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 Local Government; 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 1971. 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			
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*

Name	*Location*	*Capacity (acre feet)*	*Height of wall (feet)*	*Remarks*
EXISTING DAMS AND RESERVOIRS—*continued*				
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
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
Wyangala	Lachlan River, New South Wales	987,100	280	Storage for domestic stock, and irrigation purposes
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)
Arthur Lakes	Source of Lake River, near Great Lake, Tasmania	410,000	50	Part of Great Lake hydro-electric power development
Keepit	Namoi River, near Gunnedah, New South Wales	345,300	177	Storage primarily for irrigation also production of hydro-electric power
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	160	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	9,440,000	450	Storage for Gordon River power development
	Serpentine River	2,400,000	135	
	Upper Huon River		160	
	Lake Edgar		50	
Ord River (main)	Near Wyndham, Western Australia	4,600,000	300	For irrigation, generation of hydro-electric power and flood mitigation (additional 6,000,000 acre feet flood control proposed)
Dartmouth(*a*)	Mitta Mitta River in North-Eastern Victoria	3,000,000	590	Additional regulation of Upper Murray flow to secure River Murray irrigation development
Fairbairn	Nogo River, Central Queesnland	1,170,000	160	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	171	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
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	200,000	150	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

(*a*) *See* page 844.

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 programmes 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 and 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	Pilocene-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 National Development 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 programme 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 programme until 30 June 1973. In addition to its own commitments in the Territories, the Commonwealth is assisting the State Governments with their programmes of water resources investigations. Since 1962–63, the total annual expenditure on this programme by Australian Governments has increased more than three-fold.

The Commonwealth Government has 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 programme. This programme, aimed at improving the effciency of water management in Australia, complements research already undertaken by Commonwealth agencies, universities and other organisations. For the triennium to 1974 the Commonwealth Government has 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, a Water Resources Research Inventory (published annually), 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 programme 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 and a Colloquium for Hydraulics Laboratory Staff are held at about two-yearly intervals.

National Water Resources Development Programme

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 Programme, 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 Programme 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 programme 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 programme. 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 Programme.

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 Programme, 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 845) 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.

Although each of the four Parliaments passed Acts in 1970 and 1971 ratifying the appropriate amendments to the River Murray Waters Agreement which, amongst other things, provides for the construction of Dartmouth Dam, it is necessary that Acts be proclaimed before work can proceed on design and construction.

Inflows to the Murray System during the 1970–71 year were well above average. Storages were maintained at greater than 90 per cent of total available storage capacity until the end of January 1971. Two major floods occurred in the Upper Murray during the spring and the Darling experienced a major flood during the summer. The floods from the Upper Murray catchment occurred in August and September and these combined with flood flows from the Murrumbidgee, progressed downstream, passing Blanchetown in South Australia during early December. The flood in the Darling was caused by a succession of flood rains in its upper catchment during January and February 1971. The peak of this flood passed Bourke during early March and reached the Murray at the end of May. Of the total flow of the River Murray and its tributaries in 1970–71, 3,176,000 acre feet was diverted and impounded by the State of New South Wales and 2,872,000 acre feet by Victoria and 381,000 acre feet was diverted by South Australia. During the year, 9,032,000 acre feet passed to South Australia compared with a figure of 4,471,000 acre feet during the year 1969–70. The actual diversion from the River Murray itself in 1970–71 by New South Wales was 1,249,000 acre feet and by Victoria 1,307,000 acre feet.

River Murray Works. One of the major works of the Murray River scheme is the Hume Reservoir, situated just below the junction of the Murray and Mitta Mitta Rivers, ten miles above Albury, forming a lake of 50,000 acres. Work on the enlargement of the reservoir to its approved capacity of 2,480,000 acre feet was completed in 1961.

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), Keepit (Namoi), Burrendong (Macquarie) and Wyangala (Lachlan); Victoria—Eildon (Goulburn), Waranga (Goulburn), 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 provides 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 Water Conservation and Irrigation Commission of New South Wales (the constructing authority) 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 is also made for the construction of not more than four regulators in the effluents from the barrier rivers and for the taking over of the existing weir on the MacIntyre River at Goondiwindi and the existing weir on the Barwon River at Mungindi (the Irrigation and Water Supply Commission of Queensland is the constructing authority for new weirs and regulators). The cost of these works and of administration are to be borne by the States in equal shares. The Agreement further provides 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 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 and Cunningham Weirs on the Dumaresq River, a weir and regulator on the Barwon River at the off-take of the Boomi River, and a low level weir to establish a pumping pool at Glenarbon on the Dumaresq River. The existing Goondiwindi and Mungindi Weirs are being maintained, operated and controlled by the Queensland Irrigation and Water Supply Commission. Until a dam has been constructed it is unlikely that any other weirs will be required.

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 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. The seventh Congress was held in Mexico in April 1969.

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 845 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 (987,139); 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 1970–71 season.

AREA OF LAND UNDER IRRIGATED CULTURE: NEW SOUTH WALES, 1970-71
(Acres)

	Method of irrigation				
	Spray	*Furrow*	*Flood*	*Multiple methods*	*Total area*
Crops—					
Cereals—					
Barley	2,515	1,067	21,211	106	24,899
Maize	2,570	16,388	9,156	..	28,114
Oats	16,387	1,618	28,043	189	46,237
Rice	..	..	95,332	..	95,332
Sorghum	5,466	14,436	26,013	960	46,875
Wheat	4,886	6,797	123,772	1,003	136,458
Lucerne	92,253	1,361	72,831	1,043	167,488
Cotton	646	49,343	15,253	..	65,242
Fruit and Vines	19,167	35,003	2,080	2,216	58,466
Tobacco	2,707	254	81	..	3,042
Vegetables	24,202	7,252	3,795	1,341	36,590
Other crops(*a*)	5,371	11,311	33,346	511	50,539
Total crops	**176,170**	**144,830**	**430,913**	**7,369**	**759,282**
Pastures	76,815	8,892	765,825	8,450	859,982

(*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 403,986 acre feet, nearly 17 per cent of the total water (2,554,301 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 District 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 graizng or cultivation. The area under occupation at 30 June 1971 was 409,706 acres including 31,715 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 1971 its population was approximately 30,000, that of Leeton Shire being 11,000 and that of Wade Shire 19,000. 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 Yarrowonga 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 1,033 miles, comprising Mulwala canal 75 miles, Berrigan channel 22 miles, subsidiary channels 820 miles, escape channels 105 miles, and cross drainage channels 10 miles. Off-take capacity of the Mulwala canal is 5,000 acre feet a day. Wakool, with 428 miles of channels, contains 324 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), Ulonga (64,960), Micabil Weir (11,500), Condobolin West Weir (4,480); *Miscellaneous*—Great Anabranch of Darling River (959,184), Nidgery Weir (46,880) and Algudgerie Creek (9,760)—making in all a total area of 2,829,674 acres. Twelve 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 programme

The programme 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 1971, 341 large area farms and 22 horticultural farms had been allotted.

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 1860s 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 2,247,820 acres, rural waterworks and urban districts covering 12,127,000 acres, flood protection districts covering 148,850 acres, and urban water supplies serving 297,500 people. It also supervises the activities of local urban water supply authorities supplying 686,000 people in 267 towns, as well as 106 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 5,006,620 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 1971, to 6,358,190 acre feet, Most

of the water used from these storages is for irrigation. The area irrigated in 1970–71 totalled 1,459,621 acres (compared with 105,000 acres in 1906). Irrigation deliveries in 1969–70 totalled 2,181,469 acre feet. The value of irrigation production in 1969–70 was estimated at $191,600,000. Of the total irrigation production about one-quarter was from lands irrigated by 'private diverters', i.e. irrigators who are authroised 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 1971 were as follows:

Goulburn System—Eildon, 2,750,000; Waranga, 333,400; total, 3,130,650;

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

Broken River System—Nillahcootie, 32,260; Mokoan, 295,720; total, 327,980;

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

Loddon System—Cairn Curran, 120,600; Tullaroop, 60,000; Kerang Lakes, 57,700; total, 276,250;

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;

Macalister System—Glenmaggie, 154,300; total, 154,340;

Werribee–Bacchus Marsh—total, 48,300;

Mornington Peninsula—total, 38,340.

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 1970–71 season.

AREA OF LAND UNDER IRRIGATED CULTURE: VICTORIA, 1970-71

(Acres)

	Methods of irrigation				
	Spray	*Furrow*	*Flood*	*Multiple methods*	*Total area*
Crops—					
Cereals	1,122	366	31,618	1,306	34,412
Orchards	14,398	14,583	18,164	6,292	53,437
Vineyards	4,428	40,317	2,622	501	47,868
Vegetables	34,256	7,734	1,797	770	44,557
Other crops(*a*)	26,103	1,189	32,843	681	60,816
Total crops	**80,307**	**64,189**	**87,044**	**9,550**	**241,090**
Pastures	42,440	3,551	1,212,069	15,321	1,273,381

(*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 programme of channel works which is still in progress. Deliveries during 1970–71 amounted to 998,252 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 1,327,070 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 301,691 acres, devoted mainly to dairying, fat lambs and canning fruit. Holdings in the Torrumbarry system total 386,439 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 74,781 acres, producing mainly dried vine fruits, with some citrus fruits and table and wine grapes.

Southern systems. The Macalister district, covering 130,476 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 16,231 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, 29 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 1971 for works under its direct control was $330.3 million. Eighty-seven per cent of the cost of capital and interest repayments was borne by the State. Total expenditure on irrigation was $181.3 million; $31.9 million on rural, domestic and stock supplies; $55.5 million on urban supplies and $2.5 million on flood protection. A further $23.9 million (relating mainly to irrigation) was expended on headworks but has not yet been allocated to the above. The remaining $35.2 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 programme

In July 1963 the Government announced plans for a long-term storage programme 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 deferrred following the decision to construct Dartmouth.

Since the long-term storage programme 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).

At present work is proceeding on the Tandarra-Calavil Pondage north of Bendigo and the Rossiynne Reservoir near Gisborne.

Works expenditure of about $4,000,000 per year is carried out from about twenty-six operating centres throughout the State. Two major construction centres are spending about $2,500,000 annually on a programme of channel and drainage works in the Goulburn-Murray System, and the end of this programme is not yet in sight.

A major new development has been a grant of $3,600,000 from the Commonwealth Government to finance a scheme to reduce the flow of saline drainage water into the River Murray. Works for the diversion of saline drainage at Kerang and Sunraysia were brought into operation.

About 390 miles of pipelines will replace earthen channels in the new $2.5 million Millewa scheme situated west of Sunraysia.

Details of a projected storage on the Mitta Mitta River at Dartmouth in North-Eastern Victoria appear on page 839.

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.)

Administration

In Queensland the right to the use and flow of non-tidal surface water contained in, or flowing through or past, the land of two or more occupiers, and all artesian and sub-artesian water vests in the Crown. Subject to certain reservations for local authority and other purposes, such water is controlled by a Commissioner of Irrigation and Water Supply. Private diversions from watercourses, artesian wells and, in certain declared areas, sub-artesian wells, are subject to licence by the Commissioner. Dams and weirs are constructed by the Commissioner to safeguard supplies in streams from which private pumping for irrigation takes place, and also to provide water for irrigation areas established by the Commissioner. For a description of the development of the present administration *see* Year Book No. 42 and earlier issues.

Irrigation—extent, systems and methods

Queensland sugar cane represents in value about 45 per cent of the agricultural production of the State. In 1970–71, 20 per cent of the sugar cane acreage was irrigated, representing 33 per cent of the total area irrigated in the State. Tobacco is another major crop, and the area irrigated during 1970–71 represented 96 per cent of the total plantings.

Most irrigation in Queensland is undertaken by farmers operating under licence to obtain water by pumping from streams or from natural underground storages. Over half the total area irrigated in Queensland is supplied from underground water. The main areas where these supplies have been developed extensively are the Burdekin Delta (Ayr-Home Hill area), the Pioneer Valley, Callide Valley (Monto area), Lower Burnett (Bundaberg area), Lockyer Valley, Darling Downs, and Redlands Bay.

Furrow irrigation is used for cotton, sugar cane, some tobacco, and miscellaneous row crops. Spray irrigation is used widely on fruit, vegetables, fodder crops, sugar cane, and the major part of the tobacco crop. Irrigation is required around-the-year for most of Queensland, as the timing and duration of the summer 'wet' season are too variable to enable a definite non-irrigation season to be fixed, as can be done in southern States.

Irrigated culture

The following table shows details of the area crops and pasture and the methods employed on land under irrigated culture during the 1970–71 season.

AREA OF LAND UNDER IRRIGATED CULTURE: QUEENSLAND, 1970-71

(Acres)

	Method of irrigation				
	Spray	*Furrow*	*Flood*	*Multiple methods*	*Total area*
Crops—					
Cereals	35,021	41,431	14,293	894	91,639
Cotton	894	7,414	815	..	9,123
Fruit	9,905	341	218	938	11,402
Sugar cane	56,650	75,952	13,152	9,937	155,691
Tobacco	12,151	292	283	188	12,914
Vegetables	40,575	4,129	462	517	45,683
Other crops(*a*)	60,780	7,920	4,527	807	74,034
Total crops	**215,976**	**137,479**	**33,750**	**13,281**	**400,486**
Pastures	42,736	660	16,298	740	60,434

(*a*) Includes fodder crops.

Areas under private irrigation

In six important areas irrigation has been developed by private pumping. In the Lockyer Valley, thirty miles west of Brisbane, more than a third of an estimated total irrigable area of 60,000 acres is under irrigation. The valley comprises an extensive flood plain where heavy black alluvial soil thickly overlies gravels and sands carrying water suitable for irrigation, which is necessary for continuous agricultural production. A number of small weirs on Lockyer Creek with a total storage of 1,340 acre feet and Atkinson Dam, an off-stream storage with a capacity of 254,000 acre feet, have been constructed by the Irrigation and Water Supply Commission. The latter dam provides a regulated supply of water in Buaraba Creek and along the lower end of Lockyer Creek. The Lockyer Valley produces a substantial proportion of Queensland's onions, potatoes, pumpkins, lucerne, hay, green fodder, maize and dairy products.

The Darling Downs area west of Toowoomba is extensively irrigated from both surface and underground sources. Approximately 66,000 acres are under irrigation, of which 47,000 acres are supplied from underground sources and 6,000 acres are supplied from the sections of Sandy Creek and the Condamine River regulated by Leslie Dam (*see* page 855). Cereal, fodder, cotton and oil seed crops comprise a large proportion of the irrigated production in this region.

The Callide Valley in central Queensland is an important source of grain, dairy products, fodder, and cotton and is largely dependent on irrigation from underground water resources. Some 12,970 acres are now irrigated from underground supplies. The broad expanses of alluvium in the Pioneer Valley near Mackay have been extensively developed for cane production. The area under irrigation from groundwater and surface supplies in the vicinity of Mackay is some 15,470 acres. The lands in the vicinity of Bundaberg are cultivated for sugar cane production and over 47,300 acres are irrigated from surface and underground supplies.

The other important area is the fertile delta region of the Burdekin River, where the irrigated area is over 72,900 acres. The delta has ground water supplies at shallow depth, and these have been tapped to obtain supplies in the dry periods of the year. Sugar is the main crop irrigated. Schemes to replenish the subterranean water supplies in the Burdekin Delta by pumping from the Burdekin River are in operation under the control of the North and South Burdekin Water Boards.

Government irrigation areas and projects

The irrigation and Water Supply Commission has constructed and/or operates nine dams and forty-eight weirs with a storage capacity of 930,156 acre feet. Water from these storages supplies the following four irrigation areas operated by the Commission and regulates numerous streams from which pumping for private irrigation takes place.

Mareeba-Dimbulah Irrigation Area. In 1952 an irrigation undertaking was established to assist tobacco production in the valleys of the Walsh and Barron Rivers. Tinaroo Falls Dam on the Barron River (330,000 acre feet) was completed in 1958, and construction of irrigation works is continuing. Irrigation water from the dam is being supplied through 215 miles of channels to 563 farms in the area. Tinaroo Falls Dam is also providing a regulated flow of water in Barron River at Kuranda for the generation of hydro-electric power at Barron Falls.

Burdekin River Irrigation Area. The first stage of the Burdekin River Irrigation Area, comprising the Clare-Millaroo and Dalbeg sections, has been completed. Located from twenty-five to sixty-five miles from the mouth of the Burdekin, these areas comprise 18,862 acres and obtain water from central pumping stations drawing from the river. Eungella Dam on the Broken River with a capacity of 106,000 acre feet and two weirs on the Burdekin River upstream of the irrigation settlement with a capacity of 7,670 and 2,550 acre feet serve the areas. Eungella also provides cooling water for the Collinsville power station, water for Collinsville town and 4,000 acre feet per annum for mining development at Goonyella.

Dawson Valley Irrigation Area. A scheme for the development of the Dawson Valley providing for the irrigation of 70,000 acres was inaugurated in 1923, but work was discontinued after three weirs having a storage capacity of 10,280 acre feet had been built in this area. Recently, however, additional storage became essential to mitigate the effects of droughts in the developed area and Glebe Weir was recently completed on the Dawson River to provide a further 14,000 acre feet of storage. At present sixty-one farms (14,894 acres) are in production. Cotton and grain account for the major production from irrigated areas.

St George Irrigation Area. This area comprises twenty farms, on which some 9,069 acres were irrigated during 1970–71 from a weir on the Balonne River (8,220 acre feet), and from a further two recently constructed weirs with a combined capacity of 7,350 acre feet. These two weirs also form part of the new major supply system. Cotton, grain, fodder, wool and fat lambs are the main products. Construction is in progress on a major storage, the E. J. Beardmore Dam of 81,600 acre feet capacity, and irrigation and other works to serve a further sixteen farms and to regulate supplies along the Balonne River between the dam and its junction with the Colgoa River.

The following two irrigation areas are being developed with Commonwealth assistance.

Emerald Irrigation Area. Formal approval for the establishment of the Emerald Irrigation Area was given on 28 March 1968, following agreement by the Commonwealth Government to make a non-reimbursable grant of up to $20 million available for the construction of the dam. The project involves the construction of Fairbairn Dam on the Nogo River with a capacity of 1,170,000 acre feet and the construction of irrigation, drainage, road and other works to serve some 130 irrigation farms on which up to 49,000 acres could be irrigated annually. Construction of Fairbairn Dam is nearing completion and storage of water has commenced.

Bundaberg Irrigation Area. This area was formally established on 5 November 1970, following agreement by the Commonwealth Government to provide a $12.8 million non-reimbursable grant for construction of Monduran Dam and the Gin Gin Main Channel. The purpose of the scheme is to stabilise sugar cane production on the 1,600 farms in the area, which have suffered shortfalls in recent years owing to drought and consequent depletion of underground supplies. It is being constructed in two stages. Phase one of the first stage is now under construction and includes Monduran Dam, Gin Gin Channel and irrigation works to supply farms in four areas.

Miscellaneous Irrigation Projects. A combined bridge and weir on the Dawson River near Moura with a capacity of 5,100 acre feet was completed in 1946. The weir is the source of water supply for four farms aggregating some 21,000 acres, coal mining and urban development. Additional projects which have been completed since 1961 or for which construction work has commenced include the following: Moogerah Dam (Warrill Valley Project) on Reynolds Creek (75,000 acre feet) permits irrigation of some 7,000 acres of the Warrill Valley, and provides water for the thermal power station at Swanbank, near Ipswich. Boroumba Dam (Mary Valley Project) on Yabba Creek (34,500 acre feet) supplies the town of Gympie and will allow extension of the area irrigated from the Mary River to about 18,000 acres. Callide Dam (37,800 acre feet) on Callide Creek, nine miles upstream from Biloela, provides cooling water for the Calcap power station and compensation water for maintenance of underground supplies along Callide Creek. Leslie Dam (Upper Condamine Project), on Sandy Creek, has an initial capacity of 38,200 acre feet, with provision for later increase to 87,200 acre feet. Water from the dam is available for irrigation along the Condamine River as far as Cecil Plains and for a supply to the city of Warwick. Coolmunda Dam (Macintyre Brook Project) has a capacity of 61,000 acre feet, and provides irrigation water for up to 8,000 acres along Macintyre Brook. Wuruma Dam (Upper Burnett Project), on the Nogo River, has a storage capacity of 157,000 acre feet for irrigation of 11,000 acres along 100 miles of the Burnett River. In addition, the dam

will safeguard supplies of irrigation water to the Burdekin River Irrigation Area and private diverters along the Bowen and Lower Burdekin rivers. Bedford Weir (storage capacity 5,200 acre feet), situated on the Mackenzie River some 15 miles north of Blackwater provides an assured supply of water for mineral development and urban requirement in the Blackwater area. Atkinson Dam (capacity 25,400 acre feet), provides irrigation water to 3,100 acres on 131 holdings in the Lower Lockyer Valley. Construction is continuing on Maroon Dam (31,000 acre feet) on Burnett Creek, which will supply irrigation water along the Logan River. The development of rivers constituting portion of the Queensland–New South Wales border, under the authority of the Dumaresq–Barwon Border Rivers Commission, is described on page 845.

Rural Water Supply Areas

Although provisions existed in the Water Acts for many years for the constitution of rural water supply Areas and Boards, little advantage was taken of these powers until 1964 when an amendment of the Acts extended the purposes for which these Areas and Boards may be constituted and the methods of rating and financing of works, and provided for resumption or acquisition of lands by such Boards. This form of water supply is being sought increasingly by groups of landholders in various parts of Queensland to provide a reasonably economical measure of permanent supply for stockwatering, dairy and domestic purposes in areas prone to drought, and thus achieve a permanent form of drought relief. Usually the capital cost of works is met by a 50 per cent subsidy by the Government and the balance by a Board borrowing by Government guaranteed loan on the security of debentures.

At 30 June 1971 thirteen Rural Water Supply Areas were operating, supplying 589 rural holdings covering 273,380 acres and reticulated by 326 miles of pipelines.

Water conservation, irrigation and drainage schemes may also be carried out under these Acts. One group irrigation scheme near Brookstead is now in operation and three group drainage schemes have been approved. Further group drainage schemes are currently under investigation.

Underground water

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

Stock watering

A predominant interest in the field of water conservation has been the provision of stock and domestic water supplies in Queensland's great pastoral areas, which contain more than a third of the Commonwealth's cattle and about an eighth of the sheep. In addition to the stabilisation of water supplies in the pastoral areas, the provision of water along stock routes for travelling stock has received much attention in recent years.

At 30 June 1971, there were 882 facilities throughout the State and in addition, at that time, there were 11 facilities under construction and 3 under investigation.

Since 1935, the Queensland Irrigation and Water Supply Commission has acted as consultant and constructing authority to the Stock Routes Co-ordinating Board for watering facilities on stock routes. On completion, facilities are vested in local authorities for control and maintenance.

The two authorities mentioned above carry out a continuous investigation to ascertain general stock movements so that new facilities may be provided as required.

Technical and financial assistance to farmers

The Farm Water Supplies Assistance Acts, 1958 *to* 1965 are designed to improve the standard of water supply installations on individual holdings, encourage greater development in individual irrigation schemes, provide greater stability of production, and avoid losses in time of drought as well as generally increase production. To achieve this purpose, the Acts authorise the provision of technical and financial assistance to landowners for the investigation, design and installation of approved works of farm water supply. All projects for which finance is provided under the Acts are carried out under Commission guidance, and for the payment of a small charge the Commission will advise on the construction of works designed by its staff, but for which the landowners do not require financial assistance under the Acts.

During 1970–71, 855 requests (700 for technical assistance only and 155 for technical and financial assistance) were received in addition to 507 applications for advice on ground-water supplies. An amount of $886,069 was approved for advances and the amount actually advanced was $881,918.

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 and State Government grants.

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 1970–71 season.

AREA OF LAND UNDER IRRIGATED CULTURE: SOUTH AUSTRALIA, 1970-71

(Acres)

	Method of irrigation				
	Spray	*Furrow*	*Flood*	*Multiple methods*	*Total area*
Crops—					
Orchards	24,000	9,105	254	723	34,082
Vegetables—					
Potatoes	6,668	26	10	64	6,768
Other	7,452	1,483	55	190	9,180
Vineyards	9,306	26,433	715	1,537	37,991
Other crops(*a*)	35,490	49	12,396	209	48,144
Total crops	**82,916**	**37,096**	**13,430**	**2,723**	**136,165**
Pastures	15,069	..	35,299	125	50,493

(*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 1970–71 was 123,000 acre feet. The capital cost to 30 June 1971 was $142,070,000.

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 1971 have cost $156,722,000 (exclusive of river control and irrigation works on the Murray River) and contain 8,319 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 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 the 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 1971 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 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 the drainage water is by pumping to basins on river flats where it evaporates, or by discharge into underlying sand and limestone aquifers. The usefulness of the latter strata 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 13,610 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 3,060 acres. Wellington Dam on the Collie River with a capacity of 150,107 acre feet serves an area of 10,870 rated acres in the Collie River Irrigation District. Pastures for cattle comprise 89 per cent of water usage in these districts.

The recently completed 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 43 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. Construction of the Ord Dam commenced in 1969 and on completion will store 4.6 million acre feet of water 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 1970–71 season.

AREA OF LAND UNDER IRRIGATED CULTURE: WESTERN AUSTRALIA, 1970-71
(Acres)

	Method of irrigation			
	Spray	*Flood and furrow*	*Multiple methods*	*Total area*
Crops—				
Cotton	..	8,505	..	8,505
Orchards	10,965	1,219	1,493	13,677
Vegetables—				
Potatoes	4,715	58	93	4,866
Other	3,761	1,791	140	5,692
Vineyards	779	331	47	1,157
Other crops(*a*)	1,529	5,436	13	6,978
Total crops	**21,749**	**17,340**	**1,786**	**40,875**
Pastures	4,698	32,001	574	37,273

(*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 1971 the Goldfields and Agricultural Water Supply was serving 112 towns and localities, and water was being reticulated to farms in an area of 5.8 million acres. The total length of pipelines was 4,538 miles and the number of services was 25,946. Consumption during 1970–71, including supplies drawn from local schemes and from the Metropolitan Water Supply, was 3,693 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 1971 the Supply was serving 29 towns, the total length of pipelines was 774 miles, and the number of services was 10,006. Consumption during 1970–71, including supplies drawn from local sources, was 841 million gallons.

One hundred and twenty-five local schemes supply water from stream flow, dams, tanks, wells, and bores, mainly to country towns. At 30 June 1971 the total length of water mains was 1,125 miles and the number of services was 32,642.

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

There are no State irrigation projects at present, but the Rivers and Water Supply Commission is investigating the possibility of establishing several schemes, notably in the Huon region, the Winnaleah area, and the valleys of the Jordan, Coal and Meander rivers. The first stage of the Cressy-Longford Irrigation Scheme which involves the diversion of water from the tailrace of the Poatina Hydro-Electric power station has been tested. The main channel and west channel are complete and work on the east channel is expected to commence shortly. A total of some 60 miles of earthen channels will be constructed which will irrigate an area of approximately 20,000 acres. At least half of this area will be served by gravity. The scheme will also provide an augmented flow to two rivers which will increase the amount of water available for irrigation by downstream landowners. It is estimated that under maximum development at least 6,000 acre feet of water annually would be available to farmers connected to the scheme both inside and outside the irrigation district. With the exception of the privately owned Lawrenny estate at Ouse, which is the largest single area under irrigation in the State, there are no extensive schemes utilising one common source of water supply in Tasmania. The larger portion of the area under irrigation 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 1970–71 season.

AREA OF LAND UNDER IRRIGATED CULTURE: TASMANIA, 1970-71
(Acres)

	Method of irrigation				
	Spray	*Furrow*	*Flood*	*Multiple methods*	*Total area*
Crops—					
Fruit	4,290	107	248	332	4,977
Vegetables—					
Potatoes	4,698	16	..	1	4,715
Other	6,182	8	56	47	6,293
Other crops(*a*)	5,478	705	862	111	7,156
Total crops	**20,648**	**836**	**1,166**	**491**	**23,141**
Pastures	12,197	1,482	7,478	1,433	22,590

(*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 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 Northern Territory Administration under the control of a Director. The Branch carries out systematic stream gauging, collection of data on surface and underground water supplies, 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 country, the prospects of obtaining ground-water, 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.

At 30 June 1971, 7,457 bores and wells were registered in the Northern Territory. Of these 4,459 were for pastoral use, 395 for agricultural use, 615 served town domestic water supplies, 113 were in use on mining fields, 828 were investigation bores, 423 were Government established stock route bores and 518 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.

Irrigation

There are no large water conservation projects in the Territory with the exception of the Manton Dam (12,700 acre feet), which serves Darwin with a reticulated supply. Some water is drawn from the rising main between the Manton Dam and Darwin for irrigation purposes, but the trend is for properties in this area to develop their own water supplies, either by boring or by pumping from watercourses or lakes. Additional water will be supplied to Darwin by the Darwin River Dam which commenced filling late in 1971. Groundwater is being pumped from McMinns Lagoon area to augment the supply.

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 enlargement of the network of base gauging stations built and operated for this purpose has ceased for the present owing to lack of staff. In particular areas of development where water supply or irrigation proposals require surface water data, supplementary gauging stations are built to obtain this information. At 30 June 1971, the Northern Territory stream-gauging network comprised 266 operating stations; of these, 168 were base stations for measuring stream flow and 98 were supplementary stations.

Agricultural activity in the Territory is not extensive, being confined to 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 78 licences to divert water from streams were current at 30 June 1971. The total licensed area for irrigation is 4,000 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 but further work is needed. 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.

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.

Papua and New Guinea

Rainfall in Papua and 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.

The Territory of Papua and 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 1970–71 the Commonwealth Government continued to implement the policy of establishing a national network of stream-gauging stations which can be used in assessing the water resources of the Territory, while continuing to collect hydrological data for specified 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.