CHAPTER VIII

WATER CONSERVATION AND IRRIGATION

RESOURCES, UTILIZATION AND NATIONAL AND INTERSTATE ASPECTS

§ 1. Introduction

This issue of the Year Book contains, on pages 228-31, a description of recent developments in the measurement of Australia's water resources prepared by officers of the Department of National Development. For information concerning general, descriptive and historical matter reference should also be made to Year Book No. 37, pages 1096–1141.

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 Year Book No. 46, and a map showing the extent of known artesian basins throughout Australia is shown on page 273 of Year Book No. 48.

§ 2. Water Resources and their Utilization

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

The flow of Australian rivers is small in comparison with the flow of rivers in other continents, some examples of which, expressed as mean annual discharges in millions of acre feet, are: Amazon, 1,780; Mississippi, 474; Danube, 228; Volga, 148; Nile, 72; and the ten major 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, 1964. The list is confined to dams and reservoirs with a capacity of 100,000 acre feet or more. There are many others of smaller capacity in Australia.

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)1,300,000	40	Storage for Poatina 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 off-river 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, Tungatinah, Liapootah, Wayatinah and Catagunya hydro-electric power stations
Keepit	Namoi River, near Gunnedah, New South Wales	345,000	177	For rural water supplies and hydro-electricity generation
Arthur Lakes ..	Source of Lake River near Great Lake, Tasmania	(a)343,000	50	Part of Great Lake hydro-electric power development
Waranga	Goulburn River, Victoria	333,400	..	Irrigation storage
Tinaroo Falls ..	Barron River, north Queensland	330,000	136	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	Storage for Tarraleah, Liapootah, Wayatinah, and Catagunya hydro-electric power stations
Eppalock	Campaspe River, near Heathcote, Victoria	252,860	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)
Koombooloomba ..	Tully River, north Queensland	146,000	123	For hydro-electric and possible 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	*a*5,000,000	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	364	For regulation of discharges from stations of Snowy Mountains Hydro-electric Scheme, primarily for irrigation but also for power generation
Maraboon ..	Nogoa River, Central Queensland	1,170,000	148	For irrigation and probable thermal power station
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
Wuruma	Nogo River, Central Queensland	150,000	120	For irrigation storage
Rowallan	Mersey River, North Tasmania	110,000	140	Storage for Mersey–Forth power development

(*a*) Subject to final survey.

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 1959–60 to 1963–64, and the nature of irrigated culture in each State in 1963–64.

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*)
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 ..	1,036,846	1,151,555	220,562	112,813	51,501	24,285	434	1,247	2,599,243
1963–64—									
Cotton ..	452	..	2,717	..	1,546	..	..	..	4,715
Hops ..	..	(*f*)	..	..	(*g*)	1,463	..	..	(*h*) 1,463
Orchards ..	24,451	43,891	(*i*) 7,315	28,787	10,425	5,933	87	13	120,902
Rice ..	59,331	..	..	..	(*g*)	..	(*j*)	..	(*h*)59,331
Sugar-cane ..	(*f*)	..	98,204	..	..	..	..	..	(*h*)98,204
Tobacco ..	n.a.	n.a.	14,366	..	..	..	..	..	(*h*)14,366
Vegetables ..	2,859	24,422	36,329	10,541	9,166	6,319	105	120	89,861
Vineyards ..	12,810	45,257	(*k*)	27,954	966	..	..	..	(*h*)86,987
Other crops (including fodder and fallow land)	221,639	101,165	65,078	27,652	6,153	4,162	405	415	426,669
Total, Crops	*321,542*	*214,735*	*224,009*	*94,934*	*28,236*	*17,877*	*597*	*548*	*912,498*
Pastures ..	505,176	922,506	27,360	22,936	26,958	15,693	376	533	1,521,538
	(*h*)								(*e*)
Total, 1963-64 ..	1,060,479	1,137,241	251,369	117,870	55,214	33,570	973	1,081	2,657,797

(*a*) *Source:* Water Conservation and Irrigation Commission. (*b*) Includes total area irrigated by licensed diversions, but details for individual crops, etc., in 1963–64 (233,761 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 separately; included in Other crops. (*g*) Not available for publication; included in Other crops. (*h*) Incomplete, *see* footnotes to individual States. (*i*) Includes vineyards. (*j*) Not available for publication; excluded from totals. (*k*) Included with Orchards.

(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; the potability of saline waters for stock; the de-salting of brackish waters; and cloud-seeding over catchments.

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 Adelaide (South Australia) and 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 to co-ordinate the agricultural research of the various rural institutions working therein; to achieve close liaison between research and extension; and to conduct research in extension methods.

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 reforestation 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 underground 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.

(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
Murray ..	Victoria, New South Wales and South Australia	Miocene-Eocene ..	109,000	100 to 1,300
Georgina (including Barkly and Daly) ..	Northern Territory, Queensland	Cretaceous, Ordovician, Cambrian and Upper Proterozoic	108,000	150 to 1,000
Eucla	Western Australia, South Australia	Pliocene-Miocene ..	74,000	300 to 2,000
Carnarvon ..	Western Australia	Cretaceous, Permian..	45,000	200 to 4,000
Perth	Western Australia	Recent, Jurassic ..	21,000	200 to 2,500
Western District (Otway)	Victoria ..	Pleistocene-Upper Cretaceous	13,000	100 to 4,500
Basins of Ord-Victoria region	Northern Territory, Western Australia	Mainly Cambrian and Permian	12,000	200 to 1,000
Pirie-Torrens ..	South Australia ..	Recent, Pleistocene ..	9,000	Up to 600
East Gippsland ..	Victoria ..	Pleistocene-Eocene ..	3,500	200 to 3,500
Adelaide ..	South Australia ..	Recent, Oligocene ..	1,100	200 to 600

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 examples of use of these shallow supplies for industrial and domestic purposes occur 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. Examples of the use of shallow groundwater supplies for irrigation include the Burdekin Delta and the Bundaberg area in Queensland. In the Burdekin Delta, which covers an area of some 200 square miles, the present extraction for irrigation from underground sources is in the region of 200,000 acre feet per annum (about 150 million gallons a day) and in the Bundaberg area it is approximately 35,000 acre feet per annum (about 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 groundwater resources of river and coastal alluvium for irrigation and town water supplies.

§ 3. Some Recent Developments in the Measurement of Australia's Water Resources*

1. **Introduction.**—There has been a growing awareness in recent years that Australia does not have a reliable estimate of how much water is now available, and how much will be available in the future. Such an estimate is necessary so that the planning of water resources development projects can proceed on a sound basis. With the establishment of the Australian Water Resources Council in 1962 (*see* para. 5, p. 230) a means was provided of securing the highest level of basic information on Australian water resources and of making it readily available.

The following paragraphs offer some comments on the sources of water, the methods of assessing water resources, and the role of various authorities, including the Australian Water Resources Council, involved in the assessment which is currently proceeding.

2. **Sources of Water.**—The source of water can most generally be explained in terms of the hydrologic or water cycle. The cycle may be defined as the continuous movement of water between the ocean, the atmosphere and the land. This movement involves the physical processes of evaporation, transportation of water vapour in air masses, condensation leading to precipitation, the flow of water in streams and underground, and transpiration by vegetation.

* The following survey of recent developments in the measurement of Australia's water resources was specially prepared for this issue of the Year Book by officers of the Department of National Development.

Knowledge of the occurrence of water in the form of precipitation (rain and snow), rivers, streams and lakes and underground in the interstices of soils and rocks is a starting point in any inventory or assessment of resources. In Australia such an inventory broadly discloses that in this dry continent there is low and variable rainfall, high evaporation and low topography, with a dearth of cheap dam sites. Fortunately, underground water is fairly widespread both as pressure (artesian and sub-artesian) and non-pressure water.

3. **Assessment and Measurement of Resources.**—(i) *General.* A comprehensive national assessment of a country's water resources must show in quantitative terms the availability of water and indicate the possibilities of development of these resources by modern technology to meet specific needs such as irrigation, hydro-electric power generation, and urban, rural and industrial water supplies. Rainfall, evaporation and other meteorological elements, surface water and underground water must be measured by observations extending over long periods of fifty or more years at fixed locations or stations. Measurement of the quality of the water, particularly in the case of underground water, is essential. Although analytical methods are available for estimating water resources, there is no real alternative to direct measurement as a basis for the planning of water development projects or for the design of culverts, bridges and flood mitigation and drainage projects.

The Commonwealth Bureau of Meteorology is primarily responsible, *inter alia*, for the measurement of rainfall in Australia. The Bureau currently maintains some 7,500 rain gauges, but it is estimated that over 13,000 are required to provide an adequate national network. A continuous record of the intensity of rainfall is made by an instrument called a pluviograph. About 500 of the existing 7,500 gauges are pluviographs and a further 1,200 pluviographs are estimated to be required.

(ii) *Surface Water.* Surface water is assessed wherever possible by direct measurement of river flow (discharge) at stream gauging stations. Various authorities in each of the States and the Commonwealth are responsible for the measurement of stream flow in Australia (*see* para. 4, p. 230). The stream gauging requirements of these authorities have been compiled by the Australian Water Resources Council (*see* para. 5, p. 230), and it is estimated that a basic network of about 2,800 gauging stations is required to provide for an adequate assessment of the surface water resources of Australia. At present some 1,300 gauges are installed. Current plans call for the completion of the basic network within ten years.

Basically, stream gauging entails (*a*) obtaining records of water levels and (*b*) establishing a relationship or " rating " between the water level and the discharge.

Water levels can be recorded continuously by installing instruments at the gauging site. The discharge is obtained by visiting the site and measuring the velocity of the stream in vertical sections across the stream. Knowing the sectional area enables the discharge corresponding to the height of the stream at that particular time to be calculated. Measurement of the discharge over a range of water levels enables a relationship between discharge and water level to be established. In order to determine this relationship it is necessary to carry out measurements at the gauging site over a range of discharge conditions including periods of flood. " Rating " of the station can therefore require many years of measurement under arduous conditions before the records of water level can be correlated with discharge.

(iii) *Underground Water.* The measurement of underground water is a more complex task than is the measurement of rainfall and river discharge. The location of water beneath the ground entails surface and sub-surface geological investigations including geophysical exploration and the drilling of bores. Measurement involves controlled pumping tests and, over long periods, recording of water levels in observation bores to indicate the effects of continued pumping and the recharge capabilities of the aquifier. Quality testing is an important part of underground water investigations.

As in the case of surface water, the Water Resources Council has considered the deficiencies in underground water measurements, and many new underground water investigations extending over wide areas have been commenced. However, the large area involved and the problems encountered in attempting to measure precisely water flow in rocks mean that it could be more than fifty years before knowledge of Australia's resources becomes adequate.

4. Authorities Responsible for Water Measurement.—Surface and underground water resources are measured by both Commonwealth and State Government authorities. However, the greater part of the measurement programmes are undertaken by State Government authorities. As previously mentioned, meteorology (e.g. rainfall and evaporation measurement) is primarily a Commonwealth Government responsibility.

Commonwealth Government authorities carry out gauging in the Northern Territory (Water Resources Branch, Northern Territory Administration), and in the Australian Capital Territory and the Territory of Papua and New Guinea (Department of Works). In the Snowy Mountains Area and the Murray River basin both Commonwealth and State Government authorities have interests in stream gauging. The Commonwealth Bureau of Meteorology maintains river height stations which are used solely for flood warning.

State Government authorities are responsible for stream-gauging in their respective States. The principal authorities in each State are as follows.

New South Wales: Water Conservation and Irrigation Commission.

Victoria: State Rivers and Water Supply Commission; State Electricity Commission.

Queensland: Irrigation and Water Supply Commission.

South Australia: Engineering and Water Supply Department.

Western Australia: Public Works Department.

Tasmania: Hydro-Electric Commission; Rivers and Water Supply Commission.

Underground water resources are investigated by a number of the authorities that have responsibilities for stream-gauging, and by State Departments of Mines and the Bureau of Mineral Resources of the Commonwealth Department of National Development. The following are the principal authorities in each State and Territory.

New South Wales: Water Conservation and Irrigation Commission; Department of Mines.

Victoria: Department of Mines.

Queensland: Irrigation and Water Supply Commission; Department of Mines.

South Australia: Department of Mines.

Western Australia: Department of Mines.

Tasmania: Department of Mines.

Northern Territory: Water Resources Branch, Northern Territory Administration; Bureau of Mineral Resources.

Australian Capital Territory: Bureau of Mineral Resources.

Territory of Papua and New Guinea: Papua and New Guinea Administration; Bureau of Mineral Resources.

These authorities are assisted by various scientific and industrial foundations. In New South Wales, for example, the Hunter Valley Research Foundation is carrying out scientific investigations, including an integrated study of water, soils, and climate, in the catchment area of the Hunter River. In addition, the University of New South Wales recently formed the Water Research Foundation which has, among its objectives, research into underground water.

5. Australian Water Resources Council.—The assessment of Australia's water resources entered upon a new phase with the establishment, by joint action of the Commonwealth and State Governments, of the Australian Water Resources Council in 1962. The Council comprises the Minister for National Development as Chairman, the Minister for Territories and the Ministers for Water Supply in each State. It has as its principal objective the provision on a continuing basis of a comprehensive assessment of Australian water resources and the extension of measurement and research so that future planning can be carried out on a sound and scientific basis.

An important factor is that the Council is not concerned with particular works projects, normally the responsibility of the States or the Commonwealth, for which there are established channels for the exchange of views and allocation of funds such as the Premiers' Conference and Loan Council.

Assisting the Council is a Standing Committee of senior officers from Commonwealth and State water authorities, and there are a number of committees advising the Standing Committee, namely: Water Research and Education Steering Committee, Technical Committee on Surface Water, Technical Committee on Underground Water, Advisory Committee on Hydraulics Laboratory Facilities and several *ad hoc* panels.

The Water Resources Council has given close attention to a number of important matters of which the more urgent are the publication of a *Review of Australia's Water Resources (Stream Flow and Underground Resources)* 1963 (which was issued early in 1965) and the recommendation of accelerated programmes of stream-gauging and underground water investigations.

Australian Governments have adopted an accelerated programme of stream-gauging (surface water measurement) to extend over the next ten years, and have recognized the need for a continuous programme of underground water investigations. Under the *States Grants (Water Resources) Act* 1964, the Commonwealth Government grants financial assistance to the States in connexion with the measurement and investigation of their water resources. This means that £1,846,000 of additional funds (a sixty per cent. increase on current rates of expenditure) could be made available over the next three years relative to these programmes.

All authorities represented on the Council and its committees have agreed to work towards a common, nation-wide system of recording hydrologic data in a digital form suitable for rapid analysis by computer. The Council is also giving attention to the extent to which particular kinds of water research, and specialized training of research workers, can assist in bringing about the comprehensive water resources assessment envisaged as the Council's objective.

§ 4. 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.**—For information regarding the constitution, establishment, functions and objects of the Australian Water Resources Council *see* § 3, para. 5, p. 230.

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 River Murray Commission. The Agreement provides that the minimum quantity of water to be allowed to pass for supply to South Australia in each year shall be sufficient to maintain certain specified flows in the lower river varying from 47,000 acre feet a month in the winter months to 134,000 acre feet a month in the four summer months of maximum demand—the total amounting to 1,254,000 acre feet over twelve months. The flow at Albury is shared equally by New South Wales and Victoria, and each of these States has full control of its tributaries below Albury, subject in each case to the fulfilment of the South Australian allocation. For a brief outline of the operation of the Agreement prior to 1949, *see* Year Book No. 40, page 1065, and earlier issues.

At a conference of Ministers held in 1949 to consider the diversion of the Snowy River it was decided that, by diversion of streams in the Snowy Mountains area, an average of approximately 440,000 acre feet per annum would be added to the Murray River (*see* para. 5, Snowy Mountains Hydro-electric Scheme, p. 233) 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.

Further amendment of the Agreement to provide for the construction of a storage of approximately 5,000,000 acre feet capacity at Chowilla in South Australia was ratified by legislation in the Commonwealth and State Parliaments and came into force on 30th April, 1964. 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 quantity (in acre feet) of water diverted during 1963–64 from the Murray and its tributaries for irrigation and other purposes was as follows:—New South Wales, 1,908,000; Victoria, 2,765,000; South Australia, 269,000; a total of 4,942,000 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 of 2,500,000 acre feet was completed in 1961.

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

The Mulwala Canal, 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), Burrendong (Macquarie) and Wyangala (Lachlan); Victoria—Eildon (Goulburn), Waranga (Goulburn), Cairn Curran (Loddon) and Eppalock (Campaspe). 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. 204. 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. 204–6).

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.

§ 5. 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. 29, 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, 1912–1935, 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 233 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 451,263 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 (125,886 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 4,833 miles. This comprises 3,397 miles of supply channels (including main canals), 1,367 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 1963–64 and particulars of the areas under irrigated culture in New South Wales during the seasons 1959–60 to 1963–64.

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					
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	*c* 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	*c* 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	*c* 964,748
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	*c*1036846
1963–64—												
Irrigation Areas—												
Murrumbidgee (within the Areas)	451,263	30,122	22,556	6,651	2,626	88,020	4,793	5,161	20,566	2,429	34,563	217,487
Lands adjacent supplied under agreement	n.a.	..	..	362	326	1,136	..	..	96	..	..	1,920
Coomealla	34,672	..	..	..	7	..	..	4,610	1,580	..	..	6,197
Curlwaa	10,393	..	..	..	39	..	..	373	1,215	..	..	1,627
Hay	6,850	..	..	163	520	1,989	96	..	..	..	..	(*d*) 2,768
Tullakool	18,006	1,039	250	35	80	6,065	..	..	..	..	300	7,769
Buronga	8,693	..	..	..	1	..	..	199	525	..	..	725
Mallee Cliffs	1,900	..	..	..	16	..	..	113	124	..	..	253
Coleambally	125,886	9,162	7,009	200	175	4,655	..	40	46	77	25,472	46,836
Total	*e 657,663*	*40,323*	*29,815*	*7,411*	*3,790*	*101,865*	*4,889*	*10,496*	*24,152*	*2,506*	*60,335*	*285,582*
Irrigation Districts—												
Benerembah	112,818	5,141	9,120	1,785	1,391	32,378	1,570	..	..	50	10,062	61,497
Tabbita	32,330	358	1,035	334	50	4,867	150	..	..	..	1,015	7,809
Wah Wah	575,716	..	7,120	1,295	273	9,300	..	..	..	..	4,600	22,588
Berriquin	803,737	..	20,484	18,589	2,869	236,028	680	..	..	125	3,729	282,504
Wakool	503,322	7,034	5,440	1,856	1,560	63,119	..	..	..	..	1,020	80,029
Denimein	147,005	2,535	1,362	879	235	14,416	..	..	12	12	330	19,781
Jemalong and Wylde's Plains	224,556	..	5,788	11,411	618	12,532	1,100	..	..	..	440	31,889
Gumly	353	..	37	55	..	18	..	..	20	56	..	186
Deniboota	339,610	3,940	2,175	2,208	1,060	22,264	..	..	..	60	515	32,222
Total	*2,739,447*	*19,008*	*52,561*	*38,412*	*8,056*	*394,922*	*3,500*	..	*32*	*303*	*21,711*	*538,505*
Flood Control Districts—												
Lowbidgee	399,707	..	..	..	..	..	..	..	..	..	..	n.a.
Medgun	272,800	..	..	..	..	..	..	..	..	..	..	n.a.
Total	*672,507*	..	..	..	..	..	..	..	..	..	..	n.a.
Irrigation Trusts—												
Pomona	1,580	..	..	..	..	..	..	760	130	..	..	890
Goodnight	1,104	..	..	..	..	..	..	574	44	10	..	628
Bungunyah-Koraleigh	1,810	..	..	..	..	..	..	980	93	40	..	1,113
Glenview	661											
Bringan	4,933	..	..	..	..	..	..	..	..	..	..	n.a.
Bama	3,446											
Total	*13,534*	..	..	..	..	..	..	*e 2,314*	*(e) 267*	*(e) 50*	..	*(e) 2,631*
Water Trusts—Domestic and Stock Supplies	2,829,791	..	..	..	..	..	..	..	..	..	..	..
Licensed Diversions	n.a.	..	..	..	..	..	..	..	..	..	..	*f* 233,761
Total, 1963-64	6,912,942	59,331	82,376	45,823	11,846	496,787	8,389	12,810	24,451	2,859	82,046	1,060,479 (*c*)

(*a*) Excludes Flood Control Districts and some Irrigation Trusts, particulars for which are not available. (*b*) Citrus and deciduous; in 1963–64 deciduous amounted to 10,260 acres, of which 9,983 acres were in the Murrumbidgee Irrigation Areas. (*c*) Includes total area irrigated by Licensed Diversions, but details for individual crops, etc., are not available. (*d*) Includes lands outside irrigation areas supplied under special agreement. (*e*) Incomplete. (*f*) 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 376,824 acre feet, or nearly a quarter of the total water (1,711,180 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, 1964, its population was approximately 27,500, that of Leeton Shire being 10,500 and that of Wade Shire 17,000.

(*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, 1964, was 413,714 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, 1964, the total

length of completed canals and channels in Berriquin District was 994 miles, comprising Mulwala canal 75 miles, Berrigan channel 22 miles, subsidiary channels 783 miles, escape channels 104 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 313 holdings, and the area developed by irrigation includes about one acre in six 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 are the water trusts, other than irrigation, as at present constituted (the area in acres of each district being shown in parenthesis)—*Murray River*—Little Merran Creek (157,440), Bullatale Creek (68,320), Poon Boon (34,300), Minnie Bend Flood Prevention (2,190); *Murrumbidgee River*—Yanco, Colombo and Billabong Creeks (1,007,780); *Lachlan River*—Marrowie Creek (292,640), Torriganny, Muggabah and Merrimajeel Creeks (170,240), Ulonga (64,960), Micabil Weir (11,500), Condobolin West Weir (4,480); *Miscellaneous*—Great Anabranch of Darling River (959,184), Nidgery Weir (46,880), Algudgerie Creek (9,760), Collarenebri town water supply (117)—making in all a total area of 2,829,791 acres. Twelve 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 3,652 miles of open earth drains.

As at 30th June, 1964, 1,123 artesian bores had been constructed in the New South Wales section of the Basin. At that date, 650 bores were flowing and were capable of producing about 65,000,000 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 80,000 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, and work has commenced on a dam at Blowering on the Tumut River. Legislation has been passed authorizing the construction of a flood control and irrigation dam at Warkworth in the Hunter Valley. The Hunter River development, of which Glenbawn Dam is an integral part, 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 30th June, 1964, 183 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. 211).

§ 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. 29, 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. Subsequent 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 4,528,318 acre feet at 30th June, 1964. 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 5,889,738 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 1,137,241 acres in 1963–64, to which 1,701,468 acre feet of water were delivered. The Commission estimated the value of irrigated production in 1962–63 at £64,950,000, representing about one-fifth 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, 1964, 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:*—17,640; *Otway:*—1,080; *Miscellaneous:*—8,058; *Grand Total:*—5,889,738.

4. **Extent of Systems and Nature of Irrigated Culture.**—The following table shows the areas of the various irrigation systems in 1963–64, and the areas under irrigated culture during the seasons 1959–60 to 1963–64.

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					
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	2,236,747	26,113	43,180	22,820	858,385	61,317	45,757	43,059	22,634	28,290	1151555
1963–64—											
Goulburn - Campaspe - Loddon	1,349,100	8,862	20,581	11,985	407,744	17,496	409	23,727	3,115	6,883	500,802
Murray—Torrumbarry	359,865	4,948	4,320	4,874	209,714	16,790	4,339	1,691	730	3,962	251,368
Murray Valley Irrigation Area	302,041	200	6,841	1,053	96,400	908	42	5,814	287	340	111,885
Pumping(*b*)	80,764	10	547	136	601	302	36,976	3,373	171	1,471	43,587
Total	*742,670*	*5,158*	*11,708*	*6,063*	*306,715*	*18,000*	*41,357*	*10,878*	*1,188*	*5,773*	*406,840*
Other northern systems	n.a.	63	1,316	..	11,296	651	..	3,447	462	77	17,312
Southern systems	146,942	156	1,181	422	61,137	2,753	..	609	5,451	383	72,092
Private diversions(*c*)	n.a.	639	8,092	2,561	94,254	2,460	3,491	5,230	14,206	9,262	140,195
Total, 1963-64	**2,238,712**	**14,878**	**42,878**	**21,031**	**881,146**	**41,360**	**45,257**	**43,891**	**24,422**	**22,378**	**1137241**

(*a*) Excludes Other northern systems and Private diversions. (*b*) Includes First Mildura Irrigation Trust.
(*c*) 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.

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, located quite close to Melbourne around Werribee and Bacchus Marsh, are intensively developed for dairying and vegetable growing. An additional storage, Devilbend Reservoir (to serve the Mornington Peninsula system), was completed in 1964.

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 surplus water drawn from the Goulburn and Loddon Rivers, via the Waranga Western Channel referred to previously. 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, 24 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, 1964 for works under its direct control was £119 million. Of this amount, nearly £81 million were expended on irrigation and £9.5 million on domestic and stock supply systems Both these amounts were financed entirely by the State. The total liability for urban supply was £18.5 million, which was shared almost equally between the State and 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 water suitable 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 109,000 square miles, of which 27,000 square miles are in Victoria, 28,000 square miles in South Australia and 54,000 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 considerably expanded the work of exploration for underground water.

11. **Future Programme.**—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. Three storages, namely Chowilla Reservoir (a River Murray Commission Storage), Buffalo Reservoir, and Winton Reservoir, appear in the list of dams and reservoirs projected in the table on page 225.

Other works are:—

(*a*) Bellfield Reservoir on Fyans Creek (Grampians Mountains) to supplement the supply to the Wimmera–Mallee system (*see* paragraph 6, p. 241);

(*b*) An extensive channel enlargement and remodelling project in the Goulburn system (*see* paragraph 5 (i), p. 241);

(*c*) Tarago Reservoir on the Tarago River to supplement supply to the Mornington Peninsula area;

(*d*) Nillahcootie Reservoir on the Broken River below Mansfield, to be used for irrigation;

(*e*) 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

(*f*) 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 29, 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 1963–64, 19 per cent. of the sugar cane acreage was irrigated. This represented 39 per cent. of the total irrigated area in the State. Queensland is also Australia's major tobacco-producing State, and in recent years annual production of this crop has been greatly increased by means of development under irrigation. The area of tobacco irrigated during 1963–64 represented 96 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, some tobacco, and miscellaneous row crops. Spray irrigation is used widely on fruit, vegetables, fodder crops, and the major 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, 1960 to 1964, and for each division for the year ended 31st March, 1964.

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
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	8,562	34,258	7,020	81,506	15,801	2,206	58,029	22,341	221,161
1963–64—									
Southern Queensland ..	6,292	29 833	6,014	29,896	3,098	860	50,997	19,813	140,511
Central Queensland ..	635	1,280	385	80	15	1,781	9,588	4,053	17 182
Northern Queensland ..	1,988	5,216	916	68,228	11,253	76	4,493	3,494	93,676
Total, 1963–64 ..	**8,915**	**36,329**	**7,315**	**98,204**	**14,366**	**2,717**	**65,078**	**27,360**	**251,369**

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 Vailey, 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 Industry.

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. On the other hand, the fertile delta area, with its groundwater 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 groundwater 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 56,000 acres.

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 three dams and forty-two weirs with a storage capacity of 491,826 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, seed production, and stock fattening also appear suitable. One hundred and sixty-five miles of channels have been constructed, and irrigation water from Tinaroo Falls Dam is available to 549 farms.

In 1963–64 the value of tobacco leaf sold was £6.9 million from 518 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 were originally developed for tobacco production. However, following the recent expansion in the sugar industry, 132 of the 149 existing farms were granted cane assignments and it is expected that sugar production will be predominant in future years. 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. Two storages of 7,670 acre feet and 2,550 acre feet capacity have been constructed, about 79 miles and 72 miles respectively upstream from the mouth of the Burdekin, to augment supplies. At 30th June, 1964, 149 farms were occupied, but with the changeover to sugar production only 90 farms produced limited crops valued at £182,000.

(*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 investigation 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 £328,000. Pasture, vegetables, cotton, wheat, sorghum 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. Water supply for the area is obtained by pumping from the combined weir and road bridge on the Balonne River at St. George. A cotton crop yielding 3,100 lb. of seed cotton per acre during the year 1963–64 has paved the way for increased plantings in future years. Fat lambs, wool, and fodder crops were the main production and total returns were £91,600.

(*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.* Borumba Dam on Yabba Creek was recently completed. This is a rock-fill structure with an upstream impermeable concrete membrane 144 feet high above stream bed. In its initial stage, storage capacity is 34,500 acre feet with provision for later increase to 80,000 acre feet. In this first stage, water released from the dam is 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 233.

(*i*) *Macintyre Brook Project.* Construction of an earth and rock-fill dam at Codmunda on Macintrye Brook commenced in 1964. The dam will have a capacity of 61,000 acre feet and will allow irrigation of up to 8,000 acres.

(*f*) *Upper Burnett Project.* Approval has recently been given to the construction of a 120 feet high mass concrete gravity dam on the Nogo River to regulate water supplies available in the Upper Burnett River. This structure, to be known as Wuruma Dam, will have a storage capacity of 150,000 acre feet and will provide an assured supply for 11,000 acres of irrigation along 100 miles of the Burnett River.

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, page 244.

(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, 1964, 2,856 artesian bores had been drilled, of which 1,836 were still flowing. The total depth drilled amounted to 4,001,249 feet and the estimated daily flow was 196 million gallons. Although very few bores exceed 2,000 feet in depth (the average depth is 1,404 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 diminution are:—pressure, 1–2 feet of 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 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 11,299 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 1963–64 are:—areas constituted, 74; administered by the Commissioner, 56; administered by local boards, 6; number abolished, 12; area benefited, 4,193,237 acres; average rate per acre, 1.29d.; number of flowing bores, 56; total flow, 25,411,000 gallons a day; drains served. 2,541 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 are normally 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*) p. 244), 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 Barambah 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 of* 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, 1964, 615 facilities had been completed, and at 30th June, 1964, 31 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) Act* 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 Supply Assistance Acts*, 1958 to 1963" are 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 Acts authorize the provision of technical and financial assistance to landowners for the investigation, design and installation of approved works of farm water supply. All projects for which finance is provided under the Acts are carried out under Commission 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 Acts.

During 1963–64, 907 requests (636 for technical assistance only, and 271 for technical and financial assistance) were dealt with in addition to advice on a further 498 requests on groundwater supplies. An amount of £458,507 was approved for advances under the Acts in 1963–64, and the amount advanced was £311,678.

§ 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. Physiography, page 29, 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, 1964, 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 £1,860,746. 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 1959–60 to 1963–64.

AREA OF LAND IRRIGATED: SOUTH AUSTRALIA

(Acres)

Season and authority	Vine fruits	Tree fruits	Citrus fruits	Other crops(a)	Pastures	Total
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	27,384	26,876		36,745	21,808	112,813
1963–64—						
Department of Lands Irrigation Areas—						
Orchard land—						
Berri	4,722	1,193	1,486	..	..	7,401
Cadell	509	221	190	..	..	920
Waikerie	1,710	787	1,437	..	..	3,934
Cobdogla	4,324	249	347	..	..	4,920
Moorook	351	164	258	..	..	773
Kingston	178	77	298	..	..	553
Mypolonga	..	270	527	..	..	797
Chaffey–Ral Ral Division	744	69	8	..	..	821
Cooltong Division	3	45	2	..	..	50
War service land settlement—						
Chaffey–Cooltong Division	379	189	555	..	..	1,123
Loxton	3,240	955	2,188	..	..	6,383
Cobdogla–Loveday Division	255	29	43	..	..	327
Reclaimed swamp land—						
Monteith	..	..	..	..	992	992
Mypolonga	..	..	..	..	1,306	1,306
Wall	..	..	..	..	517	517
Murray Bridge–Burdett Division	..	..	..	..	106	106
Mobilong Division	..	..	..	..	429	429
Long Flat	..	..	..	..	338	338
Neeta	..	..	..	..	561	561
Pompoota	..	..	..	..	425	425
Cowirra	..	..	..	..	571	571
Jervois	..	..	..	..	3,635	3,635
Total	*16,415*	*4,248*	*7,339*	..	*8,880*	*36,882*
Renmark Irrigation Trust	5,366	2,477	1,000	457	..	9,300
Private landowners	6,173	13,723		37,736	14,056	71,688
Total, 1963-64	**27,954**	**28,787**		**38,193**	**22,936**	**117,870**

(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 1963–64 was 96,900 acre feet, equivalent to a consumption of 105 imperial gallons per head per day. The capital cost to 30th June, 1964 was £45,497,320.

(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, 1964, have cost £48,436,965 (exclusive of river control and irrigation works on the Murray River) and contain 7,630 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 Keppoch 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 pressure waters have been developed around the basin margin. These waters 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 1962, 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 provide 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 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 56 miles of drains, involving the excavation of 2,878,770 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 5,133,726 cubic yards of material has been excavated.

The capital cost of drainage in the South-Eastern Drainage Area System to 30th June, 1964, was £7,585,000, and the length of drains constructed was 763 miles.

An extensive system of private drains (many of which are conected to the drains constructed under Government authority) also exists in the south-east of the State.

§ 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. 29, of this issue.)

(ii) *Administration.* The Minister for Water Supply, Sewerage and Drainage administers the Departmental irrigation schemes under the *Rights in Water and Irrigation Act, 1914–1954;* he is advised by an Irrigation Commission representing the local irrigationists and governmental, technical and financial branches. The Minister for Works administers, under the *Country Areas Water Supply Act, 1947–1960,* the water supplies to about 190 towns and 4,200,000 acres of reticulated farmland, and also controls minor non-revenue producing supplies to stock routes and a few mines and agricultural areas with their associated communities. Five town supplies are administered by local boards under the *Water Boards Act, 1904–1954* which provides a large degree of autonomy with ultimate Ministerial control.

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).

The Public Works Department controls three irrigation districts in the south-west of the State, Waroona, Harvey and Collie River, the total area irrigated in these districts during 1963–64 being 29,708 acres and the total water used 106,010 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 (3,511 acres) is supplied from Samson Brook Dam (7,437 acre feet capacity) and Drakes Brook Dam (1,855 acre feet); the Harvey Irrigation District (13,821 acres) from Stirling Dam (46,191 acre feet), Logue Brook Dam (19,717 acre feet) and the Harvey Weir (8,372 acre feet); and the Collie River Irrigation District (12,376 acres) from the Wellington Dam (150,107 acre feet).

There are also three Irrigation Districts in the north of the State, Ord River, Camballin and Carnarvon.

The Ord District is served by the Bandicoot Bar Diversion Dam (80,000 acre feet capacity) completed in 1963. The principal crops are cotton, rice and safflower. Construction of channels and drains to serve 30,000 acres is proceeding. The Western Australian Government is considering a proposal to build a dam on the Ord River equipped with a hydro-electric plant, to conserve 3½ million acre feet of water, which will 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.

The Camballin District is situated adjacent to the Fitzroy River and is served by the Fitzroy Weir which diverts the wet season flow of this river. Total storage behind this weir, and a further small storage known as the 17-mile dam, is 5,700 acre feet. Rice and *sorghum almum* are grown by a company which is carrying out land development under an agreement with the Government.

At Carnarvon approximately 1,600 acres are under irrigated cultivation, water being pumped from shallow aquifers located principally in the sand bed of the Gascoyne River, which is dry for most of the year. The growers' activities are controlled by the Public Works Department to prevent the drawing in of the saline groundwaters which surround the area. A total of 3,100 acre feet was pumped by the growers during 1963–64. A pilot irrigation scheme serving 20 growers by pumping from aquifers located 5 miles from the plantation area has been in operation since 1963.

Particulars of the areas of crops and pastures irrigated in Western Australia in the seasons 1959–60 to 1963–64 are given in the table below.

AREA OF LAND IRRIGATED: WESTERN AUSTRALIA

(Acres)

Season	Vegetables	Fruit	Vineyards	Cotton	Other crops (*a*)	Pastures	Total
1959–60 ..	8,447	7,642	705	(*b*)	3,668	25,427	45,889
1960–61 ..	9,076	8,335	897	(*b*)	5,591	24,652	48,551
1961–62 ..	9,596	8,840	972	(*b*)	4,235	25,036	48,679
1962–63 ..	9,375	9,588	924	(*b*)	4,447	27,167	51,501
1963–64 ..	9,166	10,425	966	1,546	6,153	26,958	55,214

(*a*) Includes fodder and fallow land. (*b*) Not available for publication, included with Other crops.

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 and 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 88 towns, and water is reticulated to 4,200,000 acres of mixed farming lands. The total length of pipelines is 3,919 miles and the number of services is 24,114. The total quantity of water pumped from Mundaring Reservoir in 1963–64 was 3,315 million gallons. The total cost of the scheme to the end of 1963–64 was £19,425,091, of which the Commonwealth Government contributed £3,609,278 under the terms of the Comprehensive Water Supply Scheme.

(iii) *Comprehensive Water Supply Scheme.* A programme consisting of enlargements of and extensions to the existing Goldfields and Agricultural Water Supply, and the creation of a new system now known as the Great Southern Towns Water Supply, was agreed to in 1947 as a work to be financed jointly by the Commonwealth and State Governments. This so called Comprehensive Water Supply programme was completed in 1961. The Great Southern Towns Water Supply originates at Wellington Dam (built as an irrigation dam on the Collie River). Water is pumped thence through a system of three pumping stations and 87 miles of 30-inch pipes to Narrogin, thence north to Brookton and south to Katanning, thus serving all towns between these points on the Great Southern Railway. The raising of Wellington Dam to increase its capacity to about 150,100 acre feet was completed in 1960. Expenditure on the Scheme to 30th June, 1964 amounted to £10,257,902. Subsequent to the completion of the Commonwealth and State Governments' agreement referred to above, the State Government has financed and built an extension westwards from Katanning to Kojonup and has currently under construction extensions from Katanning south-eastwards to Gnowangerup and from a point north of Narrogin north-eastwards to Wickepin.

Further extensions, covering an additional area of approximately 3.7 million acres, are planned. The cost will be in the region of £10,500,000 and the Commonwealth has agreed to assist the development by the provision of an interest-bearing loan up to a maximum of £5,250,000 over a period of 7 years, the first advances to be made during 1965–66.

(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-five separate reticulated water supplies serve country towns and districts. Of these, 86 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.

There are 85 discharge measuring stations 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 is suitable only for stock. However, artesian aquifers are tapped to supply or augment the town supplies of Perth, Bunbury, Busselton, Eaton 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, Lancelin, Mandurah, Albany, Halls Creek and Gingin. 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 29 of this issue.)

(ii) *Main Purposes of Conservation and Utilization.* Bureau of the generally more adequate rainfall in Tasmania scarcity of water is not such a problem as it is in most mainland areas, though not all streams are 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 suitable for stock, minor irrigation works and for limited domestic use is exploited in the south-east, the midlands and north-western Tasmania. Supplies are mainly derived from fractured rocks by means of shallow bores which yield between 200 and 400 gallons an hour. On King and Flinders Islands water of variable quality suitable for stock and limited domestic use is obtained from aeolian sands. The township of Currie on King Island obtains up to 200,000 gallons a day for domestic use from this source. Underground water investigations, and almost all of the water boring in Tasmania, is carried out by the Mines Department.

(iii) *Administration.* In 1962 a new authority, the Metropolitan Water Board, assumed overall control of water supplies to the cities of Hobart and Glenorchy and the municipalities of Kingborough and Clarence, all of which, however, retain primary responsibility for reticulation. 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 the 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, pp. 219–20.

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, p. 254. 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, now nearing completion, 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 scheme near Cressy. 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 pumping systems.

Details of the areas of crops and pastures irrigated in Tasmania in the seasons 1959–60 to 1963–64 are shown in the following table.

AREA OF LAND IRRIGATED: TASMANIA

(Acres)

Season	Vegetables	Fruit	Hops	Other crops (*a*)	Pastures	Total
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
1963–64.. ..	6,319	5,933	1,463	4,162	15,693	33,570

(*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* 1938–1962 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.

Under the *Water Supplies Development Ordinance* 1960–1963 the Water Resources Branch gives financial assistance to landholders for the development and improvement of water supplies on agricultural and pastoral leases. 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 technical assistance to professional drillers and to landholders.

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, the 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. Outcrops of sandstone, limestone and shale also occur in this area and underlie the volcanic rocks in most places. In general, these sedimentary rocks dip gently to the east, and sub-artesian conditions prevail. Underground water in this region is obtained from sandstone aquifers which yield supplies ranging up to 4,000 gallons an hour. Most of the bores are required in areas where the sediments are overlain by basalts; selection of bore sites is usually difficult. Supplies of shallow groundwater from joints, cracks and faults in the basalt are insignificant and virtually all the bores obtain water from the sub-basalt sandstone aquifers. Successful bores in this area have ranged in depth from 200 feet to more than 600 feet. 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. Small supplies of underground water are obtained from bores intersecting joint zones in metamorphic rocks and granite of archaean age. However, except in areas close to recharge, the water quality varies from moderate to poor.

The Water Resources Branch of the Northern Territory Administration has intensified research aimed at increasing the water supplies for Alice Springs and Darwin. Bores into the Palaeozoic Mereenie sandstone, 12 miles South of Alice Springs, have intersected subartesian aquifers at depths between 500 and 1,000 feet, and water from these bores is now used to supplement the existing town supply from alluvial basins. High-yielding dolomite aquifers of Lower Proterozoic age in the area 16 miles south of Darwin are being developed to augment the Darwin water supply. Tennant Creek now has a water supply pumped from Cabbage Gum Basin, a small basin of alluvium and deeply weathered Precambrian rocks, 15 miles south of the town. A continuous check on the hydrological results of such pumping is maintained in order to adjust future yields from the basin.

Up to 30th June, 1964, 5,533 bores and wells were registered in the Territory. Of these 3,158 were for pastoral use, 246 for agricultural use, 258 served town and domestic water supplies, 19 were in use on mining fields, 252 were investigation bores, 386 were Government established stock route bores, and 114 were classified under other uses.

Registered bores which have been abandoned total 1,100. These include successful bores which have collapsed, and bores which were unsuccessful owing to drilling difficulties, insufficient quantity or poor quality of underground water.

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. At 30th June, 1964, 187 gauging stations were in operation in the Territory, under the control of the Administration's Water Resources Branch. Of these, 155 measure the volume of discharge from rivers and streams, 21 measure the level of flooding of the north sub-coastal plains, 7 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 4 measure storage water levels.

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, pages 118–19, 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 (700 miles long, situated in the western division of Papua), the Sepik (700 miles), the Ramu (450 miles), the Purari (300 miles) and the Markham (110 miles).

The main water conservation interest in New Guinea at present is the hydro-electric potential, which is extensive. An outline of schemes at present in operation is given in the previous chapter.