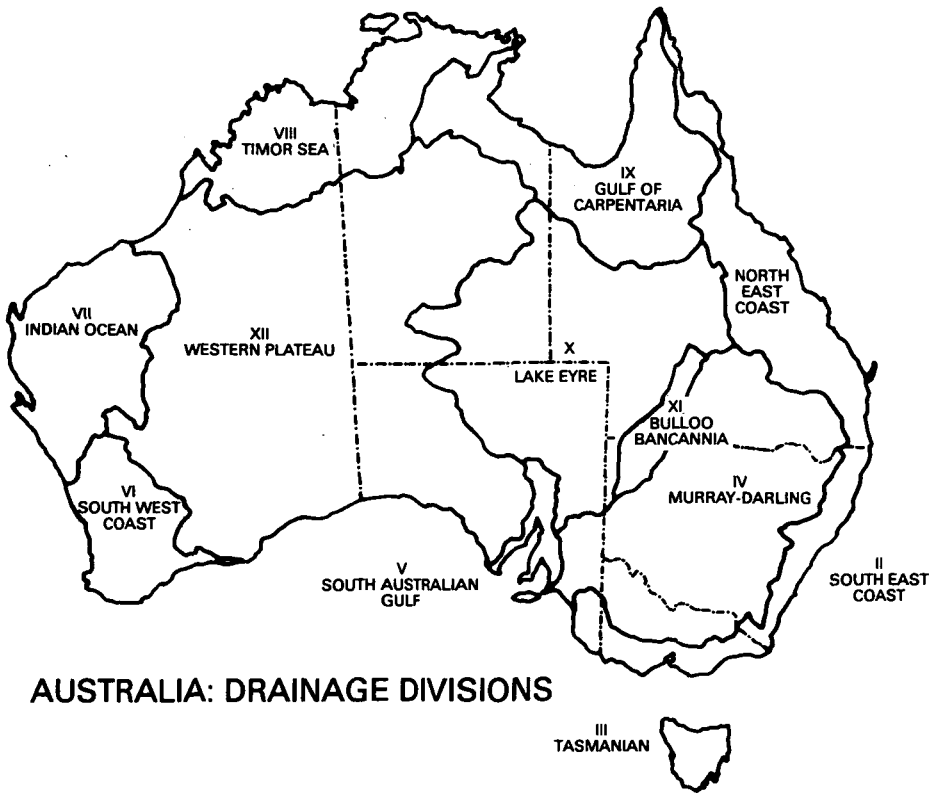
The portion of runoff able to be diverted for use is very low compared to other continents, and results from the high variability of streamflow, high rates of evaporation and the lack of storage sites on many catchments. On an Australia-wide basis, only 21.5 per cent of the divertible resource has currently been developed for use; much of the remaining resource is available in remote regions where development is impractical and uneconomic. In areas such as the Murray–Darling Division, where water is a scarce resource, there are few resources not yet developed, and management is focussing on greater efficiency in water use.

SURFACE WATER RESOURCES AND USE BY DRAINAGE DIVISIONS
(*Source*: **Australian Water Resources Council, 1987**)

		Surface water resources (teralitres per annum)				
Drainage division		*Mean annual runoff*	*Divertible resource*	*Developed resource*	*Use*	*Use as % of developed resource*
I	North-East Coast	83.9	22.9	3.5	0.97	28
II	South-East Coast	41.9	15.1	4.3	2.03	47
III	Tasmania	52.9	10.9	1.0	0.17	17
IV	Murray–Darling	24.3	12.4	10.0	8.05	81
V	South Australian Gulf	0.9	0.7	0.1	0.23	100 *
VI	South-West Coast	6.7	2.9	0.4	0.38	95
VII	Indian Ocean	4.0	0.3	—	0.00	0
VIII	Timor Sea	80.7	22.0	2.0	0.10	5
IX	Gulf of Carpentaria	92.5	13.2	0.1	0.12	100 *
X	Lake Eyre	6.3	0.2	—	0.01	33
XI	Bulloo–Bancannia	1.1	—	0.00	0.00	0
XII	Western Plateau	1.6	0.1	0.00	0.00	0
Australia		**398**	**100**	**21.5**	**12.06**	**56**

* Includes use of water from unregulated sources.

Drainage Divisions



AUSTRALIA: DRAINAGE DIVISIONS

Ground Water Supplies

About 80 per cent of Australia is significantly dependent on ground water supplies. Australia's estimated sustainable ground water yield is 14.4 TL, and annual ground water usage is estimated at about 2.2 TL.

Ground water is divided according to its occurrence in the three main classes of aquifer:

(i) **Shallow unconsolidated sediments** comprise alluvial sediments in river valleys, deltas and basins; aeolian (windblown) sediments which generally occur in coastal areas; and lacustrine (lake) sediments. These sediments are often highly permeable and porous. Permeability and porosity may vary markedly according to orientation. Unconsolidated aquifers of this group generally occur at depths of less than 150 metres and are often readily accessible to sources of water for recharge. Marked seasonal variations in water level are common.

(ii) **Sedimentary rocks** are generally made up of consolidated sediments. The aquifers owe their porosity to small voids between the grains which are often well compacted and cemented. They often cover significant areas, being continuous and of appreciable thickness. Rock strata usually dip quite gently. Nevertheless, over the full extent of the larger sedimentary basins, aquifers may reach great depths. Areas where recharge takes place may be small in relation to the extent of the aquifers. Water quality in individual aquifers may be quite good and fairly uniform over large areas. Some sediments contain a number of permeable and impermeable layers, creating a vertical sequence of separate aquifers, and water quality may vary greatly between them.

(iii) **Fractured rocks** comprise hard igneous and metamorphosed rocks which have been subjected to disturbance and deformation. Aquifers resulting from the weathering of any rock type are also included in this group. Water is transmitted mainly through joints, bedding planes, faults, caverns, solution cavities and other spaces in the rock mass. The quality of ground water varies considerably and sources are subject to pollution in much the same way as surface supplies. As a general rule, ground water from shallow unconsolidated sediments is of good quality but there are instances where ground water has been polluted, particularly around major urban centres, by sewerage effluent, drainage from refuse tips and from specific industrial pollutants. Supplies from sedimentary basins and fractured rocks are more variable in both quality and quantity, especially in the more arid regions of the continent. High nitrate concentrations tend to be a common occurrence in ground waters in northern and central Australia.

GROUND WATER ESTIMATES OF DIVERTIBLE RESOURCES AND ABSTRACTION BY DRAINAGE DIVISIONS
(Source: **Australian Water Resources Council, 1987)**

Drainage division		*Ground water (gigalitres per annum)*		*Abstraction as percentage of divertible ground water (%)*
		Total	*Abstraction during 1983–84*	
I	North-East Coast	2,010	586	29
II	South-East Coast	1,860	437	23
III	Tasmania	124	5	—
IV	Murray–Darling	2,160	501	—
V	South Australian Gulf	85	56	68
VI	South-West Coast	1,220	296	24
VII	Indian Ocean	508	52	10
VIII	Timor Sea	2,820	15	0.5
IX	Gulf of Carpentaria	1,930	95	5
X	Lake Eyre	619	172	31
XI	Bulloo–Bancannia	100	15	—
XII	Western Plateau	944	9	—
Australia		**14,400**	**2,240**	**15**

(a) The divertible ground water resource is the volume of water that can be withdrawn from an aquifer on a sustained basis without depleting the storage; however in practical operation of many ground water storages 'sustained basis' may mean about 30 years or so, rather than indefinitely.

Water Quality

The quality of surface water in Australia varies greatly and is controlled by climate, geology, stream flow rates, biological activity and land use. Most of the variability is related to water events such as storm flows, floods and drought. Water pollution is generally at a low level compared to other similarly developed countries. The great majority of Australians enjoy domestic, irrigation and recreational waters of good to excellent quality.

Very little is known of the water quality conditions which prevailed prior to European settlement and development in Australia. It is therefore difficult to judge the full impact of urban, agricultural, industrial and mining developments, and the effects that water resource development measures, such as large dams, have had on the quality of the resource. Levels of toxic pollutants have undoubtedly increased, as have the salt and sediment loads of the rivers. While water quality would, at times, have been poor prior to settlement, levels are believed to have generally declined. On the other hand, regulation of major rivers has reduced some of the impacts of floods and droughts.

An increasing appreciation of water quality in recent times has led to improved management. Measurable improvements in water quality over the last decade have resulted from pollution controls in industry and mining, and more effective sewerage treatment. Means of control of pollution from widespread agricultural activity such as problems of salinity and turbidity, are under development.

The major water quality issues and problems faced in Australia are salinity, turbidity, excessive plant and algal growths (eutrophication), and water treatment for small community water supplies. There is also a scarcity of data, information and research on some aspects of water quality and the protection of aquatic species and habitats. Many of the severe pollution problems found in other countries have been avoided in Australia, because of the general absence of highly polluting industries and the location of major cities on or near the coastline enabling ocean disposal of wastes.

Ground water is an important substitute for surface water in many parts of the country such as in the arid interior where the Great Artesian Basin provides the only reliable continuous supply of water for stock and domestic purposes. This Basin underlies 23 per cent of the continent but the high ratio of sodium to calcium and magnesium ions has an adverse effect on soil structure, rendering it impervious and generally unsuitable for irrigation.

Ground water is increasing in importance as a source of water for irrigation, industry and domestic supply.

Increasing use is made of conjunctive schemes, for example, where ground water supplies are tapped to augment surface water or where, as in the Burdekin Delta, ground water aquifers are artificially recharged during the summer wet season to enable water to be stored at low cost with negligible evaporation.

Water Use

Total water use or gross water consumed is the water supplied that is not returned to a stream or body of fresh water or diverted for use a second time. The total water use from 1 July 1983 to 30 June 1984 has been estimated to be 14,600 GL corresponding to an overall per capita use of 2,600 litres per day. Of this total, approximately 70 per cent was for irrigation, 21 per cent was for urban or industrial uses and 9 per cent was for other rural water use. Withdrawals for hydro-electric power have not been included. In terms of sources for the water used, by far the largest proportion (over 80 per cent) of water is drawn from surface water. Ground water sources, although of importance in some regions, account for only a minor percentage of the water used.

PURPOSES OF WATER USE
(Gigalitres)
(*Source*: Australian Water Resources Council, 1987)

	Irrigation				*Urban and industrial*					
Drainage division	*Pasture*	*Crops*	*Horti-culture*	*Total*	*Dom-estic*	*Indust-rial*	*Comm-ercial*	*Total*	*Rural*	*Total*
North-East Coast	71	803	92	966	353	147	41	542	149	1,660
South-East Coast	711	137	176	1,020	747	385	228	1,360	144	2,530
Tasmania	46	47	4	97	33	23	10	66	11	174
Murray–Darling	4,120	2,440	1,090	7,650	225	55	47	327	683	8,660
South Australian Gulf	28	2	45	76	141	24	34	198	38	312
South-west Coast	168	24	75	267	211	74	97	382	30	678
Indian Ocean	0.1	2	7	9	24	17	6	48	8	64
Timor Sea	20	46	5	70	23	13	6	42	16	128
Gulf of Carpentaria	17	45	13	74	15	38	4	57	113	244
Lake Eyre	—	3	—	4	10	4	5	9	113	135
Bulloo–Bancannia	0	0	0	0	—	—	0	—	18	18
Western Plateau	0	—	—	—	9	9	3	21	19	41
Australia	**5,180**	**3,550**	**1,510**	**10,340**	**1,790**	**790**	**481**	**3,060**	**1,340**	**14,600**

Major Dams and Reservoirs

A *Register of Large Dams in Australia* was published by the Australian National Committee on Large Dams in December 1982. The publication included, in chronological order, all large dams completed or under construction up to December 1982. In the list below, only dams with a gross reservoir capacity of more than 100 GL have been included. The list is based on the above publication and supplementary data for the latest years. A further edition of the Register of Large Dams in Australia is in preparation.

MAJOR DAMS AND RESERVOIRS IN AUSTRALIA

Name and year of completion	*Location*	*Gross capacity (gigalitres) (a)*	*Height of wall (metres) (b)*	*Purpose*
	NEW SOUTH WALES			
Eucumbene (1958)	Eucumbene River	4,798	116	H/E, IR, R, U
Hume (1936, 1961)	Murray River, near Albury	3,038	51	H/E, IR, R, U
Warragamba (1960)	Warragamba River	2,057	137	H/E, U
Menindee Lakes (1960)	Darling River, near Menindee	1,794	18	IR, R, U
Burrendong (1967)	Macquarie River, near Wellington	1,678	76	F/C, IR, R, U
Blowering (1968)	Tumut River	1,628	112	H/E, IR, R
Copeton (1976)	Gwydir River	1,364	113	IR, R, U
Wyangala (1936, 1971)	Lachlan River	1,220	85	IR, R
Burrinjuck (1927, 1956)	Murrumbidgee River	1,026	79	IR, R
Talbingo (1971)	Tumut River	921	162	H/E, IR,R,U
Glenbawn Dam (1958, 1987)	Hunter River, near Scone	870	100	F/C, IN, IR, R, U
Jindabyne (1967)	Snowy River	688	72	H/E, IR, R, U
Lake Victoria (1928)	Murray River, near S.A. border	680	—	IR, R, U
Keepit (1960)	Namoi River, near Tamworth	423	55	F/C, IR, U
Split Rock (1986)	Manilla River, Namoi Valley.	370	64	IR
Windamere (1984)	Cudgegong River, near Mudgee	368	69	IR
Glennies Creek (1983)	Hunter Valley, near Singleton	284	65	IN, IR, R, U
Tantangara (1960)	Murrumbidgee River	254	45	H/E, IR, R, U
Avon (1927)	Avon River	214	72	U
Mangrove Creek (1983)	Mangrove Creek, near Gosford	170	80	U
Grahamstown (1969)	Grahamstown, near Newcastle	153	12	IN, U
Lake Brewster (1952)	Lachlan River, near Hillston	150	—	IR, R
Liddell (1968)	Gardiner Creek, near Muswellbrook	148	43	IN
Tallowa (1977)	Shoalhaven River, near Nowra	115	43	U
Googong (1978)	Queanbeyan River	125	62	U, F/C

For footnotes *see* end of table.

MAJOR DAMS AND RESERVOIRS IN AUSTRALIA — *continued*

Name and year of completion	*Location*	*Gross capacity (gigalitres) (a)*	*Height of wall (metres) (b)*	*Purpose*
	VICTORIA			
Dartmouth (1979)	Mitta Mitta River	4,000	180	F/C, H/E, IN, IR, R
Eildon (1927, 1955)	Upper Goulburn River	3,390	79	F/C, H/E, IN, IR, R
Thomson (1984)	Thomson River, near Moe	1,175	164	IR, U
Waranga (1910)	Near Rushworth (Swamp)	411	12	IR, U
Mokoan (1971)	Winton Swamp, near Benalla	365	10	IR
Rocklands (1953)	Glenelg River	348	28	R, U
Eppalock (1964)	Campaspe River	312	45	IR, U
Cardinia (1973)	Cardinia Creek, near Melbourne	289	86	U
Upper Yarra (1957)	Yarra River	207	89	U
Blue Rock (1984)	Tanjil River, near Moe	198	75	IN, U
Glenmaggie (1927, 1958)	Macalister River	190	37	IR
Cairn Curran (1958)	Loddon River, near Maryborough	148	44	IR
Yarrawonga (1939)	Murray River	117	22	IR
Toolondo (1952, 1960)	Natural depression, near Horsham	107	—	IR, R
Winneke (1980)	Sugarloaf Creek, near Melbourne	100	89	U
	QUEENSLAND			
Burdekin (1986)	Burdekin River, near Townsville	1,860	55	IR, U
Fairbairn (1972)	Nogoa River, near Emerald	1,440	49	IN, IR, U
Wivenhoe (1985)	Brisbane River, near Ipswich	1,150	59	F/C, H/E, U
Somerset (1959)	Stanley River, near Esk	866	50	U
Fred Haigh (1975)	Kolan River, near Gin Gin	586	52	IR
Ross River (1974)	Near Townsville	417	35	F/C, U
Tinaroo Falls (1958)	Barron River, near Mareeba	407	47	H/E, IR
Awoonga High Dam (1985)	Boyne River, near Gladstone	250	45	IN, U
Glenlyon (1976)	Pike Creek, near Stanthorpe	261	62	IR
Boondooma (1983)	Boyne River, near Proston	212	64	IN, IR
North Pine (1975)	North Pine, near Brisbane	205	44	U
Koombooloomba (1961)	Tully River, near Innisfail	212	52	H/E
Wuruma (1968)	Nogo River, near Eidsvold	194	46	IR
Eungella (1969)	Broken River, near Eungella	131	49	IN, U, IR
Callide Dam (Stage II) (1986)	Callide Creek, near Bileola	127	35	IR, U, IN
Julius (1977)	Leichhardt River, near Mt Isa	127	35	IN, U
Leslie Dam (Stage II) (1985)	Sandy Creek, near Warwick	108	34	IR, U
Lake Moondarra (1957)	Leichhardt River, near Mt Isa	107	27	IN, U
Beardmore (1972)	Balonne River, near St George	101	17	IR, R, U
	WESTERN AUSTRALIA			
Lake Argyle (Ord) (1971)	Ord River, near Kununurra	5,797	99	F/C, H/E, IR
South Dandalup (1973).	Near Pinjarra	208	43	U
Wellington (1933, 1944, 1960)	Collie River	185	37	IR, R
Serpentine (1961)	Serpentine River	185	55	U
Harding (1985)	Harding River, Pilbara	114	42	IN, U

For footnotes *see* end of table.

MAJOR DAMS AND RESERVOIRS IN AUSTRALIA — *continued*

Name and year of completion	*Location*	*Gross capacity (gigalitres) (a)*	*Height of wall (metres) (b)*	*Purpose*
	TASMANIA			
Lakes Gordon and Pedder (1974)—				
Gordon	South West	11,316	140	H/E
Scotts Peak	South West	2,960	43	H/E
Serpentine	South West	2,960	38	H/E
Edgar	South West	2,960	17	H/E
Miena (1967)	Great Lake	3,356	28	H/E
Lake St Clair (1938)	Central Plateau	2,000	(est.) 3	H/E
Mackintosh (1981)	Mackintosh River, near Queenstown	949	75	H/E
Tullibardine (1981)	Tullibardine River, near Queenstown	949	25	H/E
Lake Echo (1956)	Lake Echo	725	19	H/E
Reece Dam (1985)	Pieman River, near Queenstown	641	122	H/E
Arthur's Lake (1965)	Source of Lake River, near Great Lake	511	17	H/E
Lake King William (Clark) (1949, 1966)	Derwent River	541	67	H/E
Devils Gate (1969)	Forth River, near Devonport	180	84	H/E
Rowallan (1967)	Mersey River	131	43	H/E
Bastyan (1983)	Pieman River, near Queenstown	124	75	H/E
Cethana (1971)	Forth River, near Devonport	109	110	H/E
	NORTHERN TERRITORY			
Darwin River (1972)	Darwin River	259	31	U

(a) Includes 'dead water', i.e., water below the operational outlet of the reservoir. *(b)* As a general rule, the figures shown for height of wall refer to the vertical distance measured from the lowest point of the general foundation to the crest of the dam, i.e., the level of the roadway or walkway on the dam.

Abbreviations: F/C—Flood control and/or mitigation, H/E—Hydro-electricity, IN—industrial and/or mining, IR—Irrigation, R—Rural (stock and domestic), U—Urban supplies.

MAJOR DAMS AND RESERVOIRS UNDER CONSTRUCTION OR PROJECTED

Name	*Location*	*Gross capacity (gigalitres) (a)*	*Height of wall (metres) (b)*	*Purpose*
Crotty Dam	King River, near Queenstown, Tas.	1,091	80	H/E
Proserpine Dam	Proserpine River, near Bowen, Qld	500	45	IR, U
Bjelke Petersen	Barker Creek, near Murgon, Qld	125	33	IR

For footnotes and abbreviations *see* previous table.

Water Management

Australia's water resources are managed by a multitude of irrigation authorities, metropolitan water boards, local government councils and private individuals. State authorities dominate the assessment and control of water resources as, under the Commonwealth Constitution, primary responsibility for management of water rests with the individual State governments. The Commonwealth Government is responsible for matters relating to its Territories, and participates indirectly through financial assistance or directly in the coordination or operation of interstate projects through bodies such as the River Murray Commission. In other instances where political boundaries intersect some river basins, cooperation between governments has been necessary to develop resources.

Australia's attitudes to water resources management have changed substantially over the last twenty years. Water management is no longer seen just in terms of storing water and regulating streams for consumption, but also in terms of conserving unregulated streams in an unmodified landscape for wild life preservation or recreation purposes or for possible social or economic use by future generations. In addition, agricultural, industrial and urban development has led to greater attention being paid to water quality management.

The development of water resources in the States has an important bearing on the Commonwealth's broad interests in economic management, resource allocation, foreign exchange earnings, distribution of income and related matters. Consequently, the Commonwealth has participated in water resource matters in the States in instances of mutual Commonwealth–States concern or in the national interest.

Commonwealth water policy

In September 1984, the Commonwealth released its new water policy. The objectives are to:

- ensure availability of water, adequate in quantity for all beneficial uses;
- adopt measures which improve the efficiency of water supply and use;
- develop a comprehensive approach to inter-related water and land management issues;
- encourage comprehensive long-term plans for the development and management of water resources;
- implement financial and economic policies which distribute the costs of water supplies equitably and provide incentives for the more economic use of resources at government and individual level.

As part of the new water policy, funds are available to the States and the Northern Territory under a program, the Federal Water Resources Assistance Program (FWRAP), which commenced in 1984–85. Funds are available for purposes which include:

- water resource development or management activities/projects for agriculture, urban or industrial purposes;
- floodplain management;
- collaborative information programs;
- salinity reduction and land drainage;
- State-wide and broad regional water plans;
- public education.

The Country Towns Water Supply Improvement Program, which commenced under the Community Employment Program, has been continued as a sub-program of FWRAP.

The Commonwealth also contributes to the expenses of the Murray–Darling Basin Commission under the River Murray Waters Agreement and the Murray–Darling Basin Agreement. This includes the Commission's expenditure on administration, the construction and investigations program related to it's regulatory responsibilities and the Murray–Darling Basin Salinity and Drainage Strategy and Natural Resources Management Strategy.

Australian Water Resources Council—AWRC

The AWRC was established in 1963 by joint action of the Commonwealth and State Governments. The Council consists of the Commonwealth, Northern Territory and State Ministers who have primary responsibility for water resources; it is chaired by the Commonwealth Minister for Primary Industries and Energy.

The Council provides a forum for the water industry. With the shift in emphasis that has occurred in the water industry in recent years from water resource development to resource management and the growing importance of urban water issues generally, the AWRC is extending its scope to focus on industry-wide issues such as pricing and financial policies, resource management, technology and organisational management and strategy. The Council's terms of reference also include the promotion of programs to assess Australia's water resources, the encouragement of education and training in hydrology, the coordination and dissemination of information, the promotion of water research, and development of liaison with overseas and international organisations in the field of water resources.

The Council is supported by a Standing Committee, comprising permanent heads of relevant State authorities and the Commonwealth Department of Primary Industries and Energy. CSIRO and the Bureau of Meteorology are also represented and Ministers can nominate additional representatives in accordance with the requirements of the agenda for each meeting.

Following a review held in late 1984, the Standing Committee is now serviced by four advisory committees which consider issues in water industry planning, surface water and catchments, ground water and water technology. The Council can also establish ad hoc task groups, for advice on particular topics, and is currently being assisted by an Expert Panel on Education and Training, and a National Coordinating Committee on Aquatic Weeds.

Water resources assessment

In 1964, in response to a perceived lack of water resources data throughout much of Australia, the Commonwealth Government instituted, through the AWRC, the National Water Resources Assessment Program. The original aim was to expand the stream gauging network in Australia and increase the level of information on ground water. In 1974, the collection of water quality data was added to the program. The program has been successful in filling many of the data gaps which existed prior to 1964, in providing data and information for water resources planning, construction projects and in the development of the understanding of the nature and function of Australia's water resources. Commonwealth involvement in this program has now ceased. However data collection programs, involving cooperation between Commonwealth and State authorities are continuing in the Murray Basin.

Water resources research

The Department of Primary Industries and Energy is responsible for Commonwealth interests in water resource matters, including research policy and coordination.

A water research program was funded and administered on behalf of the Australian Water Resources Council from 1968 until 1984. In June 1985, the Australian Water Research Advisory Council (AWRAC) was established to advise on national water research needs and on a Commonwealth funded program of water research. Funds totalling $5.9 million were allocated in 1987–88 to research programs recommended by AWRAC. Projects included work on salinity, ground water, stream ecology, water management, water treatment and quality, hydrology and soil or plant–water relations; fellowships; and activities to effectively disseminate the results of research. The Murray–Darling Freshwater Research Centre at Albury and the Urban Water Research Association also received financial support.

In 1988–89 CSIRO spent approximately $10m (from all fund sources) on water resources research, now concentrated in a few Divisions. The Division of Water Resources (resulting

from the amalgamation in 1987 of the Divisions of Groundwater Research, Water and Land Resources, and the Centre for Irrigation and Freshwater Research) has a total staff of more than 200 with laboratories in Perth, Adelaide, Canberra and Griffith. The Division's task is to develop new and improved practices for the definition, use, and management of Australia's water resources. The Division of Chemicals and Polymers, based at Clayton, Victoria, is responsible for research on new methods of water and wastewater, purification. The Centre for Environmental Mechanics conducts research on soil–water processes, evapotranspiration and physical limnology. The Division of Fuel Technology carries out research aimed at assessing the impact on natural waters of mining and industrial processing. Research on soil–water processes and erosion is conducted by the CSIRO Division of Soils.

CSIRO is a partner with AWRAC, the River Murray Commission, and the Albury–Wodonga Development Corporation in the Murray–Darling Freshwater Research Centre.

At the State level, water agencies have extensive laboratory facilities for water quality testing. However, most water related research is undertaken in research centres associated with agriculture, fisheries, forestry and environmental authorities. At the regional level, some of the larger authorities providing water supply and sewerage services undertake applied research on a very limited scale.

A significant proportion of Australian water research is undertaken by researchers in tertiary education institutions with the aid of either internal funding or grants from outside bodies, such as AWRAC or the Australian Research Grants Committee. Water research is carried out within a range of disciplines, including the biological and social sciences and engineering.

International Aspects

International water organisations

Australia liaises with international bodies and United Nations agencies concerned with water resources and participates in their activities in various ways.

Economic and Social Commission for Asia and the Pacific—ESCAP
This United Nations Commission, through its Committee on Natural Resources, reports on water policy issues in addition to other activities. By participating in this forum and in seminars arranged on selected topics, Australia contributes to, and benefits from, identification of and discussions on the main problems of water resources management in a densely populated, developing region. Australia is also an active participant in ESCAP's water information exchange system and a contributor to ESCAP's Water Resources Journal and its newsletter, *Confluence*.

Organisation for Economic Co-operation and Development—OECD
Australia's membership of the OECD since 1970 has involved participation in the work of the Environment Committee, particularly the Natural Resource Management Group, the Water Management Group and its Group of Economic Experts, which investigates problems which are the subject of international concern and the development of strategies to resolve them.

United Nations Educational, Scientific and Cultural Organization—UNESCO
Australia has contributed to the international program designed to advance the science and practice of hydrology and the International Hydrology Program (IHP), through an Australian UNESCO Committee for the IHP, Australia is a member of the Inter-governmental Council for IHP.

World Meteorological Organization—WMO
Through its Commission for Hydrology, WMO is the specialised UN agency dealing with operational hydrology—the measurement of basic hydrological elements, water resources

assessment and hydrological forecasting. WMO has an Operational Hydrology Program (OHP) which is coordinated with and complemented by UNESCO's IHP. Within the OHP is the Hydrological Operational Multipurpose Subprogram (HOMS) involving the organised transfer of hydrological technology among members. Australia is a contributor to HOMS and has established a HOMS National Reference Centre within the Secretariat of AWRC. In Australia, hydrological and meteorological activities relative to water resources are coordinated by the Secretary of the AWRC as hydrological advisor to the Permanent Representative of WMO in Australia, the Director of Meteorology.

United Nations Environment Program—UNEP
Australia participates in a world registry of major rivers covering discharge and pollutants and of clean rivers so defined and in the development of methodology for analysis and planning of water resources management.

World Health Organisation—WHO
Australia is participating in the water quality monitoring component of the WHO Global Environment Monitoring System (GEMS) which provides a consistent global overview of changes in water quality.

National and Interstate Agreements

In the section on water management above, reference was made to the responsibilities of government on the national, State and local authority levels. In this section, some additional details are provided on their roles in the management of water resources.

The flows of many of the tributaries to the River Murray which make up the Murray–Darling Basin have been regulated for irrigation and water supply purposes. Approximately 27 GL of storage has been constructed in the Murray–Darling basin. Of this, about 12 GL of storage has been constructed along the River Murray, including the barrages, locks and weirs. With an average annual diversion from the Murray of approximately 4 GL, the degree of resource utilisation is only approximately 40 per cent.

River Murray Waters Agreement/Murray–Darling Basin Agreement

The *River Murray Waters Act 1915* ratified an Agreement between the Commonwealth and the States of New South Wales, Victoria and South Australia. *Year Books* prior to No. 39 contain a number of summaries of the historical events leading to the Agreement of 1914 which provided, among other things, for a minimum quantity of water to pass to South Australia. Further details on the River Murray Waters Agreement and subsequent amendments may be found in *Year Book* No. 61, pages 870–2.

The River Murray Commission was established in 1917 to give effect to the Agreement. The main role of the Commission was to manage and regulate the Murray so that its water resources could be efficiently shared between the three States on the River, within the limitations of the River Murray Waters Agreement. It also had responsibility for management of the catchment above Hume Dam and for the management of the flow of water in the Darling River below Menindee Lakes.

From its establishment through to the end of the 1930s, the Commission coordinated the construction of Hume and Lake Victoria storages, Yarrawonga Weir, and weirs and locks along the Murray from Torrumbarry, below Echuca, to Blanchetown in South Australia. In 1940, the Murray Mouth Barrages, and Maude and Redbank weirs on the Murrumbidgee, were completed. Dartmouth Dam, the most recently constructed major structure in the system, was completed in 1979. Four storages, 16 weirs (13 with locks) and five barrages were involved in the regulation of the Murray by the Commission.

The role of the River Murray Commission evolved over the years, and the River Murray Waters Agreement was amended, as community requirements of the River changed. In the 1930s, following the Great Depression and the demise of the river trade, the main

emphasis of River regulation shifted to irrigation. From the 1940s, when water began being piped from the Murray for urban and industrial supplies in the 'Iron Triangle' and later to Adelaide, regulation had to ensure that these requirements were also met without delay. It was not until 1982, however, that an amendment to the River Murray Waters Agreement authorised the River Murray Commission to monitor and consider water quality in its operations. The amendment also enabled the Commission to have regard to the possible effect of its decisions on any river or water management objective. These could include environmental or recreational objectives. Before 1982, areas of management, other than water quantity and River regulation, were entirely State responsibilities.

On 1 January 1988, the River Murray Commission was replaced by the Murray–Darling Basin Commission, which assumed all of the responsibilities of the River Murray Commission. In addition, it is responsible for advising the Murray–Darling Basin Ministerial Council on water, land and environmental matters in the Basin. The River Murray Waters Agreement has been amended by the Murray–Darling Basin Agreement. This evolution has come about following an increased awareness that land, water and vegetation are interrelated and that it is undesirable to isolate the management of one resource, or one part of the Murray–Darling Basin, from others. A major outcome of these new arrangements has been the development of a Natural Resources Management Strategy for the Basin to address key resource degradation issues.

New South Wales–Queensland Border Rivers Agreement

As a result of an Agreement between the Premiers of Queensland and New South Wales, Acts were passed by the Parliaments of both States in 1946 and 1947 respectively, establishing the Dumaresq–Barwon, Border Rivers Commission. The Commission is responsible for the conservation and equal sharing of the waters of the Dumaresq River upstream of Mingoola, the regulation of the border rivers downstream of Mingoola and the equitable distribution of the waters of the streams which intersect the Queensland–New South Wales border west of Mungindi.

The duties of the Commission include measurement of stream flows; investigation of proposals for better conservation, regulation and distribution of water resources; and construction and maintenance of dams, weirs, regulators or other works for the storage, regulation and distribution of flows.

The Commission has constructed Glenlyon Dam on Pike Creek in Queensland which has a storage capacity of 254 GL, and a number of regulators and other water distributory works on the river systems under its control.

Snowy Mountains Hydro-electric Scheme

The Snowy Mountains Scheme is a dual purpose hydro-electric and irrigation complex located in south-eastern Australia and on its completion was one of the largest engineering works of its type in the world. It impounds the south-flowing waters of the Snowy River and its tributary, the Eucumbene, at high elevations and diverts them inland to the Murray and Murrumbidgee rivers through two tunnel systems driven through the Snowy Mountains. The Scheme also involves the regulation and utilisation of the headwaters of the Murrumbidgee, Tumut, Tooma and Geehi rivers.

The Scheme was designed and constructed by the Snowy Mountains Hydro-electric Authority, a statutory body established by the Commonwealth Government in 1949, and was substantially completed by 1974. Its installed generating capacity is 3,740 MW and its average annual electricity output is over 5,000 GWh. An average of 2,300 GL of water per year has become available for irrigation in the Murray and Murrumbidgee rivers as a result of the Scheme.

Details of the Scheme are given in a special article, included in *Year Book* No. 70, pages 430–6.

The Snowy Mountains Council, constituted of representatives of the Governments of the Commonwealth, New South Wales and Victoria and the Snowy Mountains Hydro-electric Authority, was established on 2 January 1959. Its main functions are to direct and control

the operation and maintenance of the permanent works of the Snowy Mountains Scheme, in particular the control of water and the allocation of loads to generating stations.

States and Territories

The foregoing text deals with water conservation and irrigation in Australia generally and with international, national and interstate aspects. The following material covers the local pattern of water resources and the steps taken by the State governments to bring about their development. In the various States, water policies tend to assume a distinctive and characteristic pattern closely allied with climatic conditions and specific local needs.

In Victoria, almost every form of water scheme is in operation. In New South Wales, the management of irrigation water supplies is an area of major emphasis, with approximately two-thirds of a million hectares under irrigation. In Queensland, up to the present, the predominant emphasis has fallen on water (mainly underground sources) for stock and the development of small irrigation schemes in sub-humid and humid areas, principally to stabilise production of such crops as tobacco, sugar, cotton and pastures. Apart from regular irrigation practices along the Murray River, South Australian authorities are vitally concerned with reticulated supplies for rural areas and towns. Western Australia has developed unique rock catchments and piped supplies for agricultural areas and towns in dry districts. Tasmanian interest relates almost exclusively to hydro-electric generation. The Northern Territory is concerned primarily with water supplies for population centres and mining and pastoral industries.

New South Wales

Administration

The New South Wales Department of Water Resources was set up in 1987, succeeding the previous Water Resources Commission. The Department is responsible for maximising the long term benefits of the State's water resources to meet the changing diversity of water uses and values of the community. Main responsibilities of the Department are to coordinate policies and programs of State and local government authorities providing water supplies and other water services; plan for future water needs; operate the rural water supply network; control the use and management of surface water and ground water resources through water licensing and transfer systems; provide floodplain management and flood mitigation services in non-tidal areas; provide for wetlands, wild and scenic rivers and instream or environmental water needs; improve water quality; control salinity; maintain water resource assessment programs; and effectively manage the State's water infrastructure.

Water use

Irrigation takes up the largest volume of consumption water use in NSW, on average 75 per cent, with urban water consumption in Newcastle, Sydney and Wollongong taking up the bulk of the remaining 25 per cent.

Urban water

Major metropolitan urban water supplies are managed by central water boards at Newcastle and Sydney. Water sources for major cities of Sydney and Wollongong are good quality rivers and associated storages on the Hawkesbury, Georges and Shoalhaven Rivers. Newcastle's water supply is taken from the Chichester and Grahamstown Reservoirs and from ground water in coastal sandbeds. Country towns develop their own water supply systems ranging from run-of-river pumping to ground water extractions, to dams built specifically for urban water supply. Metropolitan water authorities are increasingly managing urban water demand to reduce water consumption by a range of mechanisms including pricing and persuasion. Drought management and asset management are more recent areas of concern for metropolitan water utilities who are also increasing their interest in balanced environmental management of water supply catchments.

Irrigation

The bulk of irrigation in New South Wales is within the Murray–Darling Basin, the centre of recent Commonwealth/State initiatives in land and water management to reduce salinity problems. Twenty four storages, including four shared with Victoria and South Australia and one shared with Queensland, regulate water supplies in the Basin.

Two main irrigation arrangements exist. Statewide, licensed irrigation occurs where licensees take water from rivers, usually by pumping at their own cost. Around 1.5 million megalitres per annum is used in this way.

Irrigation Areas and Districts form the second type of irrigation. These are located on the three southern inland rivers—the Murray, Murrumbidgee and Lachlan and include over 6,300 farms and holdings covering nearly 1.4 million hectares. About a third of this area is usually irrigated using 1.4 million megalitres per annum. Extractions from licensed high-yielding bores now approach 300 gigalitres per annum.

The annual gross value of production in the Murray–Darling system is around $750 million, about 20 per cent of the State's total agricultural production. Nevertheless the growing extent of land degradation and salinisation in the Murray–Darling Basin is reducing productivity and increasing costs of production.

Future planning and programs

With large dams on all the main inland rivers in NSW, few further major irrigation storages are likely to be constructed. Water resources management is now focussed on improved management and efficiency in water allocation supply and use both in the urban and rural environments.

Improving water use efficiency is one management target for the irrigation sector and heavy industry. This is being achieved throughout the State through improved rural water delivery systems, management of urban water demand, and monitoring of agricultural and urban water losses. In the rural sector transferable water rights, licensing and variable water allocations serve to increase water use efficiency.

Ameliorating waterlogging and salinisation of farming lands is an environmental management priority for the Commonwealth and States, and NSW is pursuing this through a State funded SALTACTION initiative and through the Murray–Darling Basin Ministerial Council. For further information on salination see special article *Salinity—An Old Environmental Problem* in this *Year Book*. NSW is achieving the integration, coordination and consultation required in developing land and water management on a catchment basis including policies of a range of State agencies. Floodplain management and flood irrigation programs are being continued. Policies addressing State Wetlands, State Rivers, and Groundwater are being prepared. Aspects of development such as intensive cattle feed lots are being promoted vigourously, while potential for water quality inputs are being closely monitored.

Victoria

Administration

Water resources in Victoria are administered by three major agencies, the Department of Water Resources, the Melbourne Metropolitan Board of Works and the Rural Water Commission. The Department of Water Resources is the central policy and planning agency providing advice to the Minister of Water Resources on matters of State-wide interest. The Melbourne Metropolitan Board of Works is a statutory corporation responsible for providing water, sewerage, main drainage and managing waterways and metropolitan parks for the people of Metropolitan Melbourne. The Rural Water Commission is a public business authority whose primary mission is to sell water and water related services for irrigation, domestic and stock, commercial, industrial, recreational, environmental and other beneficial uses in rural areas throughout Victoria.

Rural water supply systems

- **Goulburn–Campaspe–Loddon.** The main storage is Lake Eildon with a capacity of 3,390 gigalitres. The main products in these systems are dairy products, fruit, wool and fat lambs. Annual production of deciduous canning fruits in the eastern part of the system is about two thirds of Australia's total.
- **Murray River System.** The Murray Valley Irrigation Area and the Torrumbarry Irrigation System are irrigated by water diverted at the Yarrawonga and Torrumbarry Weirs respectively. These areas are devoted mainly to dairying, fat lambs, fruit, vineyards, orchards and market gardens. Downstream from Swan Hill, the First Mildura Irrigation Trust and four Commission Districts are supplied by pumping, and produce mainly dried vine fruits, citrus fruits and table and wine grapes.
- **Southern Systems.** The Macalister district, supplied from the Macalister River and regulated by Lake Glenmaggie, is devoted mainly to dairying.
- **Werribee and Bacchus Marsh.** These districts produce fresh fruit, vegetables and dairy products mainly for the local domestic market. Irrigation is supplied from the Werribee River system which is regulated by three main storages: Pykes Creek Reservoir, Melton Reservoir and Lake Merrimu.
- **Wimmera–Mallee Domestic and Stock Supply System.** Storages in the Grampian Ranges ensure farm water supplies for dry land, pastoral and cereal farming in the Wimmera and Mallee. There are small areas of irrigation supplied from this system near Horsham and Murtoa.

Future programs

Proposed capital works expenditure by the Rural Water Commission continues to place increasing importance on infrastructure replacement and rehabilitation, urban water services, waterways and floodplain management, environmental protection and water quality improvement. Major provisions in the program include:

- rehabilitation of headworks—Glenmaggie, Coliban, Melton and Cairn Curran;
- replacement, rehabilitation and extensions of rural water supplies, including drainage, and salinity control works.

Queensland

Administration

The control of surface and underground water is exercised by the Commissioner of Water Resources on behalf of the Crown through the licensing of all artesian bores, sub-artesian bores within districts declared for the purpose, and works for the conservation and use of surface water together with the issuing of permits for domestic and stock water use.

In respect of the water resources of the State, the Commission is required to prepare a complete description and keep a record of naturally occurring surface and underground water; take steps to protect the resources from factors likely to be detrimental to their quality or diminish their quantity; investigate and survey any natural water resource; coordinate the investigation, evaluation and development of plans for the control of floodwaters and mitigation of flood damage; construct and manage works for the conservation, replenishment, utilisation and distribution of water; provide advice to local authorities in relation to water supply, sewerage, drainage, flood mitigation and swimming pools; and provide an extension and design service for on-farm development of water resources.

As the water resource assessment and planning authority, the coordination of this resource is ensured, for the net benefit of the community. This includes rural, urban, industrial, mining and other users to bring the overall planning together for continuity. The Commission assesses the water resources and determines how these can best satisfy present and future demands for water related activities. The Commission develops, manages, operates and maintains all State owned water conservation works, having an overall management role at the broad resource level as well as in day-to-day activities of many areas.

Summary of schemes

Approximately half of the area irrigated in Queensland now uses water from storages constructed by the Water Resources Commission. The balance is irrigated from unsupplemented surface or underground supplies spread widely throughout the State. Because of the predominance of irrigation by private diversion from streams, as opposed to channel systems delivering water to farms, most of the storages release water to maintain supplies downstream.

Irrigation areas and projects

Approximately one-third of the area irrigated in Queensland each year is concentrated in eight Irrigation Areas constituted under the Irrigation Act where the supply is generally reticulated by channel systems to the farms. Irrigation projects are schemes established under the *Water Act 1926–1983*, where water is released from storages to maintain supplies for pumping under licence to land adjacent to the streams. Details of the projects are set out in the accompanying table.

IRRIGATION AREAS AND PROJECTS, QUEENSLAND, 1988–89

	Authorised allocation				*Actual use*		
	Irrigation		*Other uses (a)*				
	Outlets	*Allocation*	*Outlets*	*Allocation*	*Irrigation*	*Other uses (a)*	*Area irrigated*
	No.	megalitres	No.	megalitres	megalitres	megalitres	hectares
Irrigation Areas—							
Bundaberg	3,260	206,748	6	13,053	(b)92,709	8,995	42,293
Burdekin River	272	70,927	80	74	(c)46,525	33	10,240
Dawson Valley	307	43,765	9	2,915	20,453	2,591	5,084
Emerald	195	84,476	3	6,080	65,525	3,568	14,048
Eton	428	35,000	30	1,024	4,446	7,878	11,100
Lower Mary River	151	15,951	—	—	2,069	—	3,400
Mareeba–Dimbulah	1,205	81,279	689	113,739	51,855	407,480	13,578
St George	296	55,629	1	2,500	(d)92,072	2,573	11,556
Sub–Total	*6,114*	*593,775*	*818*	*139,385*	*375,654*	*433,118*	*111,299*
Irrigation projects—							
Awoonga–Callide Pipeline	—	—	1	—	—	5,970	—
Bedford Weir (Company Pipelines)	—	—	15	5,043	—	3,366	—
Bingeang Weir (Company Pipelines	—	—	27	10,257	—	7,802	—
Blackwater water Supply System	—	—	26	6,768	—	5,761	—
Bowen–Broken Rivers	4	1,876	42	18,852	7	8,977	20
Boyne River	66	12,611	—	—	6,556	—	1,100
Callide Dam	361	29,521	3	5,096	19,961	10,604	10,713
Chinchilla Weir	31	3,132	1	1,160	935	527	890
Dumaresq River	178	62,744	5	1,525	(d)42,527	1,435	8,641
Fitzroy River Barrage	140	12,300	—	—	(d)2,858	—	n.a.
Logan River	162	11,145	6	4,064	3,086	1,461	3,906
Lower Lockyer	189	11,412	—	—	6,143	—	4,300
Macintyre Brook	151	18,210	1	450	6,698	309	2,580
Mary Valley	270	12,800	4	6,014	5,272	3,802	2,920
Tarong Water Supply System	—	—	19	25,847	—	26,275	—
Three Moon Creek	131	11,253	1	501	4,293	401	3,000
Upper Burnett	270	27,677	4	1,550	18,035	1,286	2,800
Upper Condamine	111	15,324	3	3,328	(d)(e)25,583	2,160	7,400
Warrill Valley	418	19,204	6	9,380	9,616	3,627	8,170
Sub–Total	*2,482*	*249,209*	*164*	*99,835*	*151,570*	*83,763*	*56,440*
Total	**8,596**	**842,984**	**982**	**239,220**	**527,224**	**516,881**	**167,739**

(a) Comprises urban, industrial, rural water supply, stockwater and other uses. *(b)* Includes 27,086 ML pumped from groundwater. *(c)* Includes 12,164 ML pumped from groundwater. *(d)* Includes water harvesting. *(e)* Includes 3,278 ML pumped from groundwater.

Underground water supplies

The availability of underground water, particularly the Great Artesian Basin, has played a major part in the development of the pastoral industry in Queensland. Underground water is also used extensively for irrigation on individual farms, particularly along the coastal fringe, and for domestic purposes. Some 45 per cent of the area irrigated in Queensland receives its supplies from underground sources. In accordance with the requirements of the *Water Resources Administration Act 1978–1984* the investigation of the availability of underground water is being pursued by geological mapping, investigation drilling and hydro-geological assessment. The predominant areas where water from this source is used for irrigation are the Burdekin Delta, Condamine Valley, Bundaberg, Lockyer Valley, Callide Valley and Pioneer Valley.

Groundwater supply and drainage schemes

The Water Act provides for the constitution of an area for various works including water supply for stock, domestic and irrigation purposes, drainage and improvement of subterranean water supplies and the creation of a Board to administer the area.

Nineteen Drainage schemes, 57 Bore Water areas and 24 Rural Water Supply schemes are in operation.

Western Australia

Administration

The Water Authority of Western Australia controls the majority of water-related services in Western Australia. It was constituted under the provisions of the *Water Authority Act 1984*, and administers 8 other Acts and associated by-laws and regulations.

The Water Authority is responsible, under the control of the Minister for Water Resources, for the general administration of the Act. An eleven-member Board of Management controls the Authority's operations and reports to the Minister.

The Water Authority is responsible for the following water related services: water supply in the Perth metropolitan area and the majority of country towns; water resources assessment and management throughout the State; Government irrigation schemes; sewerage schemes in the Perth metropolitan area and several country towns; major drains in the Perth metropolitan area and drainage in several country areas.

Water supply

Western Australia has a great variation in the size and complexity of water supply schemes, which range from town schemes serving fewer than 50 people to the Perth metropolitan scheme serving a population of 1,072,000.

The table which follows shows the principal water storages in Western Australia.

Considerable use is made of ground water by individual farmers, pastoralists, market gardeners, etc., and it is estimated that over 92,000 bores are in use in the State. Both artesian and non-artesian sources are used to supply or augment the supplies of numerous towns, including such major centres as Perth, Albany, Bunbury, Busselton, Carnarvon, Dampier, Esperance, Exmouth, Geraldton, Karratha and Port Hedland. In a number of mining towns in the north-west, mining companies are responsible for the provision of their own water supplies. Industries also use ground water in substantial quantities, particularly in the processing of titanium, iron and alumina.

RESERVOIRS—STORAGE CAPACITY (a)
(Megalitres)

Reservoir	*Storage Capacity*	*Reservoir*	*Storage Capacity*
Canning *(b)*	90,500	Samson Brook	9,170
Churchman Brook *(b)*	2,200	Serpentine Pipehead *(b)*	2,640
Drakes Brook	2,290	Serpentine *(b)*	194,500
Fitzroy	4,650	17-Mile Dam *(c)*	5,489
Glen Mervyn	1,490	South Dandalup *(b)*	208,200
Harding	63,800	Stirling	56,123
Harvey Weir	9,126	Victoria *(b)*	860
Kununurra Lake (Ord River)	97,400	Waroona	14,954
Logue Brook	24,300	Wellington	184,900
Mundaring	77,000	Wungong *(b)*	60,000
Lake Argyle (Ord River)	5,797,000		

(a) At 30 June, 1989. *(b)* On Uralla Creek, an anabranch of the Fitzroy River. *(c)* Serves the Perth Metropolitan Area.

Perth metropolitan water supply

Perth is supplied from a number of dams and pipeheads in the Darling Range and from ground water schemes located on the Swan Coastal Plain. Water gravitates or is pumped from these sources to service reservoirs and tanks located at high points over the metropolitan area for gravity feed to consumers. Perth's water consumption is currently about 194 gigalitres per year and is increasing.

Country water supplies

The Water Authority is responsible for all town water supply schemes in the country towns of Western Australia, with the exception of the Bunbury and Busselton schemes which are run by local Water Boards. There are also a small number of town water supply schemes operated by mining companies. Individual water supplies serve railways, timber mill towns, isolated mines, pastoral properties, stock routes and agricultural areas, mainly from dams, tanks, wells and bores.

In country areas total control has been exercised on ground water usage in Broome, Gascoyne, Swan and South West Coastal Ground Water areas. The control of other areas has been tailored to the specific problems known to exist.

- **Goldfields and Agricultural Areas Water Supply.** This scheme provides water from Mundaring Reservoir to consumers in the Central Agricultural Areas and the Eastern Goldfields.
- **West Pilbara Water Supply Scheme.** The West Pilbara Water Supply serves the towns of Dampier, Karratha, Wickham, Point Samson and Roebourne as well as the industrial complexes at Dampier, the Burrup Peninsula and Cape Lambert. Water is supplied exclusively from the Millstream aquifer and the Harding Dam.
- **Geraldton Regional Water Supply Scheme.** The Geraldton Regional Water Supply serves consumers in the towns of Geraldton, Dongara, Port Denison, Mullewa, Walkaway, Eradu and Narngulu with water being drawn from the Wicherina, Allanooka and Wye Springs borefields.
- **Great Southern Towns Water Supply.** This scheme provides water to the coal mining town of Collie together with towns and farmlands in the Great Southern Area. Water is drawn from Wellington Reservoir, which has a capacity of 185 million kilolitres, and supplied to towns from Brookton and Kondinin in the north to Kojonup and Gnowangerup in the south and to 600,000 hectares of farmland.
- **Port Hedland Regional Water Supply Scheme.** The Port Hedland Regional Water Supply provides water for the consumers of Port Hedland and South Hedland from the complementary De Grey and Yule River borefields.

- **Lower Great Southern Towns Water Supply Scheme.** This scheme supplies the towns of Albany, Mt Barker and Kendenup. Water is drawn from three sources; Two Peoples Bay east of Albany (from which the water is treated for colour removal), Limeburner's Creek and bores which are located on the west of Princess Royal Harbour.
- **Mandurah Regional Water Supply Scheme.** This scheme provides water to the town of Mandurah and areas to the south and east. Approximately 90 per cent of the water consumed is supplied by gravity from the South Dandalup Dam with the remainder supplied from bores at Ravenswood.
- **Supplies to other country towns.** Nearly 150 towns are supplied with water from stream flow, dams, tanks, wells and bores, the schemes being administered under the provisions of the *Country Areas Water Supply Act 1947.*

The Water Authority is responsible for the provision and maintenance of tanks and wells as a source of cartage water for farmers and a number of small communities in gold mining and agricultural areas.

The Water Authority also undertakes design and construction of water services for Aboriginal communities on behalf of the Commonwealth Department of Aboriginal Affairs. The Authority assists communities in operating and maintaining schemes and training community operators.

Irrigation schemes

The Water Authority is responsible for the operation and maintenance of 7 irrigation and 15 drainage schemes throughout the State from Albany in the south to Kununurra in the north.

Irrigation schemes have been established by the State Government on the coastal plain south of Perth in the Waroona, Harvey, Collie River and Preston Valley Irrigation Districts between Waroona and Donnybrook, the water being channelled from dams in the adjacent Darling Range.

There is a thriving plantation industry situated at Carnarvon near the mouth of the Gascoyne River. This centre is one of the major producers in Western Australia of tomatoes, watermelons, pumpkins, cucumbers, capsicums and runner beans. Carnarvon also supplies capsicums, zucchinis and pumpkins to the eastern States. It produces over half the bananas consumed in Western Australia as well as limited supplies of citrus fruit, mangoes and avocados.

The rainfall at Carnarvon is extremely variable and averages little more than 230 millimetres per annum. Agricultural development has been made possible only by irrigation with ground water. Water is obtained from the growers' own irrigation pumping plants and from the Government-controlled Carnarvon Groundwater Supply Scheme which is supplied from bores along the Gascoyne River.

The Ord Irrigation Project provides for the ultimate development of 72,000 hectares of clay soils and additional areas of sandy soils adjoining the clays. Water is currently supplied to 14,000 hectares.

South Australia

Administration

All major water resources and most public water supply schemes in South Australia are administered by the Engineering and Water Supply Department under the various statutes mentioned below.

- The *Waterworks Act 1932*, which empowers the Minister of Water Resources to impound or divert the water from any lake, watercourse or underground source for the purpose of establishing and maintaining public water supply schemes to serve proclaimed water districts throughout the State.
- The *Water Conservation Act 1935–1975*, provides for the control of small reservoirs, bores, tanks, etc. established in remote areas as emergency water supplies or to assist local development.
- The *Murray–Darling Basin Act 1988* (which replaces the *River Murray Waters Act 1983*) ratifies the Murray–Darling Basin Agreement of October 1987. The Department is the delegated constructing and operating authority for the Murray–Darling Basin Commission in South Australia and has built and operates the Lake Victoria regulating storage, nine locks and weirs along the river and the five barrages at the River Mouth.
- The *Water Resources Act 1976*, provides for the management of all aspects of water—surface and underground, quality and quantity. The Act provides for the control of diversions of surface waters from Proclaimed Watercourses and for the withdrawal of underground waters from Proclaimed Regions. It establishes a South Australian Water Resources Council and Regional Advisory Committees as vehicles for public participation in the water resources management process, and a Water Resources Appeal Tribunal to give individuals the opportunity to appeal against decisions of the Minister pursuant to the Act.

Summary of schemes

South Australian irrigation commenced with an agreement involving the Chaffey brothers in 1887 whereby an area was made available for the establishment of certain irrigation works at Renmark. Currently water diversions totalling more than 381,090 ML are made for government, cooperative and private irrigation schemes in the South Australian section of the River Murray. The authority controlling River Murray irrigation is the Engineering and Water Supply Department.

Except for quantities held in various lock pools and natural lakes, no water from the Murray is stored within South Australia for irrigation purposes. In addition to irrigation from the River Murray there are considerable areas irrigated from underground sources.

Adelaide Metropolitan Water Supply

In 1988–89, River Murray pipelines supplied 29 per cent of the total intake to the Metropolitan Adelaide Water Supply System, compared to 27 per cent for the previous year. The principal sources of supply for the nine storages in the Mount Lofty Ranges are the Rivers Onkaparinga, Torrens, South Para, Myponga and Little Para.

Country reticulation supplies

A number of reservoirs in the Barossa Ranges and other local sources are augmented by the Morgan–Whyalla, Swan Reach–Stockwell and Tailem Bend–Keith pipelines which provide River Murray water to extensive country areas. Surface and underground resources have been developed to supply most country centres not covered by the larger schemes.

River Murray irrigation areas

Where irrigation water in excess of plant requirements has been applied, perched water tables develop. Rising to the level of tree roots, these cause the death of orchards from salination and water-logging. Most orchards and vineyards are now drained by plastic and

tile drainage systems, thus restoring their health and productivity. Several measures have been taken to reduce drainage water in excess of irrigation requirements. An investigation into the feasibility of replacing open channels with pipe in the remaining unrehabilitated Government irrigation areas has been undertaken, to provide irrigators with a reliable and flexible water supply. An Irrigated Crop Management Service has been initiated by the Department of Agriculture to assist irrigators to improve water use efficiency and productivity. Disposal of drainage water is achieved by pumping to basins on river flats where it is evaporated, or by discharge into the river when it is in flood—apart from those areas connected to the Noora Drainage Disposal Scheme, completed in 1984. In the same year, another salinity project, the Rufus River Groundwater Interception Scheme, was commissioned. This scheme involves intercepting saline seepage to Rufus River (which flows from Lake Victoria to the Murray) and pumping it to an evaporation basin east of Lake Victoria and outside the river valley. Woolpunda Groundwater Intercaption Scheme which will significantly reduce the inflow of natural saline ground water in the reach between Overland Corner and Waikerie which is under construction. Studies are currently being made into the feasibility of further salinity mitigation schemes in the Waikerie area, near Loxton and in the Chowilla Creek area of the River Murray.

Tasmania

Main purposes of water conservation and utilisation

Contrary to popular belief, Tasmania is heavily dependent on water conservation in maintaining reliable sources of supply for irrigation, stock, and domestic requirements, and urban and industrial water supplies. This is due to an annual summer drought between January and March, when most run-of-the-river flows only support ordinary riparian needs or very limited irrigation and many smaller streams cease to flow.

The total surface water usage for domestic, industrial, and agricultural purposes in Tasmania is only 1 per cent of the potential exploitable yield, compared with a national figure of about 13 per cent. Despite this, economic, environmental, and social constraints are beginning to restrict further development of the total yield for these purposes.

Excluding power generation storages, the total capacity of water conservation dams in the State is about 150 gigalitres, almost half of which is in on-farm dams.

There is widespread use of farm dams for irrigation which is needed to maintain overall production because of the summer drought and the lack of pasture and crop growth in the State's cold winters.

The vast majority of the State's water resources are used for power generation, based on a large, integrated system of water storages. This system also benefits other water users by enabling greatly increased regulation of many streams.

Administration

In Tasmania, water supply was once exclusively the responsibility of local government authorities, but three statutory authorities, the Hobart Regional Water Board, the Rivers and Water Supply Commission and the North West Regional Water Authority, now operate bulk supply schemes. While the Board is responsible for bulk supplies in the Hobart area, the Commission exercises control over the use of the State's water resources and the Authority controls water supply to a number of northern municipalities.

The Department of Mines administers the development and use of the State's ground water resources.

The Hydro-Electric Commission controls most of the surface water resources in the higher rainfall areas of the State for power generation purposes, and jointly administers certain catchments with the Rivers and Water Supply Commission where other demands exist in addition to power generation.

The Rivers and Water Supply Commission, the Department of Mines and the Hydro-Electric Commission have since been amalgamated to form the Department of Resources and Energy.

Rivers and Water Supply Commission

The Commission is empowered by the *Water Act 1957* to take water at streams and lakes, or to issue others with licences to do so; licensing covers supply to specific industries and municipalities as well as for irrigation. The Commission is concerned with drainage trusts' operations, river improvements, irrigation, stream gauging, its own regional water schemes, and with assessing proposals for water supply, sewerage and drainage of towns. It operates in a similar manner to the Hobart Regional Water Board in controlling the water schemes serving the East Tamar region (North Esk Regional Water Supply), the West Tamar area (West Tamar Water Supply) and the Prosser River Scheme near Orford. The North Esk Regional Water Supply Scheme supplies industrial users at Bell Bay and municipalities on the eastern bank of the River Tamar. The West Tamar Water Supply serves the Beaconsfield municipality. The local government authorities retain primary responsibility for reticulation and sale to consumers, except to certain industrial users.

In municipalities not serviced by the Hobart Regional Water Board, the Rivers and Water Supply Commission or the North West Regional Water Authority, the supply of water is a function of the local municipal council.

Irrigation

The Rivers and Water Supply Commission is in charge of three major irrigation schemes, these being the Cressy–Longford Irrigation Scheme (opened in 1974), the South East Irrigation Scheme, Stage I (opened in 1986), both of which supply water via open channel, and the Winnaleah Irrigation Scheme which supplies water via pipelines.

Of the three schemes, Cressy–Longford is the largest (serving 88 properties) with 10,000 hectares being fit for irrigation. The Coal River Scheme is capable of serving 107 properties, of which 3,800 hectares are fit for irrigation. The Winnaleah Scheme serves 1,500 hectares on 72 properties.

The majority of land irrigated in the State in 1986–87 was watered by private schemes either by pumping directly from unregulated streams or from on-farm storages. Pasture still predominates as the major crop irrigated, but other vegetables now constitute 33 per cent of the total area irrigated.

Northern Territory

Administration

Under the *Northern Territory Control of Waters Act 1981*, control of natural waters is vested in the Crown. The diversion of water is prohibited except under prescribed conditions. The Act requires that drilling for ground water be carried out only by drillers who are registered under the Act and who are required to provide the government with information on bores drilled. In particular areas, described as Water Control Districts, where stricter control is necessary, the construction or use of a well or water bore without a permit can be prohibited.

Under the *Water Supplies Development Act 1960*, any landholder engaged in pastoral or agricultural production may seek information or advice from the Commissioner of Water Development who is appointed under the Act.

The Water Resources Group of the Power and Water Authority is responsible for the assessment, planning and management of surface and ground water resources throughout the Northern Territory. It carries out systematic stream gauging, the collection of data relating to the quantity and quality of surface and ground water, flood prevention and control, and waste disposal and baseline inventory. It is involved in water pollution studies

and control, and carries out environmental assessments of water and related developments. It also provides an advisory service under the Water Supplies Development Act and administers permits and licences under the Control of Waters Act.

These arrangements have applied since 1 July 1987. It is proposed that Northern Territory water legislation be amalgamated into a new Act to be called the 'Water Act'.

Surface water

Hydrological investigations and data collection are undertaken across the Northern Territory and the data are published by the Water Resources Group. The program includes base stream gauging stations and pluviographs (automatic rainfall recorders).

Groundwater

For information on Northern Territory ground water (and surface water) resources see the Northern Territory Department of Mines and Energy's publication *Water Northern Territory*—Volume 1, the Department of Resources and Energy's publications *Australia's Groundwater Resources, 1983* and the Australian Water Resources Council's publication *1985 Review of Australia's Water Resources and Water Use.*

Of approximately 21,300 bores and wells registered in the Territory to 30 June 1989, 24.7 per cent were for pastoral use, 14.9 per cent were investigation bores, 31.7 per cent served urban and domestic supplies, 5.2 per cent were for agriculture, 17 per cent were used for mining and the remaining 6.5 per cent for various other uses.

Water supplies

The largest water conservation projects in the Territory are the Darwin River Dam (259.0 gigalitres) and the Manton Dam (15.7 gigalitres) which both serve Darwin with a reticulated water supply. Ground water from McMinns Lagoon area can be used to augment supply.

Most other towns and communities, including Alice Springs, Tennant Creek, Jabiru and Nhulunbuy, are supplied from ground water.

Irrigation in the Territory is expanding, but is not extensive, being confined to locations near Darwin, Adelaide River, Daly River, Katherine, Ti Tree and Alice Springs for the purpose of growing fruit, vegetables, fodder crops, pastures and some dairying. Most of this irrigation is carried out using bore water.

There is increasing demand for water resources assessment studies and assistance for relatively small irrigation projects.

Australian Capital Territory

Administration

The provisions of the *ACT Electricity and Water Act 1988* give responsibility for the supply of water to the Territory to the ACT Electricity and Water Authority, a statutory authority established on 1 July 1988. ACTEW also provides the bulk water supply to Queanbeyan.

Surface water

Surface water storages supplying the ACT (population about 277,900) and the city of Queanbeyan (population about 20,500) are located to the south-west and south-east. The storages to the south-west are in the heavily timbered, mountainous Cotter River catchment within the ACT, the storages being Corin Dam (75.5 gigalitres), Bendora Dam (10.7 gigalitres) and Cotter Dam (4.7 gigalitres). The storage to the south-east in New South Wales in the Queanbeyan River catchment (over which the Commonwealth has permanent

water rights) on the western slopes of the Great Dividing Range is the Googong Dam (125.0 gigalitres).

The existing storages on the Cotter and Queanbeyan Rivers have an ultimate combined capacity to serve 401,000 persons. The remaining water resource within the ACT is the Gudgenby River which is at present not utilised but has the potential to serve approximately 200,000 persons.

A network of stream gauging stations in the ACT (run by ACT Electricity and Water) monitors surface water resources. A number of these gauging stations are provided with telemeters to provide a flood warning system in association with the Bureau of Meteorology.

Groundwater

Groundwater in the ACT and environs occurs mainly in fractures in crystalline rock such as granite and volcanic rocks; in folded and fractured slate; and, rarely, in solution cavities in limestone. Alluvial aquifers of significance are restricted to the Lake George basin and small areas along mature sections of the Molonglo and Murrumbidgee rivers. Groundwater has been used in the past by most primary producers to augment surface storage. Groundwater production bores in the ACT have yields ranging between about 0.4 and 20 KL per hour; 3 KL per hour is about the average yield. However, many farm bores have fallen into disuse as a result of the government's resumption of freehold land within the ACT, and because of the rapid expansion of urban growth. The Bureau of Mineral Resources has provided a bore-siting, ground water-quality and yield-prediction service in and around the ACT since the early 1950s and has maintained a network of observation bores which have been monitored regularly.

The Bureau of Mineral Resources provides technical advice to landholders and drilling contractors on groundwater and, occasionally, on runoff.

BIBLIOGRAPHY

ABS Publications

Agricultural Land Use and Selected Inputs, 1985–86, Australia (7411.0)

Other Publications

NATIONAL DEVELOPMENT AND ENERGY, DEPARTMENT OF. *Review of Australia's Water Resources*. Australian Water Resources Council, Canberra, 1975

RESOURCES AND ENERGY, DEPARTMENT OF. *Review of Australia's Water Resources and Water Use*. Water Resources Data set. Australian Water Resources Council, 1985