CHAPTER VIII

WATER CONSERVATION AND IRRIGATION

RESOURCES, UTILIZATION AND NATIONAL AND INTERSTATE ASPECTS

§ 1. Introduction

Official Year Book No. 37, pages 1096–1141, contained a special article on the conservation and use of water in Australia, and for details of general, descriptive and historical matter reference should be made to this article.

For further details on geographical and climatic features determining the Australian water pattern, reference should be made to Chapter II. Physiography; on water supply and sewerage in metropolitan areas, cities and towns to Chapter XX. Local Government; and on the generation of hydro-electric power to Chapter VII. 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 Official Year Book No. 46, and a map showing the extent of known artesian basins throughout Australia is shown on page 273 of issue No. 48.

§ 2. Water Resources and their Utilization

1. **Surface Supplies.**—Though river gaugings have been recorded over considerable periods in some parts of Australia, records elsewhere are intermittent, of short duration, or non-existent. At present, therefore, it is impossible to estimate, with any degree of reliability, the total average annual flow of Australian streams, but it would probably amount to only a small figure 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: Nile, 72; Danube, 228; Amazon, 1,780; Volga, 148; Mississippi, 474; and the ten main rivers of the United States of America in the aggregate, 900.

2. **Major Dams and Reservoirs.**—The table below lists existing major dams and reservoirs, together with those under construction and those projected, at June, 1963. The list is confined to dams and reservoirs with a capacity of 100,000 acre feet or more. There are, in addition, many others of smaller capacity in Australia.

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	a3,500,000	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	2,500,000	142	Part of Murray River Scheme—storage for domestic, stock and irrigation purposes. Hydro-electric power also developed
Menindee Lakes Storage	Darling River, near Menindee, New South Wales	2,000,000	..	Part of Darling River Water Conservation Scheme for irrigation and possible hydro-electric power generation
Warragamba ..	Warragamba River, New South Wales	1,670,000	379	For Sydney water supply. Also provides for generation of hydro-electricity and flood mitigation

(a) Useful storage only.

MAJOR DAMS AND RESERVOIRS IN AUSTRALIA—*continued*

Name	Location	Capacity (acre feet)	Height of wall (feet)	Remarks
EXISTING DAMS AND RESERVOIRS—*continued*				
Miena	Great Lake, Tasmania	(a)984,500	40	Regulates water to Waddamana hydro-electric power station
Burrinjuck ..	Murrumbidgee River, New South Wales	837,000	264	Storage for irrigation and production of hydro-electric power
Somerset	Stanley River, Queensland	735,000	173	Brisbane-Ipswich water supply, flood mitigation and small hydro-electric power station
Lake Victoria ..	Murray River, near South Australian border, in New South Wales	551,700	..	Natural storage for irrigation in South Australia. Storage improved by construction of embankments and control regulators
Lake Echo ..	Lake Echo, Tasmania	(a)412,200	60	Storage for Lake Echo and Tungatinah hydro-electric power stations
Keepit	Namoi River, near Gunnedah, New South Wales	345,000	177	For rural water supplies and hydro-electricity generation
Waranga	Goulburn River, Victoria	333,400	..	Irrigation storage
Tinaroo Falls ..	Barron River, north Queensland	330,000	133	For irrigation purposes in the Mareeba-Dimbulah area
Glenbawn ..	Hunter River, near Scone, New South Wales	293,000	251	Part of Hunter Valley conservation work, for irrigation and flood mitigation
Rocklands ..	Glenelg River, Victoria	272,000	..	Part of Wimmera-Mallee domestic and stock water supply system
Clark	Derwent River, Tasmania	(a)253,400	200	Serves Tarraleah hydro-electric power station
Eppalock	Campaspe River, near Heathcote, Victoria	252,900	150	To supplement supply to Bendigo and for irrigation
Wyangala ..	Lachlan River, New South Wales	(b)245,000	200	Storage for domestic, stock and irrigation purposes and for generation of hydro-electric power. (*See also* under Dams and Reservoirs under Construction)
Tantangara ..	Murrumbidgee River, New South Wales	(a)193,000	148	Part of Snowy Mountains Hydro-electric Scheme
Avon	Avon River, New South Wales	173,800	232	Part of Sydney water supply
Glenmaggie ..	Gippsland, Victoria	154,300	100	Storage for irrigation
Lake St. Clair ..	Central Highlands, Tasmania	(a)154,200	..	Improved natural storage for Tarraleah hydro-electric power station
Wellington ..	Collie River, Western Australia	150,100	112	For supply of water to irrigation districts and to agricultural areas and country towns
Serpentine ..	Serpentine River, Western Australia	144,000	171	For Perth water supply
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	..	Storage for irrigation
Upper Yarra ..	Yarra River, Victoria	110,000	270	For Melbourne water supply
DAMS AND RESERVOIRS UNDER CONSTRUCTION				
Burrendong ..	Macquarie River, near Wellington, New South Wales	1,361,000	250	For rural water supplies, flood mitigation and possible hydro-electric power generation
Wyangala ..	Lachlan River, New South Wales	1,000,000	270	Strengthening and enlarging of existing dam for increased water supply and hydro-electric power generation. (*See also* under Existing Dams and Reservoirs)
Arthur Lakes ..	Source of Lake River near Great Lake, Tasmania	(a)339,000	50	Part of Great Lake hydro-electric power development
Koombooloomba ..	Tully River, north Queensland	146,000	123	For hydro-electric and possibly irrigation purposes

(a) Useful storage only. (b) Temporary reduced level.

MAJOR DAMS AND RESERVOIRS IN AUSTRALIA—*continued*

Name	Location	Capacity (acre feet)	Height of wall (feet)	Remarks
DAMS AND RESERVOIRS PROJECTED				
Burdekin Falls ..	Burdekin River, North Queensland	6,584,000	150	For generation of hydro-electric power, irrigation and flood mitigation
Chowilla	Murray River, in South Australia, near Victorian border	4,750,000	41	Regulation of the lower Murray River
Ord River ..	Near Wyndham, Western Australia	3,500,900	200	For irrigation, generation of hydro-electric power and flood mitigation. (Additional 6,000,000 acre-feet flood control proposed)
Blowering ..	Tumut River, New South Wales	1,300,000	346	For regulation of discharges from stations of Snowy Mountains Hydro-electric Scheme, primarily for irrigation but also for power generation
Buffalo	Buffalo River, near Myrtleford, Victoria	800,000	260	For irrigation
Talbingo	Tumut River, New South Wales	600,000	500	Part of Snowy Mountains Hydro-electric Scheme
Jindabyne ..	Snowy River, New South Wales	560,000	210	Part of Snowy Mountains Hydro-electric Scheme
Warkworth ..	Wollombi Brook, Hunter Valley, New South Wales	406,000	130	Flood mitigation and irrigation dam for the Hunter Valley
Winton	Winton Swamp, near Benalla, Victoria	300,000	35	To store flood flows in Broken River for irrigation
Rowallan	Mersey River, North Tasmania	110,000	140	Storage for Mersey-Forth power development

3. **Irrigation.**—(i) *History.* For some brief remarks on the history of irrigation in Australia *see* issues of the Year Book prior to No. 39. Trends in irrigation practice in more recent years were described in Year Book No. 37, page 1099.

(ii) *Extent and Nature of Irrigated Culture.* The following table shows the area of land irrigated in each State during the seasons 1958–59 to 1962–63, and the nature of irrigated culture in each State in 1962–63.

AREA OF LAND IRRIGATED
(Acres)

Season and crop	N.S.W. (*a*)(*b*)	Vic. (*c*)	Q'land	S. Aust.	W. Aust.	Tas.	N.T. (*d*)	A.C.T.	Aust. (*e*)
1958–59 ..	641,361	965,766	154,633	85,081	44,102	13,431	274	1,224	1,905,872
1959–60 ..	889,441	1,052,782	152,136	100,899	45,889	18,108	365	869	2,260,489
1960–61 ..	837,191	1,007,180	186,697	102,023	48,551	18,934	602	1,432	2,202,610
1961–62 ..	964,748	1,117,900	209,419	108,400	48,679	23,189	538	1,303	2,474,176
1962–63—									
Rice ..	53,578	..	..	..	(*f*)	..	(*g*)	..	(*h*)53,578
Vegetables ..	4,033	22,634	34,258	11,548	9,375	4,100	112	133	86,193
Fruit ..	21,559	43,059	7,020	26,876	9,588	4,446	103	11	199,813
Vineyards ..	13,086	45,757		27,384	924	..	..	..	
Sugar-cane ..	(*i*)	..	81,506	..	..	..	..	..	(*h*)81,506
Hops ..	..	(*i*)	..	..	(*f*)	1,465	..	..	(*h*) 1,465
Cotton ..	..	..	2,206	..	(*f*)	..	..	..	(*h*) 2,206
Other crops (including fodder and fallow land)	218,748	120,403	(*j*) 73,231	25,197	4,447	2,839	123	571	445,559
Total, Crops	*311,004*	*231,853*	*198,221*	*91,005*	*24,334*	*12,850*	*338*	*715*	*870,320*
Pastures ..	520,167	919,702	22,341	21,808	27,167	11,435	96	532	1,523,248
Total, 1962-63 ..	1,036,846	1,151,555	220,562	112,813	51,501	24,285	434	1,247	2,599,243

(*a*) *Source:* Water conservation and Irrigation Commission. (*b*) Includes total area irrigated by licensed Diversions, but details for individual crops, etc., in 1962–63 (205,675 acres), are not available. (*c*) *Source:* State Rivers and Water Supply Commission. (*d*) Incomplete, excludes area of rice irrigated. (*e*) *See* footnote (*b*) to New South Wales. (*f*) Not available for publication; included in Other crops. (*g*) Not available for publication; excluded from totals. (*h*) Incomplete, *see* footnotes to individual States. (*i*) Not available separately; included in Other crops. (*j*) Includes tobacco, 15,202 acres.

Nearly half of Australia's irrigated acreage is in Victoria, and about two-thirds is situated along the Murray and its tributaries (including the Murrumbidgee) in the three States of New South Wales, Victoria and South Australia. In those areas served by the Murray and its tributaries, irrigation water is used extensively for vines, orchards, pastures, fodder, and for domestic and stock purposes. Approximately forty per cent. of Queensland's irrigated acreage is devoted to sugar cane. Western Australia's small irrigated acreage is confined to areas in the south-west where vegetables, orchards, fodder, and pastures are served. Large scale irrigation schemes have not been developed in Tasmania or the Northern Territory, although investigations are at present being carried out in the Northern Territory to determine the availability of irrigation water for agriculture.

(iii) *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 utilization of irrigated pastures by stock; growth problems affecting plants and trees; the prevention of evaporation from water storages; and the potability of saline waters for stock.

Irrigation is studied by the Commonwealth Scientific and Industrial Research Organization at a number of its research stations and laboratories, the principal one being the Irrigation Research Laboratory at Griffith (New South Wales), where investigations are concerned with 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, wine grapes and lucerne. The Organization's Division of Plant Industry studies irrigated pastures at Deniliquin (New South Wales) and Canberra (Australian Capital Territory), and tobacco at Mareeba (Queensland). At Merbein (Victoria), the Horticultural Research Section is working on problems of the dried-fruit industry. The Division of Land Research and Regional Survey conducts research on rice at the Coastal Plains Research Station, Darwin (Northern Territory), and on a number of irrigated crops, including rice, safflower, linseed and cotton, at the Kimberley Research Station (Western Australia). The Division has also carried out a number of hydrological investigations in connexion with the utilization of underground water for irrigation. The Division of Soils and the Soil Mechanics Section are studying methods of reducing seepage from earthen dams, and take part in the examination of the physical properties of sediments beneath proposed dam sites. The Division of Soils is also looking at underground water movement and the water balance in the south-east of South Australia, and at the drainage and soil moisture regime of the irrigated swamps of the lower Murray River. The Division of Physical Chemistry is investigating methods of minimizing evaporation losses from water storages by the use of monomolecular layers.

The Irrigation Research and Extension Committee plays an important part in the agricultural activity of the Murrumbidgee Irrigation Areas. 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 and certain farmers' organizations (including extension groups). 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 organization; 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 the co-ordination of 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.

4. **Preservation of Catchments.**—Since water conservation commences on the catchments, it is becoming increasingly recognized 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 minimize 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.

5. **Sub-surface Supplies.**—(i) *General.* Much of Australia's undergound water is obtained from artesian and sub-artesian basins and is used for stock purposes. These supplies are indispensable in most inland areas. The quality of the water ranges from usable to very saline. In inland areas, a considerable amount of water has been tapped that is unusable because of its high salt content. Because of this, development of an economic desalting process would provide the interior with additional large quantities of usable water.

Considerable use is also made of sub-surface water, other than pressure water, from local storages, 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, but its use for these purposes is increasing.

Commonwealth and State departments interested in underground water resources are represented on the Technical Committee on Underground Water (formerly the Underground Water Conference of Australia), which is under the auspices of the Australian Water Resources Council (*see* § 3, para. 2, p. 239).

The various States and Territories maintain Geological Surveys and Water Commissions which are continually extending the knowledge of their own States. These authorities have been assisted more recently by various scientific and industrial foundations. In New South Wales, for example, the Hunter Valley Research Foundation is carrying out scientific investigations in the catchment area of the Hunter River, and this includes an integrated study of water, soils and climate.

In addition, the University of New South Wales recently formed the Water Research Foundation which has among its objectives research into underground water. To date, research has been devoted mainly to run-off studies, to the design of large earth farm dams and to sponsoring post-graduate hydrology courses.

As a result, a general picture exists of Australia's available and potential underground water resources. Much remains, however, to be done in the mapping and assessment of individual artesian and sub-artesian basins and in the investigation of their constituent aquifers. Detailed investigations also remain to be carried out of shallower underground water in alluvial deposits, coastal sands and mantles of weathered and jointed rock.

Surveys of this nature are of great importance because of the fundamental need for underground sources of water in the settlement of large areas of Australia.

(ii) *Artesian and Sub-artesian Supplies.* Pressure water (either artesian or sub-artesian), variable in quantity and quality, is obtainable in many parts of Australia, the various artesian basins extending over about half the continent. A map of Australia showing the extent of the known artesian basins appears on page 273 of Year Book No. 48.

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

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
Georgina (including Barkly and Daly) ..	Northern Territory, Queensland	Cretaceous, Ordovician, Cambrian and Upper Proterozoic(?)	108,000	150 to 1,000
Murray ..	Victoria, New South Wales and South Australia	Miocene-Eocene ..	107,000	100 to 1,300
Eucla	Western Australia, South Australia	Pliocene-Miocene ..	74,000	300 to 2,000
Carnarvon ..	Western Australia	Cretaceous, Permian..	45,000	200 to 4,000
Perth	Western Australia	Recent, Jurassic ..	21,000	200 to 2,500
Western District (Otway)	Victoria ..	Pleistocene-Upper Cretaceous	13,000	100 to 4,500
Basins of Ord-Victoria region	Northern Territory, Western Australia	Mainly Cambrian and Permian	12,000	Unknown
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	10 to 600

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, while in certain areas sub-artesian waters are suitable for all uses including irrigation. 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 recognized early that flows were diminishing as more bores were drilled, but it is now considered that while many of the bores will ultimately cease to flow, others will assume a perpetually steady rate of flow, corresponding with the average intake of water from rainfall absorbed by permeable outcrops, mainly sandstone and limestone. Diminution in flows from artesian bores has emphasized the need to eliminate wastage as much as possible, and investigations have been made regarding wasteful methods of distribution of artesian water by open channels or bore drains and the careless use of water. (For greater detail on this subject *see* Year Book No. 37, pp. 1103–4 and § 4, para. 3.)

(iii) *Shallow Groundwater.* Shallow groundwater supplies are used in various parts of Australia for industry, irrigation, stock and domestic purposes. Two of the most important of these supplies are in New South Wales. The Hunter District Water Board pumps 15 million gallons a 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.

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

§ 3. National and Interstate Aspects

1. **General.**—As the Commonwealth Constitution makes special reference to water rights, both the Commonwealth and the State Governments have an interest in the control and conservation of water. The main responsibility for control of water resources rests with the individual State governments, but as political boundaries sometimes intersect river valleys and catchments, 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.

2. **Australian Water Resources Council.**—This Council was established in 1962 to provide a means of securing the highest level of basic information on Australian water resources and of making it readily available. The major problem faced by the Council is that Australia does not have a reliable estimate of how much water is available now, and how much will be available in the future. The Council therefore intends to provide a comprehensive assessment of Australia's water resources, and to extend measurements and research so that future planning can be carried out on a sound and scientific basis.

The first meeting of the Council was held in March, 1963. The Council comprises the Minister for National Development as Chairman, the Minister for Territories, and the Minister in charge of water supplies from each State. Provision has been made for Ministers responsible for closely related activities to be co-opted when problems of particular concern to them are under discussion. The Council is assisted by a Standing Committee of Commonwealth and State officers. Technical committees on surface water and on underground water have been established to undertake detailed investigations.

3. **Murray River Scheme.**—(i) *General.* The Murray River and its tributaries form the largest river system in Australia. The catchment is approximately 414,000 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 one-fortieth 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, 3,623,000 acre feet; Darling River, 2,896,000 acre feet; Goulburn River (including Broken River), 2,570,000 acre feet; Murrumbidgee River, 2,054,000 acre feet; and Ovens River, 1,222,000 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.

(ii) *River Murray Waters Agreement.* For a brief summary of the 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 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* para. 5, Snowy Mountains Hydro-electric Scheme, p. 241) 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 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 7th 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 6th November, 1958.

Legislation to permit further amendment of the Agreement to provide for the construction of a storage of approximately 4,750,000 acre feet capacity at Chowilla in South Australia has been passed by the Commonwealth and State Parliaments. The dam will be located some six miles downstream from the border between Victoria and South Australia, and will consist of concrete outlet structures and a bank forty-one feet high across the flood plain. The overall length of the dam will be three and one-third miles, and the lake formed behind it will extend to Wentworth Weir, a distance of about one hundred and twenty miles by river.

The estimated quantity (in acre feet) of water diverted during 1962–63 from the Murray and its tributaries for irrigation and other purposes under the River Murray Agreement was as follows:—New South Wales, 2,602,000; Victoria, 3,060,000; South Australia, 296,000; a total of 5,958,000 acre feet.

(iii) *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, 10 miles above Albury, forming a lake of 56,000 acres. The design comprises a mass concrete spillway and outlet works extending for 1,000 feet, and an earthen embankment 142 feet high extending for 4,000 feet across the river flats, the length of the total structure being approximately one mile. Work on the enlargement of the reservoir to its approved capacity 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, served by the Yarrawonga Weir, has an off-take capacity of 2,500 cubic feet a second, to serve 1,500,000 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, to serve 270,000 acres. Only a portion of each area will be 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 very materially to the large amount of irrigation development in the Murray Basin. The main storages are: New South Wales—Menindee Lakes Storage (Darling), Burrinjuck (Murrumbidgee), Keepit (Namoi) and Wyangala (Lachlan); Victoria—Eildon (Goulburn) and Waranga (Goulburn). Details of these and other State works on Murray tributaries will be found in the sections dealing with State systems. No storages exist on the Murray in South Australia at present, but the construction of a large storage at Chowilla is proposed (*see* sub-para. (ii) above).

4. New South Wales-Queensland Border Rivers Agreement.—The New South Wales-Queensland Border Rivers Agreement came into effect on 1st 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 Commission to give a storage basin with a capacity as large as is reasonably practicable and not less than six nor more than twelve weirs as may be found necessary to meet the requirements of irrigation along the rivers. Provision 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 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.

The Water Conservation and Irrigation Commission of New South Wales, which is the constructing authority for the dam, carried out investigations of several dam sites on the Dumaresq River near Mingoola Station homestead, which is approximately 39 miles from Tenterfield. Foundation drilling supplemented by a geophysical survey carried out by the Commonwealth Bureau of Mineral Resources disclosed unfavourable foundation conditions at all sites, the depth of alluvium overlying sound rock exceeding 150 feet in all cases. In an endeavour to obtain more economical storages, investigations were extended to tributary streams, and superficially suitable sites have been located on Pike Creek and the Mole River. A geophysical survey was made at each of these sites and preliminary comparative estimates 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. This report is at present under consideration.

The Irrigation and Water Supply Commission of Queensland is the constructing authority for the new weirs and regulators. Bonshaw and Cunningham Weirs on the Dumaresq River were completed in 1953 and 1954 respectively.

A weir and regulator have been constructed on the Barwon River at the offtake of the Boomi River. A low level weir to establish a pumping pool at Glenarbon on the Dumaresq River was also constructed. 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 weirs, other than those referred to above, will be required.

The catchments for the border streams (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 stabilize 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.

5. 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 is 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.

* *See also* Chapter VII. Electric Power Generation and Distribution, p. 210. For more detailed information *see* special article by the Commissioner, Snowy Mountains Hydro-electric Authority (Sir William Hudson) which appeared in Chapter XXIX. Miscellaneous, of Year Book No. 42.

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 VII. Electric Power Generation and Distribution (*see* pp. 210–12).

An additional 500,000 acre feet of water per annum is now available for irrigation in the Murrumbidgee Valley. When all works are completed, it is estimated that the total gain to the Murrumbidgee by diversion and regulation will amount to 1,120,000 acre feet per annum and the total gain to the Murray will be 800,000 acre feet per annum. This additional water should be sufficient to provide irrigation for approximately 1,000 square miles of land which is expected to result in a substantial increase in annual primary production.

§ 4. International Aspects

Australia maintains contact with international developments in water conservation and irrigation through its membership, since 1952, of the International Commission on Irrigation and Drainage. 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 fifty-four countries, including Australia, have already been admitted to membership.

The Central Office of the International Commission 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 and Japan, in that order. The sixth Congress will be held in India in January, 1966.

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

§ 1. Australian Local Pattern of Water Conservation and Use

The foregoing sections deal with water conservation and irrigation in Australia generally and with international, national and interstate projects. The following survey covers the local pattern of water resources and the steps taken by the State governments to bring about their development. It will be seen that water policies in the various States 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 stabilize 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.

§ 2. New South Wales

1. General.—(i) *Rainfall and History.* 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* Chapter II. Physiography, p. 47, of this issue.)

(ii) *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 241 of this chapter.

2. Schemes Summarized.—(i) *Location and Type.* 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, 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, and a head storage on the Macquarie River is nearing completion. 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 451,260 acres served with water through a channel system stemming from the river at Berembed Weir; the Coomealla Irrigation Area of 34,672 acres, served by pumping from the Murray; the Curlwaa Irrigation Area of 10,393 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 (8,693 acres) and Mallee Cliffs (1,900 acres) Irrigation Areas, served by pumping from the Murray; and the Coleambally Irrigation Area (109,179 acres), served by diversion from the Murrumbidgee River. All these Areas are administered by the Commission, and details of the various schemes are given in sub-section (iii) below.

(ii) *Works.* The capacities of the main storages (in acre feet) are:—

Darling—Menindee Lakes Storages (2,000,000);

Murray—Half share of Hume Reservoir, weirs and locks to Wentworth (1,361,420); Stevens Weir, Edward River (7,165);

Murrumbidgee—Burrinjuck Dam (837,000); Berembed Weir (10,000); Redbank Weir (7,360); Maude Weir (6,740);

Namoi—Keepit Dam (345,000);

Lachlan—Wyangala Dam (temporary reduced level 245,000); Lake Brewster (123,900); Lake Cargelligo (29,435); Jemalong Weir (2,200); and

Hunter—Glenbawn Dam (185,000 acre feet irrigation storage; 108,000 acre feet flood mitigation storage).

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 4,772 miles. This comprises 3,367 miles of supply channels (including main canals), 1,336 miles of drains and escape channels, and 69 miles of pipe lines.

(iii) *Extent of Systems and Nature of Irrigated Culture.* The following table shows the areas of the various irrigation systems in 1962–63 and particulars of the areas under irrigated culture in New South Wales during the seasons 1958–59 to 1962–63.

AREAS OF SYSTEMS AND OF LAND IRRIGATED: NEW SOUTH WALES

(*Source*: Water Conservation and Irrigation Commission)

(Acres)

Season and system	Total area	Area irrigated(*a*)										
		Rice	Other cereals grown for grain	Fodder crops		Pastures		Vineyards	Orchards (*b*)	Vegetables	Fallow land and miscellaneous	Total
				Lucerne	Other	Sown	Natural					
1958–59(*c*)	6,746,225	47,054	24,905	46,677	14,271	414,606	12,169	13,039	22,134	15,828	30,678	641,361
1959–60	6,781,246	48,972	79,147	31,513	12,463	464,421	4,763	12,365	17,761	4,048	47,215	*d* 889,441
1960–61	6,901,105	46,116	33,436	34,950	10,490	458,360	5,412	12,388	17,962	3,362	36,195	*d* 837,191
1961–62	6,952,579	50,223	57,779	40,273	14,024	522,748	5,097	11,515	18,080	2,784	50,443	*d* 964,748
1962–63—												
Irrigation Areas—												
Murrumbidgee (within the Areas)	451,260	27,948	26,909	5,301	3,320	78,608	5,794	5,782	18,501	3,500	29,963	205,626
Lands adjacent supplied under agreement	(*e*)	..	..	399	6	1,629	830	2	83	10	..	2,959
Coomealla	34,672	..	..	..	5	..	..	4,578	1,431	..	..	6,014
Curlwaa	10,393	..	..	..	43	..	..	381	1,196	..	..	1,620
Hay	6,850	..	..	144	612	1,976	116	..	..	..	40	2,888
Tullakool	18,006	1,000	633	35	200	6,615	..	..	..	..	200	8,683
Buronga	8,693	..	..	..	..	..	..	..	..	..	..	..
Mallee Cliffs	1,900	..	..	..	..	..	..	..	..	..	..	..
Coleambally	109,179	5,364	6,129	321	770	4,178	..	38	52	117	18,925	35,894
Total	*f 640,953*	*34,312*	*33,671*	*6,200*	*4,956*	*93,006*	*6,740*	*10,781*	*21,263*	*3,627*	*49,128*	*263,684*
Irrigation Districts—												
Benerembah	112,818	5,086	8,424	1,727	3,255	33,289	890	..	..	30	9,490	62,191
Tabbita	32,330	358	960	316	323	6,566	..	..	..	30	772	9,325
Wah Wah	575,716	..	5,685	1,610	450	11,945	250	..	..	..	4,120	24,060
Berriquin	803,737	..	18,558	18,391	1,919	236,524	745	..	..	136	4,000	280,273
Wakool	503,322	6,940	7,117	1,475	2,650	78,747	245	..	..	78	1,165	98,417
Denimein	147,005	2,796	3,069	1,170	1,778	12,490	..	..	12	8	695	22,018
Jemalong and Wylde's Plains	224,556	..	3,320	9,694	700	10,797	1,140	..	..	..	1,269	26,920
Gumly	353	..	57	69	5	11	..	..	20	77	..	239
Deniboota	337,897	4,086	4,598	2,162	2,260	26,552	230	..	..	2	1,539	41,429
Total	*2,737,734*	*19,266*	*51,788*	*36,614*	*13,340*	*416,921*	*3,500*	..	*32*	*361*	*23,050*	*564,872*
Flood Control Districts—												
Lowbidgee	399,707	..	..	..	..	..	..	..	..	..	..	(*e*)
Medgun	272,800	..	..	..	..	..	..	..	..	..	..	(*e*)
Total	*672,507*	..	..	..	..	..	..	..	..	..	..	(*e*)
Irrigation Trusts—												
Pomona	1,580	..	..	..	..	..	..	760	130	..	..	890
Goodnight	1,104	..	..	..	..	..	..	565	41	5	1	612
Bungunyah-Koraleigh	1,810	..	..	..	..	..	..	980	93	40	..	1,113
Glenview	661	..	..	..	..	..	..	..	..	..	..	(*e*)
Bringan	4,933											
Bama	3,446											
Total	*13,534*	..	..	..	..	..	..	*f 2,305*	*(f) 264*	*(f) 45*	*1*	*(f) 2,615*
Water Trusts—Domestic and Stock Supplies	2,907,871	..	..	..	..	..	..	..	..	..	..	..
Licensed Diversions	(*e*)	..	..	..	..	..	..	..	..	..	..	*g 205,675*
Total, 1962–63	6,972,239	53,578	85,459	42,814	18,296	509,927	10,240	13,086	21,559	4,033	72,179	1,036,846 (*d*)

(*a*) Excludes Flood Control Districts and some Irrigation Trusts, particulars for which are not available. (*b*) Citrus and deciduous; in 1962–63, deciduous amounted to 10,010 acres, of which 9,796 acres were in the Murrumbidgee Irrigation Area. (*c*) Includes details (except Total area) for Licensed Diversions. (*d*) Includes total area irrigated by Licensed Diversions, but details for individual crops, etc., are not available. (*e*) Not available. (*f*) Incomplete. (*g*) Details for individual crops, etc., are not available.

3. Irrigation Areas.—(i) *Murrumbidgee.* (*a*) *Description.* These areas, together with adjacent lands supplied under agreement, received 403,770 acre feet, or nearly a quarter of the total water (1,702,301 acre feet) allocated within the State for stock, domestic supply and irrigation. They are served by the Burrinjuck Dam on the Murrumbidgee, 40 miles north-west of Canberra. The catchment above the dam is about 5,000 square miles. The river rises on the high plateau north of Mount Kosciusko where the average annual rainfall exceeds 60 inches. Flow for the irrigation areas and districts is supplemented by unregulated flow from the Tumut River below the dam. The dam also provides 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 dam for that purpose. For the other undertakings, however, water is stored during the winter, fed by melting snows and spring freshets, and is released during the September-May irrigation season. It passes along the river channel to Berembed Weir, 240 miles westward, where it is diverted to the main canal with an off-take capacity of 1,600 cubic feet a second. The main canal has been completed to beyond Griffith, 106 miles from the off-take. Reticulation channels aggregate approximately 900 miles and drainage channels 880 miles. In addition, approximately 440 miles of supply channels run through irrigation districts adjacent to the Murrumbidgee Areas in which the water supply is operated and maintained by the Water Conservation and Irrigation Commission.

The land on which the Murrumbidgee Irrigation Areas and associated districts are situated originally comprised large sheep stations and was sparsely populated, but at 30th June, 1963, its population was approximately 27,000, that of Leeton Shire being 10,500 and that of Wade Shire 16,500.

(*b*) *Administration.* The Water Conservation and Irrigation Commission controls land transactions and water supplies for the Murrumbidgee Irrigation Areas only, and has no jurisdiction over land transactions in the adjacent irrigation districts, although it is responsible for the operation and maintenance of the water supply in these areas. Other local government services, including electricity and town water supply, are provided by Councils. Land is disposed of by the Commission by purchase or under perpetual lease tenure or leased for short terms for grazing or cultivation. The area under occupation at 30th June, 1963, was 408,876 acres, including 37,278 acres held for short lease grazing, agriculture, etc.

(*c*) *Production.* 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.

(ii) *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.

4. Irrigation Districts.—These Districts are set up under the *Water Act* 1912–1955 for (*a*) domestic and stock water supply and (*b*) irrigation. They differ from water trusts in that the cost of the works is not required to be repaid over a period, but annual charges are made by the State for water supplied to landholders.

Since the completion of the Hume Reservoir, several such districts have been established along the Murray to utilize 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 through a main canal which is approximately 100 miles long. 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. At 30th June, 1963, the total

length of completed canals and channels in Berriquin District was 996 miles, comprising Mulwala canal 75 miles, Berrigan channel 22 miles, subsidiary channels 782 miles, escape channels 107 miles and cross drainage channels 10 miles. Off-take capacity of the Mulwala canal is 5,000 acre feet a day.

Wakool, with 387 miles of channel, contains 309 holdings, and the area developed by irrigation includes about one acre in five of the total area. Sheep raising is the main industry.

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 and wheat growing are the main industries.

5. **Water Trust Districts, Irrigation Trusts and Flood Control and Irrigation Districts.**—The *Water Act* 1912–1955 provides for the constitution of Trust Districts for domestic and stock water and irrigation, and empowers the Commission to construct, acquire or utilize 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 water trusts—other than irrigation—have been constituted (the area in acres of each district is shown in parenthesis)—*Murray River*—Little Merran Creek (157,440), Tuppal Creek (78,080), 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), Algudgerie Creek (9,760), Collarenebri town water supply (117)—making in all a total area of 2,907,871 acres. Thirteen of these trusts have been formed for the provision of water for domestic and stock purposes, one for a town supply and one for flood prevention.

Irrigation Trusts are established under the same Act and are administered by trustees in a similar way.

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.

6. **River and Lake, and Farm Water Supplies.**—During recent years, the numbers 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 recognized as a means of stabilizing production in dry months. There has also been a considerable increase along the Murrumbidgee and Lachlan.

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, flood and spray irrigation systems.

7. **Underground Water.**—Extensive use is made of artesian, sub-artesian, and shallow underground water. The Great Artesian Basin underlies an area of some 81,250 square miles in north-western New South Wales. Eighty-seven Bore Water Trusts and 12 Artesian Wells Districts have been constituted. Bore Trusts are administered in the same way as Water Trusts, but in Artesian Wells Districts the settlers maintain the drains. Bore Trusts and Artesian Districts cover 5,597,202 acres and distribute water through 3,623 miles of open earth drains.

As at 30th June, 1963, 1,114 artesian bores had been constructed in the New South Wales section of the Basin. At that date, 641 bores were flowing and were capable of producing about 64,000,000 gallons per day. Conservation measures control this to about 50,000,000 gallons per day. The total length of bore drains, including those for Trusts and Districts, is approximately 8,000 miles.

Of other structural basins of sedimentary rocks, e.g., Murray, Sydney, Oxley and Clarence Basins, the Murray is the largest and also the most important in that it affords stock water supplies over an extensive area of the south-western section of the State. Only a few of these bores flow, the remainder being sub-artesian. Good supplies for stock and,

in some instances, small scale irrigation, are obtained from porous sandstone in the Moss Vale-Picton area, but the remainder has limited potential. Stock supplies are obtained from bores in the fringe zones of the Oxley Basin, but the centre of this basin lies under the Liverpool range. The Clarence Basin is relatively unimportant from a groundwater viewpoint, but stock supplies are obtained from some sections.

In other parts of the State, the largest and best quality groundwater supplies are obtained from sands and gravels in the alluvium of the major rivers and their tributaries, particularly the western-flowing rivers, e.g. Lachlan, Macquarie and Namoi. Supplies of up to 60,000 gallons an hour are obtained from wells and screened bores in these areas and are used for irrigation and town water supply. The Government is carrying out investigations to determine the ground-water potential of the alluvium of such valleys, particularly with regard to irrigation use, and a test-boring programme is in progress in the Lachlan Valley. Coastal river systems have a much more limited potential in this regard, the main exception being the Hunter.

Old sand dune areas along the coast provide large supplies of good quality water. However, since the soils of these areas are not suited to agricultural pursuits, exploitation has been largely confined to the Sydney and Newcastle areas. Initially a source of Sydney's water supply, the Botany sands are now utilized mainly by industry. The Tomago sands provide a considerable proportion of the Newcastle water supply.

The older rocks, which are mostly folded and jointed, are very variable in their groundwater potential and only rarely do they yield supplies sufficient and suitable for limited irrigation. Where suitable conditions obtain, they yield useful stock supplies, mostly at depths between 50 and 250 feet.

It is necessary under the *Water Act* 1912–1955 that all wells and bores be licensed, and details of over 20,500 bores and wells in the State are recorded. When assessed in relation to the geologic and topographic conditions of any particular area, such records provide valuable evidence of the groundwater potential and are thus of considerable benefit to landholders.

8. **Future Programme.**—The programme of development in hand includes the provision of additional dams and storages, diversion weirs, and flood mitigation and river protection works in various parts of the State. Construction of Burrendong Dam on the Macquarie River is nearing completion. Legislation has been passed authorizing the construction of a flood control and irrigation dam at Warkworth in the Hunter Valley and a storage dam at Blowering on the Tumut River. The Hunter River development, of which Glenbawn Dam is an integral part, concerns 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. This is the first coastal scheme initiated in New South Wales. At Wyangala Dam, on the Lachlan River, the fixed crest of the dam spillway has been lowered temporarily to enlarge the spillway for passage of greater floods. Construction has commenced on a new earth and rock-fill dam which will be built behind the present dam to give a storage of 1,000,000 acre feet. Within the new Coleambally Irrigation Area further development of farms has been carried out and water is being supplied by the new diversion weir at Gogeldrie. At the 30th June, 1963, 114 large area farms and 8 horticultural farms had been allotted south of the Murrumbidgee River, whilst 47 large area farms had been allotted north of the river and now form part of the Murrumbidgee Irrigation Areas.

9. **Hydro-electricity.**—A survey of the use of water for power generation in New South Wales may be found in the previous chapter (*see* p. 219).

§ 3. Victoria

1. **General.**—(i) *Rainfall.* Particulars of the rainfall pattern of Victoria were given on page 1117 of Year Book No. 37. (*See also* Chapter II. Physiography, p. 47, of this issue.)

(ii) *Administration.* The passing of the *Irrigation Act* 1886 put the control of surface waters under the Crown, provided for the establishment of Irrigation Trusts and marked the beginning of irrigation development. The *Water Act* 1905 established the State Rivers and Water Supply Commission and gave it control of all irrigation, rural domestic and stock supplies, town water supplies, and flood protection and drainage undertakings outside the Metropolitan area, with the exception of the irrigation area operated by the First Mildura Irrigation Trust and the town water supplies operated by locally constituted waterworks trusts or local governing bodies.

The operations of the First Mildura Irrigation Trust, the waterworks trusts and local governing bodies administering town water supplies, the river improvement and drainage trusts and the various sewerage authorities which control sewerage undertakings in country towns are also subject to general supervision by the Commission.

2. **Works Summarized.**—In 1902, a great drought emphasized the need for a concerted attack on water problems. Subsequently to the establishment of the State Rivers and Water Supply Commission, the total capacity of storages controlled by that Commission has increased from 172,000 acre feet in 1906 to 4,515,278 acre feet at 30th June, 1963. In addition, Murray River storages with a combined capacity of 2,722,840 acre feet are shared equally by New South Wales and Victoria under the River Murray Waters Agreement, subject to certain obligations to South Australia. The total storage capacity available to Victoria is thus some 5,876,698 acre feet. Most of the water from these storages is used for irrigation. The area actually irrigated has risen from 105,000 acres in 1906 to 1,151,555 acres in 1962–63, to which 1,539,890 acre feet of water were delivered. The Commission estimated the value of irrigated production in 1961–62 at £61,355,000, representing about one-sixth of the value of Victoria's total rural production.

Besides supplying water to its own irrigation districts, the Commission supervises the diversion of water for irrigation by private persons by means of licences and permits. In the last ten years, the area so licensed has doubled, and private diverters now provide a fifth of total irrigation production.

3. **Storages.**—The capacities of the main storages in the various systems (in acre feet) at 30th June, 1963, were as follows:—

Goulburn System:—Eildon Reservoir, 2,750,000; Waranga Reservoir, 333,400; Total, 3,104,100; *Murray-Loddon System:*—Half share of Murray River storages, 1,361,420; Cairn Curran, 120,600; Tullaroop, 60,000; Total, 1,690,230; *Campaspe River:*—Eppalock Reservoir, 252,860; *Wimmera-Mallee:*—Rocklands, 272,000; Total, 563,800; *Gippsland:*—Glenmaggie, 154,300; Total 154,340; *Coliban:*—62,730; *Werribee-Bacchus Marsh:*—34,900; *Mornington Peninsula:*—5,800; *Otway:*—1,080; *Miscellaneous:*—6,858; *Grand Total:*—5,876,698.

4. **Extent of Systems and Nature of Irrigated Culture.**—The following table shows the areas of the various irrigation systems in 1962–63, and the areas under irrigated culture during the seasons 1958–59 to 1962–63.

AREAS OF SYSTEMS AND OF LAND IRRIGATED: VICTORIA

(*Source:* State Rivers and Water Supply Commission)

(Acres)

Season and system	Total area (*a*)	Area irrigated									
		Cereals	Fodder crops		Pastures		Vineyards	Orchards	Market gardens	Fallow and miscellaneous	Total
			Lucerne	Other	Sown	Natural					
1958–59	2,149,466	9,436	38,752	15,228	716,951	72,802	44,267	35,349	18,595	14,386	965,766
1959–60	2,115,542	26,426	41,698	13,883	774,268	73,340	43,778	39,612	20,628	19,149	1052782
1960–61	2,188,136	7,940	39,872	10,239	754,323	67,014	44,817	40,274	21,735	20,966	1007180
1961–62	2,151,976	27,586	41,253	16,468	830,925	69,505	44,563	42,671	22,197	22,732	1117900
1962–63—											
Goulburn - Campaspe - Loddon	1,350,093	16,262	19,329	13,484	402,533	25,279	293	23,397	1,613	13,614	515,804
Murray—											
Torrumbarry	357,471	6,607	4,792	4,389	201,061	22,021	5,489	2,088	1,058	3,117	250,622
Murray Valley Irrigation Area	301,141	2,115	7,398	1,310	96,205	2,268	40	6,280	413	896	116,925
Pumping(*b*)	80,763	11	547	136	601	302	36,803	2,912	590	1,486	43,388
Total	*739,375*	*8,733*	*12,737*	*5,835*	*297,867*	*24,591*	*42,332*	*11,280*	*2,061*	*5,499*	*410,935*
Other Northern systems	(*c*)	43	1,271	..	11,022	671	8	3,281	498	..	16,794
Southern systems	147,279	207	1,288	789	61,654	2,808	..	602	5,601	411	73,360
Private diversions(*d*)	(*c*)	868	8,555	2,712	85,309	7,968	3,124	4,499	12,861	8,766	134,662
Total, 1962-63	2,236,747	26,113	43,180	22,820	858,385	61,317	45,757	43,059	22,634	28,290	1151555

(*a*) Excludes Other Northern Systems and Private Diversions. (*b*) Includes First Mildura Irrigation Trust. (*c*) Not available. (*d*) Excludes private diverters in the Torrumbarry System, but includes all other private diverters along the Murray River.

5. Irrigation Systems.—(i) *Goulburn.* The storage capacity for this system is provided principally by Eildon Reservoir, the enlargement of which was completed in 1956. Large-scale works have been in progress for several years to distribute the extra water available from this and other major storages.

Water from Eildon Reservoir flows down the Goulburn River to the Goulburn Weir, located near Nagambie. This raises the summer level of the river about 45 feet for the purpose of diversion. From this weir, water is diverted via the East Goulburn Main Channel direct to the irrigation areas around Shepparton. The western main channels from the weir convey water to the Waranga Reservoir near Murchison in addition to supplying part of the large Rodney area directly.

Two main outlet channels issue from Waranga Reservoir. One serves the western section of Rodney area, while the other serves irrigation areas as far west as Boort, and continues into the Wimmera-Mallee domestic and stock system to provide a supplementary supply as far as Beulah East (*see* para. 6, below).

Water is also supplied to part of the Goulburn-Loddon system from Cairn Curran Reservoir on the Loddon River, and from Tullaroop Reservoir on one of its tributaries, together with the new Eppalock Reservoir on the Campaspe River. Eildon itself may be used to supplement supply to the districts along the Murray River.

The main products of the Goulburn system are dairy produce, fruit, wool and fat lambs. Annual production of deciduous canning fruits in the area is about two-thirds of Australia's total.

(ii) *Murray River System.* The waters of the Murray River are used to supply the area between Yarrawonga and Merbein. The districts between Yarrawonga and Swan Hill, except Tresco near Swan Hill, are supplied by gravitation and those west of Swan Hill by pumping.

The main items produced in the Murray Valley Irrigation Area, which is served from Yarrawonga Weir, are dairy products, fat lambs and canning fruit.

The gravitation system based on Torrumbarry Weir (52 miles downstream from Echuca) serves the area around Cohuna, Kerang, Koondrook and Swan Hill. (Also included in the Torrumbarry System is the Tresco District supplied by pumping from Lake Boga.) Dairying and fat lamb raising are the major industries. Vine and orchard fruits and vegetables are grown extensively around Swan Hill.

West of Swan Hill lie four Commission districts with a pumped supply—Nyah, Robinvale, Red Cliffs and Merbein. These contain about 1,500 holdings devoted mainly to dried vine fruit, although citrus fruit and table and wine grapes are of some importance. The area around Mildura is controlled by the First Mildura Irrigation Trust, the only irrigation trust operating in Victoria. It serves an irrigated area about half the combined size of the four Commission districts and has similar major products.

(iii) *Southern Systems.* The most important southern system is the area around Maffra and Sale, devoted mainly to dairying. This is supplied from Glenmaggie Reservoir on the Macalister River and from the natural flow of the Thomson River when the flow is adequate. Other important irrigation districts are located quite close to Melbourne around Werribee and Bacchus Marsh. These districts are intensively developed for dairying and vegetable growing.

6. Wimmera-Mallee Domestic and Stock Supply System.—This system serves an area of 11,000 square miles or about one-eighth of the State. Without the artificial supply of water, development in this area would be meagre and hazardous owing to the constant threat of drought. The main supply is drawn from the Grampians storages and can be supplemented by water drawn from the Goulburn and Loddon Rivers, via the Waranga Western Channel referred to previously. Works in progress will make the Wimmera and Mallee independent of supplies from the Goulburn and Loddon Rivers in the near future. In addition, some 300 farmers in the north of the system are provided with a domestic and stock supply direct from pumps on or near the Murray River.

As far as possible, water is distributed in the winter and spring to reduce evaporation losses in 6,500 miles of Commission channels and 3,000 miles of farm channels. It is the responsibility of the 7,000 farmers served to provide sufficient storage capacity on their farms to meet their domestic and stock needs for the year. In addition to meeting rural and domestic demand, together with stock requirements, the Grampians storages provide a water supply for more than 40,000 people in 47 towns, and are used to irrigate a small area near Horsham.

7. Town Water Supplies and Sewerage.—Details of the operations of the State Rivers and Water Supply Commission with respect to water supplies and sewerage for country towns and local government authorities are given in Chapter XX. Local Government, of this Year Book.

8. 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 80,000 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 pounds 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, 20 such trusts have been formed. The importance of river improvement work is expected to continue to grow.

9. Finance.—The net capital liability of the Commission at 30th June, 1963, was £113 million. Of this amount, nearly £78 million were expended on irrigation and £8 million on domestic and stock supply systems. Both these amounts were financed entirely by the State. The total liability for urban supply was £17 million, of which 55 per cent. was borne by the State and the remainder by the districts concerned. The remaining £10 million were due for expenditure on flood protection and drainage (£2 million) and items such as loan flotation expenses, surveys and investigations, and buildings, plant and stores (£8 million).

10. Underground Resources.—A survey of these resources is being carried out by the Victorian Department of Mines. Their deep drilling plant has located suitable water for town supplies at Portland, Heywood, Port Fairy, Timboon and Petersborough during exploration to 5,500 feet in the Western District basin. Other drilling plants are engaged in other parts of the State, and up to date over 100 wells have been successfully completed.

The Murray Artesian Basin underlies an area of 107,000 square miles, of which 27,000 square miles are in Victoria, 28,000 square miles in South Australia and 52,000 square miles in New South Wales. The quality of the water varies, and is suitable for domestic purposes in much of the south-western part of the basin in Victoria, but elsewhere is suitable only for limited stock use. Maximum depth of development of underground water in Victoria is approximately 4,500 feet. Some individual bores can yield up to 2,000,000 gallons a day. In the last few years, the Department of Mines has expanded considerably the work of exploration for underground water.

11. Future Programme.—The principal works under construction are Bellfield Reservoir on Fyans Creek (Grampians Mountains) to supplement the supply to the Wimmera–Mallee system (*see* paragraph 6 above), and a channel enlargement and remodelling project in the Goulburn system (*see* paragraph 5 (i) above).

In July, 1963, the Government announced plans for a long-term storage programme to cost a total of £37.5 million between 1963–64 and 1973–74. Some of the storages are already under construction, namely Bellfield Reservoir, Devilbend Reservoir (to serve the Mornington Peninsula system) and the first stage of the large Buffalo Reservoir referred to in the table on page 235. The others are Chowilla Reservoir (a River Murray Commission storage) and Winton Reservoir, also included in the table on page 235 together with the following:—

(*a*) Tarago Reservoir on the Tarago River to supplement supply to the Mornington Peninsula area.
(*b*) Nillahcootie Reservoir on the Broken River below Mansfield, to be used for irrigation;
(*c*) Lerderderg Reservoir on Coimadai Creek, to be filled mainly from the Lerderderg River and Goodmans Creek, and used to supplement irrigation water supplies at Werribee and Bacchus Marsh; and
(*d*) Corop Lakes, two natural lakes near Rochester to be used as an adjunct to Waranga Basin for off-river storages for irrigation.

§ 4. Queensland

1. General.—(i) *Rainfall.* Particulars of the rainfall pattern of Queensland are given in Year Book No. 37, page 1122. (*See also* Chapter II. Physiography, page 47, of this issue.)

(ii) *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.

For a description of the development of the present administration *see* Year Book No. 42 and earlier issues.

(iii) *Water Utilization.* In Queensland, 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.

2. Irrigation.—(i) *General.* Irrigation as a means of stabilizing and increasing agricultural production continues to receive attention in Queensland. As a large portion of Queensland is tropical, the State's crops differ considerably from those of other States. Sugar cane is the greatest individual crop, representing in value nearly half of the total agricultural production. In 1962–63, 17 per cent. of the sugar cane acreage was irrigated. This represented 37 per cent. of the total irrigated area in Queensland. Queensland is also Australia's major tobacco-producing State, and plans are in hand to increase greatly the annual production of this crop by means of development under irrigation. The area of tobacco irrigated during 1962–63 represented 97 per cent. of the total plantings of this crop in the State.

Most irrigation in Queensland is undertaken by private farmers operating under licence to obtain water by pumping from streams or from natural underground storages. During recent years, there has been considerable development of individual water conservation projects (water harvesting) to provide storage for irrigation of pastures, fodder crops and small crops, and orchards. Where available, electricity is the most popular source of power for pumping, and the principal areas supplied with electricity are the Burdekin Delta, the Lockyer Valley, and the Darling Downs.

It has been estimated that about two-thirds of 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, Lower Burnett (Bundaberg area), Lockyer Valley and Redland Bay. Similar development is taking place in other areas such as parts of the Darling Downs.

Furrow irrigation is used for cotton, sugar cane, most tobacco and some other crops. Spray irrigation is used widely on fruit, vegetables, fodder crops and a small part of the tobacco crop. Spraying is well suited for the application of water on deep soils by small pumping plants, particularly when the quantity of water available is limited. Use of the border check method in the irrigation of pasture and fodder crops has proved successful.

The following table shows the number of irrigators and the areas irrigated for the years ended 31st March, 1959 to 1963, and for each division for the year ended 31st March, 1963.

AREA OF LAND IRRIGATED: QUEENSLAND

Season and division	No. of irrigators	Area irrigated (acres)							
		Vegetables	Fruit and vineyards	Sugar-cane	Tobacco	Cotton	Other crops	Pastures	Total
1958–59	7,149	26,597	4,876	65,613	7,490	1,520	38,135	10,402	154,633
1959–60	6,889	27,207	5,212	62,346	9,256	2,579	36,115	9,421	152,136
1960–61	7,932	29,698	5,758	68,987	13,789	2,675	50,139	15,651	186,697
1961–62	8,433	32,139	6,537	74,541	13,671	2,040	59,947	20,544	209,419
1962–63—									
Southern Queensland ..	5,952	28,061	5,775	21,949	3,181	298	44,449	17,334	121,047
Central Queensland ..	625	1,051	253	.	38	1,862	9,094	2,123	14,421
Northern Queensland ..	1,962	5,146	992	59,557	11,983	46	4,486	2,884	85,094
Total, 1962-63 ..	8,539	34,258	7,020	81,506	15,202	2,206	58,029	22,341	220,562

The pattern of irrigation in Queensland is unlike that in southern States. The spring to autumn " irrigation season " of the temperate southern irrigated lands is not applicable, as round-the-year irrigation is required throughout most of the State, the timing and duration of the summer " wet " season being too variable to enable a definite non-irrigation season to be fixed.

Two of the more important areas of development by irrigation by private pumping are the Lockyer Valley and Burdekin River Delta.

(*a*) *Lockyer Valley.* West of Brisbane and within 30 miles of that metropolitan market is the Lockyer Valley, which is portion of the Brisbane River Basin. The valley comprises an extensive flood plain where heavy black alluvial soil thickly overlies gravels

and sands carrying water suitable for irrigation. Despite a mean annual rainfall of 30 inches, the variation is great, and irrigation is necessary for continuous agricultural production. Surveys suggest that of some 60,000 acres of land highly suitable for irrigation only about a third is under irrigation. Most of the farmers operate electric pumps for irrigation purposes, and a special policy designed to encourage such development is fostered by the Southern Electric Authority of Queensland. The Irrigation and Water Supply Commission has constructed a number of small weirs on Lockyer Creek with a total storage of 1,340 acre feet. These also tend to augment and conserve underground supplies. The Irrigation Research Station established at Gatton has been converted to a Regional Experimental Farm under the control of the Department of Primary Industries.

The Lockyer Valley produces a substantial proportion of Queensland's onions, potatoes, pumpkins, lucerne, hay, green fodder, maize and dairy products.

(*b*) *Burdekin River Delta.* The Burdekin River, which enters the sea between Townsville and Bowen, is a major factor in the life of north Queensland. In most years, heavy floods from a catchment twice the size of Tasmania cause extensive damage and traffic disruptions. On the other hand, the fertile delta area, with its underground water supplies at shallow depth, has contributed greatly to the agricultural prosperity of north Queensland. The average annual rainfall of this area is some 41 inches, but the major part falls in the months December to March. Consequently, sugar growers and other farmers have tapped the underground water resources of the delta to obtain supplies in the dry periods. Sugar is the main crop irrigated, together with citrus fruits, pineapples, vegetables and tobacco. The irrigated area is in excess of 30,000 acres, with up to 1,000 acre feet of water being drawn daily from underground sources.

In the Home Hill-Inkerman areas on the south side of the Burdekin, water is obtained from shallow wells by electric pumps supplied from a local power station controlled by the Townsville Regional Electricity Board. Around Ayr, on the north side of the river, electric power from the mains of the Townsville Regional Electricity Board is now being used in place of individual internal combustion engines. At both Home Hill and Ayr, water for domestic supply is raised by a windmill on each property.

In 1940, the Burdekin River Trust was formed to safeguard the sugar areas of the delta from erosion and floods. An irrigation research station studies the development of pastures and irrigated crops under local conditions.

(ii) *Government Projects.* The Irrigation and Water Supply Commission has constructed and operates two dams and forty-two weirs with a storage capacity of 457,326 acre feet. Water from these storages supplies four irrigation areas operated by the Commission and supplements numerous streams from which pumping for private irrigation takes place.

(*a*) *Mareeba-Dimbulah Irrigation Area.* The large areas of sandy soils in the valleys of the Walsh and Barron Rivers in the neighbourhood of Mareeba and Dimbulah are suitable for tobacco production, and in 1952 an irrigation undertaking was established.

Construction of Tinaroo Falls Dam on the Barron River has been completed, and construction of irrigation works which will serve a total of 78,000 acres is proceeding. Of this area, 49,000 acres will be irrigated. It is expected that 910 tobacco farms and 180 mixed farms will be served. While tobacco will be the basic crop, peanuts, vegetables, maize, cotton and stock fattening also appear suitable. One hundred and fifty miles of channels have been constructed, and irrigation water from Tinaroo Falls Dam is available to 501 farms.

In 1962–63, the value of tobacco leaf sold was £6.3 million from 516 farms.

(*b*) *Burdekin River Irrigation Area.* While construction of the major part of the Burdekin River Irrigation, Hydro-electric and Flood Mitigation Project has been deferred indefinitely, three sections associated with the Project have been completed. These are the Clare, Millaroo and Dalbeg sections, all of which are used predominantly for tobacco production. Located from 25 to 65 miles upstream from the mouth of the Burdekin, these areas comprise 18,862 acres, and obtain irrigation waters from central pumping stations drawing on the flow of the Burdekin. A storage of 7,670 acre feet capacity has been constructed about 79 miles upstream from the mouth of the Burdekin to augment supplies. During 1962–63, a further storage of some 2,550 acre feet was completed. At 30th June, 1963, 149 farms were occupied, and total production for 1962–63 was valued at £470,736.

(*c*) *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. Much investigational and survey work on the scheme was carried out, but the general financial

depression and limited loan funds brought about the cessation of the work. However, the initial step in construction was completed, comprising a weir on the river at Theodore and irrigation works to serve an area of 3,500 acres supplied from a central pumping station. Two additional weirs have since been built, giving a total storage of 10,280 acre feet and covering some 61 farms in production, returning an estimated £292,000. Pasture, vegetables, cotton, fruit and dairy products are the principal produce. Recently, further attention has been given to the former plans for the valley, and earlier work has been under close scrutiny as a prelude to future development.

(*d*) *St. George Irrigation Area.* The St. George irrigation area comprises 19 farms engaged mainly in raising fat lambs in conjunction with irrigated pastures. Water supply for the area is obtained by pumping from the combined weir and road bridge on the Balonne River at St. George.

(*e*) *Warrill Valley Project.* Moogerah Dam on Reynolds Creek (a tributary of Warrill Creek) is of double curvature thin arch construction 105 feet high to spillway crest level, and will serve some 11,000 acres of the Valley by private diversion of water released from its 73,000 acre feet storage into Reynolds and Warrill Creeks.

(*f*) *Mary Valley Project.* The construction by contract of Borumba Dam on Yabba Creek is nearing completion. This is a rock-fill structure with an upstream impermeable concrete membrane 144 feet high above stream bed. In its initial stage, storage capacity will be 34,500 acre feet with provision for later increase to 80,000 acre feet. In its first stage, water released from the dam will be available to maintain the town water supply for Gympie, and will allow extension of the area irrigated by private diversion from the Mary River to some 18,000 acres.

(*g*) *Upper Condamine Project.* Work is continuing on the construction of Leslie Dam on Sandy Creek, a tributary of the Condamine River. This will be a mass concrete gravity dam 95 feet above foundation level. In its initial stage, storage capacity will be 38,500 acre feet with provision for later increase to 87,000 acre feet. Water released from the dam will be available for irrigation of sections of the Darling Downs downstream the Condamine River as far as Cecil Plains. In addition, the city of Warwick will be supplied by pipeline from Leslie Dam.

(*h*) *Border Rivers Project.* The development of the rivers constituting portion of the border between Queensland and New South Wales is under the authority of the Dumaresq-Barwon Border Rivers Commission on which each State is represented. For information on the project, *see* page 241.

3. Underground Water.—(i) *General.* The use of underground water supplies has been a very important factor in agricultural and pastoral development in Queensland. Detailed information is given below concerning the Great Artesian Basin, which is the major source of stock water supplies over more than half of the State. Elsewhere, supplies obtained at shallower depths, in porous, fractured or fissured rocks, are extensively used for domestic and stock purposes. Underground water also supports more than half the irrigated area in the State, supplies being obtained chiefly from alluvial formations along river valleys, and from river deltas, the most conspicuous example of which is the Burdekin River Delta. Reference has been made to these areas in para. 2 above.

(ii) *Great Artesian Basin.* (*a*) *General.* Western Queensland, beyond the 20 inch rainfall belt, is predominantly pastoral and is mainly dependent for water supplies on artesian and sub-artesian bores and, where surface storage is not readily available, on excavated tanks. The Great Artesian Basin in Queensland corresponds approximately with the area lying west and south of the Great Dividing Range, excluding the Cloncurry mineral field and the Barkly Tableland. It comprises 421,000 square miles or nearly two-thirds of the total State area of 667,000 square miles.

(*b*) *Artesian Water.* Although the number of bores has gradually increased over the years, the total flow of all bores has declined since the peak flow of 351 million gallons a day. A report on the nature and structure of the Great Artesian Basin, presented in 1954, indicated that the output would continue its decline during the next sixty years, at which stage the flow from the remaining flowing bores would be of the order of 110 million gallons a day. The discharge from windmills, springs and other leakages, together with the underflow past the Queensland borders, would then be about 20 million gallons a day. It was further expected that the total discharge, of the order of 130 million gallons a day, would be in equilibrium with the recharge of the basin. It was anticipated that numbers of bores on higher ground would cease to flow during the next sixty years and the area served by the flowing bores would contract by perhaps twenty per cent.

Up to 30th June, 1963, 2,814 artesian bores had been drilled, of which 1,898 were still flowing. The total depth drilled amounted to 3,952,832 feet and the estimated daily flow was 200 million gallons. Although very few bores exceed 2,000 feet in depth (the average depth is 1,405 feet) and a new bore greater than 3,000 feet deep is exceptional, the deepest bore recorded was sunk to 7,009 feet. Some bores which had been classified as " ceased " have been inspected and found to be still flowing, while other ceased bores have responded to deepening and have recommenced flowing. Both the pressure and flow of artesian bores are steadily diminishing, the rate of decrease varying widely throughout the basin. Present average rates of dimunition are:—pressure, 1–2 feet/head; total flow, 2–3 per cent. per annum. The greater part of the artesian discharge is distributed by some 15,500 miles of open earth channels, from which a large proportion of the water is lost by soakage and evaporation, less than 10 per cent. being actually used by stock.

Although artesian beds underlie a large area of the State, only 79,000 square miles are primarily watered by bore drains. The remaining area is watered by artesian bores (with small or no flow and limited drains), sub-artesian bores, excavated tanks, dams and natural waterholes. In many districts, artesian bores do not provide economical watering facilities because of depth, limited area to be watered, and difficult terrain for distribution of water by drains. The quality of artesian water from the greater part of the basin is not suited for prolonged use for irrigation on most soils, nor are the supplies sufficient for both large scale irrigation and stock-watering. Practically the whole of the final steady-rate discharge from flowing bores will be needed for the watering of stock.

Shallower supplies, which come from beds unconnected with artesian beds, are of variable quality and volume. These supplies are available at depths of less than 1,000 feet over a large area of the basin. Some 10,996 sub-artesian bores within the Great Artesian Basin have been registered in Queensland. An important practical consideration is that the main artesian beds are continuous and the sub-artesian beds are not continuous.

(*c*) *Bore Water Areas.* The constitution of Bore Water Areas was inaugurated in 1913 to aid pastoral settlement in districts where large flows were available at a cost beyond individual capacity, and to conserve artesian supplies by fully utilizing flows from the existing bores on the land resumed for closer settlement. Bores and drains are constructed from loan funds repayable over a period of years. The areas are administered by local boards or by the Commissioner of Irrigation and Water Supply, acting as a board. Rates are levied to meet interest, redemption, maintenance and administration costs. Statistics for the year 1962–63 are:—areas constituted, 73; administered by the Commissioner, 55; administered by local boards, 6; number abolished, 12; area benefited, 4,247,540 acres; average rate per acre, 1.34d.; number of flowing bores, 57; total flow, 26,122,000 gallons a day; drains served, 2,646 miles.

(iii) *Other Sources.* Outside the Great Artesian Basin, ground water supplies can conveniently be divided into two broad groupings, (*a*) those obtained in porous, weathered, fissured or fractured rocks, and (*b*) those obtained in unconsolidated sediments of Cainozoic age.

In the first group, supplies, often within short distances, are widely variable both in quantity and quality, but normally are sufficient only for stock-watering purposes. Because storage is generally small, seasonal fluctuation of water level tends to be high, and this can have a significant effect on the supply available during dry seasons.

Small to moderate irrigation supplies (up to a few thousand gallons an hour) are sometimes obtained and, in exceptional cases, particularly with basalts and limestones, supplies may be as much as 10,000 gallons an hour.

The second group comprises the main irrigation supplies and, although it is common to find a wide range in the supply normally available from individual bores in any area, pumping rates as high as 10,000 gallons an hour are not uncommon. The availability of underground water has been investigated in a considerable number of alluvial valleys in south eastern Queensland and in a number of coastal areas, particularly in the vicinity of the estuaries of the Burnett, Pioneer and Burdekin Rivers, where underground water is the main source for irrigation of sugar cane.

Reference has already been made to the importance of underground water for irrigation in the Lockyer Valley (*see* para. 2 (i) (*a*) above), and other areas in which irrigation supplies from alluvial formations have been extensively utilized include the Callide Valley, the Monto area, parts of Barker and Barumbah Creeks, Warrill Creek, Cressbrook Creek, the Upper Logan River and parts of the Upper Condamine River and its tributaries.

Government authorities do not normally undertake private drilling for landholders, but, as discussed below, assistance is given in the location and development of ground water supplies through the provisions of the *Farm Water Supplies Assistance Act* 1958. This assistance has considerably accelerated the use of underground water for irrigation, and there is no doubt that there are many areas with a large potential for future expansion.

4. Stock Watering.—(i) *General.* 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 a seventh of the sheep. In addition to the stabilization of water supplies in the pastoral areas, the provision of water along stock routes for travelling stock has received much attention in recent years.

(ii) *Main Stock Routes.* The Queensland Irrigation and Water Supply Commission acts 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. From 1935, when the scheme was inaugurated, to 30th June, 1963, 593 facilities had been completed, and at 30th June, 1963, 48 facilities were under construction or investigation. A State-wide investigation is being carried out by the two authorities mentioned above to ascertain the general movement of stock, determine primary and secondary routes, register existing water facilities, and formulate a co-ordinated plan in regard to the provision of new watering facilities.

(iii) *Channel Country Stock Routes.* Under *The State Grants (Encouragement of Meat Production) Acts* 1949–1954, the Commonwealth Government agreed to meet half the cost of providing additional watering facilities in stock routes leading into, along, and out of, the Channel country and on the route from Camooweal to Mount Isa. These routes connect with the main far-western route included in the State scheme inaugurated in 1935.

This scheme was completed during 1962–63. The total number of watering facilities constructed since the commencement of the scheme was 37, at a total cost of £299,592.

5. Technical and Financial Assistance to Farmers.—The *Farm Water Supplies Assistance Act* 1958 is designed to improve the standard of water supply installations on individual holdings, encourage greater development of individual irrigation schemes, and provide greater stability of production and avoid losses in time of drought together with generally increasing production.

To achieve this purpose, the Act authorizes 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 Act are carried out under Commission supervision, and for the payment of a small charge the Commission will supervise the construction of works designed by its staff, but for which the landowners do not require financial assistance under the Act.

During 1962–63, 767 requests (569 for technical assistance only, and 198 for technical and financial assistance) were dealt with in addition to advice on a further 285 requests on groundwater supplies. An amount of £282,966 was approved for advances under the Act in 1962–63.

6. Hydro-electricity.—An outline of hydro-electricity schemes operating in Queensland is given in the previous chapter (*see* p. 224).

§ 5. South Australia

1. General.—(i) *Rainfall.* Brief particulars of the climatic conditions in South Australia are given on page 1129 of Year Book No. 37. (*See also* Chapter II. Physiograpy, page 47, of this issue.)

(ii) *Administration.* Water supplies, other than irrigation works, are under the control of the Engineering and Water Supply Department, which administers the *Waterworks Act* 1886 governing the supply of water through mains in water districts for townships and farm lands. The *Water Conservation Act* 1886 provides for the construction of storages in non-reticulated areas, and authorizes the Minister concerned to " divert and impound the water from any streams or springs or alter their courses, and take water therefrom, or any other waters as may be found in, under, or on, any land entered upon for the purpose of supplying water to the inhabitants of any water district ".

(iii) *Methods of Catchment and Conservation.* Early in the history of the State, the rights to all running streams, springs and soaks were vested in the Crown. The Water Conservation Act was passed in 1886 and, up to 30th June, 1963, more than 550 dams, tanks and rainsheds, together with 460 wells and 340 bores, had been built or acquired by the State at a total cost of £1,853,585. The rainsheds are timber frameworks roofed with galvanized iron to collect rainfall which is delivered to storage tanks and is available for surrounding settlers and travellers. Rainshed catchments vary from a few hundred square feet to four acres in extent. Over most of the State, extraordinary precautions are taken to counteract

evaporation, and pipelines in preference to open channels and covered storages are used for this purpose. Meters are attached to practically all services to check usage by individual consumers.

2. Irrigation.—Australian irrigation originated in the upper Murray of 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 that 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 and is self-contained and self-controlled. Every settler is entitled to vote for the election of Trust members. The Trust maintains 100 miles of reticulation channels.

The following table shows particulars of the areas of crops and pastures irrigated in South Australia during the seasons 1958–59 to 1962–63.

AREA OF LAND IRRIGATED: SOUTH AUSTRALIA
(Acres)

Season and authority	Vine fruits	Tree fruits	Citrus fruits	Other crops(a)	Pastures	Total
1958–59	25,389	20,795		26,372	12,525	85,081
1959–60	26,014	22,315		33,183	19,387	100,899
1960–61	26,071	22,706		34,198	19,048	102,023
1961–62	27,167	25,236		36,653	19,344	108,400
1962–63—						
Department of Lands—						
Orchard land—						
Berri	4,888	1,203	1,430	..	..	7,521
Cadell	543	186	175	..	..	904
Waikerie	1,752	689	1,446	..	..	3,887
Cobdogla	4,268	252	348	..	..	4,868
Moorook	308	140	257	..	..	705
Kingston	180	81	286	..	..	547
Mypolonga	..	286	514	..	..	800
Chaffey–Ral Ral Division	727	237	24	..	..	988
War service land settlement—						
Cooltong Division	385	245	493	..	..	1,123
Loxton area	3,166	1,059	2,307	..	..	6,532
Loveday Division	248	38	39	..	..	325
Reclaimed swamp land—						
Monteith	..	..	..	..	992	992
Mypolonga	..	..	..	..	1,306	1,306
Wall	..	..	..	..	512	512
Burdett	..	..	..	..	109	109
Mobilong	..	..	..	..	429	429
Long Flat	..	..	..	..	338	338
Neeta	..	..	..	..	561	561
Pompoota	..	..	..	..	425	425
Cowirra	..	..	..	..	571	571
Jervois	..	..	..	..	3,637	3,637
Total	*16,465*	*4,416*	*7,319*	..	*8,880*	*37,080*
Renmark Irrigation Trust	5,366	2,477	1,000	457	..	9,300
Private landowners	5,553	11,664		36,288	12,928	66,433
Total, 1962-63	**27,384**	**26,876**		**36,745**	**21,808**	**112,813**

(a) Includes fodder and fallow land.

3. Water Supply Schemes.—(i) *Adelaide Metropolitan Water Supply.* Adelaide derives its water from six 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 87,400 acre feet and the pipeline has a capacity of 65,000 acre feet a year.

To the north, the new city of Elizabeth receives water from South Para Reservoir in the Barossa system and from the metropolitan storages. The consumption for the whole area for the year 1962–63 was 88,800 acre feet, equivalent to a consumption of 100 imperial gallons per head per day. The capital cost to 30th June, 1963 was £43,648,315.

(ii) *Country Reticulated Supplies.* Areas extending to a distance of 90 miles north of Adelaide are supplied from the Warren, Barossa, and South Para Reservoirs (50,350 acre feet) in the Barossa Ranges. Agricultural towns and areas further north are supplied from Beetaloo, Bundaleer and Baroota Reservoirs, and the Morgan-Whyalla Pipeline. There is a supplementary supply from the Mannum-Adelaide pipeline through the Warren Reservoir. The 223-mile pipeline from Morgan to Whyalla can carry up to 10,000 acre feet of water a year from the Murray River. Work is commencing on a second main of more than double that capacity. 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 (9,160 acre feet), the sand beds of the Uley-Wanilla Basin, the Lincoln Basin, and the newly developed 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. 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 30th June, 1963, have cost £44,257,662 (exclusive of river control and irrigation works on the Murray River) and contain 7,267 miles of water mains.

4. Underground Water.—The occupied portion of South Australia is, on the whole, well endowed with underground water, and the extent of the several artesian basins is reasonably well known. There are also considerable areas in which groundwater occurs, notably in the south-east of the State where, in the Keppock district, supplies exceeding 100,000 gallons an hour are not uncommon. Quality varies widely, but a great deal is at least useful for watering stock, and this is the major use to which it is put.

The deepest portion of the Great Artesian Basin (in the north-east) is not extensively developed because development costs are high in proportion to the carrying capacity of the arid land. Deep boreholes have been drilled by the Government to provide watering places along stock routes, and bores around the basin margin have developed pressure waters which occur at comparatively shallow depth, as at Marree township, where the deepest flowing bore is 575 feet. In addition to the pressure waters, the non-pressure aquifers of the subsidiary basins provide pastoralists with stock water supplies which can be readily and economically developed.

The use of the waters of the Murray Basin is essential to settlement in the Murray Mallee country and in the south-east of the State, especially for farms and township supplies. Mount Gambier draws its water from Blue Lake, which is fed from the Basin. Bores supply a number of towns in this Basin, the deepest bore being 1,805 feet.

On Eyre Peninsula, the Uley–Wanilla Basin has been in use since 1949, the Lincoln Basin since 1960, and the Polda Basin since 1963, to supplement surface water supplies. Investigations are being made in another basin south-west of the Uley–Wanilla Basin.

The Lincoln Basin is now fully developed and is yielding up to 20 million gallons a week which provides a water supply for the town of Port Lincoln on Eyre Peninsula.

The Polda Basin near the township of Lock was brought into operation late in 1962. The present pumping plant has a capacity of 7 million gallons a week. The water is reticulated to townships and farming properties on the upper Eyre Peninsula. Investigations are currently proceeding for the further development of this basin.

Pastoralists, farmers, market gardeners and others have been assisted with expert advice on drilling, and the Government maintains and operates 25 drilling plants which to date have developed an underground water supply potential in excess of 150 million gallons of water a day throughout the State. The whole of the Murray River Basin has been examined critically to ascertain the extent of land which could be used for lucerne, and considerable tracts of previously undeveloped country in the upper south-east, Kangaroo Island and Yorke Peninsula have been found to have usable water and are now being opened up.

Groundwater resources surveys are undertaken continually by geologists of the Department of Mines, the results being published in various bulletins and reports issued from time to time. The *Groundwater Handbook* published in 1959 by the department provides a comprehensive detailed review of the State's groundwater resources.

5. **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 use and suitability of underground water for irrigation and stock purposes. In addition, a great part of the farming areas is supplied with water under pressure from the extensive distribution systems connected to various reservoirs or the Murray River.

6. **South-Eastern Drainage.**—In the south-east of South Australia it has been necessary to construct costly 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 Government at national cost, 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 £720,876. 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 in progress. The southern section of 260,000 acres, which involved the excavation of 8,100,000 cubic yards and the provision of 343 miles of new or enlarged drains, has been completed. Work is in progress on the northern section of 140,000 acres, where 48 miles of drains, involving the excavation of 2,787,000 cubic yards of material, have been completed. In addition, work is in hand for the drainage of 727,000 acres of land in the Eastern Division of the south-east, situated east of Bakers Range, and extending from near Kalangadoo to north of Naracoorte. As part of the first stage of the work (which involves the construction of a main diversion drain from Beachport to Struan), an existing drain from Beachport to Legges Lane (a distance of over 24 miles) has been enlarged, and work is proceeding between Legges Lane and Struan (a distance of 33 miles). A total of 4,156,000 cubic yards of material has been excavated.

The capital cost of drainage in the South-Eastern Drainage Area System to 30th June, 1963, was £7,060,000, and the length of drains constructed was 745 miles.

§ 6. Western Australia

1. **General.**—(i) *Rainfall.* Brief particulars of the climatic conditions in Western Australia are given on page 1133 of Year Book No. 37. (*See also* Chapter II. Physiography, p. 47, of this Year Book.)

(ii) *Administration.* Natural water rights in the State, with few exceptions, are vested in the Crown. Irrigation districts are administered by the Minister for Water Supply, Sewerage and Drainage under the *Rights in Water and Irrigation Act* 1914–1954, and he is advised by an Irrigation Commission representing the local irrigationists and governmental, technical and financial branches. Water supplies in country areas in Western Australia coming under the provisions of the *Water Boards Act* 1904–1954 and the *Country Areas Water Supply Act* 1947–1960 are controlled either by the local authority or by the Public Works Department. Those controlled by the Department (except for some local water supplies to country towns still under the provisions of the Water Boards Act) form the Country Areas Water Supply, consisting of the Goldfields and Agricultural Water Supply, the Great Southern Towns Water Supply and local water supplies to country towns and districts. The Department also controls individual water supplies serving isolated mines, stock routes, and agricultural areas.

2. **Irrigation.**—The main irrigation areas are situated in the south of the State along the South-Western Railway between the towns of Waroona (70 miles from Perth) and Dardanup (116 miles from Perth). In the north, new irrigation areas are being established at Carnarvon on the Gascoyne River, Camballin on the Fitzroy River and at Kununurra on the Ord River.

The Public Works Department controls three irrigation districts—Waroona, Harvey and Collie River—the total area irrigated in these districts during 1962–63 being 27,974 acres and the total water used 94,785 acre feet. Investigations are being carried out with a view to irrigating a further 30,000 acres south of the Collie River Irrigation District.

The Waroona Irrigation District (3,051 rated acres) is supplied from Samson Brook Dam (7,437 acre feet capacity) and Drakes Brook Dam (1,855 acre feet); the Harvey Irrigation District (12,863 rated acres) from Stirling Dam (46,191 acre feet) and the Harvey Weir (8,372 acre feet); and the Collie River Irrigation District (10,490 rated acres) from the Wellington Dam (150,107 acre feet). The Logue Brook Dam (19,246 acre feet) within the Harvey Irrigation District was completed in November, 1963.

An area of approximately 1,350 acres of Gascoyne River flats adjacent to Carnarvon is under irrigated cultivation. The principal crops are bananas and beans, but others such as tomatoes are also grown. For this agriculture, some 3,500 acre feet of water were drawn during 1962-63 by the individual growers pumping from aquifers situated in and adjacent to the dry bed of the Gascoyne River. The quantity of water which any grower may pump is controlled by the Public Works Department, assisted by an advisory committee with local representation. Allocations of water are granted on a monthly basis, and are based on river behaviour and the capital values of the properties concerned. A pilot scheme to augment the supply to 20 settlers by pumping from aquifers five miles upstream was completed in 1962–63.

On the Liveringa flood plain adjacent to Camballin, 65 miles south-east of Derby, commercial production of rice has been achieved following successful experimental work. Irrigation water from the Fitzroy River is diverted through Uralla Creek for 25 miles to the rice growing area where a natural storage of approximately 1,200 acre feet exists. During periods of low flow in the Fitzroy River, the supply of water is augmented by pumping. Further storage with a capacity of 4,500 acre feet has been provided by the construction of a dam on Uralla Creek 18 miles from the Fitzroy River. A weir which has been constructed across the Fitzroy River provides gravity flow to Uralla Creek while the Fitzroy River is flowing.

The Ord River in the Kimberley Division of Western Australia traverses a tropical area served with monsoonal rains of irregular incidence and quantity, varying from 20 inches in the south to 30 inches in the north. The hottest months (December to March) are also the months of highest rainfall. Communications and population are sparse. The Western Australian Government is considering a proposal to build a dam equipped with a hydro-electric plant, to conserve 3½ million acre feet of water, which might supply water for an area of some 200,000 acres agriculturally and topographically suitable for irrigation. Investigations show that the climate and soil conditions are suitable for the cultivation of sugar cane, rice, cotton, safflower and various oil seeds. The economic production of these and other crops, as well as the possible use of such irrigation areas for fattening cattle, is being examined at the Kimberley Research Station on the Ord River. Construction of a diversion dam at Bandicoot Bar, some 30 miles downstream from the main dam site, was virtually completed by June, 1963. Irrigation of safflower on the first five farms commenced in May, 1963. This dam will provide water for an area of 30,000 acres.

Particulars of the areas of crops and pastures irrigated in Western Australia in the seasons 1958–59 to 1962–63 are given in the table below.

AREA OF LAND IRRIGATED: WESTERN AUSTRALIA

(Acres)

Season	Vegetables	Fruit	Vineyards	Other crops (a)	Pastures	Total
1958–59.. ..	8,211	6,850	630	3,429	24,982	44,102
1959–60.. ..	8,447	7,642	705	3,668	25,427	45,889
1960–61.. ..	9,076	8,335	897	5,591	24,652	48,551
1961–62.. ..	9,596	8,840	972	4,235	25,036	48,679
1962–63.. ..	9,375	9,588	924	4,447	27,167	51,501

(a) Includes fodder and fallow land.

3. Water Supply Schemes.—(i) *Metropolitan.* Particulars relating to the Metropolitan Water Supply are given in Chapter XX. Local Government.

(ii) *Goldfields and Agricultural Water Supply.* Western Australia has one of Australia's most spectacular water supply schemes, and a brief account of its development will be found on page 1134 of Year Book No. 37. Mundaring Reservoir on the Helena River, 26 miles from Perth, is the source of water supplied to the Eastern Goldfields and has a capacity of 62,435 acre feet and a catchment of 569 square miles. The water passes through 346 miles of main pipeline, mostly steel and 30 inches in diameter, equipped with eight pumping stations.

Maximum pumping capacity from Mundaring Pumping Station is 13.75 million gallons a day with provision to increase this to 18.5 million gallons a day. The total capacity of all receiving, regulating, standby and service tanks along the main pipeline is 154 million gallons, which includes three standby reservoirs at Kalgoorlie having a combined capacity of 60 million gallons.

Hundreds of miles of branch pipelines have been laid to mining areas, agricultural areas and country towns, a notable one being the Norseman extension of 103 miles. The system serves some 87 towns, and water is reticulated to 4,200,000 acres of mixed farming lands. The total length of pipelines is 3,782 miles and the number of services is 24,963. The total quantity of water pumped from Mundaring Reservoir in 1962–63 was 3,184 million gallons. The total cost of the scheme to the end of 1962–63 was £18,991,388, of which the Commonwealth Government contributed £3,609,278 under the terms of the Comprehensive Water Supply Scheme.

(iii) *Comprehensive Water Supply Scheme.* A comprehensive water supply scheme to supplement water supplies to the goldfields, agricultural areas, and country towns, authorized in 1947 as a joint work between the Commonwealth and State Governments, was completed towards the end of 1961. The northern section is an enlargement and extension of the Goldfields and Agricultural Water Supply. The southern section is the Great Southern Towns Water Supply. Linked with Wellington Dam (initially an irrigation work on the Collie River) by 80 miles of 30-inch diameter pipe through three pumping stations to Narrogin, it now supplements the existing water supplies to country towns along the Great Southern Railway, north to Brookton and south to Kojonup. The raising of the impounding wall of Wellington Dam to increase its storage to about 150,100 acre feet was completed in 1960. Expenditure on the Scheme to 30th June, 1963, amounted to £10,248,861.

(iv) *Local Water Supplies.* Local schemes other than as above comprise those in the remaining agricultural and mining areas, including the North-west and Kimberley Divisions. Ninety-three separate reticulated water supplies serve country towns and districts. Of these, eighty-four are controlled by the Water Supply, Sewerage and Drainage Department and the remainder by local authorities.

(v) *Commonwealth and State Government Railways.* 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, e.g., Public Works and Metropolitan Water Supply Departments.

(vi) *Catchments.* The water supplies to these country schemes come from stream flow, dams, tanks, wells and bores.

A total of 81 rated stream gauging stations is operating in the South-west, North-west and Kimberley Divisions. Three types of catchment peculiar to this State developed in connexion with local water supplies and deserving special mention are:—rock catchments, which consist mainly of clear granite out-cropping rock, from which the overall run-off from rain amounts to approximately 40 per cent.; bituminous catchments, which are areas which have been sealed with emulsified bitumen—some hundreds of acres have been so treated and yield a run-off of approximately 80 per cent. of the rainfall; and roaded catchments, where selected areas of a catchment are cleared, graded and formed into roads to assist in obtaining additional rainfall run-off.

4. Underground Water.—Considerable use is made of underground water by individual farmers, pastoralists, market gardeners, etc., and it is estimated that over 50,000 bores are in use in the State. The quality of the water varies from place to place and much of the water in only suitable for stock. However, artesian aquifers are tapped to supply or augment the town supplies of Perth, Bunbury, Busselton and Denham, and non-pressure water is used in the public supplies of thirty-five other towns.

Considerable advances in the knowledge of aquifers and quality of water in the main sedimentary basins has been made as a result of extensive geological surveys by oil exploration companies in recent years. The Hydrology Division of the Geological Surveys of Western Australia is investigating and assessing the underground water resources of the State. A detailed survey of the Perth Basin, including systematic exploratory drilling, is in progress. The Geological Survey undertakes geological investigations in connexion with new town water supplies or extensions of existing town water supplies, and arranges for the drilling of recommended exploratory bores. Projects are in progress, or have recently been completed, for the towns of Northampton, Geraldton, Morawa, Watheroo, Lancelin, Mandurah, Capel, Eaton and Busselton. The Geological Survey advises Local Government authorities, private industry and individuals on underground water problems, and supervises departmental exploratory drilling.

§ 7. Tasmania

1. **General.**—(i) *Rainfall.* Brief particulars of the rainfall pattern in Tasmania are given on page 1136 of Year Book No. 37. (*See also* Chapter II. Physiography, page 47 of this Year Book.)

(ii) *Main Purposes of Conservation and Utilization.* Owing to 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 by any means 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.

Until a few years ago, irrigated areas were negligible except for long-established hop fields, but there is a rapidly extending use of spray irrigation on orchards and pastures, and to some extent on potatoes and beans. Up to the present, there has been almost complete dependence on natural stream flows, but the need for some regulating storages is now apparent. A few 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 is generally of poor quality through mineralization, but a small quantity, exploited to a minor degree by bores and pumps, exists over an area in the midlands, on the north-west coast, and on King Island.

(iii) *Administration.* In 1962, a new authority, the Metropolitan Water Board, assumed control of water supplies to Hobart, Glenorchy, Kingborough and Clarence. Water supplies to other areas are primarily the responsibility of local councils, subject to approval of plans and finance by the Rivers and Water Supply Commission.

While the Commission does not own the waters of streams and lakes, it is empowered to take them, or issue licences, subject to pre-existing statute and common law rights. These include water reserved for specific industries, municipal requirements, and ordinary riparian rights. The Commission is also concerned with drainage trusts' operations, river improvement, including repairs after flood damage, and stream gauging.

2. **Hydro-electricity.***—With the exception of a small diesel plant on King Island, electricity generation in Tasmania has resulted entirely from the development of its plentiful waters, and on a world basis this State ranks second to Norway in electricity consumption per head of population. The Hydro-Electric Commission, the authority controlling the generation of electricity in Tasmania, conducts a continuous survey of the water power resources of the State assisted by modern methods such as aerial photography and geophysical exploration.

3. **Regional Water Schemes.**—Three regional water schemes are in operation. The first draws water from the east bank of the River Derwent at Lawitta to provide domestic and industrial supplies in five southern municipalities, and a second, which increases existing supplies to Hobart, pumps water from the west bank of the River Derwent at Lawitta. These two schemes are controlled by the Metropolitan Water Board. In addition, the State government has constructed a regional water scheme to serve the aluminium refinery at Bell Bay on the River Tamar and to supply several municipalities with bulk water for domestic and industrial purposes.

* *See also* Chapter VII. Electric Power Generation and Distribution, p. 228.

Potential sources capable of greater development without storage exist on the Derwent, South Esk, Huon, Lake, Mersey and Forth Rivers. There is also a great reserve of untapped permanent streams in the western half of the State, which is largely unsettled. Diversion to the eastern half of the watersheds is not regarded as practicable.

4. **Industrial.**—Three principal industrial schemes have been installed privately. About 10 million gallons of water a day are being pumped from the Derwent River at Lawitta for use in a nearby paper mill. Another paper mill at Burnie uses several million gallons of water a day from the Emu River, and a factory at Heybridge reticulates water from Chasm Creek.

The State Government has constructed some water schemes for use primarily for industrial purposes. The scheme serving the aluminium refinery at Bell Bay is referred to in para. 3 above. A new wood-pulping plant near Geeveston uses several million gallons of water a day and, in order to supplement the summer flows of the Kermandie River for use by the industry, the State Government in 1962, through the Hydro-Electric Commission, constructed a storage on Riley's Creek by means of a 37-foot high rock-fill dam. The Prosser River Scheme, at present under construction, is designed to supply water to a sodium alginate industry at Louisville near Orford and to supplement the water supply of the township of Orford.

5. **Irrigation.**—There are no State irrigation projects at present, but the Rivers and Water Supply Commission is investigating the possibility of establishing a storage for the Coal Valley. Preliminary investigations have also been made in the Jordan Valley. The *Water Act* 1957 provides for irrigation works to be undertaken by municipalities and by trusts constituted for the purpose, but no such works have been undertaken to date. All systems operating are privately owned, and with one exception (at Bushy Park) are single-farm units. At Bushy Park, a small system serves a group of properties. The larger proportion of the area under irrigation is watered by gravitational systems and the remainder comprises areas devoted to vegetables and served by municipal water supplies or private spray systems.

Details of the areas of crops and pastures irrigated in Tasmania in the seasons 1958–59 to 1962–63 are shown in the following table.

AREA OF LAND IRRIGATED: TASMANIA

(Acres)

Season	Vegetables	Fruit	Hops	Other crops (a)	Pastures	Total
1958–59.. ..	1,386	1,737	1,292	1,514	7,502	13,431
1959–60.. ..	1,235	2,350	1,311	1,873	11,339	18,108
1960–61.. ..	2,103	3,311	1,364	1,787	10,369	18,934
1961–62.. ..	3,388	3,930	1,447	2,711	11,713	23,189
1962–63.. ..	4,100	4,446	1,465	2,839	11,435	24,285

(a) Includes fodder and fallow land.

§ 8. Northern Territory

1. **Climate and Topography.**—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 Chapter II. Physiography, and a brief outline of contour and physical characteristics in Chapter V. The Territories of Australia.

2. **Administration.**—Under the *Control of Waters Ordinance* 1938–1961 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 diversion of water is prohibited except under prescribed conditions. There is a Water Resources Branch of the Northern Territory Administration under the control of a Director. The functions of the branch include 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.

Another function of the branch, which is increasing in importance as it builds up a body of technical data and information about the Territory's water resources, is the dissemination of this knowledge by the provision of advice and assistance to professional drillers and to landholders for the development and improvement of water supplies on agricultural and pastoral leases.

3. Underground Water.—The marked seasonal rainfall over the whole of the Northern Territory is one of the basic factors affecting the pastoral industry, which provides a large proportion of the Territory's income. The inadequacy of surface water during the dry season emphasizes the importance of underground water supplies in the Territory, where most of the cattle numbers are dependent on underground supplies for three to five months each year.

Rainfall is one of the factors controlling cattle numbers, but geological features, controlling both soils and the storage of underground water, are equally important. In the northern-most portion of the Territory, which receives from 25 to 60 inches of seasonal rainfall a year, surface water supplies are, in general, adequate for the pastoral industry. Despite this, however, this area has a comparatively low carrying-capacity for cattle, and the pastoral industry is concentrated more in inland areas where feed retains more nutritive value in winter, despite dry conditions.

South from this well-watered northern-most portion, the Territory becomes progressively drier, with an average annual rainfall of only 5 inches at the margins of the Simpson Desert in the south-east corner. In the lower rainfall areas, the search for potable underground water becomes exacting, but in the Ord-Victoria region and the Barkly Tablelands, the best pastures are generally in areas where sub-surface conditions are suitable for the storage of underground water.

In the Ord-Victoria region, the best grass lands overlie volcanic rocks and extend over some 10,000 square miles. Groundwater is obtained in shallow bores averaging 70 to 80 feet in depth and producing small supplies which range up to 1,500 gallons an hour. For the most part, water is stored in joints, faults or cracks in the rocks, although in places sub-artesian conditions exist. On the whole, selection of bore sites is difficult. Outcrops of sandstone, limestone and shale also occur in this area and underlie the volcanics in most places. In general, these sedimentary rocks dip gently to the east, and sub-artesian conditions obtain. Sandstone aquifers within the group yield good supplies of water ranging up to 4,000 gallons an hour. There are also small basins of younger sedimentary rocks in the region, some of which yield sub-artesian, and in places artesian, water and provide areas of good pastures.

The Barkly Tablelands, which extend into Western Queensland, overlie flat-lying limestone, sandstone and shale of the Barkly Basin. In most places, underground water is under pressure (sub-artesian), but no flowing bores are known. Sandstones and beds of limestone with fractures and solution cavities provide a number of aquifers within the Basin. The hydraulic surface (to which pressure water will rise in bores) ranges between 500 and 600 feet above sea level and adequate supplies for the watering of stock are available at depths ranging from 150 to 400 feet from the surface. The water from over 90 per cent. of the bores is suitable for stock and over 50 per cent. of it is suitable for human consumption. Investigations by the Commonwealth Bureau of Mineral Resources indicate that underground water supplies will be more than sufficient for the future development of the pastoral industry on the Tablelands.

In the Alice Springs district, valuable pastures occur on a great variety of rock types, and from some of these very little underground water is available. Many shallow bores obtain water from alluvium near stream channels. There are also many successful bores in porous sands and limestone in Mesozoic and Cainozoic sedimentary basins and in some Upper Proterozoic and Palaeozoic limestones and sandstones. However, boring in the metamorphic rocks and granite of the basement has, on the whole, met with little success. In many areas, the underground water is of poor quality.

Considerable research has been undertaken in recent years by the Water Resources Branch of the Northern Territory Administration into increasing the Alice Springs town water supply from alluvial basins and providing a water supply for the mining town of Tennant Creek from the Cabbage Gum Basin, a small basin of alluvium and deeply weathered Precambrian rocks, 15 miles south of the town. Recent work by this authority has also proved the existence of high-yielding dolomitic aquifers of probable Lower Proterozoic age in the region of Darwin.

Up to 30th June, 1963, 3,855 bores and wells had been registered in the Territory. Of these 2,342 were on pastoral properties, 170 on agricultural properties, 311 served town and domestic water supplies, 27 were located on mining fields, 334 were being used as test-bores and 390 were used by defence Departments during World War II. The number of registered stock route bores established by the Government is 281.

4. **Irrigation.**—There are no large-scale 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. Investigations for a further dam site to augment Darwin's water supply and to provide reticulated water to properties without natural waters have commenced in the Berry Springs area.

Hydrological investigations are being carried out by the Administration to determine the supply of water and the best methods of control and use in the potential rice-growing areas of the Territory. One hundred and forty-eight gauging stations were in operation in the Territory at 30th June, 1963, under the control of the Administration's Water Resources Branch. Of these, 126 measure the volume of discharge from rivers and streams, 5 record tide levels (one of these being the Darwin Harbour Tide gauge, which is operated on behalf of the Harbour and Marine Branch) and the remaining 17 measure the level of flooding of the north sub-coastal plains.

Agricultural activity in the Territory is not extensive, being confined to the Darwin, Adelaide River, Coomalie Creek, Daly River, Katherine River and Alice Springs areas, with only small acreages being utilized. In these areas, a total of 320 acres on 49 farms is under irrigation. Purposes for which irrigation water is used include the growing of fruit, vegetables, crops and pastures, and for dairying and mixed farming.

The Katherine River appears to offer irrigation potentialities on the level soil below the township. Approximately 14 properties in and around Katherine are at present drawing water from the Katherine River for irrigation purposes, vegetables and pastures being the usual crops grown. The Katherine River passes through a gorge upstream of the town under conditions which appear suitable for dam construction. The Administration and the Commonwealth Scientific and Industrial Research Organization are investigating the potentialities of the Katherine area for agricultural production.

The possibility of using the Daly and Adelaide Rivers for irrigation is also being investigated. The Commonwealth Government recently approved the establishment of three pilot farms on the Marrakai Land System along the Adelaide River to ascertain whether rice and fodder crops could be grown on a commercial scale in this area.

§ 9. Papua and New Guinea

1. **Rainfall.**—Rainfall in Papua and New Guinea varies considerably from approximately 250 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).

2. **General.**—For a general description of these territories *see* Chapter V. The Territories of Australia, page 116, of this Year Book. Irrigation has not been developed on any organized 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. However, complete data regarding water resources are not available.

The largest rivers in the Territory include the Fly (at least 500 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 the previous chapter.