CHAPTER 23

WATER CONSERVATION AND IRRIGATION

RESOURCES, UTILISATION AND NATIONAL AND INTERSTATE ASPECTS

Official Year Book No. 51, pages 228–31, contains a description of recent developments in the measurement of Australia's water resources. For information concerning general, descriptive and historical matter *see also* Year Book No. 37, pages 1096–1141.

An article on droughts in Australia appeared in Year Book No. 54, pages 991–6.

For further details on geographical and climatic features determining the Australian water pattern, *see* the chapter Physical Geography and Climate; on water supply and sewerage in metropolitan areas, cities and towns, the chapter Public Finance; and on the generation of hydro-electric power, the chapter Electric Power Generation and Distribution, of this issue.

A series of maps showing the location of major dams and reservoirs and the various irrigation schemes operating in each of the States may be found on pages 259–65 of Year Book No. 46, and a map showing the extent of known artesian basins throughout Australia is shown on page 273 of Year Book No. 48.

Water resources and their utilisation

Surface supplies

An assessment of Australia's surface water resources has been made, based on measured and estimated stream flows within 197 river basins, as follows. The total average annual discharge of Australian rivers has been assessed at 280 million acre feet. This can be divided into 108 million acre feet measured discharge and 172 million acre feet estimated for areas where there are generally no gauging records. For the whole area of Australia (approximately 3 million square miles) only 1.9 million square miles are regarded as contributing to stream flow (i.e. there is practically no flow from Western Plateau drainage division and from arid parts of other divisions).

The flow of Australian rivers is small in comparison with the flow of rivers in other continents, some examples of which, expressed as mean annual discharges in millions of acre feet, are: Amazon, 2,950; Mississippi, 465; Mekong ,405; Niger, 308; Volga, 205; and the ten major rivers of the United States of America in the aggregate, 900.

Major dams and reservoirs

The table below lists existing major dams and reservoirs, together with those under construction and those projected, at June 1972. The list is confined to dams and reservoirs with a capacity of 100,000 acre feet or more. There are many others of smaller capacity in Australia. As a general rule, the figures shown for the height of wall (feet) refer to the vertical distance measured from the lowest point of the general foundations to the 'crest' of the dam, i.e. the level of the roadway or walkway on the dam.

MAJOR DAMS AND RESERVOIRS IN AUSTRALIA

Name	*Location*	*Capacity (acre feet)*	*Height of wall (feet)*	*Remarks*
EXISTING DAMS AND RESERVOIRS				
Lake Argyle (Ord River)	Near Wyndham, Western Australia	4,600,000	323	For irrigation. Flood storage capacity above full supply level is 28,000,000 acre feet
Eucumbene . .	Eucumbene River, New South Wales	3,890,000	381	Part of Snowy Mountains Hydro-electric Scheme
Eildon . . .	Upper Goulburn River, Victoria	2,750,000	260	Storage for irrigation and for the generation of electricity
Hume . . .	Murray River, near Albury, New South Wales	2,480,000	167	Part of Murray River Scheme—Storage for domestic, stock and irrigation purposes. Hydro-electric power also developed
Miena . . .	Great Lake, Tasmania .	1,710,000	60	Storage for Poatina hydro-electric power station

MAJOR DAMS AND RESERVOIRS IN AUSTRALIA—*continued*

EXISTING DAMS AND RESERVOIRS—*continued*

Name	*Location*	*Capacity (acre feet)*	*Height of wall (feet)*	*Remarks*
Warragamba	Warragamba River, New South Wales	1,670,000	450	For Sydney water supply. Also provides for generation of hydro-electricity
Menindee Lakes Storage	Darling River, near Menindee, New South Wales	1,468,700	60	Part of Darling River Water Conservation Scheme
Burrendong	Macquarie River, near Wellington, New South Wales	1,361,000	250	Storage for rural water supplies and flood mitigation
Blowering	Tumut River, New South Wales	1,322,400	368	For regulation of discharges from stations of Snowy Mountains Hydro-electric Scheme, primarily for irrigation but also for hydro-electric power generation
Wyangala	Lachlan River, New South Wales	987,000	280	Storage for domestic stock, and irrigation purposes
Burrinjuck	Murrumbidgee River, New South Wales	837,000	264	Storage primarily for irrigation also production of hydro-electric power
Talbingo	Tumut River, New South Wales	747,000	530	Part of Snowy Mountains Hydro-electric Scheme
Somerset	Stanley River, Queensland	735,000	173	Brisbane-Ipswich water supply, flood mitigation and small hydro-electric power station
Jindabyne	Snowy River, New South Wales	558,000	235	Part of Snowy Mountains Hydro-electric Scheme
Lake Victoria	Murray River, near South Australian border, in New South Wales	551,700	..	Natural off-river storage for irrigation in South Australia. Storage improved by construction of embankments and control regulators
Lake Echo	Lake Echo, Tasmania	442,000	60	Storage for Lake Echo hydro-electric power station (and seven others downstream)
Clark	Derwent River, Tasmania	434,000	220	Storage for Butler's Gorge and Tarraleah hydro-electric power stations (and six others downstream)
Keepit	Namoi River, near Gunnedah, New South Wales	345,300	177	Storage primarily for irrigation also production of hydro-electric power
Arthur Lakes	Source of Lake River, near Great Lake, Tasmania	343,000	50	Part of Great Lake hydro-electric power development
Waranga	Goulburn River, Victoria	333,400	45	For irrigation storage
Tinaroo Falls	Barron River, North Queensland	330,000	155	For irrigation purposes in the Mareeba-Dimbulah area
Mokoan	Winton Swamp, near Benalla, Victoria	300,000	35	For irrigation storage
Glenbawn	Hunter River, near Scone, New South Wales	293,200	251	Storage for irrigation purposes and flood mitigation
Rocklands	Glenelg River, Victoria	272,000	93	Part of Wimmera-Mallee domestic and stock water supply system
Eppalock	Campaspe River, near Heathcote, Victoria	252,860	150	To supplement supply to Bendigo and for irrigation
Tantangara	Murrumbidgee River, New South Wales	206,000	148	Part of Snowy Mountains Hydro-electric Scheme
Devils Gate	Mersey River, North Tasmania	190,000	250	Storage for Mersey Forth power development
Avon	Avon River, New South Wales	173,800	232	Part of Sydney water supply
Upper Yarra	Yarra River, Victoria	162,000	293	For Melbourne water supply
Wuruma	Nogo River, Central Queensland	157,000	151	For irrigation along Burnett River
Glenmaggie	Gippsland, Victoria	154,300	121	Storage for irrigation
Lake St Clair	Central Highlands, Tasmania	154,200	..	Improved natural storage for eight Derwent River hydro-electric power stations
Wellington	Collie River, Western Australia	150,100	121	For supply of water to irrigation districts and to agricultural areas and country towns
Grahamstown	Grahamstown River, near Newcastle, New South Wales	147,000	35	To supplement supply to Newcastle and district
Koombooloomba	Tully River, North Queensland	146,000	170	For hydro-electric and irrigation purposes
Serpentine	Serpentine River, Western Australia	144,000	171	For Perth water supply
Cethana	Mersey River, North Tasmania	143,000	360	Storage for Mersey Forth power development
Lake Brewster	Lachlan River, near Hillston, New South Wales	123,900	..	Storage of rural water supplies for the lower Lachlan
Cairn Curran	Loddon River, Victoria	120,600	144	For irrigation storage
Rowallan	Mersey River, North Tasmania	110,000	140	Storage for Mersey Forth power development
Eungella	Broken River, North Queensland	106,000	146	Provision of cooling water for Collinsville power station, supply to Collinsville town and for irrigation purposes

MAJOR DAMS AND RESERVOIRS IN AUSTRALIA—*continued*

Name	*Location*	*Capacity (acre feet)*	*Height of wall (feet)*	*Remarks*
DAMS AND RESERVOIRS UNDER CONSTRUCTION				
Lakes Gordon and Pedder	South-west Tasmania: Gordon River	9,600,000	460	Storage for Gordon River power development
	Serpentine River	2,286,080	126	
	Scotts Peak		140	
	Lake Edgar		50	
Dartmouth	Mitta Mitta River in North-Eastern Victoria	3,000,000	590	Additional regulation of Upper Murray flow to secure River Murray irrigation development. Hydro-electric power also to be developed.
Fairbairn	Nogoa River, Central Queensland	1,170,000	145	Storage for the Emerald Irrigation Area
Copeton	Gwydir River, New South Wales	1,105,000	357	For irrigation storage
Monduran	Kolan River, near Gin Gin, Queensland	475,000	166	For irrigation storage
Ross River	Near Townsville, Queensland	338,000	115	Flood mitigation and water supply to Townsville (First and Second Stages)
Cardinia	Near Emerald, Victoria	234,000	270	For off river storage for Melbourne water supply
Darwin River Dam	Near Darwin	210,000	100	Darwin Water Supply
South Dandalup	Dandalup River, Western Australia	168,500	140	For Perth water supply
DAMS AND RESERVOIRS PROJECTED				
Buffalo (second stage)	Buffalo River, near Myrtleford, Victoria	800,000	260	For irrigation storage
Warkworth	Wollombi Brook, Hunter Valley, New South Wales	406,000	130	Flood mitigation and irrigation dam for Hunter Valley
Windamere	Cudgegong River, New South Wales	280,000	200	For irrigation storage
Pike Creek	Near Stanthorpe, Queensland	212,000	190	For irrigation, part of Dumaresq-Barwon Border Rivers Scheme
North Pine	North Pine River, near Petrie, Queensland	164,000	142	To supplement supply to northern Brisbane area
Tallowa	Shoalhaven River and Kangaroo River Junction, New South Wales	120,000	140	Water supply and pumped storage power development
Julius	Leichardt River, near Mt. Isa, Queensland	100,000	115	Water supply to Mt. Isa mines, city and other mining development

Irrigation

For some brief remarks on the history of irrigation in Australia *see* issues of the Year Book prior to No. 39. An article on the conservation and use of water in Australia appeared in Year Book No. 37, page 1096 and subsequent developments have been covered in later numbers of the Year Book.

Irrigation research

Comprehensive programs of research and investigation are being pursued by State water and agricultural authorities and the Commonwealth Scientific and Industrial Research Organization, often in collaboration. Special attention is being given to the following: high water tables due to the application of water; surface accumulation of salt and other soil changes associated with irrigation; methods of applying water efficiently; soil treatments to improve the physical condition of irrigated heavy clay soils; the utilisation of irrigated pastures by stock; and growth problems affecting plants and trees and reduction of salinity in river systems.

The Commonwealth Scientific and Industrial Research Organization conducts research on irrigation and irrigated crops at a number of its research stations and laboratories. The Division of Irrigation Research at Griffith (New South Wales), is investigating ways of limiting the degradation of land by irrigation, improving the quality and range of irrigated crops, and assessing the amount of water required by irrigated crops and the most economical means of applying it. The crops being studied include citrus, cotton, rice, lucerne and vegetables. Design criteria for irrigation channel networks are being studied to help solve problems related to the transient flow in natural and artificial channel systems. The Division of Environmental Mechanics at Canberra (Australian Capital Territory) studies water movement in soils, evaporation from field crops, water movement in plants and the physics of water stress. Summer forage crops, winter legume crops and irrigated pastures are

being investigated by the Division of Plant Industry at Swan Coastal Plain (Western Australia). Salt tolerant rootstocks for grape vines and other problems of grapes and pome fruits are being evaluated at Merbein (Victoria) and Adelaide (South Australia) by the Division of Horticultural Research. The Division of Land Research conducts research on a number of irrigated crops, including rice, safflower, linseed and cotton at the Kimberley Research Station (Western Australia) and tobacco at Mareeba (Queensland). The Division has also carried out a number of hydrological investigations on the utilisation of underground water for irrigation and is studying infiltration characteristics of soils. The Division of Applied Geomechanics is studying the engineering aspects of water movement through earth embankments. The Division of Soils is studying the rate of recharge of aquifers in the south-east of South Australia and the effect that the type of plant cover (grassland or forest) has upon that rate. This Division is also looking at the effect that clearing has upon the salinity of water obtained from catchments in the south-west of Western Australia.

The Irrigation Research and Extension Committee plays an important part in the agricultural activity of the Murrumbidgee Irrigation areas and associated districts, and the Coleambally Irrigation Area. It is representative of the New South Wales Department of Agriculture, the Commonwealth Scientific and Industrial Research Organization, the Rural Bank of New South Wales, the Soil Conservation Service of New South Wales, the Water Conservation Service of New South Wales, the Rice Marketing Board of New South Wales, the Wine Grape Marketing Board of New South Wales, co-operative and secondary industries, and farmers' organisations. Finance is provided by these authorities on an agreed basis. The objectives are: to enable the agricultural extension services to the farmers in the defined sub-region to be continued and developed; to provide a system for advising on local agricultural policy and organisation; to provide means for farmer opinion to have due weight in the consideration of regional agricultural administration and policy; to achieve a unified approach to sub-regional extension in all branches of agriculture; to advise on the research needs of the sub-region and to co-ordinate the agricultural research of the various rural institutions working therein; to achieve close liaison between research and extension; and to conduct research in extension methods.

Two other organisations with similar objectives are the Victorian Irrigation Research and Promotion Organisation which operates from Shepparton, and the Murray Research and Extension Committee centred at Deniliquin.

Preservation of catchments

Since water conservation commences on the catchments it is becoming increasingly recognised that anything which interferes with catchment efficiency affects the quantity of water available for all purposes. Active steps are being taken to counteract soil erosion, to conserve soil generally, and to minimise the effects of floods, overstocking, bush fires, and the destruction of vegetative cover. All States and the Commonwealth have initiated forestry policies which provide for reafforestation and the preservation of catchments. In recent years efforts to counteract soil erosion have been intensified, and there is some evidence of a more unified approach to catchment, water, forestry, and land use, factors regarded as parts of a single problem.

Sub-surface supplies

Much of Australia's underground water is obtained from artesian and sub-artesian basins and is used for stock purposes and domestic use. These supplies are indispensable in the dry areas which comprise most of the inland and extensive coastal areas as well. The quality of water ranges from usable to very saline.

Considerable use is also made of sub-surface water, other than pressure water, from localised groundwater basins, particularly in the well-settled areas. The water is used mainly for domestic and stock purposes. Compared with other countries with similar rainfall and climate, underground water is not used extensively for town and individual industrial supplies and irrigation, but its use for these purposes is increasing.

Artesian and sub-artesian supplies. Pressure water (either artesian or sub-artesian), variable in quantity and quality, is obtainable in many parts of Australia, from the various artesian basins extending over about half the continent.

The Great Artesian Basin, the most extensive in the world, underlies an area of approximately 676,250 square miles, comprising about 421,000 in Queensland, 135,000 in South Australia, 81,250 in New South Wales and 39,000 in the Northern Territory. A table showing the principal defined water-bearing basins in Australia is shown on the following page.

More than 18,000 artesian bores have been drilled within the Great Artesian Basin, while the daily free discharge from all bores continuing to flow in Australia has been stated as exceeding 350 million gallons, of which the loss by evaporation and seepage has been estimated at more than 90 per cent. Sub-artesian bores and wells throughout Australia number more than 200,000.

Artesian water generally is good stock water, but most is unsuitable for plant life; in certain areas sub-artesian waters are suitable for all uses. Some of these areas are in the Canning, Murray, Georgian and Barkly, Perth, Ord-Victoria, Pirie-Torrens and Adelaide Basins. In the Eucla Basin and parts of the Murray and Pirie-Torrens Basins the water is of poor quality, being barely suitable for stock.

In common with other countries possessing artesian supplies, Australia has been faced with the problem of flow diminution. It was recognised early that flows were diminishing as more bores were drilled, but it is now considered that while many of these bores will ultimately cease to flow, others will assume a perpetually steady rate of flow, corresponding with the average recharge from rainfall absorbed by permeable outcrops, mainly sandstone and limestone. Diminution in flows from artesian bores has emphasised the need to eliminate wastage as much as possible. Licences issued for the construction of new artesian bores prohibit the distribution of water through drains, channels, etc., as formerly, and the supplies must be confined to the borehead or piped to appropriate watering points.

PRINCIPAL WATER-BEARING BASINS IN AUSTRALIA

Name	*State*	*Geological age of chief aquifers*	*Approximate area*	*Depth to pressure water*
			square miles	feet
Great Artesian	Queensland, New South Wales, South Australia and Northern Territory	Mesozoic	676,250	Up to 7,000
Canning	Western Australia	Mesozoic-Palaeozoic	150,000	100 to 1,800
Murray	Victoria, New South Wales and South Australia	Miocene-Eocene	109,000	100 to 1,300
Georgian (including Barkly and Daly)	Northern Territory, Queensland	Cretaceous, Ordovician, Cambrian, and Upper Proterozoic	108,000	150 to 1,000
Eucla	Western Australia, South Australia	Pliocene-Miocene	74,000	300 to 2,000
Carnarvon	Western Australia	Cretaceous, Permian	45,000	200 to 4,000
Perth	Western Australia	Recent, Jurassic	21,000	200 to 2,500
Western District (Otway)	Victoria	Pleistocene-Upper Cretaceous	13,000	100 to 4,500
Basins of Ord-Victoria region	Northern Territory, Western Australia	Mainly Cambrian, and Permian	12,000	200 to 1,000
Pirie-Torrens	South Australia	Recent, Pleistocene	9,000	Up to 600
East Gippsland	Victoria	Pleistocene-Eocene	3,500	200 to 3,500
Adelaide	South Australia	Recent, Oligocene	1,100	200 to 600

Shallow groundwater. Shallow groundwater supplies are used in various parts of Australia for industry, irrigation, stock, and domestic purposes. Two examples of the use of these shallow supplies for industrial and domestic purposes occur in New South Wales. The Hunter District Water Board pumps up to 15 million gallons a day (average use over 30 years is 9.2 million gallons per day) for general use from the Tomago coastal sands near Newcastle, and at Botany, Sydney, private industry pumps 8–10 million gallons a day for its own use from similar sands. Exploration of the coastal sands north of the Tomago Sands has revealed a further potential production of 25 million gallons a day. Examples of the use of shallow groundwater supplies for irrigation include the Burdekin Delta and the Bundaberg area in Queensland. In the Burdekin Delta, which covers an area of some 200 square miles, the present extraction for irrigation from underground sources is in the region of 200,000 acre feet per annum (about 150 million gallons a day) and in the Bundaberg area it is approximately 50,000 acre feet per annum (about 37 million gallons a day).

Schemes for artificial recharge of underground supplies have been implemented on both sides of the Burdekin River delta. Diversions from unregulated river flows of 61,000 acre feet per annum to the north side and of 40,200 acre feet per annum (when available) to the south side have been authorised.

In recent years there has been a marked increase, particularly in Queensland, New South Wales and Victoria, in investigation into the groundwater resources of river and coastal alluvium for irrigation and town water supplies.

National and interstate aspects

In terms of the Commonwealth Constitution primary responsibility for control and conservation of water rests with the individual State Governments. The Commonwealth Government is responsible for matters relating to water in its Territories. However, because political boundaries sometimes intersect river valleys and underground water basins, co-operation between Governments has been necessary to develop resources in certain cases. Specific examples of Commonwealth-State and interstate co-operation and approach are given in the following paragraphs.

Australian Water Resources Council

The Australian Water Resources Council was established by joint action of the Commonwealth and State Governments in 1962. The council comprises Commonwealth and State Ministers primarily responsible for water resources, with the Commonwealth Minister for the Environment and Conservation as Chairman, and is serviced by a Standing Committee consisting mainly of the heads of Departments responsible to these Ministers, and by a number of technical committees, including one on water quality.

The primary objective of the Council is the provision of a comprehensive assessment on a continuing basis of Australia's water resources, and the extension of measurement and research to provide a sound basis for the planning of future development. In terms of its objectives and functions, the Council has dealt with a wide range of topics, making recommendations and stimulating action by appropriate bodies.

An accelerated water resources measure program involving many more new or improved gauging stations and groundwater investigations by Commonwealth and State Government authorities began in 1964–65. The Commonwealth Government approved extension of the program until 30 June 1973. In addition to its own commitments in the Territories, the Commonwealth is assisting the State Governments with their programs of water resources investigations. Since 1962–63, the total annual expenditure on this program by Australian Governments has increased more than three-fold.

The Commonwealth Government provided $400,000 during the three years ended 30 June 1971 for the Water Research Fund administered by the Council which has approved eighteen projects in a new research program. This program, aimed at improving the efficiency of water management in Australia, complements research already undertaken by Commonwealth agencies, universities and other organisations. For the triennium to 1974 the Commonwealth Government allocated $700,000.

Research results published or on open file, deal with a number of topics, for example:

Hydrology of small rural catchments in Australia, effects of land management on quantity and quality of available water, Australian desalination plants, streamflow measurement, evaporation studies, bore logging, and extraction of water in unconsolidated sediments.

The Council has given attention to the collation of available data on Australia's water resources. In 1965, a *Review of Australia's Water Resources (Stream Flow and Underground Resources)* 1963 was published, this being the first official assessment. *A Review of Australia's Water Resources (Monthly Rainfall and Evaporation)* by the Bureau of Meteorology was issued in 1969. Other council publications include a twice a year Newsletter, a Hydrological Series, a Technical Paper Series, an *Inventory of Water Resources Research in Australia* (published biannually), a Stream Gauging Information Catalogue (published five-yearly with annual supplements) and miscellaneous publications. Systematic publication of information is encouraged.

The Council continues to support Australian participation in the scientific program of the International Hydrological Decade (1965–74). An important contribution follows from the decision of the Council to establish ninety-three representative basins throughout Australia for detailed hydrological studies. The continuance and introduction of post-graduate study in hydrology is being encouraged at the universities. Under the auspices of the Council, a Groundwater School is held at about two-yearly intervals.

National Water Resources Development Program

In developing water resources, the Commonwealth Government's role in the past, while important, had been confined to assisting special projects or areas, e.g. the Snowy Mountains Scheme, participation in the River Murray Commission, and financial support for individual State projects such as the Ord River project. However, the National Water Resources Development Program, announced in November 1966, represents a very important move towards closer collaboration between State and Commonwealth Governments, and a more continuing and detailed involvement by the Commonwealth in the development of Australia's water resources.

Under the National Water Resources Development Program the Commonwealth has undertaken to provide grants to the States amounting to a total of about $50,000,000 over five years for water conservation works aimed at reducing the hazards of droughts and expanding primary production. The grants under this program apply to the Emerald dam and irrigation project in Central Queensland ($20,000,000); two Victorian schemes to reduce salinity levels in the Murray River ($3,600,000); Tailem Bend–Keith pipeline, South Australia ($6,000,000); Copeton dam on the Gwydir River, New South Wales ($20,000,000); King River dam, Victoria ($4,000,000); and the Cressy–Longford irrigation scheme, Tasmania ($750,000). In October 1969 the Commonwealth undertook to provide a further sum of $100,000,000 under this program. Further grants made are for major irrigation works in the Bundaberg region, Queensland ($12,800,000), for flood mitigation works in New South Wales ($9,000,000) and $4,650,000 for assistance with construction of the Pike Creek Dam on the New South Wales–Queensland border rivers system. Commonwealth financial assistance to water resources measurements and investigations by the States is now included under this Program.

Proposals submitted by the States are examined by the Commonwealth to determine which are suitable, from a national point of view, for inclusion in the Program, and accordingly grants are announced from time to time.

Murray River scheme

The Murray River and its tributaries form the largest river system in Australia. The catchment is approximately 408,000 square miles, or one-seventh of the area of the Australian continent, comprising five-sixths of New South Wales, over one-half of Victoria, one-sixth of Queensland and approximately one-fourteenth of South Australia. The Murray proper is 1,600 miles long. Its main tributaries are the Darling (1,700 miles), the Murrumbidgee (980 miles), and the Goulburn (350 miles). The average annual flow of each of the chief contributory streams is as follows: Upper Murray, including the Mitta Mitta and Kiewa Rivers, 3,820,000 acre feet; Darling River, 2,820,000 acre feet; Goulburn River (including Broken River), 2,580,000 acre feet; Murrumbidgee River, 2,050,000 acre feet; and Ovens River, 1,266,000 acre feet. Irrigated production in the Murray River Basin is mainly grapes for wine, dried fruits, fresh fruits, rice, vegetables, dairy produce, wool, and fat lambs.

River Murray Waters Agreement. For a brief summary of historical events leading up to the River Murray Agreement (1915) by the Governments of the Commonwealth, New South Wales, Victoria and South Australia *see* issues of the Year Book prior to No. 39. Under the Agreement construction works are carried out by the States (which are also responsible for maintenance) subject to the approval and direction of the River Murray Commission. The Agreement provides that the minimum quantity of water to be allowed to pass for supply to South Australia in each year shall be sufficient to maintain certain specified flows in the lower river varying from 47,000 acre feet a month in the winter months to 134,000 acre feet a month in the four summer months of maximum demand—the total amounting to 1,254,000 acre feet over twelve months. The flow at Albury is shared equally by New South Wales and Victoria, and each of these States has full control of its tributaries below Albury, subject in each case to the fulfilment of the South Australian allocation. For a brief outline of the operation of the Agreement prior to 1949 *see* Year Book No. 40, page 1065, and earlier issues.

At a conference of Ministers held in 1949 to consider the diversion of the Snowy River it was decided that, by diversion of streams in the Snowy Mountains area, an average of approximately 440,000 acre feet per annum would be added to the Murray River (*see* Snowy Mountains Hydro-electric Scheme, page 855) and that increased storage should be provided in order to give additional regulation of the Murray River itself as well as to provide for regulation of the diverted waters. Hydro-electric potentialities would also affect the size of the storage.

The River Murray Commission investigated the position and subsequently recommended to the contracting Governments that the River Murray Waters Agreement be amended to provide for enlargement of the Hume Reservoir by 500,000 acre feet to approximately 2,500,000 acre feet. A conference of Ministers in 1954 agreed to the enlargement, and it was also agreed that the Commission should be given power to construct regulators and to carry out such other work on the Murray River between Tocumwal and Echuca as it considered necessary to reduce the losses from the regulated flow in that stretch of the river. The amended Agreement was ratified in the Parliaments of the Commonwealth and the three States and was proclaimed on 7 April 1955. In view of the proposed diversions by the Snowy Mountains Authority to and from the Murray River, and for other reasons, amendments to those sections of the River Murray Waters Agreement dealing with the distribution of the waters of the Murray were considered desirable. Following ministerial conferences, amendments were ratified by the four Parliaments concerned, and came into force on 6 November 1958.

Further amendment of the Agreement to provide for the construction of a storage of approximately 5,000,000 acre feet capacity at Chowilla in South Australia was ratified by legislation in the Commonwealth and State Parliaments and came into force on 30 April 1964. However, in view of the greatly

increased costs by the time the project came to tender in 1967 and other significant factors (including water quality in the Lower Murray) which had arisen in the interim, the River Murray Commission resolved that, pending further investigations, construction of Chowilla Dam should be deferred. Further investigations then followed, including a re-assessment of the likely yield from both Chowilla and alternative storages on the Upper Murray and Mitta Mitta Rivers. Following careful consideration of this re-assessment, the River Murray Commission in February 1969 agreed that a 3,000,000 acre feet storage at Dartmouth on the Mitta Mitta River provided the greatest overall benefits in terms of cost and yield and should be the next development of the resources of the River Murray. The question of sharing the benefits could not be resolved by the Commission and was therefore referred to the respective Governments. Subsequently, Ministers representing the four Governments concerned met in March 1969 and agreed on conditions for the construction of the Dartmouth Project and for the sharing of the increased system yield between Victoria, New South Wales and South Australia. Among other things, the meeting of Ministers agreed to continue the Menindee Lakes Agreement in perpetuity.

The Commonwealth Government has offered to assist the three States with financing the project by way of a loan to the extent of 50 per cent of each State's contribution. At the same time the Commonwealth itself will make its own quarter contribution of the cost of the project.

The Acts ratifying the amendments to the River Murray Waters Agreement were proclaimed by the four contracting Governments on 30 March 1972, and work commenced on the construction of Dartmouth Dam on 1 April 1972.

Inflows to the Murray system during the 1971–72 year were about average. The spring of 1971 was again marked by floods, the first and smallest occurring at the end of August, the second towards the end of September and the third and largest flood early in November. During these floods Yarrawonga Pool was operated to achieve the maximum degree of flood mitigation possible. With high uncontrolled flows in the Murray and its tributaries, close regulation of flow was not achieved until early 1972. The combination of sustained surplus river flows until December, ample storage resources and dry conditions in the irrigation areas resulted in record quantities of water being diverted by New South Wales and Victoria from the Murray system. Of the total flow of the River Murray and its tributaries in 1971–72, 3,401,000 acre feet was diverted and impounded by the State of New South Wales and 2,541,000 acre feet by Victoria, while 401,000 acre feet was diverted by South Australia. During the year 5,197,000 acre feet was passed to South Australia compared with 9,032,000 acre feet in the previous year. The total diversion for irrigation, town water and other purposes from the River Murray itself by New South Wales was 1,750,000 acre feet and by Victoria 1,523,000 acre feet.

River Murray Works. Dartmouth Dam when completed in 1977 will store 3,000,000 acre feet of water and will be the largest reservoir in the River Murray system. It will complement Hume Reservoir, situated just below the junction of the Murray and Mitta Mitta Rivers, which has a storage of 2,480,000 acre feet and forms a lake 50,000 acres in area.

The Yarrawonga Diversion Weir, which was completed in 1939, raised the river level so that water could be diverted by gravitation into main channels constructed on either side of the river. Between the Yarrawonga Weir and the Murray mouth, thirteen weirs and locks have been built. Two flood diversion weirs have been constructed on the Murrumbidgee—one between Hay and the Lachlan junction and the other below the Lachlan junction.

The Mulwala Canal, supplied from the Yarrawonga Weir, has an off-take capacity of 2,500 cubic feet a second, serving 1,800,000 acres of land in New South Wales. The Yarrawonga Channel, on the Victorian side, has an off-take capacity of 1,250 cubic feet a second, serving 300,000 acres. Not all of this area is irrigated.

Adjoining the river in New South Wales, and 35 miles from the Murray–Darling junction, Lake Victoria storage, with a surface area of 27,670 acres, was completed in 1928. The water released from Lake Victoria is used by the South Australian settlements. The inlet channel to Lake Victoria was enlarged in 1957 to permit greater diversion of periodical flood flows of short duration.

Five barrages across channels near the Murray River mouth connecting Lake Alexandrina with the sea were completed in 1940 to prevent ingress of salt water to Lakes Alexandrina and Albert and to the lower river, thereby increasing the productivity of adjacent lands. The structures maintain a sufficiently high level for 50 miles up river to permit watering by gravitation of a considerable area of reclaimed river flats. The total distance across the barrages and intervening islands is 15 miles.

In addition to the works carried out under the auspices of the Commission, the separate States have constructed thousands of miles of distribution channels and have provided a number of storages on the tributaries, thereby contributing materially to the large amount of irrigation development in the Murray Basin. The main storages are: New South Wales—Menindee Lakes Storage (Darling), Blowering (Tumut), Burrinjuck (Murrumbidgee), Copeton (Gwydir), Keepit (Namoi), Burrendong

(Macquarie) and Wyangala (Lachlan); Victoria—Eildon (Goulburn), Waranga (Goulburn), Mokoan (Broken), Eppalock (Campaspe) and Cairn Curran (Loddon). Details of these, and other State works on Murray tributaries will be found in the sections dealing with State systems.

New South Wales-Queensland Border Rivers Agreement

The catchments for the border streams of New South Wales and Queensland (2,000 square miles) extend to the granite areas in the vicinity of Tenterfield (New South Wales) and Stanthorpe (Queensland), and elevation rises to 3,000 feet. Average rainfall is 30 inches. The catchments and the areas suitable for irrigation are approximately equal in each State. Climatic conditions are such that from April to October it is necessary to supplement rainfall by irrigation to stabilise and increase production. The capacity of the area to grow lucerne and tobacco under irrigation has already been demonstrated. Other possible development of the area includes irrigation of cotton, root crops, cereals, and citrus fruit, and expansion of the fat stock industry.

The New South Wales–Queensland Border Rivers Agreement came into effect on 1 July 1947. The Agreement provided for the construction of certain works on those sections of the Severn, Dumaresq, MacIntyre, and Barwon Rivers, which constitute part of the boundary between New South Wales and Queensland for the furtherance of water conservation, water supply and irrigation in those States.

The works to be constructed comprise a dam on the Dumaresq River at a site to be selected by the Border Rivers Commission to give a storage basin with a capacity as large as is reasonably practicable, and not less than six nor more than twelve weirs as may be found necessary to meet the requirements of irrigation along the rivers. Provision was also made for the construction of not more than four regulators in the effluents from the Border Rivers and for the taking over of the existing weirs on the MacIntyre and Barwon Rivers at Goondiwindi and Mungindi respectively. The cost of these works and of administration are to be borne by the States in equal shares. The Agreement further provided that the water discharge from the Dumaresq storage, whether by regulated or unregulated flow, shall be available to the two States in equal shares.

After unfavourable foundation conditions were disclosed at several dam sites on the Dumaresq River, investigations were extended to tributary streams, and superficially suitable sites located on Pike Creek and the Mole River. A geophysical survey was made at each of these sites and preliminary comparative estimates were prepared to determine the relative economy of providing one large storage at Mingoola or two smaller storages on the tributaries. Following exploratory drilling of the tributary sites, a report dealing with alternative storage proposals and possible amendments to the existing Agreement was submitted to the participating States. Consequent upon these investigations an Amending Agreement was executed between the States of New South Wales and Queensland in November 1968, which included, *inter alia* provision for the construction of storages on Pike Creek (Queensland) and the Mole River (New South Wales). The new agreement also provided for investigation and construction of works for the improvement of flow and of the distribution of flow in streams which intersect the New South Wales–Queensland border west of Mungindi.

Works completed under the original agreement include Bonshaw, Cunningham and Glenarbon Weirs on the Dumaresq River, a weir and regulator on the Barwon River at the off-take of the Boomi River. Until a dam has been constructed it is unlikely that any other weirs will be required.

Dam on Pike Creek. In December 1970 following a request by the two States, the Commonwealth agreed to contribute one third of the cost of the dam on Pike Creek up to a maximum of $4.65 million, dependent upon a check by the Snowy Mountains Engineering Corporation of the cost estimate. Pending the outcome of the check the two States authorised expenditure to enable the preparation of plans and specifications for the dam to continue. In May 1972 the Commonwealth advised the check of the estimates had been completed. The two States subsequently approved that the dam be constructed to provide a gross storage capacity of 212,000 acre feet, at an estimated cost of $14 million and the time of its commencement be 1 July 1972. Preliminary works are now in hand and the major contract for construction of the dam is expected to be let late in 1973.

Improvement of distribution of flow—Rivers crossing the border. During 1971–72 the two States considered proposals for the better distribution of flows in the Balonne–Culgoa River System. The proposals provide for the construction of four regulating structures one in each stream immediately downstream of the four main bifurcations, namely, the Culgoa/Balonne Minor, the Balonne Minor/Donnegri Creek, the Ballandool/Bokhara and the Bokhara/Birrie bifurcations. The works, estimated to cost $152,000, to be met equally by the two States, were commenced in November 1972 and scheduled for completion late in 1973.

Snowy Mountains Hydro-electric Scheme

Following a comprehensive investigation into both the water and power potential of the Snowy River waters by a Technical Committee representative of the Commonwealth and the States of New

South Wales and Victoria in 1947 and 1948, and the submission by the Committee of reports in 1948 and 1949, the Commonwealth Parliament passed the *Snowy Mountains Hydro-electric Power Act* 1949 setting up an Authority to implement the proposals agreed upon.

The basis of the proposals was to impound the Snowy River waters at high elevations and, by diverting them into tunnels passing under the Alps, to use their potential power for the generation of electricity and then to discharge them into the Murray and Murrumbidgee River systems for use in the irrigation areas.

The scheme involves two main diversions, that of the Eucumbene, a tributary of the Snowy, to the Upper Tumut River, and that of the main stream of the Snowy River at Island Bend and Jindabyne to the Swampy Plain River. In addition, works required to make use of the waters of the Upper Murrumbidgee, the Upper Tumut, the Upper Tooma and the Geehi Rivers for power generation also provide additional regulation of these streams, and this makes more water available for irrigation. Details of the two trans-mountain diversions and the associated power works together with details of progress and construction are given in Chapter 27, Electric Power Generation and Distribution.

The average total gain by diversion and regulation now that all storage works are completed is assessed at 1,120,000 acre feet per annum to the Murrumbidgee and 800,000 acre feet per annum to the Murray.

International aspects

Australia maintains contact with international developments in water conservation and irrigation through its membership of the International Commission on Irrigation and Drainage since 1952. This Commission was set up in India in 1950 in order that the technical experience of all countries might be pooled for the benefit of all, and to promote the development and application of the science and technique of irrigation and drainage in the engineering, economic and social aspects. The Commission is constituted of National Committees of participating countries, and sixty-one countries, including Australia, have so far been admitted to membership.

The Central Office of the International Commission on Irrigation and Drainage is situated in New Delhi, India. Congresses, which are held every three years, have taken place in India, Algeria, the United States of America, Spain, Japan, in that order and again in India in 1966, in Mexico in April 1969, and Bulgaria in 1972.

An Australian National Committee was established following a meeting of representatives of Australian authorities held in Melbourne in 1953. At that meeting it was decided, *inter alia*, 'that a National Committee should be formed and that the National Committee would consist of representatives of Government Departments, Statutory Authorities, firms, and individuals actively interested in irrigation and drainage'. The Committee meets annually.

STATES AND TERRITORIES

The foregoing text deals with water conservation and irrigation in Australia generally and with international, national and interstate aspects. The following survey 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 major emphasis at present is on irrigation and stock development in the dry areas along the Murray and Murrumbidgee Rivers, though a substantial scheme of intensive irrigation is being conducted in the Murrumbidgee Irrigation Areas. 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, especially to stabilise sugar production. 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 stock supplies and the safeguarding of long stock routes.

New South Wales

On page 1110 of Year Book No. 37 information is given on the pattern of rainfall and the history of irrigation in New South Wales. (*See also* the chapter Physical Geography and Climate of this issue.)

Administration

The Water Conservation and Irrigation Commission of New South Wales consists of three members appointed by the Governor. The operations of the Commission cover water conservation, control of irrigation areas, the establishment, operation and maintenance of works for domestic and stock water supply, irrigation districts, flood control districts, sub-soil drainage districts, constitution of water trusts, the issue of licences for private irrigation, artesian and shallow boring, assistance under the provisions of the farm water supplies scheme, and river improvement works.

Under the Water Act, 1912–1955 the right to the use and flow, and the control of water in all rivers and lakes which flow through, or past, or are situated within, the land of two or more occupiers, is vested in the Commission for the benefit of the Crown. A system of licences operates for the protection of private works of water conservation, irrigation, water supply, drainage and prevention of inundation.

For particulars of the New South Wales–Queensland Border Rivers Agreement ratified by Acts of both States in 1947, *see* page 855 of this chapter.

Schemes summarised

The bulk of irrigated land is along the Murray and its tributary the Murrumbidgee. Smaller areas are served by the Wyangala Dam, Lake Cargelligo and Lake Brewster on the Lachlan (a tributary of the Murrumbidgee), by Glenbawn Dam on the Hunter River, by Keepit Dam on the Namoi River, by Burrendong Dam on the Macquarie River, and by the Menindee Lakes Storage on the Darling River. None of the other rivers is regulated by large head storages, though weirs and dams have been provided for town supplies, etc. in many places. Copeton Dam on the Gwydir River is in the course of construction. In addition, substantial use is made of artesian and sub-artesian water in pastoral areas.

New South Wales legislation provides for the constitution and control of various schemes having different characteristics and including irrigation areas, irrigation districts, water trust districts, flood control and irrigation districts, and river improvement districts. There are nine irrigation areas, although two of these, Yanco and Mirrool, are generally described under the one heading, namely, the Murrumbidgee Irrigation Areas. The Areas are: The Murrumbidgee Irrigation Areas, consisting of 451,263 acres served with water through a channel system stemming from the river at Berembed Weir; the Coomealla Irrigation Area of 34,626 acres, served by pumping from the Murray; the Curlwaa Irrigation Area of 10,388 acres, supplied from the Murray by pumping; the Hay Irrigation Area of 6,850 acres, supplied with water pumped from the Murrumbidgee; the Tullakool Irrigation Area of 18,006 acres, supplied from the Edward River by diversion at Stevens Weir; the Buronga (8,739 acres) and Mallee Cliffs (1,900 acres) Irrigation Areas, served by pumping from the Murray; and the Coleambally Irrigation Area (234,637 acres), served by diversion from the Murrumbidgee River. All these Areas are administered by the Commission.

The capacities of the main storages for irrigation in New South Wales (in acre feet) are:

Darling—Menindee Lakes Storages (1,468,700);

Murray—Half share of Hume Reservoir, weirs and locks to Wentworth (1,351,420); Stevens Weir, Edward River (7,165);

Tumut (tributary of Murrumbidgee)—Blowering Dam (1,322,400);

Macquarie—Burrendong Dam (964,200 irrigation storage; 396,800 flood mitigation storage);

Murrumbidgee—Burrinjuck Dam (837,000); Redbank Weir (7,360); Maude Weir (6,740);

Namoi—Keepit Dam (345,300);

Lachlan—Wyangala Dam (987,000); Lake Brewster (123,900); Lake Cargelligo (29,430);

Hunter—Glenbawn Dam (185,300 acre feet irrigation storage; 107,900 acre feet flood mitigation storage);

Belubula (tributary of Lachlan River)—Carcoar Dam (30,000); and

Snowy Mountains Hydro-electric Scheme—Lake Eucumbene (3,890,000); Jindabyne Reservoir (558,000); Tantangara Dam (206,000).

The total length of supply channels, drains, escape channels and pipe lines constructed by the Water Conservation and Irrigation Commission in New South Wales is 5,227 miles. This comprises 3,564 miles of supply channels (including main canals), 1,594 miles of drains and escape channels, and 69 miles of pipe lines.

Irrigated culture

The following table shows details of the area of crops and pasture and the methods employed on land under irrigated culture during the 1971–72 season.

AREA OF LAND UNDER IRRIGATED CULTURE: NEW SOUTH WALES, 1971-72

(Acres)

	Method of irrigation					
	Spray	*Furrow*	*Flood*	*Trickle*	*Multiple Methods*	*Total Area*
Crops—						
Cereals	35,944	50,430	486,882	..	2,929	576,185
Cotton	..	57,986	14,237	..	200	72,423
Fruit	17,361	16,992	1,851	946	474	37,624
Linseed	170	320	1,510	..	53	2,053
Safflower	51	1,078	..	..	1,393	2,522
Sunflower	1,467	6,497	21,926	..	330	30,220
Tobacco	2,795	226	74	..	51	3,146
Vegetables	27,673	7,879	1,567	52	222	37,393
Vineyards	2,368	17,823	1,253	1,394	371	23,209
Other crops (*a*)	6,211	7,399	18,915	43	877	33,445
Total crops	**94,040**	**166,630**	**548,215**	**2,435**	**6,900**	**818,220**
Lucerne	85,935	916	80,981	..	506	168,338
Pastures	122,509	8,175	817,373	..	4,506	952,563

(*a*) Includes fodder crops.

Irrigation areas

Murrumbidgee. This area, which consists of Yanco and Mirrool Irrigation Area, together with adjacent lands supplied under agreement, received 396,340 acre feet, nearly 12 per cent of the total water (3,297,956 acre feet) used within the State for stock, domestic and irrigation purposes. The area is served by the Burrinjuck Dam on the Murrumbidgee River and Blowering Dam on the Tumut River, which joins the Murrumbidgee River near Gundagai. The catchment of the Burrinjuck Dam is about 5,000 square miles and water storage in Blowering Dam is from the natural flow of the Tumut River and water released into that river from the Snowy-Tumut Development Section of the Snowy Mountains Hydro-electric Scheme. This includes water from the Eucumbene, Upper Murrumbidgee, Tooma and Upper Tumut Rivers. The dams also provide town supplies for Gundagai, Wagga, Narrandera, Hay, Balranald, and for towns served by the South-West Tablelands scheme.

Domestic and stock water and water for irrigation are supplied to the Irrigation Districts of Tabbita, Benerembah and Wah Wah, and the Flood Control and Irrigation District of Lowbidgee. Flood flows are relied on to serve the Lowbidgee district, and water is not released from the dams for that purpose. For other areas and districts, however, water is stored during the winter, fed by melting snows and spring freshets, and is released during the September-May irrigation season. To supply the Yanco and Mirrool Areas, water is diverted by Berembed Weir, into the main canal which has an off-take capacity of 1,600 cubic feet a second. The main canal has been completed to beyond Griffith, a distance of approximately 96 miles. These areas are served by approximately 797 miles of supply channels and pipes and 880 miles of drainage channels. In addition, approximately 444 miles of supply channel run through the Tabbita, Benerembah and Wah Wah Districts which are adjacent to the Areas.

The Water Conservation and Irrigation Commission controls land transactions and water supplies for the Murrumbidgee Irrigation Areas only, and has no jurisdiction over land transactions in the adjacent irrigation districts, although it is responsible for the operation and maintenance of the water supply in these areas. Other local government services, including electricity and town water supply, are provided by Councils. Land is disposed of by the Commission by purchase or under perpetual lease tenure or leased for short terms for grazing or cultivation. The area under occupation at 30 June 1972 was 408,226 acres including 29,348 acres held for short lease grazing, agriculture, etc.

The land on which the Murrumbidgee Irrigation Areas and associated districts are situated originally comprised large sheep stations and was sparsely populated, but at 30 June 1972 its population was approximately 33,825, that of Leeton Shire being 11,500 and that of Wade Shire 21,500. The principal products of the Murrumbidgee Irrigation Areas are wool, livestock for slaughtering, rice, citrus fruits, peaches and nectarines, grapes, tomatoes, peas, beans, and root vegetables. Rice growing was initiated on the Areas in 1924 and has since become the most important crop. In a normal season, the water supplied for rice represents about half the total delivered to the Areas.

Other Irrigation Areas. The Coomealla, Tullakool, Buronga, Mallee Cliffs, Hay, Curlwaa, and Coleambally Irrigation Areas follow the same administrative pattern as the Murrumbidgee Areas—that is, land transactions are administered by the Water Conservation and Irrigation Commission which is responsible also for the operation and maintenance of works to supply water.

Irrigation districts

These districts are set up under the Water Act, 1912–1955 for (*a*) domestic and stock water supply and (*b*) irrigation. The essential difference between an 'Area' and a 'District' is that in the case of the former, all the land to be included in the area is acquired by the Crown and then subdivided into such number of separate holdings as may be determined. Within the District, however, existing ownership of land is not disturbed other than to acquire land required for water distribution works.

Since the completion of the Hume Reservoir, several such districts have been established along the Murray to utilise the New South Wales share of the storage. Water is not available for the whole of the 5,000,000 acres adjacent to the Murray in New South Wales, and therefore the schemes are based on 'extensive' irrigation, that is, water rights are allotted to holdings on the basis that only a portion of each holding (one acre in three, five or ten, according to the district, etc.) will be irrigated, but additional water, when available, may be obtained by landholders. 'Water right' means right to such a quantity annually of water, 12 inches deep, as will cover an area of one acre.

Water to serve Berriquin, Deniboota and Denimein Districts is diverted from the River Murray at Yarrawonga into the Mulwala Canal. Water for the Wakool Irrigation District and the Tullakool Irrigation Area is diverted from the Edward River at Stevens Weir, and a supplementary supply is also obtainable from Mulwala Canal. The total length of completed canals and channels in Berriquin District is 1,045 miles, comprising Mulwala canal 75 miles, Berrigan channel 22 miles, subsidiary channels 824 miles, escape channels 114 miles, and cross drainage channels 10 miles. Off-take capacity of the Mulwala canal is 5,000 acre feet a day. Wakool, with 430 miles of channels, contains 322 holdings, and the area developed by irrigation includes about one acre in six of the total area. Sheep raising and rice growing are the main industries. Considerable subdivision has occurred within the Berriquin District, and the proportion of the total area developed for irrigation is higher than in the case of Wakool. Sheep (including fat lambs), dairying, wheat, and rice growing are the main industries.

Water Trust Districts, Irrigation Trusts and Flood Control and Irrigation Districts

The Water Act, 1912–1966 provides for the constitution of Trust Districts for domestic and stock water and irrigation, and empowers the Commission to construct, acquire or utilise necessary works. When the works are completed, they are handed over to trustees to administer. The trustees are elected by the occupiers of the land and act with a representative of the Commission. They are empowered to levy and collect rates covering the cost of the works repayable to the Crown by instalments and also the cost of operation and maintenance of the works. The rates are struck according to the area of land which benefits. The following are the water trusts, other than irrigation, as at present constituted (the area in acres of each district being shown in parenthesis): *Murray River*—Little Merran Creek (157,440), Bullatale Creek (68,320), Poon Boon (34,300), Minnie Bend Flood Prevention (2,190); *Murrumbidgee River*—Yanco, Colombo and Billabong Creeks (1,007,780); *Lachlan River*—Marrowie Creek (292,640), Torriganny, Muggabah and Merrimajeel Creeks (170,240), Micabil Weir (11,500), Condobolin West Weir (4,480); *Miscellaneous*—Great Anabranch of Darling River (959,184), Nidgery Weir (46,880) and Algudgerie Creek (9,670)—making in all a total area of 2,764,714 acres. Eleven of these trusts have been formed for the provision of water for domestic and stock purposes and one for flood prevention.

Irrigation Trusts are established under the same Act and are administered by trustees in a similar way. There are seven of these trusts.

The Lowbidgee Provisional Flood Control and Irrigation District, the first of its kind, was constituted in 1945. Its purpose is to provide flood irrigation for pasture lands on the lower Murrumbidgee by water diverted from the Maude and Redbank Weirs. Another district, Medgun, near Moree in the north-west, is also in operation.

River, lake and farm water supplies

During recent years the number of licences and permits issued to individuals to draw water from rivers and lakes for irrigation have increased substantially, especially along the coastal streams in sub-humid districts where the value of supplementary irrigation is becoming more recognised as a means of stabilising production in dry months. There has also been a considerable increase along the Murrumbidgee, Lachlan, Namoi, and Macquarie Rivers.

Under the Farm Water Supplies Act, 1946, technical advice and assistance, and also financial assistance, are made available to help individual farmers and groups of farmers to provide and improve water supplies for domestic, stock and irrigation purposes by means of wells, bores, excavated tanks, weirs or dams, and flood and spray irrigation systems.

Underground water

For information on underground water resources in New South Wales *see* Year Book No. 55 and earlier issues.

Future program

The program of development in hand includes the provision of additional dams and storages, weirs, and flood mitigation and river protection works in various parts of the State. Work is continuing at Copeton Dam site on the Gwydir River. Legislation has been passed authorising the construction of Windamere Dam on the Cudgegong River, a dam on the Brogo River and existing legislation authorises the construction of a flood control and irrigation dam at Warkworth in the Hunter Valley. The Hunter River development, of which Glenbawn Dam is an integral part, incorporates an exceptionally fertile coastal valley, forming the hinterland to Newcastle, where the annual rainfall is not heavy and variations from month to month are considerable. The strengthening and enlargement of Wyangala Dam, on the Lachlan River, has been completed and storage capacity has been increased to 987,139 acre feet following installation of radial gates in the spillway. Within the new Coleambally Irrigation Area further development of farms has been carried out and water is being supplied by the Coleambally Canal which off-takes from the Murrumbidgee River at Gogeldrie Weir. At 30 June 1972, 313 large area farms and 22 horticultural farms were occupied.

Victoria

Particulars of the rainfall pattern of Victoria were given on page 1117 of Year Book No. 37. (*See also* the chapter Physical Geography and Climate of this issue.)

Administration

Victorian Governments have been active in the development of country water supplies since the 1860's when major works to supply the Bendigo goldfields were undertaken. Local trusts to construct and operate waterworks under Government supervision were provided for in the *Water Conservation Act* 1881. Development under the trust system was greatly stimulated by the *Irrigation Act* 1886, which provided for the construction of national headworks by the State, and vested in the Crown the right to the use and control of all surface waters. By 1900 there were 33 irrigation trusts and 18 other rural water supply trusts, but the system of local control was then breaking down under financial difficulties.

The *Water Act* 1905 established the State Rivers and Water Supply Commission to take over the Irrigation Trust districts (except the still-existing First Mildura Irrigation Trust) and to exercise the State's functions in the further control and development of surface waters outside the metropolis. The Commission now supervises all private diversions from streams and directly administers irrigation districts covering 2,259,280 acres, rural waterworks and urban districts covering 12,120,000 acres, flood protection districts covering 148,850 acres, and urban water supplies serving 312,600 people. It also supervises the activities of local urban water supply authorities supplying 798,700 people in 274 towns, as well as 111 local sewerage authorities and 31 river improvement and drainage authorities.

Works summarised

Since the State Rivers and Water Supply Commission began its operations in 1906 the capacity of storages under its control has been increased from 172,000 acre feet to 5,015,920 acre feet. In addition, Victoria has in effect a half share in River Murray Commission storages totalling 2,703,150 acre feet, bringing total capacity available to Victoria at 30 June 1972, to 6,367,490 acre feet. Most

of the water used from these storages is for irrigation. The area irrigated in 1971–72 totalled 1,472,591 acres (compared with 105,000 acres in 1906). Irrigation deliveries in 1971–72 totalled 2,566,832 acre feet. The value of irrigation production in 1970–71 was estimated at $194,600,000. Of the total irrigation production about one-quarter was from lands irrigated by 'private diverters', i.e. irrigators who are authorised to take water from streams, lakes, etc., but who do not come within the boundaries of an irrigation district.

Storages

Capacities of principal storages (in acre feet) and system totals at 30 June 1972 were as follows:

Goulburn System—Eildon, 2,750,000; Waranga, 333,400; total, 3,133,150;

Murray System—half share of Murray storages, 1,351,570; total, 1,392,430;

Broken River System—Nillahcootie, 32,260; Mokoan, 300,000; total, 332,260;

Ovens System—Lake Buffalo, 19,500; Lake William Hovell, 10,000; total, 29,500;

Loddon System—Cairn Curran, 120,600; Tullaroop, 60,000; Laanecoorie, 6,300; total, 186,900;

Campaspe–Coliban System—Eppalock, 252,860; Coliban storages, 64,930; total, 317,790;

Wimmera–Mallee Systems—Rocklands, 272,000; Toolondo, 86,000; Bellfield, 63,680; total, 627,890;

Maffra–Sale System—Glenmaggie, 154,300; total, 154,340;

Werribee–Bacchus Marsh—total, 48,300;

Mornington Peninsula—total, 47,640.

Irrigated culture

The following table shows details of the area of crops and pasture and the methods employed on land under irrigated culture during the 1971–72 season.

AREA OF LAND UNDER IRRIGATED CULTURE: VICTORIA, 1971-72
(Acres)

	Method of irrigation					
	Spray	*Furrow*	*Flood*	*Trickle*	*Multiple methods*	*Total area*
Crops—						
Cereals	2,221	840	35,737	21	24	38,843
Fruit	14,610	10,620	17,979	3,964	1,862	49,035
Vegetables	33,313	6,823	2,361	54	214	42,765
Vineyards	5,829	37,464	2,642	204	196	46,335
Other crops(*a*)	12,518	441	8,604	27	603	22,193
Total crops	**68,491**	**56,188**	**67,323**	**4,270**	**2,899**	**199,171**
Lucerne	14,979	66	42,345	20	291	57,701
Pastures	51,638	25	1,175,989	14	8,390	1,236,076

(*a*) Includes fodder crops.

Irrigation systems

Goulburn–Campaspe–Loddon. The principal storage for Goulburn waters is Lake Eildon, which was completed in 1956, submerging the original 306,000 acre feet Eildon storage completed in 1927. For the distribution of additional supplies available from Eildon and from other new storages on the Loddon and Campaspe rivers it has been necessary to undertake major enlargements in the distribution system by a long-term program of channel works which is still in progress. Deliveries during 1971–72 amounted to 1,089,495 acre feet, compared with 395,000 acre feet in 1954–55. Goulburn River water is diverted to the irrigation areas by gravitation from the pool formed by the Goulburn Weir, near Nagambie, completed in 1890 as a State work. The East Goulburn main channel of 1,000 cusecs capacity supplies the areas around Shepparton. Two 1,500 cusec channels to the west convey water to the off-river Waranga Reservoir and supply part of the Rodney area through

off-takes on the way. From Waranga Reservoir there are two main outlets, one supplying the western part of the Rodney area and the other, of 1,200 cusecs capacity, supplying the Waranga Western Main Channel, which runs 230 channel miles west across the Campaspe and Loddon Valleys to beyond Birchip.

Flows in the Waranga Western Main Channel are augmented by the injection of Campaspe water through a pumping station of 200 cusecs capacity near Rochester. Supply to the Tragowel and Boort areas is augmented by gravitational diversion of Loddon water.

The gross area of holdings in the Goulburn–Campaspe–Loddon systems is 1,333,888 acres. The main products are dairy produce, 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. Water is diverted from the Murray by gravity at the Yarrawonga Weir for the Murray Valley Irrigation Area and at the Torrumbarry Weir for the Torrumbarry irrigation system which extends to Swan Hill. Holdings in the Murray Valley area total 301,423 acres, devoted mainly to dairying, fat lambs and canning fruit. Holdings in the Torrumbarry system total 396,825 acres, devoted mainly to dairying and the production of fat lambs, with a concentration of vineyards, orchards and market gardens around Swan Hill.

Downstream from Swan Hill there are 5 districts supplied by pumping: the district of the First Mildura Irrigation Trust and the 4 Commission districts of Nyah, Robinvale, Red Cliffs and Merbein. These districts together serve 80,577 acres, producing mainly dried vine fruits, with some citrus fruits and table and wine grapes.

Southern systems. The Maffra–Sale–Central Gippsland district, covering 130,460 acres around Maffra and Sale, is supplied from the Macalister River, regulated by Lake Glenmaggie, and from the unregulated flow of the Thomson River. Dairy Farming is the principal activity. The Bacchus Marsh and Werribee District, supplied from storages in the Werribee River only 20 miles west of Melbourne, cover 16,107 acres intensively developed for dairying and vegetables.

Wimmera-Mallee domestic and stock supply system

Storages in the Grampians in south-west Victoria ensure farm water supplies over an area of 11,000 square miles extending northward through riverless pastoral and cereal lands to the Murray. Farm dams throughout this region, which covers one-eighth of the total area of the State, are filled once each year, in the winter-spring season, through the medium of 6,600 miles of Commission channels and about 4,000 miles of private channels. Without this supply, occupation of the region would be extremely hazardous. Storage capacity has now been increased from 564,210 acre feet to 627,890 acre feet by construction of Lake Bellfield. Fifty towns, with a population of 46,000, receive their supply from the same system. Near Horsham and Murtoa, close to headworks in the south, a supply is maintained for the irrigation of an area of 7,500 acres, mainly for dairying.

Drainage, flood protection and river improvement

The largest work in this category undertaken by the State Rivers and Water Supply Commission is the Koo-wee-rup–Cardinia flood protection district embracing 89,245 acres of a continuous depression along the seaboard of Westernport. Once useless, indeed a hindrance to communication, this area now yields primary products worth several million dollars each year.

By the *River Improvement Act* 1948, the formation of local river improvement and drainage trusts under the supervision of the Commission has been greatly facilitated and since 1950, 31 such trusts have been formed (including the Dandenong Valley Authority). The importance of river improvement work is expected to continue to grow.

The Dandenong Valley Authority was created in 1963 by special legislation, with jurisdiction over the whole catchment of the Dandenong Creek (300 square miles) for purposes of arterial drainage, river improvement and flood protection. In June 1966 the Authority took over the Commission's Carrum Drainage District.

Finance

The net capital liability of the Commission at 30 June 1972 for works under its direct control was $343.1 million. Eighty-six per cent of the cost of capital and interest repayments was borne by the State. Total expenditure on irrigation was $185.6 million; $32.7 million on rural, domestic and stock supplies; $58.5 million on urban supplies and $2.6 million on flood protection. A further $25.9 million (relating mainly to irrigation) was expended on headworks but has not yet been allocated to the above. The remaining $37.7 million was for expenditure on storages for private diversion and to supplement supplies to local authorities, and for items such as loan flotation expenses, miscellaneous surveys and investigations, and buildings, plant and stores.

Future program

In July 1963 the Government announced plans for a long-term storage program for irrigation purposes to cost a total of $75 million between 1963–64 and 1973–74. This included the projected Chowilla Reservoir, which will not now be constructed, and the Lake Buffalo project, which has been deferred following the decision to construct Dartmouth.

Since the long-term storage program came into operation, storages have been completed for the Wimmera–Mallee System (Lake Bellfield, near Horsham); the Mornington Peninsula System (Devilbend Reservoir and Tarago Reservoir); private diverters near Benalla (Lake Nillahcootie); on the Buffalo River (first stage of Lake Buffalo); the Goulburn-Murray System (Lake Mokoan near Benalla, Corop Lakes); and irrigators in the King River Valley (Lake William Hovell on the King River).

Construction of an access road to the Dartmouth Dam site and preparation of the site area commenced during the 1972 winter. It is planned that the project, including a hydro-electric power station with associated pondage area, will be completed late in 1978.

Construction of the Rosslynne Reservoir (20,000 acre feet), near Gisborne, is well advanced with May 1973 set as the target date for the commencement of filling. The reservoir will provide domestic water supplies for the Sunbury area and will regulate down-river releases to existing users.

Field investigations into the reduction of salt in the Lake Victoria and Chowilla areas, by means of control works proposed for the Murray River, are being undertaken jointly with the States of New South Wales and South Australia.

Details of a storage on the Mitta Mitta River at Dartmouth in North-Eastern Victoria appear on page 849.

Queensland

Particulars of the rainfall pattern of Queensland are given in Year Book No. 37, page 1122. (*See also* the chapter Physical Geography and Climate of this issue.)

Introduction

The important primary industries of Queensland are subject to relatively frequent and serious losses by drought and also to extensive flooding. There is therefore a definite and widespread need for the provision of works for water conservation for irrigation, stock watering and for flood mitigation.

The average annual flow of all streams in Queensland of 108 million acre feet, equivalent to 39.2 per cent of that for all Australian streams, gives ample scope for such works.

Water resources investigation

The Commissioner of Irrigation and Water Supply is required, under the *Land and Water Resources Development Acts* 1943 to 1946, to (a) prepare a complete description of the natural water resources of the State, both surface and underground, (b) undertake and carry out a survey of such resources, and (c) keep a record of all such natural water resources, surface and underground. For this purpose the Commission has installed and operates 524 stream gauging stations (448 of them being equipped with automatic water level recorders) and collects rainfall data from 187 stations in addition to Commonwealth Bureau of Meteorology stations.

Licensing and control

As required under the Water Act, rights to underground and surface water are allocated and use controlled by a system of licensing of—(a) all artesian bores in the State; (b) all sub-artesian bores in areas proclaimed by the Governor in Council; the main purpose of proclaiming areas is to ensure the equitable distribution of available supplies and to obtain information on the quantity, quality, extent and use of those supplies. (c) all conservation and use (other than for stock and domestic supplies) of flow in watercourses.

The Commission is required to control use to share supplies as equitably as possible in periods of shortage of supply. At 30th June, 1972, 13,412 waterworks licences were in existence, 10,142 being for pumps and 2,596 for dams and weirs and 674 for other works. Areas of sub-artesian water supply proclaimed in which all bores and wells require a license total 544,400 square miles. A total of 26,757 bores (artesian and sub-artesian in proclaimed areas) were registered at 30th June, 1972.

Development of water resources

The Commissioner of Irrigation and Water Supply is required to prepare a co-ordinated program of work for the conservation, utilisation and distribution of water resources, and to make recommendations to the Government regarding the carrying out of works in this program.

The Commissioner is principally responsible for water conservation and supply works for rural purposes, including irrigation, stock and domestic supply. However, in planning such works, particularly storages, economies to all users can accrue by providing where possible for dual or multi-purpose use of works for irrigation, rural, urban and industrial including power generation and mining purposes. As a result of this approach, 14 cities and towns now draw supplies from Commission storages or by diversion from regulated streams, four storages provide supply for power generation at three thermal stations (Swanbank, Calcap and Collinsville) and one hydro-electric station (Barron Falls), supply for mining operations is drawn from three other storages, and stock water supplies are or will be provided from two Commission and two private pipeline systems serving power stations or mining operations. Urgent water requirements of the expanding mining activities in Central, North and North West Queensland have brought out the need to further ensure the orderly and efficient development of the limited water resources in these areas, to provide for immediate and future needs for both urban, mineral and rural purposes.

Water conservation

At 30 June 1972, the Irrigation and Water Supply Commission controlled and operated 11 dams (2 approaching completion) and 50 weirs with a total available storage capacity of 2,135,027 acre feet. Two dams (Tinaroo Falls and Eungella) are located in North Queensland; two (Fairbairn and Callide) in Central Queensland; the other seven (Moogerah, Leslie, Borumba, Coolmunda, Wuruma, Atkinson and Beardmore) in South Queensland. Of the weirs 28 are in South, 11 in Central and 11 in North Queensland. Weir capacity ranges from 14,000 to less than 50 acre feet; 13 of them having a capacity each of over 1,000 acre feet. Completion of Beardmore, Maroon and Monduran Dams, Kolan Barrage and Chinchilla Weir now under construction will provide additional storage of 585,000 acre feet.

Irrigated culture and sources of supply

The total area under agriculture in Queensland in 1971–72 was 5.0 million acres. Of this area some 453,562 acres were irrigated. In 1971–72 crops or pastures were irrigated on 9,907 holdings or 22.9 per cent of all rural holdings in the State. The area of crops (excluding lucerne and sown and native pastures) irrigated was 348,059 acres, or 6.8 per cent of the total area under crop. In addition there were 47,864 acres of lucerne irrigated and 57,639 acres of other sown and native pastures. The average area irrigated per holding using irrigation was 46 acres.

Unlike other States, the greater part of the area irrigated is by individual private pumping plants drawing supply from streams or underground sources, spread widely throughout the State, rather than in constituted irrigation areas where supply is provided by channel systems delivering water to farms.

The following table shows details of the sources of supply for the area of land under irrigated culture during 1971–72.

AREA OF LAND UNDER IRRIGATED CULTURE AND SOURCES OF SUPPLY: QUEENSLAND, 1971-72

Source of supply	*Area irrigated*		*Percentage of total area irrigated*	
	acres	acres	%	%
Underground supplies—				
Naturally replenished Artificially replenished	..	260,464	..	57.4
Surface supplies—				
Irrigation areas	53,603		11.8	
Regulated streams Unregulated streams	107,684		23.7	
Farm dams	31,008	192,295	6.8	42.4
Town water supplies		803		0.2
Total all sources		**453,562**		**100.0**

Because of the predominance of irrigation by private diversion pumping, most of the storages are used to release water downstream to maintain supplies for such diversion.

The following table shows details of the area of crops and pastures irrigated and the methods employed on land under irrigated culture during the 1971–72 season.

AREA OF LAND UNDER IRRIGATED CULTURE: QUEENSLAND, 1971–72
(Acres)

	Method of irrigation					
	Spray	*Furrow*	*Flood*	*Trickle*	*Multiple methods*	*Total area*
Crops—						
Cereals	38,328	32,696	23,757	..	114	94,895
Cotton	643	11,936	920	..	130	13,629
Fruit	9,363	248	173	986	434	11,204
Sugar	54,577	68,255	15,189	..	6,262	144,283
Tobacco	11,010	282	246	..	174	11,712
Vegetables	43,936	3,594	374	540	256	48,700
Other crops(*a*)	8,362	11,135	3,786	73	280	23,636
Total crops	**166,219**	**128,146**	**44,445**	**1,599**	**7,650**	**348,059**
Lucerne	46,607	533	693	..	31	47,864
Pastures	40,305	318	16,402	..	614	57,639

(*a*) Includes fodder crops.

Irrigation areas

About 8 per cent of the area under irrigation in the State is concentrated in the four established Irrigation Areas constituted under the *Irrigation Acts*, 1922 to 1965, where the supply is generally reticulated by channel systems, by means of gravity or by pumping, from the storage. In addition some supply is also provided from streams regulated by the storage. Details of Irrigation Areas established and two under construction are set out below.

Dawson Valley Irrigation Area. The scheme is situated around the town of Theodore and the area is supplied by four weirs (with a capacity of 24,280 acre feet) on the Dawson River. Pumping stations deliver water through channel systems to 61 farms. Cotton and grain crops account for the major part of production from irrigated farms. In addition to irrigation demand the towns of Theodore and Moura and the Theiss Peabody Mitsui Mining Group obtain supplies from the storages.

Burdekin River Irrigation Area and Water Supply Scheme. This scheme is a complex system of water conservation, irrigation, industrial, urban and stock water supply. Storages are Eungella Dam on the Broken River, and Gorge and Blue Valley Weirs on the Burdekin River. From Eungella Dam, water is diverted directly by a privately owned 75 mile piped supply system to coal mining operations at Goonyella and Peak Downs and the town of Moranbah. Supplies for other purposes are maintained along the Bowen and lower 71 miles of the Burdekin River by release of water from the storages as required. These purposes and the arrangements for supply comprise (i) a pumping station on the Bowen River delivering supply through 21 miles of pipeline to the Collinsville Power Station, Collinsville Town and nine grazing holdings along the pipe line. (ii) Six pumping stations delivering water through channel systems to 152 individual irrigated holdings in Clare, Millaroo and Dalbeg sections of the Burdekin River Irrigation Area. Principal production crops from irrigated farms are sugar cane, rice and seed crops. (iii) private diversion by pumping for irrigation on individual holdings along the Bowen and Lower Burdekin Rivers.

Mareeba-Dimbulah Irrigation Area. This area is supplied by Tinaroo Falls Dam and weirs on the Barron and Walsh River systems. Water is delivered through channel systems and regulated streams to 562 farms on which the principal crop is tobacco. In addition, water is supplied to the towns of Mareeba, Dimbulah, Walkamin, Mutchilba and Tinaroo Falls and to the Hydro-electric Generating Station at Barron Falls.

St George Irrigation Area. This area is located near the town of St George and the principal storages for this area are Beardmore Dam (nearing completion) and Taylor Weir on the Balonne River and two weirs on Thuraggi Watercourse. Water is supplied to 20 farms on which the principal

crops are cotton and cereals and to the town of St George. The construction of works to extend the area by some 16 farms is in progress.

Emerald Irrigation Area. This scheme, a joint Commonwealth and State undertaking now under construction involves the construction of Fairbairn Dam (nearing completion) on the Nogoa River, some 12 miles upstream from Emerald. Water from this dam and associated irrigation, drainage and roadworks could ultimately serve 80 irrigation farms on which 32,000 acres could be irrigated annually. In addition, supplies will be provided for coal mining and urban water supply in the Blackwater area.

Bundaberg Irrigation Scheme. This is a joint Commonwealth and State undertaking, estimated to cost $51.84 million aimed at raising the efficiency and security of the established sugar industry in the region. Phase 1 of the Scheme now under construction involves the construction of Monduran Dam (capacity 475,000 acre feet) on the Kolan River, tidal barrages on the Kolan and Burnett Rivers, pumping stations and distribution works. The scheme will ultimately provide an assured water supply to 1,485 assignments with a gross area of 119,830 acres and 5,000 acre feet annually to augment supplies to the city of Bundaberg.

Irrigation projects

These are schemes established under the *Water Act* 1926 to 1968 where water from storage is released downstream to maintain adequate supplies for private pumping under licence, to land adjacent to the watercourse. Details of existing Irrigation Projects are set out in the following table.

IRRIGATION PROJECTS: QUEENSLAND

Project	*Storage*	*Number of licensed pumps*	*Annual water allocation*	*Water supplied 1971–72*		
				Irrigation	*Other purposes*	
			(acre ft.)	(acre ft.)	(acre ft.)	
Warrill Valley	Moogerah Dam	293	8,191	6,787	8,797	Power generation and urban
Mary Valley	Borumba Dam	147	4,358	2,821	1,662	Urban
Upper Condamine	Leslie Dam	69	11,660	8,414	483	Urban
Macintyre Brook	Coolmunda Dam	90	3,511	2,531	153	Urban
Upper Burnett	Wuruma Dam	251	21,124	19,001	511	Urban
Lower Lockyer	Atkinson Dam	141	6,038	2,955	..	

Other projects currently under construction or approved are set out below.

Logan River Project. Maroon Dam, under construction on Burnett Creek, a tributary of the Logan River, is designed to permit expansion of irrigation from the present 3,475 acres to 9,900 acres along Burnett Creek and the Logan River for about 80 miles.

Border Rivers Project. The Dumaresq-Barwon Border Rivers Commission consisting of representatives of New South Wales and Queensland was created to control works on these rivers where they form the boundary between the two States, and to allocate the water. (For details *see* page 855).

Leichhardt River Project. This scheme, which involves the construction of Julius Dam on the Leichhardt River and a supply system to convey the water to the Mount Isa area is designed to provide water for the rapidly expanding needs of Mount Isa City and Mount Isa Mines Ltd and to maintain a reserve supply for possible other users in the forseeable future. Construction of the dam commenced during 1972–73.

Blackwater Water Supply. Construction of a supply system with a capacity of 3,700 acre feet per annum from Bedford Weir to Blackwater and a capacity of 1,800 acre feet from Blackwater to Leichhardt Mine has been approved and will be completed in 1973. Initially to supply the Leichhardt Colliery and Town of Blackwater, the works are estimated to cost $2.3 million.

Rural, stock and domestic supplies

Rural Water Supply Areas. Improvements to stock and domestic water supplies are assisted by the development of Rural Water Supply Schemes, where water from a central source is distributed through pipelines to individual farms and properties. Investigation and design of these schemes are carried out by the Irrigation and Water Supply Commission. The schemes attract a Government subsidy of 50 per cent of the capital cost, the balance being provided by way of Government guaranteed loans raised by the individual water boards. Operation and maintenance costs and capital charges are wholly met by rates levied on benefited properties. Fourteen schemes are in operation with a total benefited area of 274,120 acres on 589 rural holdings.

Bore Water Supply Areas. Bore Water Supply Areas are constituted under the Water Act for the purpose of supplying water from artesian or sub-artesian bores to groups of adjoining properties for the watering of stock. The construction or acquisition of a bore and distribution system within an Area is financed by a Treasury loan, and rates calculated on the basis of area benefited are levied annually to meet loan repayments and maintenance and operating costs. Of the 60 Bore Water Supply Areas currently operating in the State, 54 are administered by the Commission and six by local boards elected by the ratepayers within the areas. A total daily flow of 23,398,000 gallons was distributed through some 2,374 miles of drains to serve a benefited area of 4,613,253 acres on 397 holdings.

River improvement trusts

These trusts are virtually autonomous bodies whose responsibility is to carry out and maintain works to improve stream channels, to increase their flood carrying capacity, to prevent or repair bank erosion and to mitigate flooding. Thirteen trusts are constituted throughout the State.

Drainage areas

Eight Drainage Areas—five in irrigation areas and three administered by autonomous drainage boards—have been constituted. These Areas served 296 holdings by 163 miles of drain; a total area of 61,337 acres being drained.

Underground water supplies

The availability of underground water in Queensland has played a very big part in the development of the pastoral industry, and of irrigation on individual farms, particularly along the coastal fringe. Underground water is also used very widely for irrigation, stock, and domestic purposes outside the Artesian Basin. Over half the area irrigated in Queensland receives its supplies from underground sources, and in accordance with the requirements of The *Land and Water Resources Development Acts*, 1943 to 1946, the investigation of availability of underground water is being pursued by geological mapping, investigation drilling and hydro-geological assessment. The most important areas where water from this source is used for irrigation are in the following river basins; the Lower Burdekin, the Don (Bowen), the Pioneer, the Callide Valley, the Lower Burnett, many parts of the Brisbane Basin, including the Lockyer, and parts of the Upper Condamine Basin.

Burdekin Delta recharge. For the first time in Australia, the artificial replenishment of underground water supplies has been implemented in the Burdekin Delta. The North and South Burdekin Water Boards divert unregulated supplies of water from the Burdekin River for the purpose of artificially recharging the underground supplies from which some 70,000 acres of sugar cane are irrigated and supplies for stock and domestic purposes, including the towns of Ayr and Home Hill are drawn.

Artesian water. The Great Artesian Basin in Queensland consists approximately of the area lying west of the Great Dividing Range, excluding the Cloncurry Mineral Field and the Barkly Tablelands. It comprises 434,000 square miles, or about two-thirds of the total State area. This part of the State is predominantly pastoral and is mainly dependent for water supplies on artesian and sub-artesian bores, and, where normal surface storage is not readily available, on excavated tanks. At 30 June 1972, a total of 3,265 artesian bores had been drilled in the Great Artesian Basin, of which 2,206 continue to flow, providing a supply of 195 million gallons per day. Although this supply will continue to diminish for a further 30 to 40 years, after that time a steady and continuous flow of some 130 million gallons per day is expected to be maintained.

Stock route watering

In 1935 the Trunk Stock Route System was inaugurated and from then on the construction of watering facilities on stock routes was greatly expanded. The Irrigation and Water Supply Commission acts as a constructing authority for the Stock Routes Co-ordinating Board in these matters, and had to 30 June 1972, completed 632 facilities with a further 7 under construction and 3 under investigation. The two authorities mentioned above carry out continuous investigation to ascertain general stock movements so that new facilities may be provided as required.

Farm water supplies

Under The *Farm Water Supplies Assistance Acts*, 1958 to 1965, technical assistance is available to landholders throughout the State on all matters relating to water conservation and ulitisation for domestic, stock and irrigation purposes, on individual holdings or groups of holdings, covering construction of farm dams, irrigation bores and stock bores, and pumping and distribution systems. In addition, the Government provides finance to farmers by way of special Agricultural Bank loans, and technical advice on construction and installation. During 1971–72, 734 applications were received for assistance under these Acts, and $446,527 was paid in advances by the bank, bringing advances over the 14 years of operation of the Acts to $8,457,732.

South Australia

Brief particulars of the climatic conditions in South Australia are given on page 1129 of Year Book No. 37. (*See also* the chapter Physical Geography and Climate of this issue.)

Administration

Water supplies, other than irrigation works, are under the control of the Engineering and Water Supply Department, which administers the Waterworks Act, 1932–1971 and Water Conservation Act, 1936–1969, both of which empower the Minister of Works to impound or divert the water from any lake, watercourse or underground source for the purpose of establishing and maintaining public water supply schemes. The Waterworks Act, 1932–1971 governs the principal reticulated water supplies in proclaimed water districts throughout the State. A feature of these supplies is the extensive network of water mains supplying country townships and farmlands where local water resources are practically non-existent.

Under the Water Conservation Act, 1936–1969, small dams, wells, bores, rainsheds, storages and, in some instances, minor reticulation works are provided in remote areas to assist local settlers in development and to supply travellers and travelling stock.

Irrigation

Australian irrigation originated in the upper Murray in South Australia and the Mildura area of Victoria. South Australian irrigation commenced with an agreement between the Government and the Chaffey brothers in 1887 whereby an area of land at Renmark was made available for the establishment of certain irrigation works. In South Australia, irrigation is almost exclusively confined to the Murray Valley. Except for quantities held in various lock pools, no water from the Murray is stored in South Australia. Water is either pumped onto the land or gravitated from the river.

The two major authorities administering irrigation areas are the Department of Lands and the Renmark Irrigation Trust. The Trust is controlled by a local board of management consisting of seven members. This area differs from other South Australian irrigation areas in that the land is freehold instead of leasehold. Every settler is entitled to vote for the election of Trust members. The Trust maintains eighty miles of reticulation channels, which are being progressively replaced by underground pipelines financed by Trust revenue, State Government grants and loans.

Irrigated culture

The following table shows details of the area of crops and pasture and the methods employed on land under irrigated culture during the 1971–72 season.

AREA OF LAND UNDER IRRIGATED CULTURE: SOUTH AUSTRALIA, 1971-72

(Acres)

	Method of irrigation					
	Spray	*Furrow*	*Flood*	*Trickle*	*Multiple Methods*	*Total Area*
Crops—						
Cereals	477	..	220	..	..	697
Fruit	22,349	8,302	181	981	234	32,047
Vegetables	13,788	1,676	98	55	137	15,754
Vineyards	10,690	25,356	994	1,914	194	39,148
Other Crops(*a*)	1,382	26	284	2	23	1,717
Total crops	**48,687**	**35,360**	**1,777**	**2,952**	**588**	**89,363**
Lucerne	31,212	40	9,355	..	139	40,746
Pastures	19,796	299	37,670	..	119	57,884

(*a*) Includes fodder crops.

Water supply schemes

Adelaide Metropolitan Water Supply. Adelaide and surrounding areas of development including Elizabeth derive their water from nine reservoirs in the nearby Mount Lofty Ranges and by means of pumping stations and a pipeline from the Murray River at Mannum. The reservoirs have a storage capacity of 153,000 acre feet and the pipeline has a nominal capacity of 95,500 acre feet a year.

A second pipeline extending from Murray Bridge to convey River Murray water to the metropolitan supply system is under construction. This pipeline will initially have a capacity of 132,200 acre feet per year. The consumption for the whole area for the year 1971–72 was 120,460 acre feet. The capital cost to 30 June 1972 was $153,395,000.

Country reticulated supplies. Areas extending to a distance of 90 miles north of Adelaide are supplied from the Warren, Barossa and South Para Reservoirs (50,470 acre feet) in the Barossa Ranges. Supplies to these areas are supplemented by River Murray water delivered into the Warren trunk main by a pipeline extending from Swan Reach to a point near Stockwell. This pipeline has a nominal capacity of 20,200 acre feet per year. Agricultural towns and areas further north are supplied from Beetaloo, Bundaleer and Baroota Reservoirs, and the Morgan–Whyalla Pipeline. The original 223-mile pipeline from Morgan to Whyalla and a second and larger pipeline completed in 1966 are at present able to carry 53,300 acre feet of water a year from the River Murray. A large part of Eyre Peninsula is supplied, through the 240-mile Tod River Main and the 104-mile East Coast Main, with water from the Tod River Reservoir (9,196 acre feet), the sand beds of the Uley–Wanilla Basin, the Lincoln Basin, and Polda Basin. Along the Murray River all towns are supplied from the river. Water from the river is also reticulated through adjacent farmlands for up to 30 miles, and a pipeline extended from Tailem Bend to Keith provides the means of reticulating Murray water to numerous towns and a large area of farmlands in the upper south-east. Surface and underground resources have been developed to supply most rural centres not covered by the larger schemes. Water conservation and distribution works in country districts to 30 June 1972 have cost $166,201,000 (exclusive of river control and irrigation works on the Murray River) and contain 8,659 miles of water mains.

Underground water

For information on underground water resources in South Australia *see* Year Book No. 55 and earlier issues.

Farm water schemes

The Department of Mines gives assistance to individual farmers in the provision of supplies from underground sources, and the Department of Agriculture provides an advisory service on water conservation and irrigation designs on farms, and on the suitability of surface and underground water for irrigation and stock purposes. In addition, a great part of the farming areas is supplied by the Engineering and Water Supply Department with water under pressure from extensive distributions systems connected to various reservoirs and the Murray River.

South-eastern drainage

In the south-east of South Australia it has been necessary to construct drainage schemes to dispose of surplus water from areas where a series of valleys or flats is separated by low ranges, parallel to the coastline, which prevent natural drainage. The Millicent Drainage System, completed in 1885, reclaimed 100,000 acres. The South-eastern Drainage Area System, which is controlled by the South-eastern Drainage Board, comprises drains constructed by the State Government at public expense, plus those undertaken by the Government in co-operation with the landholders. The area is bounded on the east by the State boundary, and on the west by the sea coast. It extends from about 55 miles north of Kingston, southerly to near Millicent and Kalangadoo. Up to 1948 about 430 miles of drains had been provided at a cost of $1,441,752. These were of a developmental nature intended more to promote the rapid removal of floodwaters than to provide a complete system of drainage. Since 1948 the complete drainage of the Biscuit, Reedy Creek and Avenue Flats in the Western Division has been carried out. The southern section of 260,000 acres involved the excavation of 8,100,000 cubic yards in providing 343 miles of new or enlarged drains, whilst the northern area of 140,000 acres required the excavation of 3,051,500 cubic yards in the construction of 99 miles of drain.

The drainage of 727,000 acres in the Eastern Division of the South-east, situated east of Bakers Range and extending from near Kalangadoo to north of Naracoorte, was commenced, in 1960 and completed in 1970. The work required the construction of a main diversion drain (consisting of the enlargement of 24 miles of existing drain and the construction of 22 miles of new drain) from the sea at Beachport to the Naracoorte–Mount Gambier railway line near Struan. The provision of new branch drains and the enlargement and extension of existing branch drains completed the approved works. A total excavation of 7,300,000 cubic yards over a length of 117.5 miles of new or enlarged drains was involved.

The capital cost of drainage in the South Eastern Drainage Area System to 30 June 1972 was $18 million, and the length of drains constructed was 875 miles. An extensive system of private drains (many of which discharge into drains constructed under Government authority) also exists in the South-east of the State.

Murray River 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. Disposal of drainage water is achieved by pumping to basins on river flats where it evaporates, or by dicharge into the river when flow is high. It may also be discharged into underlying sand and limestone aquifiers. The usefulness of these aquifiers is declining as they are becoming fully charged with water.

Western Australia

Brief particulars of the climatic conditions in Western Australia are given on page 1133 of Year Book No. 37. (*See also* the chapter Physical Geography and Climate of this issue.)

Administration

The Minister for Water Supply, Sewerage and Drainage administers the departmental irrigation schemes under the *Rights in Water and Irrigation Act, 1914–1971*. He is advised by an Irrigation Commission representing the local irrigationists and governmental, technical and financial branches. He also administers, under the *Country Areas Water Supply Act, 1947–1964*, the water supplies to certain country towns and reticulated farmland. As Minister for Works he controls minor non-revenue producing supplies to stock routes and a few mines and agricultural areas with their associated communities. A small number of town supplies are administered by local boards under the *Water Boards Act, 1904–1969*, which provides a large degree of autonomy with ultimate Ministerial control.

Irrigation

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

Logue Brook Dam with a capacity of 19,717 acre feet, Harvey Weir (7,194 acre feet) and Stirling Dam (46,191 acre feet) supply the Harvey Irrigation District, the rated area of which is 13,783 acres. The Harvey District links up with the Waroona Irrigation District, which is served by Waroona Dam (12,105 acre feet), Drakes Brook Dam (1,855 acre feet) and Samson Brook Dam (7,437 acre feet) and comprises a rated area of 3,483 acres. Wellington Dam on the Collie River with a capacity of 150,107 acre feet serves an area of 12,115 rated acres in the Collie River Irrigation District. Pastures for cattle comprise 88.6 per cent of water usage in these districts. Glen Mervyn Dam (1,209 acre feet) stores water for regulated release down the Preston River for irrigation of orchards and crops when the natural summer stream flow is insufficient to meet the demand.

Since the mid 1930's, a centre of tropical agriculture has been developed at Carnarvon, near the mouth of the Gascoyne River. Private pumping from sands of the Gascoyne River is the principal source of irrigation water for the 158 plantations. Because of the high risk of drawing in surrounding saline ground waters by over-pumping, the usage of water by the planters is controlled strictly by the Government. The Government is developing up-river sources and delivers water by pipeline to 70 plantations in the district. Bananas for the Perth market and fruit and vegetables for the Perth and Adelaide markets are the principal crops. A tropical research station is maintained at Carnarvon by the Department of Agriculture.

A project has been embarked upon to provide water supplies for irrigation in the area traversed by the Ord River in the Kimberley Division. The project provides for the eventual development of an area of 178,000 acres of land agriculturally and topographically suitable for irrigation.

The first stage, in which water was supplied to 30 farms averaging 660 acres plus a 2,400 acre pilot farm from the Bandicoot Bar Dam with a capacity of 80,000 acre feet, was completed in 1965. Cotton has been the principal crop but considerable interest is now being shown in grain sorghum. The Ord River Dam was completed in 1971 and will store 4.6 million acre feet in Lake Argyle to serve a further area of 148,000 acres, approximately one-third of which is located in the Northern Territory.

On the Liveringa flood plain, water is diverted from the Fitzroy River into a dam on Uralla Creek, which together with a natural storage of about 1,200 acre feet, provides for irrigation at Camballin 65 miles south-east of Derby. Grain and fodder sorghums are grown in the area.

Irrigated culture

The following table shows details of the area of crops and pasture and the methods employed on land under irrigated culture during the 1971–72 season.

AREA OF LAND UNDER IRRIGATED CULTURE: WESTERN AUSTRALIA, 1971-72
(Acres)

	Method of irrigation					
	Spray	*Furrow*	*Flood*	*Trickle*	*Multiple methods*	*Total area*
Crop—						
Cereals	154	1,870	1,922	3	3	3,952
Cotton	..	9,540	..	..	..	9,540
Fruit	9,638	789	305	1,951	605	13,288
Vegetables—						
Potatoes	4,812	32	25	13	52	4,934
Other	3,752	1,278	254	43	75	5,402
Vineyards	875	38	97	307	27	1,344
Other Crops(*a*)	801	249	49	3	3	1,105
Total crops	**20,032**	**13,796**	**2,652**	**2,320**	**765**	**39,565**
Lucerne	3,489	6,880	25,563	511	347	36,790
Pastures	1,561	..	64	1	26	1,652

(*a*) Includes fodder crops.

Country water supplies controlled by Department of Public Works and Water Supply

Since 1947 enlargement and extensions of the Goldfields and Agricultural Water Supply and the development of the Great Southern Towns Water Supply have been carried out, mainly in accordance with a project known as the Modified Comprehensive Scheme. Under this scheme water has been supplied to towns and farms in an area of five million acres in mixed farming (cereal and sheep) districts of Western Australia. The modified scheme was completed in 1961 at a cost of $20.6 million, of which the Commonwealth contributed $10 million under the *Western Australia Grant (Water Supply) Act* 1948. A further request was made by the State Government in 1963 for a grant of $10.5 million representing half the estimated cost of proposed extensions which would increase by 3.7 million acres the area served by the scheme. The Commonwealth agreed to provide assistance in the form of an interest-bearing loan up to a maximum of the amount requested, advances to be made during a period of eight years commencing 1965–66. Legislative authority for the loan is given by the *Western Australia (South-west Region Water Supplies) Agreement Act* 1965.

Mundaring Reservoir on the Helena River, 26 miles from Perth, is the source of water supplied to the Eastern Goldfields. It has a capacity of 62,435 acre feet and is connected to Kalgoorlie by a pipeline with extensions to towns and agricultural areas. At 30 June 1972 the Goldfields and Agricultural Water Supply was serving 112 towns and localities, and water was being reticulated to farms in an area of 6.2 million acres. The total length of pipelines was 4,654 miles and the number of services was 26,670. Consumption during 1971–72, including supplies drawn from local schemes and from the Metropolitan Water Supply, was 3,885 million gallons.

The Great Southern Towns Water Supply pipes water from Wellington Dam to towns on the Great Southern Railway from Brookton to Katanning as well as a number of other towns. At 30 June 1972 the Supply was serving 30 towns and water was being reticulated to 1.5 million acres of farmland. The total length of pipelines was 968 miles, and the number of services was 10,202. Consumption during 1971–72, including supplies drawn from local sources, was 897 million gallons.

One hundred and twenty-eight local schemes supply water from stream flow, dams, tanks, wells, and bores, mainly to country towns. At 30 June 1972 the total length of water mains was 1,157 miles and the number of services was 33,677.

Other country water supplies

As well as the schemes controlled by the Department of Public Works and Water Supply, there are four local Water Boards which draw supplies from stream flow, dams, wells, and bores. In addition, some local authorities supply water within their boundaries. The Forests Department, sawmilling companies, and mining companies operate schemes to supply water to their towns and

operations. Railways of the Commonwealth and State Governments make independent provision for supplies of water for their own purposes, although considerable additional quantities are consumed by the railways from other sources, such as those controlled by the Department of Public Works and Water Supply and the Metropolitan Water Supply, Sewerage and Drainage Board.

Underground water

For information on underground water resources in Western Australia *see* Year Book No. 55 and earlier issues.

Tasmania

Brief particulars of the rainfall pattern in Tasmania are given on page 1136 of Year Book No. 37. (*See also* the chapter Physical Geography and Climate of this issue.)

Main purposes of water conservation and utilisation

Because of the generally more adequate rainfall in Tasmania, scarcity of water is not such a problem as it is in most mainland areas, though not all streams are permanently flowing. The only large scale conservation by reservoirs is for hydro-electric power generation, but there are some moderately sized dams built by mining and industrial interests and by municipal authorities for town water supplies. 'Run of the river' schemes are quite adequate for assured supply in many municipalities. The main supply for Hobart and adjacent municipalities originates from a 'run of the river' scheme based on the Derwent River. The river is controlled in its upper reaches by eight dams, built for hydro-electric power generation, and these tend to stabilise river flow.

Until a few years ago irrigated areas were negligible except for long established hop fields, but there is a rapidly expanding use of spray irrigation on orchards, pastures, potatoes, and beans. Until recent years there has been almost complete dependence on natural stream flows, but the need for some regulating storages has become apparent. Increasingly, farmers are constructing storages of their own, and the extension of this practice is foreseen as the logical solution in most areas, as valleys are narrow and steep sided. Single large reservoirs cannot economically serve large areas of suitable land, as nearly every valley is separated from others by pronounced hills, prohibiting the construction of cross-country channels.

Underground water suitable for stock, minor irrigation works and domestic use is exploited in the consolidated rocks of southern, midlands and north-western Tasmania. In the south and midlands nearly all groundwater is obtained from Permian and Triassic rocks. In the north-west, water is recovered from a variety of rocks ranging from Precambrian dolomites, quartzites and schists to Tertiary basalts and Quaternary sands. The highest yields are obtained from the dolomites and the basalts. In the central north and north-east unconsolidated Tertiary clays and gravels yield water of variable quality, and in some coastal areas, notably King and Flinders Islands, water is obtained from Aeolian sands.

The Mines Department is charged with the investigation of underground water resources and is currently drilling in the Longford (central north) and Scottsdale-Bridport (north-east) Tertiary areas, and is also examining the prospects of coastal sand supplies on the East Coast. There is a great reserve of untapped permanent streams in the western half of the State, which is largely unsettled. The State's largest rivers discharge in the west, but diversion to the eastern half of the watersheds is not regarded as practicable.

Administration

In Tasmania, water supply was once exclusively the responsibility of local government authorities, but two statutory authorities, the Metropolitan Water Board and the Rivers and Water Supply Commission, now operate bulk supply schemes, piping water for distribution by the local government authorities in the Hobart and Launceston regions, and directly to certain industrial consumers.

Metropolitan Water Board. The overall control of the supply of water to the cities of Hobart and Glenorchy and the municipalities of Kingborough and Clarence is vested in the Metropolitan Water Board, the local government authorities retaining primary responsibility for reticulation and sales to consumers. Water is also supplied by the Board to urban areas in the Sorell, New Norfolk and Brighton municipalities. The major source of water is the River Derwent at Lawitta, where two pumping stations are installed. The Metropolitan Water Board controls two schemes, the West Derwent Water Supply and the Southern Regional Water Supply. The first was originally constructed

to serve Hobart, Glenorchy, Kingborough and Clarence; the second constructed by the Rivers and Water Supply Commission, but now under the control of the Board, serves that portion of Greater Hobart situated on the eastern shore of the River Derwent. The responsibility for raising loans and debts servicing necessary to meet the capital cost of constructing and adding to the schemes rests with the Metropolitan Water Board.

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 irrigation. The Commission is concerned with drainage trusts' operations, river improvements (including repairs after flood damage), stream gauging, its own regional water schemes, and with water supply, sewerage and drainage of towns. It operates in a similar manner to the Metropolitan 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, which supplies water to a sodium alginate industry at Louisville near Orford, and supplements the water supply of the township of Orford. The North Esk Regional Water Supply was constructed to meet industrial requirements of the aluminium refinery and other industries at Bell Bay, and to provide bulk supplies to surrounding municipalities on the eastern bank of the River Tamar. The West Tamar Water Supply was constructed primarily to meet domestic requirements of urban areas in 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 Metropolitan Water Board or the Rivers and Water Supply Commission, the supply of water is a function of the local municipal council. Where the construction of water and sewerage schemes is beyond the financial capacity of a local government authority, or if it requires assistance to pay for water supplied from regional schemes, the Commission may make recommendations to the Minister for payment of a subsidy.

Industrial water schemes

Four principal industrial water schemes have been installed privately—for a paper mill near Lawitta on the Derwent River, for a paper mill at Burnie using water from the Emu River, for another at Wesley Vale using water from the Mersey River, and for a factory at Heybridge reticulating water from Chasm Creek. The State Government has constructed some water schemes for use primarily for industrial purposes. These include the scheme serving the aluminium refinery at Bell Bay referred to above, a storage supplementing the summer flows of the Kermandie River for use by a wood-pulping plant at Geeveston, and the Prosser River Scheme referred to above.

Irrigation

The Cressy-Longford Irrigation Scheme has commenced operations servicing some 40 farms with irrigation water by either flood or spray sprinkler systems. This scheme, which was designed and is operated by the Rivers and Water Supply Commission, involves the diversion of water from the tailrace of the Poatina hydro-electric power station through some 60 miles of earthen channels to irrigate eventually some 20,000 acres. At least half this area will be served by gravity and it is estimated that under maximum development 6,000 acre feet of water annually would be available to farmers both inside and outside the irrigation district. The scheme will provide an augmented flow to two rivers which will increase the amount of water available for irrigation by downstream landowners. It is expected that the scheme will be fully operational for the 1973–74 irrigation season.

The Rivers and Water Supply Commission has completed preliminary investigations for establishing schemes in the valleys of the Jordan, Coal and Meander Rivers. It is currently investigating possible schemes to serve the Winnaleah area and the Brid River valley.

With the exception of the Cressy-Longford Scheme and a privately owned scheme at the Lawrenny estate at Ouse there are no other extensive irrigation works utilising one common source of water supply in Tasmania. A large portion of the area under irrigation in the State is watered by private schemes pumping water from natural streams.

Irrigated culture

The following table shows details of the area of crops and pasture and the methods employed on land under irrigated culture during the 1971–72 season.

AREA OF LAND UNDER IRRIGATED CULTURE: TASMANIA, 1971-72
(Acres)

	Method of irrigation					
	Spray	*Furrow*	*Flood*	*Trickle*	*Multiple methods*	*Total area*
Crops—						
Cereals	1,568	..	..	..	..	1,568
Fruit	6,614	87	264	102	330	7,397
Vegetables—						
Potatoes	5,525	13	..	..	30	5,568
Other	6,891	3	1	..	5	6,900
Other crops(*a*)	2,257	437	330	..	23	3,047
Total crops	**22,855**	**540**	**595**	**102**	**388**	**24,480**
Lucerne	2,154	..	25	..	..	2,179
Pastures	12,633	1,500	8,221	..	55	22,409

(*a*) Includes fodder crops.

Northern Territory

Some particulars of the climate and main topographical features of the Northern Territory are given on page 1138 of Year Book No. 37, and in this issue information on climatic conditions will be found in the chapter Physical Geography and Climate, and a brief outline of contour and physical characteristics in Chapter 28, The Territories of Australia.

Administration

Under the *Control of Waters Ordinance* 1938–1971 of the Northern Territory, natural waters are vested in the Crown. Where a watercourse or lake forms a boundary of any land alienated by the Crown, the beds and banks are deemed to remain the property of the Crown (except in special cases) and the diversion of water is prohibited except under prescribed conditions. The Ordinance requires that drilling for ground-water be carried out only by drillers who are registered under the Ordinance. Registered drillers are required to provide the Government with information on bores drilled including the location, depth and size of bore, strata encountered and water produced. 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 Ordinance* 1960–1971 any landholder engaged in pastoral or agricultural production may seek information or advice from the Commissioner of Water Development who is appointed under the Ordinance. He may also apply for an advance towards the cost of work proposed to be carried out. The Ordinance also provides for a refund to the landholder of the cost of drilling an unsuccessful bore where the landholder had applied to the Commissioner for advice on its construction and has carried out all drilling operations in accordance with advice given.

There is a Water Resources Branch of the Department of the Northern Territory under the control of a Director. The Branch carries out systematic stream gauging, the collection of data relating to the quantity and quality of surface and groundwater, the planning of water use for irrigation and town water supplies, and flood prevention and control. It also provides a general advisory service to the public on water resources and water conservation by providing information on the geology of the Territory, the prospects of obtaining groundwater, the possible location of bore sites, the method of drilling and equipping bores, information on stream flows, surveys of dam sites, the design of water supply schemes and reticulation layouts, and on the chemical and bacteriological quality of water supplies.

Underground water

For information on underground water resources in the Northern Territory *see* Year Book No. 55 and earlier issues, and the Australian Water Resources Council's 1972 publication, "Groundwater Resources of Australia".

At 30 June 1972, 7,981 bores and wells were registered in the Northern Territory. Of these 4,753 were for pastoral use, 415 for agricultural use, 645 served town domestic water supplies, 140 were in use on mining fields, 906 were investigation bores, 431 were Government established stock route bores and 691 were classified under other uses. These include successful bores which have collapsed and bores which were unsuccessful owing to drilling difficulties, or to insufficient quantity or poor quality of underground water.

Community water supplies

The largest water conservation projects in the Territory are the Darwin River Dam (210,000 acre feet) and the Manton Dam (12,700 acre feet) which both serve Darwin with a reticulated water supply. Groundwater is also pumped from McMinns Lagoon area to augment supply.

Most other towns and communities are supplied by groundwater. A few are supplied by both ground and surface waters depending on relative quality variations throughout the year.

Surface water measurement

The hydrological investigations required in the Northern Territory as part of the National Water Resources Assessment Programme are being carried out by the Water Resources Branch. The program for the Northern Territory includes establishment of base gauging stations and pluviograph rainfall recorders. In particular areas of development where water supply or irrigation proposals require special or extra surface water data, supplementary gauging stations are built to obtain this information. At 30 June 1972, the Northern Territory stream-gauging network comprised 272 operating stations; of these 198 were base gauging stations and 74 were supplementary gauging stations.

Irrigation for agricultural purposes in the Territory is not extensive, being confined to isolated areas near the Darwin, Adelaide River, Coomalie Creek, Daly River, Katherine River, Wickham River, Douglas River, Edith River and Alice Springs area, with only small acreages being utilised. In the Territory 81 licences to divert water from streams were current at 30 June 1972. The total licensed area for irrigation is 5,130 acres, but the actual area irrigated is less than this. There are also a number of farms irrigated from bore supplies, particularly in the Alice Springs area. Purposes for which irrigation water is used include the growing of fruit, vegetables, crops and pastures, and also dairying and mixed farming.

Both the Daly and Adelaide Rivers appear to offer considerable potential for irrigation development with regulation of the rivers. Extensive investigations are being conducted into possible dam sites and areas of land suitable for irrigation in the region, and there is a need for other associated studies. Irrigation trials are in progress using water from the high-production bores in the Daly Basin. Further exploratory drilling in this area is being carried out. There is an increasing demand for water resource assessment studies and assistance for relatively small irrigation projects.

Investigations are continuing into areas of the Northern Territory which may be suitable for irrigation from the main storage on the Ord River in Western Australia.

Australian Capital Territory

The climate of the Australian Capital Territory (*see* Chapter 2) with its moderate rainfall and high evaporation over the growing season is such that water conservation and irrigation are practised.

Groundwater in the A.C.T. and environs occurs mainly in fractures, joints and weathered zones of crystalline rocks such as porphyry, granite, limestone and metasediments. Alluvial aquifers are restricted to the Lake George basin and small areas along mature sections of the Molonglo and Murrumbidgee Rivers. Very minor perched aquifers occur. Recharge mainly takes place in the cooler months of the year.

Currently there are 103 bores for all purposes in the A.C.T.; 69 cater for domestic, stock and irrigation purposes, four are for industrial purposes and 30 are observation bores which the Bureau of Mineral Resources has progressively established over the past 12 years as part of its policy of assessing the groundwater resources of the region and gathering basic hydrogeological data. The yield from the bores ranges mainly from 100 to 1,800 gph and exceptionally to 10,000 gph.

In 1971–72, a total area of 971 acres was under irrigated culture in the A.C.T. The crop areas were orchards, 17 acres; vegetables, 113 acres; nurseries, 5 acres; fodder crops, 59 acres; lucerne for hay, 370 acres; and pastures accounted for 407 acres. Of the total area irrigated, 848 acres was irrigated from surface sources, 115 acres from bores and 8 acres from the reticulated water supply. The spray method of irrigation was utilised on 967 acres.

Control of irrigation and farm water supplies is exercised by the Conservation and Agriculture Branch of the Department of the Capital Territory. The Bureau of Mineral Resources of the Department of Minerals and Energy provides technical advice on groundwater, and occasionally on run-off, to landholders.

Water conservation on farm holdings was shown to be deficient in the severe 1965–68 drought when stock were moved to areas outside the A.C.T. Improvements by the provision of additional or larger farm dams and of bores have been made in recent years.

Papua New Guinea

Rainfall in Papua New Guinea varies considerably from approximately 240 inches near Lindenhafen (New Britain) and 230 inches at Kikori (Papua) to about 70 inches near Marienburg (New Guinea) and 40 inches at Port Moresby (Papua). For a general description of these territories *see* Chapter 28, The Territories of Australia of this Year Book. Irrigation has not been developed on any organised basis owing to the availability of high rainfall and the nature of agricultural development.

Papua New Guinea is well served with large rivers deriving their water from heavy tropical rains and high mountains which rise to over 14,000 feet, but complete data regarding water resources are not available. During 1971–72 the Government continued the development of a national network of stream-gauging stations which can be used in assessing the water resources of Papua New Guinea, while continuing to collect more detailed hydrological data for proposed hydro-electric projects.

The largest rivers in the Territory include the Fly (700 miles long, situated in the Western division of Papua), the Sepik (700 miles), the Ramu (450 miles), the Purari (300 miles), and the Markham (110 miles). The main water conservation interest in New Guinea at present is the hydro-electric potential, which is extensive. An outline of schemes at present in operation is given in Chapter 28 The Territories of Australia.